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# **Final Report**

# Developing an evaluation and progress methodology

to underpin the intervention logic of the Action Plan to Boost Demand for European Innovations – ENTR2008/006

# technopolis<sub>[group]</sub>

#### Title:

#### Developing an evaluation and progress methodology to underpin the intervention logic of the Action Plan to Boost Demand for European Innovations

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# o. Executive summary

While supply-side policies are well-known and well used instruments to foster innovation, demand-side policies are recognised as somewhat less well tapped. Several academics suggest that they are potentially powerful policy instruments with large potentials to spur innovation and growth.

The European Commission, aiming to foster innovation and growth, envisages that with the help of demand-side policies, innovation can be fostered and new markets can be established where European firms are likely to have a competitive advantage leading to employment and economic growth.

To this end, this study looks at a number of issues and questions and tries to provide guidance.

The first issue relates to "what are demand-side policies, how are they used, and what are the results?" Demand-side policies contain a mix of instruments. **Public procurement** is most likely the most known and widely used instrument. However, it is almost entirely not used as an instrument with the explicit aim to spur innovation. Yet, it is the instrument where the highest leverage effects are expected if only a small percentage of the current procurement budget would be used to purchase innovative goods and services. A special form of public procurement is pre-commercial procurement yet, it is strictly speaking not a demand-side innovation policy. A few countries experiment with this type, basically to support SMEs. Regulation, in form of laws but in particular in form of technical standards receive a mixed assessment: standards are seen as an important driver since standardisation allows for a cheaper and faster diffusion, but it is also seen as a barrier since it hampers possibly innovative solutions that do not match an existing standard. Standards thus need revisions in order to maintain their driving force. There are a number of **policies supporting private demand** – ranging from tax incentives, awareness-raising campaigns to labelling. Systemic policies as a demand-side instrument require a more holistic approach and include several policy instruments. The creation of lead markets is probably the best-known example for this instrument.

How are these demand-side policies used to foster innovation? While there were and are several policies in place, only a few were evaluated and many are not even planned to be evaluated. Thus, not only is empirical evidence on the effects of the policies hardly available, but the **lack of successful examples** is certainly not helpful in a further uptake of demand-side policies for innovation.

Based on 13 demand-side policies that were identified *and* for which an evaluation or review was conducted, several policies were initiated with a specific industrial, transport, energy or environmental concern.

Impact indicators on innovation were however rarely perceived in the policy design and are also lacking in the evaluations. A main message one can draw from the various cases is that **demand-side policies do not work in isolation but they need to be designed complementary to supply-side policies**.

For a better understanding of their functioning and effects on innovation, there is a clear need to design demand-side policies also with the aim to monitor implementation and assess the effects.

The second issue concerned the *identification of priorities*, or basically those future markets which would benefit from supporting demand-side measures of the European Commission. To this end, policy priorities at national level were analysed as well as priorities identified at the EC level. These priorities are in general very broad, leaving ample room for different technological developments, products and services. There are two aspects to consider: first, depending on the development stage of the underlying technological knowhow, the development of a specific market may take from a few to several years. Second, the choice of the demand-side instrument depends equally on the perceived timeline.

Since companies are more likely to plan future markets and there is no objective intelligence what will succeed on a future market, a selection of priorities based on political decisions will not necessarily be the best way to obtain competitive future markets. However, since the support involves public funding, it is legitimate to define broad avenues, for example based on the grand challenges.

The third issue concerns *concrete examples for proposals, their structures and the development of roadmaps.* To provide support for the proposing consortia as well as providing a basis for the selection process, a number of templates providing a structure for proposals were developed. Clearly, proposing consortia need to have a clear idea about the current situation and need to have a realistic vision. This will be translated in form of a roadmap. Thus, the study includes tables which can simply be filled in (e.g., on the current market situation, drivers, and barriers). For illustrative purposes a few case studies such as smart textiles or 3D printing are included which show that for different markets, differing available information – including data – may be relevant.

# 1. Introduction

This report brings together the results of the study in support to the first phase of the Action Plan to boost demand for European innovations. The report deals with basically three predominantly methodological tasks, namely:

- The development of assessment methodologies and data sources for the definition of markets and the baseline condition which is needed for the 'Identification of markets and sectors' in phase one.
- Provision of assessment methodologies and data sources for the conceptualisation and implementation of roadmaps.
- Provision of an inventory of practices for evaluating and defining demand-side innovation policies.

The report includes a number of case studies of evaluations of demandside innovation policies and a number of market analyses in its annexes. They provide a wealth of information and insights on this type of instrument. They also suggest that their use can be widened and their implementation needs to be carefully designed in a suitable policy mix, often with supply-side measures, in order to trigger innovation and obtain the set goals.

### Why demand-side policies ?

Demand-side policies are a more and more popular topic in policy circles. Whether or not this is triggered by the academic uptake of the subject is a moot point.

20 years ago, Lundvall (1992) noted that the public sector plays an important role in the process of innovation being the single most important user of new products and services, and that its regulations and standards influence the rate and direction of innovations.

While the literature on innovation systems acknowledges the importance of demand, academia did not widely address the concrete role of the public sector and public policy. There were some notions already in the 1970s, when von Hippel (1976), Mowery and Rosenberg (1979) argued that a systemic innovation policy needs to organise the interactions between users, consumers and other innovation stakeholders. The "re-vival" of the role of the public sector as a potential large innovation driver, occurred within academia with Edler and Georgiou (2007). Since then the attention of policy makers is rather strong.

What are demand-side policies that spur innovation? According to Edler it is "a set of public measures to increase the demand for innovations, to improve the conditions for the uptake of innovations or to improve the articulation of demand" (Edler, 2007).

Edler and Georghiou (2007) proposed to classify demand-side policy instruments in four categories:

- public procurement,
- regulation,
- policies supporting private demand, and
- systemic policies.

*Public procurement* to support innovation is most likely the best analysed demand-side policy (Mowery & Rosenberg 1979, Geroski 1982, Edler, 2010). In practice, large, mission-oriented technology procurement policies have existed since several decades. However, those activities were often individual measures designed to achieve specific goals, and most often they were part of a more conservative approach of industrial policy. Public procurement for innovation can be defined as ordering of a public organisation for the fulfilment of certain functions that could be fulfilled through a new product or service. The purpose is not the new product or service as such, rather than the need to satisfy human needs or societal problems (Edquist 2012).

*Pre-commercial public procurement* obtained attention as a special form of public procurement. Since it "*concerns the research and development (R&D) phase before commercialisation*", (EC, 2008) and does not involve a buyer, it is strictly speaking not a demand-side policy (Edquist, 2012).

Concerning *regulation* (including standardisation) there are some analyses, often sector-specific (Blind 2011, 2012; OECD 2011).

Other demand-side innovation policies are much less in the focus of academia as well as policy makers; at least there are not too many evaluation studies of relevant measures to be identified.

Several demand-side innovation policies take time – often a year or two to be implemented, and their direct and indirect impacts may show even much later. It is thus a more than welcome approach of the European Commission to foster innovation while equally fostering the uptake of demand-side measures. The implementation of pilot cases – to be developed via a roadmapping process - is a timely and valuable approach for providing successful examples, which then again may trigger more and more demand-side innovation policies.

# 2. Inventory of policy evaluations

The following sections compile an inventory of policy evaluations of demand-side innovation policy measures primarily at national level. The objective is to describe the current practice of evaluation methods, indicators and data used in this policy area; furthermore the subject of a more general indicator development for assessing demand for innovations is presented.

Strong demand for innovative goods and services constitutes an important basis for innovations to be taken up and thrive. This is also recognised in the most recent national and regional innovation policy papers in the EU, which often draw attention to the obstacles that a low level of demand for innovations can pose. A wide-range of demand-side policy instruments is at the disposal of policy-makers such as public procurement of innovation, standardisation, stimulating public and private consumption of innovations, incentives in regulatory frameworks or fostering user-driven innovation. Various pilot initiatives and policy measures have been launched across Member States, and these are reasonably well documented in terms of their objectives and mechanisms, however, there is much less information in the public domain concerning their impacts, related evaluations and their findings.

In order to begin to fill this information gap, the following draws upon the available literature and establishes an inventory of evaluation studies and reports of demand-side policy measures. 13 specific evaluations are explored in further detail in terms of the evaluation methodology, indicators used and evidence found (Appendix B).

The objective of the case studies is primarily to learn about the evaluation process itself and not only about the outcomes and impacts of the policy measures. In the following, evaluation practices are summarised in terms of the evaluation methods and tools applied and key findings of the evaluation reports are synthesised. We then explore the issue of identifying demand-side indicators that can help assessing the demand conditions for innovation. Finally, the last part provides five policy recommendations based on the key observations of this review.

# 3. Evaluating demand-side innovation policies

#### 3.1 Background

Innovation-support measures are increasingly deployed throughout the EU, however evaluation practice while improving is still not quite as systematic or considered as it perhaps should be. This patchiness is commonplace with newer policy initiatives, such as demand-side innovation policy measures. Innovation policy funders publish evaluation studies only selectively and there is an occasional practice of evaluating and monitoring the impacts of demand-side measures. This statement might not be such a surprise since many of the demand-side policy support measures have been recently launched and insufficient time has passed to be able to measure their real impact.

For the purposes of this report, demand-side innovation policies are defined as policy instruments aiming to increase the demand for innovations, to improve the conditions for the uptake of innovations or to improve the articulation of demand (Edler, 2007). These measures have only emerged into the mainstream in the past decade, even if some market transformation programmes existed since the 1980s (detailed classification see in Appendix A). There is a need to improve the evaluation record for several reasons:

Demand is one of the strongest drivers of innovation. Ignoring that fact will create a somewhat skewed policy mix and may depress aggregate rates of innovation, productivity and economic growth. This is especially important in economies increasingly dominated by services and where growth opportunities often link back to the public sector or consumers. The fledgling evaluation record cannot yet provide the kind of encouragement or insight found in other policy settings, and must in some sense at least hold back the deployment of the most effective measures.

The potential of new innovations depend on the extent to which customers are able and ready to purchase the new products and services and if the products are according to their preferences and needs. Thus optimally, the assessment of the demand side of innovation shall form an integral part of any innovation system reviews. Countries and regions shall have a framework at hand that helps monitoring to what extent has innovative entrepreneurial base broadened, to what extent has the absorption capacity for innovations developed and how has the demand for novel products and services from final beneficiaries evolved. As the literature on evaluation methodologies suggests, evaluators need to take a holistic view of the innovation systems and of the policy mix.

The presumed efficiency or high "value for money" of demand-side measures is also of considerable interest to governments under severe financial pressure. Evaluation of demand-side policies are of great interest at a time of constrained public budgets, when there is a need of a good understanding of the potential impacts of the chosen policy mix and there is an interest in turning to (seemingly) less costly, yet effective, innovation policy measures such as demand-side regulations, public procurement, standards or support for user-driven innovation.

#### 3.2 The inventory

Based on an extensive desk research, this report gathers together the mid-term or ex-post evaluation studies of 28 demand-side support measures and reviews the evaluation methods and indicators applied. It also includes a review of the key findings about the effects on innovation activities and performance (see Figure 1). Out of this list of 28 reports, 13 are presented in detail in Appendix B.

The literature review has focused sharply on official evaluations commissioned by authorities (such as ministries, innovation agencies) and on evaluative reports from the academic and grey literature, which explicitly consider the impact of demand-side measures on innovation. This explains why the list (28 items) is really very short. The list would be one or two orders of magnitude longer were it to include all reports describing demand-side measures.

The reports were sorted according to the definition of demand-side innovation policies as outlined in Annex A, distinguishing four main groups:

- 1) public procurement
- 2) regulations and standards
- 3) support to private demand
- 4) other measures such as user-driven innovation or systemic policies.

The inventory includes a proportionately larger number of papers relating to 'support for private demand' and 'public procurement.' We found just four papers presenting evaluations or critical reviews of more systemic policy approaches.

Figure 1 Inventory of evaluation reports and studies of demand-side policies

Country	Policy measure	Reference of the evaluation study or report
Public procurement		
NL	Dutch Small Business Innovation and Research	Technopolis Group (2010), 'Eerste evaluatie Small Business Innovation Research (SBIR) programma's in Nederland', Evaluation performed for the Ministry of Economic Affairs, March 2010
UK	UK Small Business Research Initiative	Bound K., Puttick R. (2010). Buying Power? Is the Small Business Research Initiative for procuring R&D driving innovation in the UK? NESTA Research report June 2010.
CA	Innovation Commercialisation Programme	House of Commons Canada (2011). "Effectiveness of the office of small and medium enterprises and the Canadian innovation commercialization program", Report of the Standing Committee on Government Operations and Estimates, Pat Martin, M.P. Chair

NO	Public and Industrial Research and Development Contracts	Morten Staude et. al. (2000). Til beste for de beste, en evaluering av offentlige og industrielle forsknings- og utviklingskontrakter, STEP- report R-03 2000, Oslo
SE	Technology Procurement	Lewald, A., Bowie, R., (1993) What is happening with the Swedish Technology Procurement Program? A condensed version of the procurement program's first process and impact evaluation
US	US SBIR	Wallsten, S. (2000), The Effects of Government-Industry R&D Programmes on Private R&D: The Case of the Small Business Innovation Research Program. Rand Journal of Economics, Vol. 31, N°1 (Spring 2000). National Survey to Evaluate the NIH SBIR Program, National Institutes of Health. Office of Extramural Research. January 2000
ES	22@UrbanLab Barcelona	Case Study 22@UrbanLab: Barcelona's initiative to foster pre- commercial and public procurements of innovative products and services

#### **Regulations and standards**

NL	Energy Performance Regulations	Beerepoot M., Beerepoot N. (2007). Government regulation as an impetus for innovation: Evidence from energy performance regulation in the Dutch residential building sector. Energy Policy 35 (2007) 4812–4825
BE	Standardisation programme	Technopolis France (2004). Evaluation of "Standardisation" programmes, for the Belgian Federal Public Planning Service Science Policy, Final report
UK	British Building Regulations	David M. Gann , Yusi Wang & Richard Hawkins (1998): Do regulations encourage innovation? - the case of energy efficiency in housing, Building Research & Information, 26:5, 280-296
UK	Standardisation and innovation	DTI (2005). The Empirical Economics of Standards
UK	Regulation and innovation	BERR Economics Paper Number 4, Regulation and innovation: evidence and policy implications, December 2008
DK	Regulations in the construction	Øster J., Napier G. and Hvidberg M. (2011). How intelligent regulation can become an active element in Danish innovation policy - Based on cases from the Danish construction sector. FORA. Danish Enterprise and Construction Authority

# Supporting private demand

NZ	Heat Smart Programme	Grimes A., et al (2012). Cost Benefit Analysis of the Warm Up New Zealand Heat Smart Programme (revised) , Final report for the Ministry of Economic Development, revised
AU	Thermal renovation programme	WIFO (2010). Thermische Gebäudesanierung nutzt Umwelt und Wirtschaft Erfahrungen mit dem Sanierungsscheck 2009 und Perspektiven fur eine Fortsetzung
US	US solar tax	Rich D., Roessner J.D. (1990). Tax credits and US solar commercialization policy. Energy Policy March 1990
UK	UK Climate Change Levy	Martin, R., de Preux, L.B. and U.J. Wagner (2009). The Impacts of the Climate Change Levy on Business: Evidence from Microdata, Centre for Economic Performance Discussion Paper 917, London School of Economics, UK.
DK	Danish Energy Labelling Scheme	Kjærbye H. (2008). Does Energy Labelling on Residential Housing Cause Energy Savings?
US	Incentives for hybrid-electric vehicles	Diamond D. (2008). The impact of government incentives for hybrid- electric vehicles: Evidence from US states
SE	Market transformation programmes	Neij L. (1999). Evaluation of Swedish market transformation programmes. Lund University
DE	Market incentive programme/ Renewable Energies	Langniß et al (2010). Evaluierung von Einzelmaßnahmen zur Nutzung erneuerbarer Energien im Wärmemarkt (Marktanreizprogramm) für den Zeitraum 2009 bis 2011
PL	IFC/GEF Poland Efficient Lighting project; CFL Subsidy Programme	Navigant Consulting (1999) "Evaluation of the IFC/GEF Poland Efficient Lighting Project CFL subsidy program. Final Report, Edition 1" Washington DC, International Finance Corporation

DE	Ecological Tax Reform	Knigge M., Gorlach B. (2005). Effects of Germany's Ecological Tax Reforms on the Environment, Employment and Technological Innovation Research Project commissioned by the German Federal Environmental Agency (UBA)
Other demand-side policies		
FI	Finnish Demand and User-driven policy	Interim Report 13 April 2012 Ministry of Economy Finland Evaluation of the Finnish National Innovation System – Full Report - 2009
DK	Danish Programme for User-driven Innovation	DAMVAD (2009). Midtvejsevaluering af program for brugerdreven innovation Udarbejdet af DAMVAD for Erhvervs- og Byggestyrelsen.
JP	Future City initiative	Interim report, Low-Carbon Society Scenario toward 2050: Scenario Development and its Implication for Policy Measures, Multi criteria on evaluating long-term scenario and policy on climate change, 2008 http://2050.nies.go.jp/report/file/interim/H19_S-3-2_abstract_e.pdf
CA	Transportation Science and Technology Programmes of Natural Resources Canada's Energy Sector	Natural Resources Canada, Evaluation of the Transportation S&T Sub-sub activity (2010), http://www.nrcan.gc.ca/evaluation/reports/2010/2977#c2-1
	Nordic Swan Ecolabelling scheme	Aalto K., Heiskanen E., Leire C., Thidell A. (2008). The Nordic Swan – From past experiences to future possibilities. The third evaluation of thee Nordic ecolabelling scheme. TemaNord 2008:529.

This inventory of evaluation studies shows that there is some experience with the evaluation of public procurement of innovation and precommercial public procurement schemes. Several impact assessments were published on market incentives for innovation, and some exist on regulations and standards (many of them academic studies and not officially commissioned by authorities). There is a lack of practice for evaluating labels, user-driven innovation programmes and living labs and even more so for systemic policies that embrace both demand and supply side measures at the same time.

Although ideally demand-side instruments ought to complement supply-side instruments, system-wide evaluations covering both dimensions are rare. Interesting exceptions are for instance the Japanese 'Future City' initiative or the Canadian Transportation Energy S&T Sub-sub Activity. The latter consists of basic to applied R&D; support for the development of standards; and demonstration of technologies. The evaluation of this activity was performed in 2010 through qualitative case studies and interviews and based on a costeffectiveness calculation. Some reviews of national innovation systems exist, which assessed both the demand and supply-side innovation policy instruments in a holistic approach. For instance the evaluation of the Finnish National Innovation System in 2009 took a broad-based approach and assessed all policies including demand-side measures.

In thematic terms, a majority of the evaluation papers reviewed for this study address issues to do with environment and energy, which may point to the critical importance of user behaviour in challenges related to material and energy efficiency, waste and emissions. One might expect to see similar strategies with respect to public health, through for example developments in food labelling and the combined ambition of changed consumer behaviour and the creation (innovation) of healthier food options.

These measures that targeted energy, sustainability or transport are often evaluated in terms of their environmental or social impacts rather than the impact on innovation. For instance the evaluation of the French Bonus-Malus system on registration of cars with low levels of fuel consumption and CO<sub>2</sub> emissions assessed the costs and benefits of the scheme. We know less, however, how this increased demand influenced further innovation or R&D in the area. Similarly, the Swedish environmental excise duty has been analysed in terms of the consumption patterns of cars.

The majority of evidence on the impact of demand-side innovation policies are provided through academic papers and research syntheses rather than formal evaluations of public policies, which suggests a potentially significant proportion of the total body of evaluation work is not in the public domain (or that is has not been undertaken, which seems less likely given the amounts invested in these kinds of schemes).

Overall, the inventory has something of an English-language bias, however we have identified several relevant reports written in other languages.

The geographical coverage of evaluations are very concentrated around certain countries such as Denmark, Finland, Germany, the Netherlands, Sweden and the UK and international examples such as from the US, Canada or New Zealand.

#### 3.3 Evaluation methods

Evaluation is a systematic and objective process that assesses the relevance, efficiency and effectiveness of policies in attaining their originally stated objectives (EC, 2002). Figure 2 presents an overview of the methodologies used in the reviewed evaluation reports grouped in four main demand-side policy categories, which will be discussed in this section in more detail.

The evaluation reports identified in this study are sometimes limited in their scope and they report on the direct results and outcomes of the measures and appraise less the wider impact on innovation performance or other economic objectives. The objective of these evaluations is often to decide if to continue the programme or not and to explore the lessons learnt of the implementation process. Although experience suggests that short run and long run impacts should be distinguished and both assessed, the evaluations focus on shorter-term efficiency and effectiveness rather than on long-term results except for some of the market incentive programmes and regulations.

Ex-ante impact assessments of demand-side innovation policies are rare (or are not published), although ex-ante studies could offer a good baseline and help later on the comparison of targeted and realised objectives.

Type of measure	Usual evaluation tools	Indicators	Data sources
Public procurement	Case studies, surveys	Number of projects, Number of supported companies, Budget of the calls, Procurement budget of innovation, industry sector, Innovative products developed, Number of projects that have been become real purchase Share of innovative public procurement in the total public procurement	Survey data, Data from supported projects
Regulations and standards	Statistical analysis, regression, case studies, interviews	Type of new technologies developed, Energy performance calculations, consumers adopted the technology	Primary data collection through semi- structured interviews, statistics of standardisation authorities, Databases of municipalities
Support to market demand, tax incentives	Case studies, surveys, statistical analysis, cost-benefit analysis	New product sales, Export of products	National Statistics
User-driven innovation and living labs	Case studies	Number of projects, Number of supported companies, Innovative products developed, Number of users involved	User survey data, Project data

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Own elaboration based on the reviewed evaluation reports and studies

What we find is that qualitative approaches prevail and the **evaluation reports are based on case studies, surveys and interviews** in most of the cases. This finding is not surprising since assessing the results of demand-side innovation policy and attribute cause and effect to them is a very complex task with almost impossible to find control groups and very hard to attain statistical data.

Based on this inventory, it appears that more elaborate micro-level econometric analysis is rare, although it was applied in the case of some regulations (e.g. the UK Climate Levy) or certain programmes such as the US Small Business Innovation Research programme. An interesting method here suggested by Martin et al (2009) in their report on the UK Climate Levy relies on the combination of the interview and revealed preference methods with micro-data. This method needs, however, high-quality data and databases, which are difficult to obtain. Econometric approaches might not be the most useful given also the systemic nature of demand-side innovation policies (Tsipouri, 2012).

Other evaluation methods applied are for instance international benchmarking and peer review used in the case of procurement schemes such as the Dutch SBIR variants were compared with the SBIR programmes in the U.S. and in the UK.

Correlation and linear regression or multivariate regression analysis were also applied in some cases of analysing the impact of regulations or market incentive programme's on innovation such as the Dutch energy performance regulation or in the Danish programme for userdriven innovation.

There is also an example identified for a cost-benefit analysis that helped to attribute the innovation or environmental effects of the measure to activities supported such as in the case of the New Zealand Heat Smart programme. It has to be noted though that using costbenefit analysis involves uncertainties and methodological problems as well. Evaluations of demand-side eco-innovation policies often relied on a method of comparing the intervention outcome with the baseline situation.

Identifying a baseline situation is rare, although it could be extremely helpful. The evaluation of the Dutch Energy Performance Policy for instance, suggested defining a reference situation in order to assess the effects of regulations. This 'baseline' states the situation in the absence of the measure. The baseline should preferably be determined ex-ante, but it can be defined ex-post.

The evaluation reports' main query was in general the effectiveness and quality of the measures thus give indications if the measure has lived up to expectations, if the return on investment was adequate and what would have happened without the measure. They usually seek answers to questions such as: what types of projects were supported; what type of new technologies and products were developed; who were the beneficiaries; what was the impact on certain target groups.

Although several evaluation tools would have their potential to be applied such as more complex micro-economic modelling in the case of market incentives, network analysis to capture user-driven innovation programmes or techniques such as webometrics or value chain analysis, this report could not identify such practices (see Figure 3). Peer reviews and prospective studies could also have much more potential as currently applied.

In terms of the indicators used in the evaluation reports reviewed, they relate to output indicators in genera such as

- number of projects supported;
- number of applicants and proposals;
- number of firms supported;
- average funding per project;

and outcome indicators such as

- number of new innovative products;
- technologies developed;
- collaboration with other organisations;
- revenues and sales generated.

Policy evaluation tools	Procurement	Regulations	Market incentives	Systemic policies
Cost-benefit analysis			Х	
Statistical approaches	Х	Х	Х	Х
Econometric models	Х	Р	Р	
Innovation surveys	Х	Х	Х	Х
Expert panels/ Peer review	Х	Р	Р	Р
Case studies	Х	Х	Х	Х
Network analysis	Р	Р	Р	Р
Prospective studies (foresight and technology assessments)	Р	Р	Р	Р
Bibliometrics and patent analysis		Х	Х	
Webometrics			Р	
Value chain analysis	Р	Р	Р	Р
Benchmarking	Р			

Figure 3 Applied evaluation tools and the ones that could be potentially applied

Note: P = potential X = the tool is applied

Source: Adapted list following the RTD-Evaluation Toolbox Assessing the Socio-Economic Impact of RTD-Policies (EC, 2002)

Some of the evaluations also make an attempt to measure the adoption of new products or the consumers' interest in the new products such as in the case of the German ecological tax. Finding appropriate indicators is very much dependent on the sectoral or thematic specificities in case the measure addressed a specific area such as environment, energy or health. The indicators do not include specific demand-side indicators (see Chapter 4).

The evaluation of demand-side innovation policies is, however, a difficult exercise. First of all problems arise in terms of indicators and baseline data that are even more difficult to find than in the case of supply-side innovation policies (Edler, 2012). A further constraint is that the markets or thematic areas targeted by demand-side are often transversal and cut across sectors. Most of the established statistical systems, notably NACE classification, are based on the traditional view of economic sectors and cannot be easily used for market analysis.

For instance, in the case of energy regulations it is very hard to find indicators on the pattern of standards, innovation and information exchange. Nevertheless, a solution can be to extract survey data for instance from the World Economic Forum's World Competitiveness Year Books. A Swedish study on energy efficient lighting designed a measurement model and time dynamic analysis on the effects of energy performance standards on energy use in Sweden. This approach could be useful but there are still many unverifiable assumptions. Identifying baseline data can be done through primary collection through innovation panels, or innovation networks' workshops as it was done in the case of a review of the impacts of the British Building Regulations (Gann et al, 1998).

A further constraint is that it is difficult to identify a control-group to assess the impact (OECD, 2011), it is problematic to separate the effect of one instrument from other supply-side instruments that are simultaneously in place, and it is not straight-forward to run a counterfactual analysis. As a solution, for demand-side innovation policies, the OECD suggests as counterfactuals through experiments or participant opinion and expert review (OECD, 2010).

In sum, there is no evident and distinct approach to the evaluation of demand-side policies and there is no best practice to evaluate them. Differences in approach appear to reflect differences in circumstances and external factors, rather than the specific nature of the entity to be evaluated. It seems that the case study and survey-based approach proved to be the most popular to analyse policy effects on the innovation activities of firms. Nevertheless, some methods or combination of methods can be more suitable to certain stages of demand-side policy implementation, and the methods should be selected according to the timing and requirements of the concrete policy measure (Arnold, 2009).

In terms of the methodology applied, it is also a question at which level is the demand-side policy evaluated: project, programme or policy level. While evaluations at the project level can be methodologically more consistent, evaluations at the programme or policy level require further insights into the causal relations between inputs and outputs (EC, 2002).

Conceptually, one could construct an evaluation framework, which starts at an ex-ante identification of the baseline situation, thus later on it allows the mid-term or ex-post evaluator to draw upon this and compare the evolution in terms of the baseline indicators. The evaluation ideally shall embrace not only the appraisal of supported projects but explore the economic impact and the potential spillovers and diffusion of innovation. The latter can be important since some of the demand-side policy measures have an important cross-sectoral impact. Increased innovation demand by one firm may create positive externalities to others, which might constitute an important change in the economy. Figure 4 below depicts this conceptual framework for the evaluation of demand-side policies. Figure 4 Conceptual framework for evaluating demand-side innovation policies



Ideally, the evaluation should take into account the wider policy mix as well and analyse the role of the measure on the policy landscape. The interactions with other relevant measures or the complementary measures launched parallel are important to put under scrutiny. This wider policy context is especially important if to better understand the policy impacts.

Another relevant issue to explore is the question of how the demandside policy measure managed to trigger private demand and analyse the value chain related to the targeted sector or thematic area.

### 3.4 Findings

The academic literature reveals a mixed picture of the impacts of demand-side policies on innovation performance and innovation activities of firms, although they tend to emphasise the positive effects. In the following section the findings of the evaluation studies reviewed for this paper will be summarised and complemented with the learning from other academic studies. The objective here is to briefly report on the findings without providing a comprehensive assessment of the effectiveness of demand-side innovation policies.

### Public Procurement of Innovation and Pre-commercial Public Procurement

Evidence on the effectiveness of public procurement of innovation or pre-commercial public procurement schemes has been discussed through a number of official evaluations or in an increasing number of policy and academic reports. The examples are pre-commercial procurement schemes such as the US, UK and Dutch SBRI programmes, or procurement of innovations such as the Swedish technology procurements, the Norwegian OFU/IFU schemes or Spanish regional examples. For certain policy measures it would be too soon to assess the impact on the commercialisation of the selected innovations, such as in the case of the recently launched Canadian Innovation Commercialisation Programme (2010) where it was estimated that it should take 5 to 10 years to get the innovations to market.

The evaluation reports arrive to similar conclusions. First of all, they confirm that the public sector plays an important role as a partner to commercial interests in developing innovations. They often stress that procurement of innovation schemes need to pay particular attention to awareness raising, to train competent procurers, to develop organisation skills and mechanisms to risk-sharing if to be successful. One of the key findings across SBRI types of schemes is that it accelerates the time to market and entrepreneurs value the fast procedure, accessible registration and low administrative costs. Companies are distinctly enthusiastic about the opportunity SBIR provides to mobilise their entrepreneurship and innovative strength to help the government solve societal issues.

The Norwegian OFU/IFU (Public and Industrial Research and Development Contracts) scheme was evaluated in 2000, which showed that this policy measure has been successful in terms of achieving its basic objectives and providing value-for-money. Approximately half of the OFU/IFU contracts have led to sales, both to the customer company/public institution and to others, however half of the contracts are considered to be unprofitable or unclear as regards profitability. The scheme identified ex-ante indicators such as - at least 50 per cent of the projects shall one year after they have been finalised lead to sales to other parties than the project partners - or - at least 25 per cent of the funding shall go to projects leading to cooperation between parties that have not cooperated before.

The progress of pre-commercial public procurement or procurement of innovation schemes is usually monitored on a project-basis, by reviewing and following up the supported projects such as in the case of the UK SBRI initiative. More sophisticated monitoring systems have been also established. For instance, NUTEK applied two computer models to estimate future savings that resulted from the Technology Procurement Programme that run between 1988 and 1992. The tool helped to forecast energy-use patterns at the end-use level and followed up sales statistics, types of residences, the number of inhabitants, and technical specifications (NUTEK, 1990). The ex-ante indicators set out by the Spanish Innodemanda scheme is a target of 3% of the total public budget should be innovative public procurement kind of incentive.

Numerous further studies have been published that are analysing the role of public procurement in fostering innovation and several case studies exist that explore its success factors. For instance, public procurement was found especially effective for SMEs and thus promising for firms with limited resources, moreover also powerful in regions with economic challenges (Aschhoff and Sofka, 2009). Case studies proved especially useful to present good and bad practices, such as in the study of Edquist and Zabala (2011). These case studies usually showcased individual examples where the public sector bought research or innovation and helped the uptake of the developed new products such as hearing aids, e-books or greenhouse solutions. They also present several cases to learn from mistakes such as the Swedish highspeed train, where the lack of experience and too strict technical specifications led to the procurement of solutions that were less competitive on the world market.

# **Regulations and standards**

In some of the Member States such as Germany, UK and Sweden it was found that there is a practice in the responsible ministries to commission impact assessment of regulations or standards, however, it is not a general trend across Member States to assess the effects of regulations on innovation performance. Empirical evidence on the impact of regulations and standards on innovation exists primarily in the field of environmental and energy policies. The lessons learned so far, however, are still limited (FORA, 2011).

The evaluation reports usually rely on statistical analysis based on national statistics, energy performance databases or primary collection of information. The evaluation reports stress that the characteristics of particular products and technologies need to be understood within their market contexts. Regulations shall match the requirements of the sector, the structure of industry and technical infrastructure. It is likely that without appropriate detailed knowledge within regulatory authorities, regulations may miss their intended goals.

A study by Gann et al (1998) for instance analysed energy regulations in UK housing based on a case study of the British Building Regulation, which set minimum thermal performance levels for domestic and nondomestic buildings in England and Wales. As it was found, the availability of new knowledge, together with development of appropriate mechanisms all influence if the regulation has an effect on innovation. On paper, regulations can be nothing more than a brief 'functional requirement' which is left for designers and builders to interpret and meet. In practice, most designers and builders appear to comply with prescriptive standards set out, however, they do not have real incentive to adopt new technologies, indeed doing so may only complicate the process. One of the conclusions of the report was that more clarity and simplicity is needed in the regulatory process to enable the up-take of good practice and encourage innovation.

The study on the Dutch energy performance regulations found a strong correlation between energy performance regulations and 'incremental' energy-saving innovations in hot water technologies in the Dutch residential building sector during the 1996–2003 period, however, it did not contribute to the diffusion or development of 'really new innovation' in hot water production technologies during the 1996–2003 period. As a result of the complex nature and defensive character of the building process, builders are generally unable to be flexible in using different technologies so as to comply with the energy performance standard. Energy regulations might not target the right level of the value chain in the construction sector. It would be more effective to target manufacturers of energy technologies directly and encourage them to innovate.

In academic papers, it is argued that regulations and standards can take over the role of demanding buyer, thus it can foster innovations. The often cited Porter hypothesis shows that strict environmental policy can induce innovation: environmental regulations might be challenging for industry at first instance, but then it contribute a lot to improve international competitiveness. By imposing requirements, which are too strict for current technology, they force industry to develop new technology in order to comply. High standards may therefore induce demand for improved technologies which otherwise would be commercially unsuccessful.

New environmental regulations have resulted in enabling the introduction of new production techniques and helped the emergence of new industries such as the clean-tech environmental industries. It was also shown that safety regulations increase the acceptance of new products and services among customers and promotes their diffusion (Day and Frisvold, 1993).

Similarly, economic theory suggests that standards may in certain ways impede the innovation process. One important issue relates to timing as an inappropriate time can lead to economic inefficiency. "Too early, and a standard may effectively shut out promising and ultimately superior technologies. Too late and the costs of transition to the standard may be too high – preventing diffusion" (Swann, 2005).

There is a debate, however, on how regulations influence innovation and its effects are seen as ambivalent at least at the short run. Creativity can be blocked, constricting the scope for learning, progress through experimentation and the selection of superior techniques (Thompson, 1954). Perhaps the worst case occurs where mandatory prescriptive standards detail both product design and production methods, without scope for change.

The nature of regulatory effects can vary substantially, depending on the structure of the regulatory process, the industry and the economic environment (Joskow, 1989). A recent study (Rennings and Rammer, 2010) found that both product and process innovations driven by environmental regulations generate similar success in terms of sales as other innovation, however, the effects are different when investigating different fields or sectors.

### Support to market demand and tax incentives

Support to market demand aims at fostering the commercialisation of innovation when there might be uncertainty about the new product, reluctance to pay the price early in the diffusion cycle (Edler, 2011). The target of such private subsidies or tax incentives can be found usually in the area of energy, environmental industries or transport/electric vehicles.

There are some examples where the impact of support to private subsidies has been assessed. In Germany, Sweden, US, UK, Austria and Denmark there are reports commissioned or academic studies conducted. The studies rely on statistical and econometric analysis and are based on national statistics and data on sales and customer surveys.

For instance, the German ecological tax reform was assessed as contributing substantially towards energy conservation and the reduction of greenhouse gas emissions while stimulating employment. Nevertheless objections were raised stating that an increase in energy costs would compromise German competitiveness, especially in energyintensive sectors, thus impairing macroeconomic development.

In the case of the Austrian thermal renovation programme, private entities and companies could receive a non-refundable subsidy for renewing the insulation and for changing windows to energy-efficient windows. The whole investment catalysed from private entities and companies was €667.5m more than the Austrian government expected.

The impact of support to market demand is, however, ambiguous. Sometimes the behaviour of innovators and customers are directed by the price and other factors than the subsidy or the tax incentives and thus it is a windfall gain rather than a real incentive. Higher gas prices are also likely encourage consumers to purchase more fuel efficient cars in general, and to induce the innovation of new energy efficiency technologies by manufacturers (Newell et al., 1999), all without the need for government tax expenditures.

The impact assessment of government incentives for hybrid-electric vehicles in the US suggested a strong relationship between gasoline prices and hybrid adoption, but a much weaker relationship between incentive policies and hybrid adoption. Dealers might factor state incentives into their pricing structure and charge consumers more for the vehicles. If this is the case the incentive rather serves as a subsidy to the dealers without influencing the adoption of vehicles.

Financial incentives might also rather make high-income consumers to benefit that are more likely to purchase the innovations who would have bought it anyway (Newell et al., 1999).

### User-driven innovation and living labs

Very few evaluations have been identified that assess user-driven innovation programmes or living labs. The exceptions come from

# Denmark and Finland where mid-term reports and review of results of their related programmes have been published recently.

Type of measure	Positive features	Negative features
Procurement	Creating demand for innovation, catalysing private demand, Easy implementation procedures for SMEs Especially useful to unlock innovations in underdeveloped areas	The developed new technologies might not become real purchased products. There is a technological risk. Too strict and detailed specifications can result in less competitive solutions.
Regulations	Spurring new industries, innovative technologies Reduces competition for incumbents, e.g. for infant industries	Effects can vary substantially, depending on the structure of the regulatory process, the industry and the economic environment
Standards	Taking the role of demanding buyers Spurring new industries, innovative technologies	Blocking creativity in the short run
Support to private subsidy	Decreasing uncertainty about the new product, reluctance to pay the price in the early life cycle	Buyers might be more responsive to other signals such as price
Tax incentives	Incentives demand for new, innovative products and services	It might become a windfall gain and favour high-income buyers that would have bought the products anyway.
Labels	Decreasing uncertainty about the new product	Stifling creativity in the short run
User-driven innovation	Fostering the commercialisation of RTD	
	Increasing the potential of sales of new products	
Living labs	Fostering the commercialisation of RTD	
	Increasing the potential of sales of new products	

Figure 5 Summary of findings of evaluations of demand-side policies

The evaluation of the Danish User-driven Innovation Programme found a positive correlation between the use of certain methods for userdriven innovation and innovation impact of the projects. In industry a positive association was found between the identification of nonrecognised user needs and innovation.

A recent study on the potential of the Living Lab approach (European Commission, 2009) evaluated the user-led innovation concept in its transition from research and development to real market implementation. The impact assessment methodology in the study included implementing the MASAI® - Marketing Strategies And Business Intelligence. The MASAI approach focuses on the transition

phases from R&D towards industrially and commercially viable solutions.

Recently, the CentralLiving Lab<sup>1</sup> project published a guide (2011) on how to set up, implement and monitor living lab initiatives. They suggest to focus on the following evaluation targets: community building and proper functioning; user driven, Open innovation methodology implementation; pilot outputs (and outcomes); stakeholder satisfaction; cost / Benefit analysis; reuse / Transferability potential.

<sup>&</sup>lt;sup>1</sup> http://www.centralivinglab.eu/index.php/en/

# 4. Indicators to measure the demand for innovation

In the quest of complying with the need to measure not only the supply but the demand side of innovation as well, a valid question is how and where to find suitable indicators and data sources that can help us better capture the demand conditions for innovation. Although demand for innovation has got a prominent place in innovation theories for a long time and there is an increasing policy interest in demand-side measures, indicators are still scarce.

As we saw in the previous sections, the demand-side policy evaluation reports tend to use innovation performance indicators and do not assess demand conditions in general; hence they are not a good source for ideas on indicators. A further problem is that even if there are some indicators to assess demand for innovative products, there is not much literature on how to assess demand for services innovation, organisational innovations or business model innovation. Despite of these difficulties, there are certain reports and articles that have dealt with this topic and will be reviewed in this section.

First of all, it is important to keep in mind why we need demand-side indicators. Demand-side innovation indicators can be both useful in the phase of ex-ante impact assessments or in the ex-post evaluation of demand-side policies. Innovation policy papers often stress the need for a combined use of supply and demand-side instruments and to think in a supply-demand policy mix, thus the use of indicators should not be limited to demand-side policy instruments only either. Demand-side indicators are essential in order to develop a better understanding of the potential for innovation in the case of any type of innovation policy, not only demand-side measures. Innovation policy design and innovation policy reviews should take much more use of demand-side indicators in general.

Secondly, one has to understand the nature of demand. While demand and lead users are crucial drivers for developing innovations, new knowledge and solutions also drive demand for innovations, a demand that did not exist before. Lead user communities might arise because of favourable innovation-oriented culture, an infrastructural ิล precondition (broadband, 4G networks, cluster environment) or available skills. Moreover, spillover between different sectors in the innovation and global supply value chains can trigger additional demand in related areas. This suggests that a better understanding of demand factors and cross-sectoral linkages can help us using innovation output indicators of one area, as a proxy for a potential demand of innovations. For instance. development related in certain manufacturing industries might create demand for innovations for new logistic solutions or developments in ICT, which then create a demand for business model innovations in printing industries.

As a starting point for the identification of demand-side indicators, a distinction must be made among five different dimensions of demand such as

- public or private demand;
- consumer (final) or business demand (intermediate, producers);
- domestic or foreign demand;
- responsive demand or innovation triggering demand;
- sectoral differences in terms of demand conditions.

In the above list, public demand refers to the extent to which government takes the role of a lead user for innovation through public procurement or specific regulations and standards. There is also a difference between indicators that can measure consumer/final demand and those providing an indication about the demand of producers. Responsive demand is determined by the willingness and ability to absorb innovations once they are produced, as long as innovationtriggering demand stimulates innovation as private or public actors express a new need for an innovation (Edler, 2012). Although local demand is often more important as companies prefer to locate closer to customers, one cannot forget about the increasing relevance of foreign demand. When looking for demand-side indicators, one also has to note the huge differences that exist in terms of demand in different sectors or technological areas.

The current key statistical sources and reports on innovation indicators such as Eurostat, the Community Innovation Survey, the Global Competitiveness Report, the Innovation Union Scoreboard or the Innobarometer reports offer a first guide for assessing demand conditions of innovation, even though the coverage of data is very limited and sometimes not optimal being at European or global level or being just on-off surveys.

In the following we review these sources and the available literature such as for instance the thorough work done by NESTA on demand-side indicators according to the key types of demand dimensions.

# **Public demand**

A straightforward indicator to measure public demand for innovation is the share of innovation procurement within the total public procurement of the public sector, even though data on this is not that easy to get. The Eurostat provides data on the value of calls for tender published in the Official Journal as a percentage of GDP per EU Member States, and the related input-output tables can be used as a proxy for public demand. Other indicators for public demand can be demanding regulatory standards (Arundel and van Cruysen, 2008), the existence of regulations influencing innovation processes such as environmental laws or green tax as a percentage of public budgets. The World Economic Forum's Global Competitiveness Report reports include an indicator of the role of procurement in encouraging innovation "government purchases for the procurement of advanced technology products". The Innobarometer 2009 edition surveyed the opinion of businesses on public demand for innovation and the 2010 edition included a chapter on public procurement and innovation, which provided information on the role of procuring innovative solutions with attention as well as to services innovation. Although this data is extremely useful, it is not an annual exercise that would allow following trends and the evolution in public demand.

#### **Business demand**

In terms of business (intermediate) demand for innovations the data availability and reliable indicators are as patchy as for public demand. Official innovation statistics and scoreboards provide a weak help. The Innovation Union Scoreboard focuses primarily on supply factors for the development of innovations, on innovation inputs, innovation expenditures or human resources, but it also includes indicators such as the 'sales of new to market and new to firm innovations' or 'medium and high tech product exports' that can give an indication about demand conditions. The Community Innovation Survey (CIS) collects data on innovation, but its questions are not specifically focused on the nature of demand, although it captures for instance if customers are a source of information for innovation or not. One exception is Denmark, where the frequency of user-driven innovation activity has been included. The Global Competitiveness Report 2010-2011 edition includes indicators such as buyer sophistication or degree of customer orientation that can be used as good proxies for demand conditions. The data is provided at national level and every two years.

There is, however, scope to make much more use of data resulting from market trend analysis and market studies. Arundel and van Cruysen suggest using indicators such as the extent of market dominance or intensity of local competition. Market reports of Euromonitor International or other market research consultancies can be here useful. For instance an approach followed by the European Cluster Observatory's third phase and developed by PricewaterhouseCoopers is a new methodology that is based on data collection on cross sector mergers and acquisitions on target sectors and fundraising activities of companies in the target sector. They rely on databases such as Zephyr and Europe Unlimited, which help to identify activities in emerging industries and give a proxy also for an increasing demand in that area.

As several authors stress there is also a need to better understand the size and nature of market niches when assessing the potential for lead user communities (Arundel and van Cruysen, 2008). Data on this can be gathered through chambers of commerce and business associations, although a disadvantage is the geographical coverage of data. Demand for emerging niche markets could be also captured through data on clusters. For instance cluster organisations in emerging areas can serve

as an indication. Another initiative of the European Commission, the 'Statistical Indicators Benchmarking the Information Society'<sup>2</sup> project collected indicators of technological evolution and emerging technologies and indicators of behaviour such as choice or motivation to use a particular form of ICT access or appliance that can be also taken use of.

Although direct indicators are hard to get, there are several further options for proxies. For instance indicators on mobility and networking patterns might be used as to forecast demand for innovations in ICT and social media technologies. Following the logic of supply chains, indicators such as 'new to the firm innovators' can be used as a proxy for business demand for innovation since these enterprises have introduced product innovations that are novel for domestic markets, but not necessarily new for international markets, thus should be a result of innovation diffusion (Arundel and Hollanders, 2006). Data on the market of creative industries can be used as another proxy to determine its potential for innovation. Florida and Tinagli (2004) measure creativity referring to talent, technology and tolerance that can give an indication about the pre-condition for the development of a lead user community.

# **Consumer demand**

The NESTA report (2009) on the nature of demand for innovation considers four factors that can give a guidance for indicators on consumer demand among others:

- 1) receptiveness to innovative products and services,
- 2) customers involvement in the innovation process,
- 3) understanding of customers needs
- 4) money spent on innovative products and services.

Consumer demand can be captured through various proxies such as the level of education or of disposal income, or the use of internet. These can give a good first indication since for instance non-internet users most probably won't become e-consumers and thus there will be less demand for internet-based innovations.

More sophisticated indicators are also available, although they are not regular data sources. The 2005 edition of the Eurobarometer conducted a survey on how receptive Europeans are towards innovation. It equally measured the innovation readiness of the population. Unfortunately, this has been a one-off publication.

Another possible source is the Consumer Innovation Confidence index that was developed by the Institute for Innovation & Information Productivity (Levie, 2007). It is measuring consumer demand for

<sup>&</sup>lt;sup>2</sup> http://www.sibis-eu.org/

innovation, more specifically the "degree to which individuals are willing to engage with and perceive benefits from new products or services, or products or services that embody new technology. The index relies on three different consumer surveys; for instance in 2009 a survey of 51,000 individuals in 18 nations has been conducted.

#### **Foreign demand**

Although companies tend to locate close to customers, it also has to be borne in mind that developing economies are increasingly accounting for the global demand of manufactured goods (nearly 70% by 2025 following an estimation of McKinsey, 2012). Hence, assessing the importance and trends in foreign demand conditions has its relevance.

In a study (Blind, 2011), export intensity is used as an indicator for being successful in fulfilling the demand of foreign customers. The Global Competitiveness Report includes indicators such as sophisticated local demand that signal the geography of demand conditions.

#### **Potential indicators**

Based on the above literature review, a list of potential indicators and data sources are summarised in Figure 6.

This review of demand-side indicators provides us with a rather fuzzy picture. Given the importance of assessing demand conditions, it is discouraging that there are so few statistical sources and data at hands of policy designers and evaluators. It cannot be emphasised more the need to address this issue both at European and national levels and pay more attention to this topic in the upcoming Eurobarometer reports, the Community Innovation Survey or in sectoral market analysis.
Indicators	Data sources	Reference		
Public demand		·		
Government procurement for advanced products	Eurostat input-output tables and Global Competitiveness Report	NESTA report		
Value of public procurement that are openly				
advertised	Eurostat input-output tables	NESTA report		
Demanding regulatory standards	Statistics of standardisation bodies	NESTA report		
Green tax as a percentage of public budgets	OECD data			
Private, business demand				
Firm-level technology absorption	Global Competitiveness Report	NESTA report		
Extent customers are a source of info for innovations	CIS	NESTA report		
Extent uncertain demand is a barrier to innovation	CIS	NESTA report		
Technology asset acquisition	National statistics	COTEC report		
Cooperation with clients	Innobarometers			
Market for new products	Market trend analysis reports			
Market for technology transfer services	Reports on technology transfer statistics			
Market for knowledge intensive services	Market surveys, national statistics			
Size of the market	Market survey statistics	Arundel and van Cruysen		
Extent of market dominance	Market surveys	Arundel and van Cruysen		
Private, consumer demand				
Responsiveness of customers to innovation	Eurobarometers, Special Survey on Science and Technology	NESTA report		
Consumption expenditure of households	OECD National Accounts Database			
Disposable income of households	National Statistics	VDI/VDE-IT report		
Demographic factors	National Statistics	VDI/VDE-IT report		
Effect of advertising in creating demand	User surveys	Global Competitiveness Report		
Buyer sophistication	Global Competitiveness Report	Arundel and van Cruysen		
Euro creativity index	National Statistics	Arundel and van Cruysen		
Youth share of the population	National Statistics	Arundel and van Cruysen		
Consumer Innovation Confidence Index	User Surveys	Levie/ GEM reports		
Number of citizens involved in living labs	User surveys	Centralab report		
Organisational innovation confidence index	CIS	NESTA report		
Population innovation readiness	Special Eurobarometer 2005	NESTA report		
Household expenditure patterns	User surveys	NESTA report		
Foreign demand				
Export intensity	National statistics	Blind		
Breadth of international markets	Surveys	Arundel and van Cruysen		

Figure 6 List of potential indicators to assess demand conditions

5. Policy recommendations for evaluating demand-side innovation policies

Based on the analysis of existing evaluation practice of demand-side innovation policies and the review of demand-side indicators, the following recommendations are made.

# 1. The assessment of demand conditions for innovation shall constitute an integral part of all innovation policy reviews, not only of demand-side measures classified as such.

Demand is one of the strongest drivers of innovation. Optimally, the assessment of demand for innovation shall form an integral part of evaluating all types of innovation policies and programmes. Countries and regions shall have a framework at hand that helps identifying to what extent has innovative entrepreneurial base broadened and what has been the absorption capacity for innovations. More overarching evaluations shall be pursued that can help better understand both the demand and supply-side dimensions of any type of innovation policy measures.

#### 2. The evaluation of demand-side innovation policy measures should not be done in isolation but looking at the wider policy mix.

Demand-side innovation policy measures do not act in isolation but ideally they complement supply side policies and form a part of a combination of demand-side tools intervening at different points of the innovation process. As a consequence when performing evaluation, the wider framework of interacting policy tools should be also assessed and the demand-side policy measure should be put into context. A systematic review of demand-side innovation policies should be encouraged.

# 3. More metrics shall be developed for measuring the demand-side of innovation and a wider combination of evaluation methods should be explored.

Reviewing and considering existing metrics for demand side, it is proposed to develop new indices for capturing both responsive and innovation-triggering demand. New indices could specifically refer to sectoral/thematic dimensions such as along lead markets identified or societal challenges addressed by innovation policies. This would also enable more evidence-based demand-oriented policy making. The development of such new indicators should be integrated into upcoming Community Innovation Surveys or Euro/Innobarometer surveys. Concerning the evaluation methods applied, the options of a wider selection of tools should be explored beyond the case study and survey approach such as using network analysis, econometrics or foresight techniques.

# 4. Assessing the impact of demand-side policies on innovation launched outside of the realm of innovation policy should be strengthened.

Several demand-side support measures originate outside of the realm of innovation policy and they form part of e.g. environmental, energy or transport policies. While the evaluations of these measures focus primarily on the environmental impact, they are not assessing the impact on the innovation activities of firms systemically. The effects of these policies on innovation activities should become an integral part of evaluations.

# 5. More efforts shall be laid on ex-ante appraisals and putting in place monitoring systems for demand-side policies.

While ex-post evaluations are important, there should be a system in place where the potential impacts of regulations, tax incentives, subsidies, public procurement etc. are appraised ex-ante before launching new demand-side measures and emphasis should be also laid on monitoring systems to follow up progress.

#### 6. Market development with the help of demand-side policies

The section is structured as following: It starts with a conceptual framework of the development of markets and their interface with demand-side policies. Since the methodological approach included a testing of top-down and/or bottom-up priority setting, an analysis of priorities in the MS and at EU level and a synthesis of mega-trends is provided as well. Section 8 then provides a toolkit for future proposals. It suggests that proposal development takes into account a couple a important factors that are either provided in table format or in a more narrative manner. For the latter, several market descriptions are provided as inspiring material for the description of the approaches. Since selected proposals will be implemented in form of roadmaps, Section 9 shows successful examples of roadmaps and roadmap development, that can equally be taken as background information for future proposing parties.

#### 6.1 Market development

How do product markets evolve? The literature provides a number of explanations. Since the Action plan aims to boost innovation with the help of demand-side policies, it may be useful to look at the whole innovation process. We choose the model of market development by Grupp (1995). The model differentiates eight phases in which three curves develop: starting with a development curve of scientific findings, this is then further co-developed by applied research and technological developments, and again with some delay, the production of innovations starts. A technology like nanotechnology fits within this model as much as a more narrowly defined field such as bio-based engineering, but also the development of products can be analysed using this model. The following Figure 7 only includes the development curve for innovations. Following the literature and empirical examples, we "assigned" demand-side policies to the various stages.

# Figure 7 Matrix of demand-side instruments and market development phases for products



Source: Technopolis Group, adaptation of Grupp 1995

Phase I is pure non-oriented research in the sense of the Frascati Manual which turns into oriented, applied research in Phase II once the basic principles have been established. In some cases, Phase II research shows some promising results - research is pushed further and also attracts some industrial research. In this phase pre-commercial procurement schemes can be developed since they foster the research, have vet no buver in sight, and no individual products. In Phase III research still continues but its peak seems to be attained, technology is gaining momentum and industry develops concepts and prototypes. The applied research and experimental development continues in the next phases where there is still new knowledge created by the science system, but the focus is on the development of applications. While the scientific development curve continues to stabilise in Phases IV to VIII, there are ups and downs in the technological development one. The latter starts in Phase IV where there are complications in terms of the economic transformation of research results. This is a Darwinian "survival of the fittest" phase where it is important that framework conditions and access to funding are provided. Technical standardisation can be a useful demand-side policy to slightly stabilise and diminish the turbulences. Catalytic public procurement of innovation can also be a means in Phase IV to VI in order to further steer innovation avenues (technological trajectories). Despite the ups and downs in the technological developments, the industry-internal innovation process starts in Phase V and VI. Production processes are still rather flexible

and quality is an important argument for the success. *Labelling* can support this phase. Commercial applications are tested in Phase VI, they rise in Phase VII and finally market diffusion is achieved in Phase VIII.

Depending on the (stylised) development stage, there are less options in terms of applications and products, the more advanced a field is.

We can use the example of 'graphene', which is now a new flagship research initiative of the EC. "Graphene research is an example of an emerging translational nanotechnology where discoveries in academic laboratories are rapidly transferred to applications and commercial products. Graphene and related materials have the potential to make a profound impact in ICT in the short and long term: Integrating graphene components with silicon-based electronics, and gradually replacing silicon in some applications, allows not only substantial performance improvements but, more importantly, it enables completely new applications." (Graphene Flagship website). While there are many visionary developments and applications of graphene, this field is currently only in its research stage since it is not vet possible to create a larger piece of graphene - which is needed for any application. A product, which can basically retrospectively be analysed is laser. Laser was developed in the 1950s and there are a number of laser-based products such as the CD or DVD player, printers or barcode scanners. Laser technology as such is scientifically understood but even there, R&D is still trying to develop new types of lasers. While it may have been used predominantly used for medical applications (surgery), laser is more and more used in material processes. Beside cutting and welding, it 'diffuses' into less obvious applications and can replace existing technologies such as optical thin-film coating. Since the further use of laser is not necessarily in defined products but rather in its *replacing* use in production processes, future markets seem numerous and further diffusion rather a question of price.

A drawback of the model is its perspective from a single field – it does as such not include technological spillover as some other models do<sup>3</sup>. There are a number of studies analysing diffusion patterns either geographically or sectorally. A recent study by Schoenmakers and Duysters (2010) suggests that radical innovations do not occur out of the blue but rather through the recombination of existing knowledge over several domains. The cross-fertility of horizontal **key enabling technologies** such as nanotechnology or biotechnology (which are based on several individual research disciplines) have equally been analysed in order to better understand the underlying research ideas of a given industry or technology.

<sup>&</sup>lt;sup>3</sup> For an overview see Frenzel, A.; Grupp, H. (2009). Among the analysed models, there are only two with a good forecasting ability. However, their data requirements are high.

In order to obtain an idea about scientific and technological watermarks and their cross-technological or sectoral diffusion, scientometric and technometric techniques are used such as co-word analysis in order to analyse changes and/or patterns between scientific fields. The analysis of the non-patent (scientific) literature references in patents can show where a technological field sources its knowledge from. Direct patent references in patents on the other hand indicate prior art and are less often spillover from far away fields.<sup>4</sup>

A study for the IUPAC (2012) aimed to see in which chemical speciality field, nanotechnology research plays a role. This was done using a keyword search strategy. The analysis revealed for example that the share of articles related to nanotechnology in chemistry journals increased from 12% in 1996 to 26% in 2006 suggesting that the technology plays an increasing role in chemical research too. However, there are marked differences: nanotechnology plays a significant role concerning materials and macromolecules, and is the lowest in organic chemistry.

Technological spillover may also be interesting and important to revitalise traditional industries and to trigger so-called low or medium tech industries into more high-tech. An example here is the textile industry. Europe's textile industry faced an enormous price competition with Asian countries and thus has lost in market shares. An avenue to revitalise the industry is via smart textiles and fabrics (see Annex C). Today, fibers and nonwoven materials are highly researched. Fiber innovations go hand in hand with the goal to minimize environmental impacts. Currently around €850 million are spent by European fiber producers on R&D. Carbon fiber reinforced plastics are another interesting avenue. Concerning industrial textiles, innovative technical textile applications in the construction industry are becoming more and more important. Industrial applications using ceramic fibers for fire protection materials, as well as materials and systems for thermal and acoustic insulation can be mentioned here as examples. Technological spillover are however one aspect – other mega trends need to be taken into account when it comes to the quest of revitalizing European manufacturing industries.

These future aspects of framework conditions should in one way or the other be taken into account for the roadmap development and the explanations and selection of priority action lines.

<sup>&</sup>lt;sup>4</sup> For example Maurseth and Verspagen (2002); Schoenmakers and Duysters (2010)

### 7. Priority setting – top down or botton-up

#### 7.1 Screening of information and setting the selection criteria

Priorities can be set top down or bottom-up, or as a mix thereof. Since it is rather arbitrary to look at individual technologies or techniques and speculating about potential applications, we screened priorities at EU and Member State level. For the former, the identified Grand challenges were the starting point while at MS level, individual strategies were screened.

#### 7.1.1 Grand Challenges

Following several policy reports such as the Lund declaration, societal Grand Challenges have made it as priorities into the Europe 2020 strategy, in particular the Innovation Union flagship initiative with climate change, energy and resource scarcity, health and ageing. In a slightly more extended form, they are also included under the new framework programme Horizon 2020 with:

- Health, demographic change and wellbeing,
- Climate action, resource efficiency and raw materials,
- Secure, clean and efficient energy,
- Inclusive, innovative and secure societies,
- Food security, sustainable agriculture, marine and maritime research and the
- Bio-economy,
- Smart, green and integrated transport

#### 7.1.2 Screening of EU27 priorities

In order to obtain an idea about the future priorities in the EU-MS, their relevant policy documents were checked. The first screening of the recent strategy papers shows, that 23 out of the 27 MS are defining priorities which are in general based on one or more of the following criteria:

- a large global market where enterprises already compete or can realistically compete,
- public R&D is necessary to exploit the priority area and complements private sector research and innovation,
- strengths in research disciplines relevant to the priority area,
- priority area represents an appropriate approach to a recognised national challenge and/or a global challenge.
- In several cases, the prioritisation used foresight exercises or broad stakeholder involvement.

A dedicated focus on industries or sectors is rarely expressed. Given financial constraints but also political intensions, the countries clearly prefer generic, horizontal measures or broad-based technologies with a wide range of applications. The focus on **societal challenges and key technologies** or a mix thereof, are most often found. Only in a small number of countries, there is no prioritisation from the political level (LV, CY, SL, SK, ES, PT, PL, FI) but in some countries, a 'prioritisation' shows de facto in form of thematic programmes or measures such as dedicated technology platforms (Poland) or centres of excellence (Finland). Traditional industry sectors based on the NACE classification are not much focussed. Textile, chemicals, aerospace, mining, wood/forestry are the few notable exceptions, mentioned by one or two countries. When analysing the strategies it becomes obvious that an industry-based approach of the innovation or growth strategy is rather outdated. Hungary and Lithuania are the only countries listing a number of individual industry sectors among their priorities but in times of budget constraints, policy makers seem to be more eager to develop synergies and integrated policies that are built around challenges, priority fields or horizontal technologies.

The majority of priorities can be classified in a limited number of broader fields or themes such as energy or mobility, but there are a few which are mentioned only in one or two countries such as 'horticulture' in the Netherlands or 'mining' in Poland, or 'tourism' in Greece and Italy.

The tag cloud below gives an idea about the priorities in the EU27-MS. The size of the words indicate how often they appear. There are a few main priorities with ICT, health, energy, biotechnology and technologies.



Figure 8 Priorities

Source: Technopolis by use of http://www.tagxedo.com

By grouping related subjects to broader headings, energy is a top priority. Given the broad challenge related to energy (costs, availability, efficiency, alternatives, etc.) it may be no real surprise that the topic is a priority in 80% of the MS indicating a priority. Energy issues are however horizontal. They touch on a number of other fields such as ICT ('smart grids', 'smart communication technologies') or mobility ('emobility'), and can easily be connected to sustainability. Similarly often are ICT and sustainable development issues mentioned, again both themes can be connected to other subjects such as health ('e-health') manufacturing, energy, etc.





Source: Technopolis

So far, the priorities are at a highly aggregated level. Many can be broken down further into industries, technologies or research fields, and Figure 8 shows a number of lower-level priorities such as "smart grids", "waste management" or "cloud computing".

Within the national strategies however, only a few countries provide more narrow choices such as the UK which identified next to broad priorities four emerging fields with "synthetic biology", "energy efficient computing", and "graphene".

Figure 10 provides a comparison of the priorities - those following Grand Challenges and being transformed into Horizon 2020 priorities, the ones mentioned by the EU27-MS (at broader level), and those, identified in the Industrial Policy Communication Update COM(2012) 582 final. There are some gaps but to a large extent one can also see a broad overlap. The most significant gap is concerning the health priority. This is a clear priority in many MS, also a Grand Challenge but not included in the Industrial Policy priority action lines.

Clearly, the majority of the EU Member States is not trying to be 'prescriptive' and interfering into individual markets. There are

different foci by the MS for example in the field of 'mobility'. Mobility as such is mentioned for Italy, Hungary, and Lithuania. 'e-mobility' is specified for Austria and Germany, the latter has even developed a dedicated national roadmap (see section 9.1.). 'Logistics' would be another related field which is mentioned by Hungary, Italy, Lithuania, Luxembourg and the Netherlands. And if we also look for 'transport', Germany and Bulgaria join Italy and Lithuania. The countries may have very different approaches and ideas what should be or what is addressed and in which form (for example as a relatively open thematic programme or an instrument such as Centres of Excellence, technology platforms, or roadmaps.

Grand Challenges/ Horizon 2020	Priorities of EU27-MS		Priority Action fields, Industrial Policy Communication Update
Health, demographic change and wellbeing	Health, quality of life, wellbeing	+++	
Climate action, resource efficiency and raw materials	<b>Eco-innovation</b> , environmental technologies, built environmental innovations	+++	Sustainable industrial and construction product policy
Secure, clean and efficient energy	Energy, energy efficiency, climate	+++	Smart grids
Inclusive, innovative and secure societies	Security	+	
Food security, sustainable agriculture, marine and maritime research and the	Food industry/processing/safety, agriculture; marine energy, maritime industry	+	
Bio-economy	Biotechnology, Life sciences	+++	Bio-based product markets
Smart, green and integrated transport	Logistics, Mobility, Transport	++	Clean vehicles
	ICT	+++	
	Intelligent/advanced manufacturing	++	Advanced manufacturing for clean production
	KIBS	+	
	new materials, <b>nanotechnology</b> ,	+++	Key enabling technologies
	Creative industries	++	
	Chemicals/green chemistry	+	

Figure 10	Comparison	of priorities
0	-	-

Note: priorities in bold show which ones are most often mentioned by EU27-MS

In order to narrow down the sectors while maintaining an objective selection process, one may set up a couple of objectives. These objectives could be for example:

- 1. A wide overlap between Grand Challenges, MS priorities and European Commission priorities.
- 2. The fields to be chosen should provide room for testing different demand-side policies and as such, their technological development status should be in different phases of the innovation process.
- 3. There could be roadmaps where only a few countries/industries would be involved and others with a wider involvement.

- 4. The timeline of the roadmaps could be shorter for some and (much) longer for other fields.
- If the first criteria is applied and Figure 9 taken as the basis, the overlap between the three levels is evident in the fields of energy and resource efficiency, biotechnology, and transport/mobility. Given the overlap with new materials which are not under the Grand Challenges but important priorities for the MS a well as the European Commission, as well as ICT which as enabling technology is only a high priority in the MS, the choices are slightly narrowed down.
- In order to not start from scratch, it also makes sense to use existing initiatives for leveraging the effects and lowering the preparatory phases. For energy, transport, etc. there are a number of European Technology Platforms which should be consulted and possibly (if a specific field where a platform exists is chosen), integrated in the roadmap development.

#### 7.2 Mega trends shaping industrial revival

There are several structural trends<sup>5</sup>, which influence future framework conditions and future demand such as the **ageing of populations**, **increased mobility** and **urbanisation** with the rise of mega cities, regions and corridors.

The **international division of labour** increases. Observable are the development or conversion of global value chains, an accelerated integration of global product and service markets, the growing importance of exports as a share of GDP, as well as increases in offshoring and outsourcing. Drivers for this further international division of labour has already been the integration of eastern European and in particular BRIC countries into the world economy, having augmented the available labour capacities. Ongoing drivers are the model of an open, knowledge-based society, which has influenced the liberalisation of services, and technological progress. The latter enables the global restructuring of value chains.

The above mentioned technological spillover can be seen in the light of an evolving **integration of scientific fields**. Basic sciences are combined and transdisciplinary fields evolve, leading to new products and services. The drivers for this trend are at the one hand policies which encourage and ask for interdisciplinary research, curiosity driven research of scientists and researcher out of the box, and on the other hand an increase of socio-economic changes and challenges such as climate change, resource efficiency, ageing populations and a growing need to find solutions for complex system innovations concerning for example transport, logistics, or energy.

<sup>&</sup>lt;sup>5</sup> Trends were taken from DB Research (2007), Frost and Sullivan (2012)

This leads to the growing share of science-based products. There can be several scientific watermarks from several disciplines and fields of these products, thus increasing the spillover effects. These products benefit from their transdisciplinary background – they tend to be smart and green and have problem-solving capacities. These advanced, smart but also increasingly complex products also set limits to in-house development and/or production. Cooperation partners, the focus on core competences in-house and identification of complementary external knowledge becomes crucial.

There is thus an interdependency between these structural trends and some seem to propel each other. There are equally several innovative future technologies which enable much of the changes. The **smartness of products and processes** will feed into smart cities, smart buildings, smart mobility, or smart energy concepts. Energy efficiency is a premise, but smart implies also new lifestyles and consumption patterns. Robotics and artificial intelligence will assist humans in manufacturing processes or transport but also in providing personal services. Innovation in materials will lead to substitute materials with superior characteristics such as flexible electronics, leading to smart materials. This will change many sectors such as aerospace, electronics, healthcare, information technologies etc. Other innovative technologies are laser, sensors, energy harvesting, micro-electro-mechanical systems (MEMS) for industrial automation processes, micromachines, and nanotechnology. These will be key drivers for an array of applications.

It will be less and less sufficient to develop a smart product and expect to meet the demand; the tech-savvy young consumers show propensities to *share* and *use*, but not necessarily to *buy* and *own*. Thus, car makers of electric or driverless cars will need to **develop new business models** including for example personalised mobility options and customised infrastructures. The new business models will then again influence new products and services and future technologies and create new business dynamics.

#### 8. Developing a toolkit for the selection of priorities

The previously mentioned theoretical concept for market development suggested that different demand-side policies can play their role in different development stages.

There are two intertwined viewpoints to consider, first the European Commission which needs to evaluate and choose from possibly a larger pool of proposals, and second, the applicants which need to develop sound proposals. For both parties, a clear structure of the proposal is benefitting since it allows a proposal development that responds to the needs for evaluation, but it also requires the proposing parties to analyse the current situation, identify potential markets and think beyond the involved consortium partners about the road ahead for a successful development. Since this is a complex process, this study tries to provide a number of 'checking tables' which can be used directly or as a guide. It also includes a number of market analyses, equally for inspiration. Every applicant is of course asked to develop its own proposal and reflect industry and market specificities.

On the other hand, the requested information should not be too resource intensive to be obtained and provided. Links to official data sources are provided (linked) in the tables. We do however stress the need to provide forward looking expectations and explanations in the proposals, as well as drivers and barriers. A more complete picture will help in the evaluation process.

#### 8.1 Definition of future priority areas

There will be a number of items that cannot be objectively chosen, if the priority actions will be identified "purely" bottom-up, for example without any constraint in terms of technology or time frame. If for example a future, rather secured application (market) in one specific area is suggested in one proposal and in a second one a risky, but possibly far reaching key development which may lead to several product markets. In the end, it will be difficult to compare the two since their outset is very different. However if from the beginning wide fields are suggested, like with like will be compared.

Thus, we suggest to include in the identification table a number of classifications from which to tick. Proposals within the same classification can be thus evaluated among themselves and only then, the outcomes within the classifications are compared and finally chosen.

And as a further differentiating category we suggest the breath or width for the application in terms of technological spillover potential, i.e., will the application/process only influence a limited number of markets/industries or are a wide range of applications with several markets expected. This is again -not as such- a "quality" criteria if only one industry is affected or several (if any). A severe transformation of one industry due to a radical innovation can have more impact on growth and employment than the creation of a number of small new markets. Again this distinction will render the selection more conscious and objective.

# **8.2** Development of indicators and selection criteria for the identification of priorities

Obviously, not all type of information is available or equally relevant for all technologies (markets) and the development of roadmaps in particular at the stage of identification and selection of priorities. However, we suppose that proposals will stem from a group of companies and/or industry associations which tend to collect information on their own or are able to use relevant industry specific information. It is also a necessary requirement for proposals to demonstrate the proposing parties' understanding of the current situation in terms of actors, innovation performance, and possibly more importantly, their visionary views and ideas.

While this can be a heavy duty if a wide variety of information is asked for, we suggest to limit this to a minimum since its main purpose is to provide an objective selection basis. Once a roadmap will be developed, more detailed information will most likely be collected.

The basic logic starts from the current situation in terms of market profile of the industry (supply side) and the user (demand side). The analysis of current strengths and weaknesses is important, however since the focus is on future developments, at least as much attention should be given to the development of a vision in terms of future markets and applications while taking into account megatrends.

A proposal should try to include information on expected growth levels of specific markets for the anticipated products, services, or processes. In which markets is Europe weaker compared to its main competitors? Which markets have a fast turnover of innovative products? Which markets are emerging or are at an infant stage but might offer important growth potentials?

The following tables can be used as a 'toolbox' of indicators that the proposal developers of priority actions could check and use.

We developed this in form of templates which can be filled in but another option is to leave it open to the proposers to use the templates or use the structure and provide the information in form of text and tables. In Annex C, a number of market analysis in a descriptive format are provided for various fields.

We suggest a number of indicators which are numeric, data based. For many factors however, hard data is either not available or conceivable and thus, we suggest qualitative assessments to be included.

The following tables provide a skeleton for the description of the future priority action, to be developed by the proposing parties. They start with

a simple categorisation, ask for data-based information of the current market(s), and then move to more qualitative descriptions concerning barriers and drivers and the view on useful instruments.

Templates or questions on the composition of the consortium/team or description of approaches and methodologies are not included; those will be up to the proposal developers.

#### 8.2.1 Identifying information

1. The following table gives some indications on which basic information could be provided, if applicable.

Indicator	Further information	Please complete
In which sector are you classified?	Core activity/application sector by NACE two digit level	
Do you consider it a low to medium R&D intensive sector?	Yes/No	
Do you consider it a high-tech sector?	Yes/No	
Are you suggesting as priority action a process technology ?	Yes/No	
Are you suggesting as priority action a key enabling technology?	Yes/No	
Are there firms from any secondary activity/application sector(s) involved in the development of the proposed market?	If yes, please provide either names of industries or NACE two digit level classes	
What is the anticipated timeline for the roadmap; when would the market be developed?	Number of years	
In case of one or more special targeted market sector(s), please mention	List (e.g., textile industry - > market sector: medical textiles	
Has your anticipated market spillover effects to other industries	Can the process or product be applied in other industries? Please explain briefly	

Note: NACE classification and explanations can be found here

#### 8.2.2 Current market description

2. This table gives an overview of relevant data that could be sought for description of the current market situation. This includes a number of different suggested variables. In case you find it difficult to provide data<sup>6</sup>, please provide a short, concise description. Consider national, EU or global markets as appropriate. It would be desirable to provide the trends for the past five years, for which data is available.

Theme	Indicator	Suggested source	Please fill in either data or provide graphs separately
Productivity	Production index, % change from previous year	Eurostat	
Turnover	Turnover index, % change from previous year	Eurostat	
R&D	Business R&D expenditure	<u>Eurostat</u> : BERD by economic activity and type of costs; industry data from associations	
	Public R&D expenditure	Eurostat: GOVERD and HERD	
	Patent applications per capita	<u>Eurostat</u> (NACE sectors); or <u>espacenet</u> ; specific studies (e.g., for key technologies)	
Employment	Gross employment, % change from previous year	Eurostat	
	Absolute employment	Eurostat	
Trade	Trade balance EU27 vs main competitors (volume/price)	Eurostat or OECD	
Global Trade		Eurostat, COMTRADE, industry associations' data	
Internal Demand	Final consumption expenditure (absolute or % change)	Eurostat	
Other indicators			
•••••			
••••••			

<sup>&</sup>lt;sup>6</sup> Industry data can be taken for example from Eurostat (<u>http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search\_database</u>) but also industry associations collect and provide data which can be taken.

## 8.2.3 Barriers & challenges

3. What are the preliminary barriers and challenges for the industries/market in the short and longer run? Can you provide an assessment of the barrier/challenge in terms of importance on a scale from 1-5 (1=very important ... 5=non-important)? Please provide more detailed explanations.

	up to 5 years	6-10 years
Inadequate own financial resources		
Lack of access to finance		
High innovation costs		
Shortage of qualified internal technological skills		
Shortage of skills related to innovation management		
Limited abilities to spot market opportunities – lack of information on markets (EU and global)		
Risk aversity		
Limited abilities to test market readiness		
Current industry structure with high share of larger incumbents		
Market power of competing products / substitution potential of these products		
Technological challenges (use and integration of spillover)		
Enabling infrastructures		
Other factors		

#### 8.2.4 Drivers influencing prospective demand

4. The following table includes a number of factors that <u>may influence future</u> <u>demand</u> – several are equally challenges - which may influence the future demand of your envisaged application. If you imagine other factors to be important please list them as well. Please indicate the role of the individual factor by ranking the relevant factors from 1 (very important) to 2,3..x (less important). Non-important factors should remain empty. Since you may start with a limited home market before addressing all Europe or global markets, please tick also, for which geographic entity the demand factor will be important.

DEMAND FACTORS	up to 5 years	Н	Е	G	6-10 years	Н	Е	G
Population growth								
Population decline								
Ageing of the population								
Environmental concerns								
National or European policies								
Geopolitics and world conflicts								
Regulations								
Trade agreements								
Public procurement								
Industrialization								
Deindustrialization								
Quality of life								
Facility of transportation								
Urbanisation								
User sophistication level								
Personalisation								
Other factors:								

Note: H=home market, E=Europe, G=global market

#### 8.2.5 Supporting policy instruments

5. Which of the following demand and/or supply-side policy instruments do you envisage as benefiting for the development? Please tick the stage(s) for the instrument. Several instruments can be envisaged in the same stage.

	Early stage (~Y1-2)	Years 3 - 5	Years 6-10
Public procurement for innovation			
Development projects			
Prototypes			
Labelling			
Direct funding			
Regulation			
Standardisation			
Tax incentives on R&D (tax credits, allowances)			
Credit loans & guarantees			
Competitive grants			
Technology consulting services			
Innovation voucher			
Equity financing			
Venture capital			
Other instruments:			

#### 8.2.6 Actors in the future roadmappign process

6. Think about which of the following types of actors should be involved in the development of the roadmap and its implementation? How would you estimate the importance of these actors for a successful implementation? Please provide an assessment of the actors to be involved in terms of importance on a scale from 1-5 (1=very important ... 5=non-important)

	Importanceforinvolvementofactors(1-5),(1=very important5=non-important)
Leading established SMEs from the core sector(s)	
Leading established SMEs from the secondary sector(s)	
Leading large companies from the core sector(s)	
Leading large companies from the secondary sector(s)	
Start ups from the core sector(s)	
Start ups from secondary sector(s)	
Specialised academic partners (universities/public research organisations)	
Local/regional policy makers	
National policy makers	
Legal advisors	
IPR specialists	
Technology transfer specialists/organisations	
Financial institutions	
Chambers of commerce	
Other actors:	

#### 9. Roadmapping

Roadmapping is developing as a tool for a coordinated and consolidated development process. It has been widely used for technology development. It can be used at a single company level or in a much wider concept. It combines a number of individual methods such as brainstorming, targeted SWOT analysis, technology radar, and forward looking techniques. Key items are the setting of several milestones – and not just one fuzzy goal in a few years time. Regularly, the milestones – their achievements or non-achievements - are reviewed and adapted if necessary. In the case of roadmaps which are being prepared for demand-led or demand-side innovation, possible measures, tools, instruments or policies need to be included in the roadmap which could help to bridge the gap between innovation and the market or which could support the acceleration of market uptake.

The roadmaps are often put in a graphic format which can then show the interconnectedness of a number of items and their timewise development (Figure 11).



Figure 11 Graphic illustration of a roadmap

Source: Fraunhofer ISI

The complexity of a roadmap can range from limited to very complex. Also in terms of timeline, the roadmap process may envisage a rather short- to medium term development up to ten years, or a much larger time horizon of 20, 30 or more years.

There are many formal roadmap processes documented focussing on more research related planning in basic fields like nanotechnology (<u>Technology roadmap for productive nanosystems</u> of the US American Foresight Institute and Batelle 2008), the very well documented Australian national roadmap on <u>enabling technologies</u> (nanotechnology, biotechnology, ...) analyses drivers, barriers, risks and identifies challenges. There can be roadmaps and sub-roadmaps. For example in case of the German national e-mobility plan, the German technical standard body has developed a '<u>German standardization</u> <u>roadmap for electromobility</u>'. Standardization has been identified in the national roadmap as one of the key items necessary to foster a broad uptake.

The more complex the process, i.e., the more (and different) actors are involved or the more complex the product to be developed, the more fine-grained a roadmap can end up.

The roadmap process includes the following steps:

- 1. Definition of goals and time horizon of the process
- 2. Analysis of the demand, technology development, and market potential (drivers/barriers).
- 3. Consistency analysis and deduction of challenges and action fields
- 4. Development of the roadmap, including policy recommendations

It is vital to have a dedicated responsible for the monitoring of the roadmap process – someone who will call for meetings and critical review of the achievements.

#### 9.1 Roadmapping: the case of electronic mobility

In order to provide a good example, how a Member State is identifying future products and using a roadmap process in order to attain its goals, the following describes the process of "electronic mobility" in Germany.

The German government has set in its coalition agreement two goals, namely, "to become the lead market for electric mobility until 2020" and "to bring 1 million electric vehicles to the road until 2020". Electro mobility is also included in its High-Tech-Strategy. A "national development plan electric mobility" (2009), and a "national platform electric mobility" (2010) followed. In order to create a successful electric mobility market, lithium ion batteries were identified as the key technology. Unfortunately, the market for these technologies is to almost 100% in Asian hands – German companies had never developed into that market prior to the growing interest of electrical and hybrid cars. The national alliance "Lithium Ion Battery" (LIB 2015) which was initiated by the Federal Ministry for Science and Research in 2007 brings together 60 industrial partners and public research institutes. Within the alliance, the partners set targets for the research and development of a new generation of these batteries by 2015. The long term vision ends in 2030. The federal government provides €60 million for R&D in this alliance. Five of the larger members committed €360 organised million in R&D. R&D is in called SO

'Verbundforschungsprojekte' which are goal oriented research consortia between industry and public research with a clear view on scientific and technology transfer.

The innovation alliance includes all kind of aspects such as material research, electrochemistry, material availability, recycling, battery management, production processes, system integration, and technical standardisation. It also includes a dedicated roadmapping process to support the involved partners.

The process involved three preliminary steps which are taken up in the following Table 1.

	Step 1 Expert opinions	Step 2 Bibliometric analysis	Step 3 Monitoring
Aim	Identification of technological developments and current knowhow	Quantification of technological development, identification of actors via publications and patents	Identification of developments in the technological field
Method	Expert interviews within the Innovation alliance	Publication and patent research	Technology field analysis
Result	Input for bibliometrics and monitoring: technological developments	Input for monitoring: Actors, countries, international comparison, technological field	Input for roadmap: competing, complementary and substituting technologies

Based on FhG 2012

#### This was/is then used for the roadmaps as following:

Table 2Roadmapping

	Technology Roadmap	Product Roadmap	Roadmap integration
Aim	Collection of technological developments, assessment	Applications of battery technology, assessment	Linking of the technology and production roadmaps, assessment
Method	Workshop battery developers	Workshop battery users	Combined workshop with battery developers and users
Result	Technology roadmap	Product roadmap	Combined roadmap

Based on FhG 2012

The two separate, developed roadmaps were then presented in a graphic format which provides different layers. The **technology roadmap** looked for example on the developments of characteristics such as efficiency, costs, or security as well as competing and substituting technologies. This roadmap is clearly R&D driven. Other actors than the ones involved in the R&D of the lithium-ion batteries are not addressed.

The **product roadmap** comprises the markets: the technical requirements or applications for electric mobility and other applications

for lithium ion batteries. It also includes policies. The graphic description shows when and for which item policies may be relevant. In terms of demand side policies, in particular regulation, standardisation and technical norms are identified. User acceptance and infrastructures are two other aspects mentioned under the layer of "markets and politics".

The roadmapping process was accompanied by a professional management team developing the milestone meetings and providing methodological know-how. Complex roadmapping processes seem to benefit from such a service.

#### 10. Examples of market analyses

Since there may be proposals varying from very narrow and precise products or services to more wider ranges including production processes, the following sections provide examples from a mix of products, services and industries:

- **Technical textiles** as an example for the possible transformation of the established, rather low tech textiles industry;
- **Car-sharing** is certainly a trend to be watched in particular in the highly industrialised countries. It is a societal trend with disruptive powers to the automotive industry.
- Societal challenges are covered with the energy sector were **smart grids** show potentials for energy savings and new markets, but also **sustainable construction** offers a wide array for new markets and new products.
- Changing production processes with **laser** and thus obtaining products with superior characteristics can apply to several industries.
- **3D printing** may be the next industrial revolution offering a wide range of new services and business models.

In Annex C these market analyses are provided. They are following a common structure, providing first information on the current markets. This is then followed by looking at barriers and challenges as well as drivers.

Such an analysis is key for the proposal development and key for the development of specific roadmaps. Ideally, it identifies R&D leaders such as individual firms which should be on board for the technological development; based on drivers and barriers, possibly other actors are identified (regulators, banks,....) which may be involved in the roadmapping process at one point in time. Analysing which policies stimulated and or triggered different developments, and creative thinking which ones may foster a suggested priority are equally important for the roadmapping in terms of their necessary timeline as well as the dialogue with policy makers. The following examples are written from a more neutral, often EU perspective and do not necessarily include information for a few countries. The latter will most likely be the main perspective, reflecting the strengths and perspectives of a proposing consortia.

#### 11. Conclusions and Recommendations

#### **Identification of priorities**

Where future markets are to be found is a core question, many if not all companies struggle with, pursue R&D, and invest. Clearly, many companies know very well what they will have on the market in 2-3 years, several may have even a wider time-horizon. This is necessarily based on strategic market analysis and risk taking. Since there are thousands of new applications, products and processes one can think of just by simply taking into account advances in material sciences and efficiency technologies, it seems impossible to select a few future markets on a top-down political decision.

However, there are selection criteria, the priorities should meet. Obviously, there are **societal challenges** that drive many innovations. Climate change, resource efficiency, health and ICT are mentioned by many EU-MS and at EU-level. This is a key driver of research and innovation strategies in many industries and companies, and it may be a necessary selection criteria to chose relevant priorities.

The second criteria concern **demand-side policies**. Ongoing work on demand-side policies has shown, that despite their appeal, they are partly less well used (such as procurement for innovation), or time consuming (formal standardisation processes), and as a stand-alone instrument, possibly not the most effective. Our review on evaluations of demand-side instruments showed that these instruments are not that often used by policy-makers. In order to foster the use of these policy instruments, good practice examples are needed, thus it is important to choose priorities which have a potential for demand-side policies. While the aim to develop demand-side policies to stimulate industrial competitiveness seems vital, it is difficult to anticipate if a demand-side policy will be a useful or necessary tool in the development of a future market. Applicants should be in a position to envisage the use of demand and supply side measures for their suggested priority. If in the end both types of measures are suggested, this mix may prove successful.

The **time** needed for market developments may vary wide between proposals. The longer the time frame planned, the more likely a demand-side policy such as demonstration projects, standards or innovation procurement can be taken into account and be implemented. Shorter roadmaps (3-5 years), may only involve campaigns or labelling measures.

We thus recommend to have an open call for proposals without mentioning of politically set R&D priorities but referring to the grand challenges.

#### New markets' development in a roadmap process

Since the development paths of different future markets will not fit one model, we suggest only a common structure for the proposals, consortia will develop in greater detail. This structure reflects basically what is needed in the first step of a roadmapping process: actors (here the proposing consortia) need to have an idea what they want to achieve (here: the new market). They need to analyse the current situation on the market, drivers as well as barriers, potential spillover potential. Then they also need to identify relevant actors in the process. The development of the new market should benefit from demand-side policies - it is up to the proposers to imagine which type of policy and in which stage of the development this would be relevant. Thus, the roadmapping process will not only concern the relevant innovators (which would largely be the consortium partners), but possibly also an interface with regulators, standardisation bodies, when necessary.

For this necessary preliminary step in the roadmapping process, we suggest a **limited core set of economic indicators** which could serve as a backbone. This 'current' situation benchmark may be altered due to drivers, barriers or simply due to lags in the innovation process during the roadmapping process. The latter is not a simple linear development of a product, but since it includes or at least addresses a number of actors beyond the core consortium, it is necessary that the proposing consortia defines very clearly a **responsible for facilitating or even manage the roadmapping process**. Since this is a competence not necessarily developed in companies, a viable option is to include a partner or sub-contractor which has experience in facilitating this kind of process.

We recommend to select different types priorities such as a roadmap in a traditional sector, one which needs a longer time span but allows for example testing of public procurement of innovation, one which is relatively close to market diffusion, etc. This enables to study the different processes and provides a broader basis for policy learning.

#### Better understanding of effects of demand-side policies

It would certainly benefit further learning about the effects of demandside policies, if the selected priorities and the roadmapping processes are monitored during the implementation. A process evaluation may seem to be an expensive tool, however this allows structured analyses and insights which can be communicated widely and can be used for spreading good practices as well as showing difficulties, which need to be addressed.

Our analysis of cases suggests that the need for a combined use of supply and demand-side instruments is important. This complexity will be better understood if the individual policies' effects and impacts are known. However, empirical evidence on the effects of demand-side innovation policies are lacking. This is mainly related to the absence of evaluations of measures. Thus, encouragement of systematic evaluations, suggestions for demand-side indicators etc. would clearly benefit the policy making, and a better policy-mix.

We recommend to support a process evaluation for the selected roadmaps for improving the evidence-base of effects of demand-side policies currently hardly available.

# Appendix A Typology of demand-side policy instruments

Demand-side innovation policy instruments	Short description	
Public procurement		
Public procurement of innovation	Public procurement of innovative goods and services relies on inducing innovation by specifying levels of performance or functionality that are not achievable with 'off-the-shelf' solutions and hence require an innovation to meet the demand. (NESTA)	
Pre-commercial public procurement	Pre-commercial procurement is an approach for procuring R&D services, which enables public procurers to share the risks and benefits of designing, prototyping and testing new products and services with the suppliers.	
Regulation		
Use of regulations	Use of regulation for innovation purposes is when governments collaborate broadly with industry and non-government organisations to formulate a new regulation that is formed to encourage a certain innovative behaviour. (FORA)	
Standardisation	Standardisation is a voluntary cooperation among industry, consumers, public authorities and other interested parties for the development of technical specifications based on consensus and can be an important enabler of innovation.	
Supporting private demand		
Support to market demand	Support to market demand by SMEs or products/services offered by mand SMEs, and measures that support market demand in supply chains and by private (business and 'households') consumption	
Tax incentives	Tax incentives can increase the demand for novelties and innovation by offering reductions on specific purchases.	
Awareness raising campaigns, labelling	Awareness raising actions supporting private demand have the role to bridge the information gap consumers of innovation have about the security and the quality of a novelty.	
Systemic policies		
Lead market initiatives	Lead market initiatives support the emergence of lead markets. A lead market is 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.	
Support to user-centred innovation	User-centred innovation refers to innovation driven by end- or intermediate users. (Von Hippel)	

Other complementary instruments		
Prizes	As method to incentivise the development of innovative solutions for specific problems and to raise public awareness of these innovations.	
Public-private partnerships focusing on solving societal challenges	Enhancing the communication and coordination between private sector and policy-makers on the innovation policy needs (including e.g., European technology platforms)	
Small prototyping and testing activities	Support to having innovations tested by users (e.g. in LivingLabs)	
Large pilot and demonstration projects	Better integration of demand-side and user-centred aspects in large pilot / demonstration/trial projects to enhance building innovation eco- systems around important break-through innovations (e.g. large scale tests for the use of electric cars)	
Public sector innovation and social innovation	Redefining public sector's role as actor, test-bed and lead-customer for innovations to enhance its cost efficiency and improve its services and infrastructures.	

## Appendix B Evaluation case studies

Country	Programme evaluated		
Belgium	Evaluation of "Standardisation" programmes		
Germany	Evaluation of the German Market Incentive Programme for renewable energies in the heat market		
Germany	Evaluating the impact of the German Ecological Tax on Innovation and Market Diffusion		
Denmark	Survey-based mid-term evaluation of the Danish Programme for User-Driven Innovation		
France	Evaluation of the PACA Labs initiative		
Netherlands	Energy performance regulation in the Dutch residential building sector		
Netherlands	Survey and interview-based evaluation of the Dutch Small Business Research Initiative scheme		
Austria	Austrian Federal Programme to incentivise Thermal Renovation		
Finland	Mid-term review of the Finnish Demand- and User-driven Innovation Policy Action Plan 2010-2013		
UK	"Health Checks" of the UK Small Business Research Initiative scheme		
Canada	Evaluation of the Transportation Science and Technology (S&T) Programmes of Natural Resources Canada's Energy Sector		
Japan	Monitoring the Future City Initiative		
New Zealand	Cost-benefit analysis of the Warm up New Zealand programme		

### Overview of case studies

1. Evaluation of "Standardisation" programmes, for the Belgian Federal Public Planning Service Science Policy

#### Compiled by Nelly Bruno

#### January 2012

#### 1.1 SHORT DESCRIPTION OF THE MEASURE

The Belgian Federal Office for Science Policy (formerly the Belgian Federal Office for Scientific, Technical and Cultural Affairs, OSTC) has initiated in 1994 the federal support to standardisation through the implementation of two consecutive programmes in 1994 (Programme of scientific support to standardisation, so-called NO, 29 projects funded for a total amount of  $\notin$ 4.5m) and 1998 (Programme of scientific support to a federal policy concerning the whole of activities relating to standardisation and technical regulations, so-called NM, 21 projects for a total amount of  $\notin$ 5.9m). The main objectives of these programmes were:

- To encourage work on standards in Belgium and make the scientific worlds aware of the importance of standards, so that ultimately Belgium can play a larger role in the European standardisation process;
- To study and evaluate the impact of standards and technical regulations on economic and social life.
- Apart from these objectives, a major purpose of the two programmes was to generate scientific knowledge and tools necessary to policy-makers and other users from industry, services, as well as (final) users/consumers.

The ultimate aim was thus to upgrade Belgium's position in international standardisation forums, increase its impact on future standards, but also to more efficiently adopt new European directives and related standards. The programmes have indeed taken place in a context of a relatively minor position of Belgium in the standardisation and normalisation fora. At that time, this was an original initiative since at least in the countries studied for the evaluation, such programmes attempting to deal with standardisation matters through research per se did not exist. NO and NM integrated many different types of actions. NO revolved around the following three sub-programmes:

- Current state of standardisation and certification;
- Pilot projects;

• Promoting standardisation and certification.

Three types of projects were expected, not all research projects:

- Studies on standardisation: inventories, states of the art, etc. in every sector;
- Projects of pre normative or co-normative research;
- Projects dealing with dissemination activities.

NM was divided in three parts as well but issued only one call for proposals:

- Pilot projects;
- Assessment of the social impacts of activities related to standardisation;
- Dissemination.

Given the various objectives of both programmes, the projects were diverse and heterogeneous, with four types of projects: longer term oriented research projects; pre-normative research; implementation of standards at the Belgian level; dissemination of information on standards. Selected projects were funded at 100%.

#### **1.2 THE EVALUATION METHOD**

The evaluation of the programmes was carried out by a panel of foreign experts supported by a consultant, between October 2002 and March 2003. The federal government aimed to understand research results and their impacts, as well as eventual shortcomings, in order to determine the necessity, relevance and design of new actions in the standardisation area. The following figure provides an overview of the methodology used to address each of the evaluation criteria.



Figure 12 General overview of the methodological approach

Source: Technopolis France, Evaluation of "Standardisation" programmes, for the Belgian Federal Public Planning Service Science Policy, 2004

The main steps of the evaluation methodology have been the following:

- Analysis of programme documentation: design of programmes, management data, project reports and publications;
- Three meetings with the expert panel;
- Questionnaire survey sent to all 50 project coordinators (37 responses obtained);
- Interviews with programmes managers, policy makers at national and European levels, researchers and with members of "user committees" of selected projects.
- International case studies on France, the Netherlands and the Nordic Countries, carried out by the experts, and on Great-Britain and Germany completed by the consultant.

The assessment of the scientific quality of funded projects and the valorisation of the outputs have been performed through the analysis of intermediary and

final reports and, above all, through the hearing of 16 research teams by the expert panel.

#### 1.3 INDICATORS USED

- Number of proposals received and projects supported per call/priority area/programme;
- Amounts of funding per programme, average funding per project/ per team;
- Programmes' management costs as a share of total programmes' costs;
- Delays in months between calls for proposals and project notification;
- Employment (incl. researchers) generated by the project (survey results);
- Nature of funded projects: projects' progress report, continuity, (survey results);
- Reasons for participation and origins of the projects (survey results);
- Characterisation of participants: parent organisation, age of the units, part of the funded projects in the units' activities, number of projects in units besides the funded projects on standardisation, collaborations outside of the project consortiums, participation in other national or international research programmes (survey results);
- Degree of satisfaction with different aspects of the programmes and collaboration with standardisation bodies (survey results);
- Collaboration patterns, incl. distribution of types of co-ordinators over the projects and previous and future collaborations (survey results);
- Types of partnerships in the project (survey results and programme data);
- Size of consortia (survey results and programme data);
- Key factors allowing the progress and achievement of the projects (survey results);
- Thematic division of budget (programme data);
- Projects outputs (survey results and case studies), incl. publications, conferences and standards.

#### 1.4 FINDINGS OF THE EVALUATION

Given the Belgian position in standardisation bodies, and given the national needs for standardisation, the idea to start a programme for research related to standardisation was an original and **relevant** objective at the time. However, needs in Belgian society or, more narrowly, needs related to standardisation, normalisation or technical regulation issues had not been explicitly and systematically defined for any of the programmes. Their relevance could have been improved by evaluating these needs pro-actively and designing the programmes in view of those. Also a final or ex post evaluation of the first programme, which was not carried out, might have improved the relevance of the second programme, which was mainly a continuation of the first.

Whereas the programmes were clearly internally coherent and well thought through, improved readability of this **coherence** could have been beneficial for the outside world. One issue is that different types of actions, in particular, technical research work, dissemination and information related activities, and more future oriented strategic work, could have been more explicitly distinguished. Although it is not necessarily recommended to split different activities into different programmes (were it only for budgetary reasons), compared to the other countries studied in the international comparison, Belgium appeared to be the only one in combining such different aspects in one single programme.

In terms of effectiveness, both programmes have lead to an obvious increase in awareness on standardisation issues among the academic population that participated. Several projects funded under the programmes have lead to **new standards and norms**, or to proposals for these. Concrete results of projects are however mainly publications and conferences. Standards are quoted as outputs of projects in 21 cases (61%), studies or advice in 28 cases (64%). Transfer of results between research and users (whether they are industry, services, consumers, standardisation bodies) could still be improved: the potential utilisation of the results of their research are often unknown by researchers. Three main reasons may explain what sometimes can be interpreted as a "loss" of results. First, the researchers, when they are academics, appear not to be very interested in economic valorisation, and this includes work within standardisation bodies. A second problem encountered is the lack of money for the maintenance and up-dating of tools developed under the programme. Finally, there appears to be, in most of the cases, a **huge gap** between researchers and standardisation bodies. Links between the PPS Science Policy and the Belgian Institute for Normalisation, that could have helped building bridges between the research projects and standardisation, were weak or absent, and this absence probably led to missed opportunities.

The Evaluation Panel judges the **scientific quality** of projects and results overall being of a good level. At the same time it was found that the programmes are extremely diversified and heterogeneous since they include very different sorts of projects. These range from highly technical research, via inventories or states of the art (including socio-economic studies), to projects for the dissemination of information on standards. The projects can therefore be hardly evaluated according to a single set of criteria, even if, according to the Panel, the nature of the link with standardisation matters and the valorisation of results appear as being the overarching criteria to assess the achievements of the programmes. **While the overall scientific quality of projects and results thus is good, this does not mean that they provide substantial contributions to standardisation**. In some cases, teams have reached a leader position but the question of the follow-up is raised.

#### 1.5 Bibliography and Further information

Technopolis France, Evaluation of "Standardisation" programmes, for the Belgian Federal Public Planning Service Science Policy, Final report, September 2004

### Annex

## Objectives trees of the Standardisation programmes

Exhibit 1 NO's Objective tree

Global Objectives	Intermediary Objectives	Specific Objectives
To be in a position to define the actions needed to optimally encourage Belgian normalisation activities and reinforce Belgium's European position (NO, I)	Obtain current state of the art in standardisation in Belgium	<ul> <li>analyse strengths and weaknesses; and analyses of specific issues</li> </ul>
Develop, in Belgium, capacity for the design of scientifically and technically proven methodologies, that can help to actively participate in European normalisation committees (NO, II)	Perform pilot projects	<ul> <li>research of strategic interest</li> <li>translation of European directives on the level of the country [i.e. Belgium], or contribute substantially development of new norms &amp; standards, eventually preparing new directives</li> </ul>
Increase dynamics, and raise awareness, around standardisation (NO, III)	Promote standardisation and certification	<ul> <li>focus on "embryonic offer" providing new services that could be implemented in the rather short term</li> <li>pay specific attention to (1) continuous education, awareness building and information provision of different actors; (2) development of multifunctional interactive information systems concerning progress in national and international normative processes; (3) developing and making available platforms (preferably intersectorally)</li> <li>take into account needs and problems of SMEs</li> <li>integrate in consortia actors that are able to transpose the R&amp;D results towards users</li> </ul>

#### Exhibit 2 NM's Objective tree

Global objectives	Operational objectives
Increase the Belgian scientific potential	<ul> <li>Pilot projects: to reinforce the scientific potential and to generate a large interest within scientific world</li> </ul>
Increase the participation of actors not     anough involved	• Projects related to assessment of social impacts of standardisation activities
enough involved	• Projects aiming at the generation of information about standardisation
# 2. Evaluating the impact of the German Ecological Tax on Innovation and Market Diffusion

## Compiled by Kincsö Izsak

#### January 2013

### 2.1 SHORT DESCRIPTION OF THE MEASURE

The German ecological tax was introduced in 1999 with the objective to make energy and resource consumption more expensive, thus protecting the environment and on the other hand to create new jobs. The tax was levied on final energy consumption in relation to the quantity consumed. The new tax revenues were used for pension contributions, thus lowering labour costs and promoting employment. Another part of the revenues was used for fostering investments in renewable energies.

The reform represented an important pillar in the German contribution to climate and environment protection. The idea behind such environmental taxes is to enable policy-makers to reallocate between the types of taxes without increasing the overall burden on firms and as a result reducing economic distortions.

The eco-tax is also expected to prepare for potential shortages and price increases of fossil resources. Since the increase of energy prices linked to the ecological tax reform are predictable, it gives a certain security for businesses to plan and to make investments in energy-saving technologies and development of new solutions.

Since its inception, the eco-tax reform has been the subject of major criticism. It has proven to be effective in reducing CO<sub>2</sub> emissions and stimulating employment and innovation, however, it was attacked by indicting that it has a negative impact on economic competitiveness.

## 2.2 EVALUATION

The German Federal Environmental Agency commissioned Ecologic and the German Institute for Economic Research (DIW) in 2005 to complete an expost evaluation of the ecological tax reform to determine whether it reached its targeted goals.

The resulting study investigated the impacts of the ecological tax reform on industry and producers in 5 sub-reports:

- Benefits for different economic sectors;
- Macro-economic analysis of the impact;
- Effects on private households;
- Effects on selected businesses; and
- Impacts on innovation and market diffusion.

The innovation effects of the ecological tax reform were explored **through case studies and expert panels**. Concerning innovation, statistical analysis could not be performed due to the short time and lack of data. It would have been difficult to extract the effects of the tax reform among other conditions influencing innovative activities such as the energy efficiency of buildings or facilities of electrical equipment.

The evaluation methodology was composed of several steps. First the study examined the effects in terms of newly created employment opportunities, technical innovation and development and the launch of new products and services. This was done based on a group of identified businesses, which benefited from the tax reform. In addition a survey was conducted on the adaptation of private households to the new taxation framework.

The effects caused by the reform were calculated by drawing up a macro economic model, so as to determine the adaptive reactions of the different sectors of the economy, and the effects on GDP, employment and CO2 emissions. The calculations were carried out using a scenario method, where the reference scenario (describing a development without the ecological tax reform), and a political scenario (with the inclusion of the measures of the reform) were compared. The differences between the results for both scenarios were interpreted as being due to the ecological tax reform.

The innovation effects were investigated by selecting examples of products and services through literature review and interviews with experts. Examples used were for instance energy-saving lamps and LED lamps, the insulation glass or energy performance contracting.

#### **INDICATORS USED**

The following indicators were used in the evaluation in terms of innovation and market diffusion:

- Price evolution of selected products and services
- Technical developments and market penetration of innovative products and services
- Level of emissions of carbon dioxide
- Evolution of non-wage labour costs and employment

Concrete indicators applied in the case of specific examples where case studies were conducted:

- Sales of insulating glass and windows (newly installed units) 1990-2002
- Shares of petroleum (including eco-tax) in the development of natural gas prices for households (1999-2003), are Cent/kWh77
- Share of natural gas vehicles in the inventory changes all motor vehicles
- Market share of gas-powered vehicles

#### 2.3 KEY FINDINGS OF THE EVALUATION

The ecological tax reform was found to have a positive impact on ecoinnovation. It was concluded that the tax had a 'noticeable effect' on innovation and diffusion, although it was not possible to quantify the scale of that effect.

The reform generated **additional financial incentives** for an economical use of energy resources. The decrease in non-wage labour costs supported the effect on innovativeness. As innovation processes are often work-intensive processes, it fostered research and development, energy consultancy and the development of energy-saving technology.

The ecological tax has contributed to **increasing the reliability of investments in R&D** and innovation, because it made energy taxes and prices more predictable.

The ecological tax reform has resulted in a signalling effect that **strengthened consumers' and companies' awareness** for the importance of renewable energy.

The eco-tax was found to play an important role in the development of **gas powered vehicles**. As a result of the tax, the payback period for energyefficient products was reduced and the various exemptions favoured efficient energy use and renewable energy sources.

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## 3. Evaluation of the German Market Incentive Programme for renewable energies in the heat market

#### Compiled by Kincsö Izsak

January 2013

### 3.1 SHORT DESCRIPTION OF THE MEASURE

The German Market Incentive Programme (MAP) had been launched in 1999 and is still a central instrument of the German Federal Government to support the uptake of environmental friendly solutions in the field of renewable energies. Within MAP a volume of €490m have been designated in 2009 with an additional investment of €3b. The MAP supports not only environment protection, but is also intended to create jobs, investments and innovation. The programme is implemented partly by the Federal Office of Economics and Export Control and through the KfW banking group in Germany.

The aim of the programme is to strengthen incentives for buying renewable energy technologies in the heating market and lowering their costs. Support is provided as project funding with fixed amounts through grants. The level of support depends on the nature and scope of the project.

The programme is funding several new installations such as solar collectors, biomass facilities, heat pumps, facilities for the use of geothermal energy, district heating systems supplied from renewable energies, and innovative technologies for heat and cooling from renewable energy sources.

#### **3.2 EVALUATION**

The German Federal Ministry of Environment, Nature Protection and Reactor Security commissioned an evaluation of the programme with a view to assessing the effects generated in the period 2009-2011. A consortium led by Fichtner – a German engineering and consultancy service – conducted this assessment. The evaluation mainly looked at the facilities supported by the Federal Office of Economics and Export Control (BAFA) and the KfW banking group in 2009 out of the entire number of facilities constructed in 2009 and 2010.

The study was composed of three steps:

- Target achievement: assessing if the measure has accomplished the predefined objectives and if the objectives fit the measure.
- Effects: assessing whether the measure was suitable for the achievement of objectives and assessing all the intended and unintended effects.
- Efficiency: assessing if the implementation of the measure was economically efficient in relation to the consumption of financial resources.

In the preliminary phase the objectives of MAP were studied and the indicators achieving them discussed. This was followed by a prioritisation of goals and indicators, as well as the identification of the methods and databases to be used. The following preparatory works were performed: examination of the targets and objectives, operationalisation, investigating previous evaluations and the indicators used, complete missing indicators, comparison with the recommendations of previous evaluations; and comparison with the indicators of the National Climate Initiative<sup>7</sup>. The study also conducted a survey with 850 programme beneficiaries.

The KfW's internal statistics recorded in an internal database was one of the data sources that helped the evaluation process to a great extent, which contained essential data on loan applications. The data covered technical and economic information on the projects as well.

The study found that the demand for the programme support was high. From 2009 till September 2010 more than 217,000 facilities had been installed in the framework of the programme. The proportion was particularly relevant in the field of solar panel installations. This was seen as a very good result given the difficult economic conditions in that period. By BAFA 253,225 projects were funded with a total support of € 374.357m. The funded projects included an investment from € 2,746.425m. Beyond this there have been 2136 new commitments granted under the KfW Renewable Energies Programme. The commitments included a loan volume of €298m and a redemption grant volume of €96m. The investment triggered totalled € 3,045.171m.

MAP was also found having an important influence on the development of technologies and improving environmental standards. The study concludes that MAP had managed to encourage technological innovations and develop new application areas. The increased rate of support for solar facilities contributed to an increased solar thermal performance.

As it was highlighted, MAP induced positive economic effects. The solar thermal industry contributed with 44% as the largest to the MAP induced investments and took the 80% share of domestic market. The biomass was a large proportion of the total investment, but two-thirds of this market was foreign, especially dominated by Austrian companies. The study confirmed the hypothesis that in many cases the MAP has increased the quality, the degree of innovation and the size of the plant.

Although around 80% of surveyed funding recipients said that the MAP played a very important role for the establishment of the facilities, the study also revealed that the development of energy prices greatly influenced investment decisions. Almost half of the 850 surveyed beneficiaries would have installed the facility without the programme as well. This windfall gain could have been clearly lower with lower energy prices as 2009/2010. The deadweight is technology-dependent. The survey resulted in a higher deadweight for heat pumps and for firewood and woodchip boilers.

## 3.3 INDICATORS USED

The extent to which the objectives of the programme have been reached were assessed by using 11 indicators:

- **1.** Achievement of quantitative targets
- 2. Growth of markets and exploiting potential
- **3.** Reduction of energy costs
- 4. Reduction of investment costs
- 5. Market development of renewable heat technologies
- 6. Sales of renewable energy technologies in the heating market
- 7. Long-term liability of the FP
- 8. Substitution of fossil-nuclear energy sources and reducing CO2
- 9. Promotion of future infrastructure and system efficiency
- 10. Reduction of price risk and increasing the security of supply
- 11. Technological Development

<sup>&</sup>lt;sup>7</sup> http://www.bmu-klimaschutzinitiative.de/en/home\_i

## 3.4 KEY FINDINGS OF THE EVALUATION

The study found that the MAP contributed to setting technological standards through its technical requirements, as well as by the extensive promotion and fostered the introduction of innovative technologies.

Around 10-20% of the interviewed projects participants have installed an innovative facility supported by the programme and approx 50% said that they would have installed less innovative solutions without the programme.

The total sales of renewable heating systems in 2009 remained stable as compared to 2008, even though sales for heating systems has increased slightly overall by 3%. The goal to make the market grow for renewable heating facilities was missed, which is largely attributable to the general economic situation at that time.

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# 4. Survey-based mid-term evaluation of the Danish Programme for User-Driven Innovation

#### Compiled by Kincsö Izsak

#### December 2012

### 4.1 SHORT DESCRIPTION OF THE MEASURE

The Danish Programme for User-driven Innovation8 was launched in 2007 and ran till 2010 with the objective to helping companies and public sector institutions integrate customer experiences in their product development processes, to facilitating access to skills and competencies in the assessment of user needs, and to fostering the use of user surveys. The programme has been administered by the Danish Enterprise and Construction Authority and had a  $\pounds$  13,5m budget per year.

Applicants from both the private and public sector took part, including educational institutions, cultural institutions, and knowledge institutions. Projects working in cross-sectoral consortiums were particularly encouraged. To obtain grants from the programme, projects had to examine user needs in news ways. This included, for instance, the development and testing of new methods and tools, building competencies, training, networking, or knowledge dissemination.

Themes were selected from year to year and were related to areas with particular business competencies, for instance environment and energy technology, construction, health, design, and foodstuffs; cross-sectoral issues relating to societal problems with promising market potential, for example healthy and energy saving construction, or fighting obesity and welfare areas.

## THE EVALUATION METHOD

The programme's midterm progress was evaluated in 2009 by DAMVAD<sup>9</sup> a research-based consultancy with the purpose to explore the preliminary effects and find out whether the programme meets its objectives. The key questions of the evaluation were:

- Has the programme fostered the development of new products, services and concepts?
- Has the programme contributed to make Danish companies and public institutions more innovative, including employees' conditions for innovation?
- To what extent has knowledge been spread about user-driven innovation?

The analysis covered 48 projects that received a grant in 2007 and 2008. Private actors represented 66%, public service (including public administration, education, elderly and care, and hospital sector) represented 18% and knowledge institutions (including universities, university colleges and approved technological services) accounted for 16% of project participants.

<sup>&</sup>lt;sup>8</sup> http://www.w2l.dk/file/17694/insight\_into\_user\_driven\_innovation.pdf

<sup>&</sup>lt;sup>9</sup> http://www.damvad.com/

The analysis comprised the following steps:

- Review of basic information on project participants and project applications;
- Analysis of data from the Company Database 'Experian' and of the Community Innovation Survey 2006, research and development work in the public sector 2006 (Research Statistics 2006) and from previous studies by DAMVAD;
- Extensive survey among all project participants who received support from the programme in 2007 and 2008;
- Target group analysis, intended to identify knowledge dissemination activities;
- A media analysis, where the change in coverage of user-driven innovation in the Danish media was examined prior to programme and during the programme period.

The mid-term evaluation was based on two surveys among project participants. Questionnaires were sent out to all companies participating in the projects both before and after the completion of the projects. The questionnaire aimed to shed light on the evolution of the company's innovation activities and measure change between two points in time. Based on the collected questionnaires it was possible to assess the effects of the projects and on a more aggregate level effect of the programme for user-driven innovation as a whole. The questionnaire was based on the questionnaire Statistics Denmark in the implementation of the European Community Innovation Survey. The questionnaire asked about the results achieved through the programme, interaction patterns in the projects, the project's contribution to changes in behaviour among participants, participants' motivations and expectations, as well as the perceived barriers in relation to user-driven innovation.

The evaluation first reviewed the projects and project participants and drew a picture of the activities and actors covered by the programme. Then it examined the purpose and activities of the projects on the basis of questionnaire survey among project participants. Finally it illustrated the effects that the programme had on the project participants' innovation activity and their knowledge and skills bases. It also examined the perceived barriers to user-driven innovation among project participants.

The evaluators established control groups based on the Community Innovation Survey 2006 (CIS 2006), participants in the programme of the Council for Technology and Innovation and participants in programmes under the Strategic Research. The characteristics investigated were the industry, company size, geographic location, innovation degree, collaboration, sources of innovation and turnover ratio.

To calculate the effect of the private actors and public institutions participation in the programme, a logistic regressions model was used. The regression measured the relationship between the outcome of a specific factor and a number of explanatory variables. Data have been tested for potential multicollinearity, since it was a relatively small database - 132 respondents for the private sector and 68 respondents for the public institutions. The study differentiated three groups of private actors: "High performers"; "Apprentices" and "The majority" to perform a cluster analysis of project participants. There were several barriers to measure the impact of the programme as pointed out in the study. Changes in participants' behaviour provide an important indication of the observed effects, but the direct effects may be difficult to measure in the project towards innovation. The effects can be difficult to isolate from the individual participants in terms of which companies or public service may experience an increased innovation activity, without necessarily linked to participation in the programme. Moreover, there is typically a time lag from participation in and completion of a project for the purpose of capturing an effect among participants.

## 4.2 INDICATORS USED

Based on the Community Innovation Survey questions, the indicators that the evaluation report used were:

- Innovations in goods introduced to the market
- Process innovations introduced
- Marketing innovations introduced
- Collaboration with other organisations

## 4.3 FINDINGS OF THE EVALUATION

- 74% of the companies have developed or expect to develop innovative products. Approximately two-thirds of the project participants would not have initiated similar activities without the support of the programme.
- There was a positive correlation found between the use of certain methods for user-driven innovation and innovation impact of the projects. In industry a positive association was found between the identification of non-recognised user needs and innovation.
- Participation contributed to a strengthened relationship with users.
- The evaluation showed that project participants continued to experience a number of barriers to user-driven innovation, particularly lack of knowledge of users' unrecognised needs, and lack of internal focus and resources for user-driven innovation.
- It was highlighted that it is not straight forward that uncovering user needs leads to innovation. Innovation from users takes time and requires the involvement of top management in firms.
- Projects under the programme for user-driven innovation have been much more interdisciplinary than other programmes, as measured by the width of the actors involved in projects and the areas they represent.
- Service companies were particularly well represented in the programme, with 69% of business participants are employed in the service sector, including knowledge services, trade and ICT.

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## 5. Evaluation of the PACA Labs initiative in France

#### Compiled by Johanna Castel

#### January 2013

#### 5.1 SHORT DESCRIPTION OF THE MEASURE

The PACA Labs is a measure of the Digital Territories programme, under the Regional Strategy for Innovation of the Provence-Alpes-Côtes d'Azur (PACA) region. Launched in 2008 and running until 2013, it implies territories (particularly local authorities), businesses (particularly SMEs), academia and in general innovation actors. It was designed to foster digital innovation and territorial development in the region through projects involving experiments and new uses of ICT. The initiative receives funding from the European Regional Development Fund (ERDF).

Objectives of the measures are to:

- Support ICT companies in the PACA Region for the development of innovative products and services and valorise their expertise through experimentation
- Accompany local authorities to anticipate new usages (i.e., in public services)
- Foster the exploration of new digital practices and implication of various stakeholders including users and promote open innovation models
- Stimulate PACA region as an innovative region and enhance territorial development

Two projects calls are launched per year, under three axes: Experimentation projects, research-exploration projects, and digital ecosystem projects. Under the initiative, around 10 to 12 projects are selected yearly. For the first two calls, 23 projects have been supported for a total cost of  $\bigcirc 7$  270 102, of which  $\bigcirc 2$  415 894 from the PACA Region and  $\bigcirc 814$  966 from ERDF funding. Each project can receive up to  $\bigcirc 240$  000, participation depending on status of the project holder. Companies can receive up to 60% of the project cost whereas other types of stakeholders are entitled to receive up to 80%. The third call for projects took a longer time and less projects were selected, namely four projects. The fourth call was launched in September 2012.

This measure can be qualified as a user-driven innovation policy measure, its rationale being to encourage open innovation and consideration of user needs through user-centered actions.

#### 5.2 THE EVALUATION METHOD

An operational committee, a strategic orientation committee and external experts to evaluate projects pilot the initiative. Deixis-Sophia, a research team from Telecom Paritech was asked to integrate the initiative as scientific experts and give support in implementation and evaluation. Prior to this partnership, Deixis-Sophia presented a proposed intervention, formalised in a yearly and renewable partnership agreement. The approach adopted by the research team is inductive and qualitative, and based on ethnographic research. They also participate in the governance of the programme, such as other members of the operational committees (Méditeranée Technologies, The competitiveness pole SCS and Fing).

Sociological support and accompanying were performed by Deixis-Sophia during the implementation of the initiative. The Deixis-Sophia team is composed of three permanent social sciences researchers and is part of the Telecom ParisTech school, a French engineering Grande Ecole specialised in ICT. Their research interests gather behaviours of use/usage and social, cultural and organisations transformations occurring from the use of ICT, territorial innovation systems and integration of usage in product or services development. Since 2008, they have been associated to the initiative as partners and scientific experts. Their mission was defined as the production of an usages observation system ("dispositif d'observation des usages"). They integrated the evaluation of the programme as an innovation scheme that would be monitored through surveys based on interviews with various stakeholders as well as the elaboration of a methodological framework to observe ICT usages in projects developed under the initiative.

Several research papers were published on the subject by the research team in parallel of their intervention in the programme. These documents, although not part of the PACA labs evaluation give some information on the approach and methodological reflexions surrounding programme support. The Deixis-Sophia team elaborated reflexion on how to measure involvement and contribution of users to innovation processes, how to identify users and what methods to assess and collect data on this type of initiative, given the fact that definitions and concepts of living labs, of users and the methodologies to assess them can be different. This paper takes the example of the PACA Labs as a case of scheme witnessing methodological issues regarding involvement of users in innovation processes. The raised the need for mediation and support of the process through strong collaboration between innovation actors and skills from social sciences and others fields for what they call analysis of use and through four actions.

Figure 1: Proposed methodological framework

1. Identify "good" users: through funnelling each issues and ask the following questions: who has to do with the innovation? Who is likely to be interested about it? Who could buy it? Who will use it? Two principal modes of users recruitment are also described a the direct (i.e suggestion box) and indirect (i.e mediator) methods of recruiting

2.Chose "good" ratings/evaluations: Given the diversity of projects a living lab can cover, it is difficult to assess how to apply user-centered approaches. Three types of assessment are distinguished: assessment of the contexts of use (i.e socio-professional characteristics of users, economic and social context), assessment of the meanings of use (i.e representation), assessment of the situations of use (i.e adaptation)

3. Use the "right" methods: based on the work done by the Computer Supported Cooperative Work (CSCW). Methods are collaborative ethnography (ethnographer + designer) for the identification of use scenarios, evaluative ethnography for impact analysis, located ethnography, for analysis of the interaction and quantitative ethnography for recors of use of utilisation.

4. Rely on "good" skills.

Source: Dreaetta, Labarthe 2010

The measurement of impacts is very detailed. Based on general objectives and difficulty to make comparison with existing programme as similarity is rare at all levels and it is also delicate to measure economic and social performance gap and in general impacts of this initiative and the absence of an specific indicator to measure it. The researchers have based their analysis on the theoretical elements of the programme ("Triple helix" model developed by Etzkowitz and Leydesdorff in 1997, in which business/university/government

collaborations foster innovation). Following critical analysis of this model, they shaped a first question on training and impact of collaboration in the Labs and in terms of expected effects and non-effective effects. The conduct of a qualitative survey among various stakeholders (companies, academia and public sector) in 2009 was considered the most effective way to answer the question, as well as analysis based on the new economic sociology such as the analysis of networks and innovation sociology ("Acteur-réseau", Latour 1995). Analysis of networks and related information collected through the survey were useful to highlight opportunities and constraints witnessed. Their also first saw the need to define what was considered as "users" and related semantic fields and consider the feasibility of the design of such a methodological framework. The research team proposed to produce guidelines to ensure better comprehension and engagement, following observations from first call for projects, although not a requirement from the convention.

Type of evaluation and objectives	Methods	Techniques of data collection
Evaluation of meaning of use Adoption	Collaborative Ethnography Quantitative Ethnography	Brain storming / paper board / paper prototype Eyes tracking / capteurs divers / trace analysis
Evaluation of situations of use Adaptation	Directed Interviews / Focus Group Evaluative Ethnography Located Ethnography	Audio recording Video of users in activity Observation in natural situation
Evaluation of usage contextes Integration/Appropriation	Archive research Statistic analysis Speeches analysis Semi-directed interviews Quick and dirt ethnography	State of the art of the documents and the studies Questionnaire/Survey/Infometry Audio recording Field diary/ Notes Taking / Photography

Figure 13	Crossing t	vpes of eva	aluation.	methods	and to	echniques

Source: Draetta Labarthe 2010

Another paper from the same authors deals with the researcher dilemma and sociological interventions based on the PACA labs experience, seeing it as a global context for increasing demand from public sector for scientific and sociological expertise for territorial development. The particularity of this intervention is that it was also asked to participate in the governance of this programme and the methods they developed to respond to this demand and what they describe as "partenarial research". In terms of participation to the programme, the research team contributed to shape projects evaluation criteria, for example adding the users mobilisation parameters. They also encouraged association of researchers to projects and conducted surveys to assess impacts of these partnerships, in terms of knowledge capitalisation for example. Surveys preparation and conduct were closely linked to debates and discussions following their results within the operational committee. Main impact assessed by the team is the capacity to create jobs.

The programme has been evaluated at different steps of implementation. Some feasibility studies were led for projects in the third axis (Digital ecosystem projects). The Deixis-Sophia research team conducted surveys after each call for projects. Finally, a socio-economic survey was carried out in 2012 to measure impacts of the initiative after four years of implementation. Feasibility studies were conducted to develop the third axis of the initiative, to develop digital ecosystems, in the form of a two day workshop were different stakeholders were invited to exchange ideas on several projects to be developed under the axis, in terms of , among others, stakes, vision, objectives, benchmark, types of users and usages and types of services and thematics, SWOT analysis. Some projects presented surveys conducted. Methods used varied according to projects. In December 2011, with the release of the synthesis of surveys led, the authors report that two surveys were led on the basis of the first and second call for projects, involving around 60 interviews with various stakeholders. A socio economic survey was conducted by the operational committee under the Regional Innovation Observatory, at the end of 2012 and results released in November 2012. This survey was sent to all structures that participated to PACA Labs in the form of an online questionnaire.

## 5.3 INDICATORS USED

Indicators used for the first surveys conducted by the Deixis-Sophia team are the quantitative repartition of projects for the first and second call (number of projects and by stakeholder type), followed by a thematic typology of projects under for instance sustainable development, digital culture or e-health. A comparison of number and type of stakeholders involved was also useful to measure progress and increase of interest among stakeholders. Geographical analysis for the first and second project was also performed, with comparison between geographical repartition in the first and second project.

Indicators used for the 2012 survey conducted under the Regional Innovation Observatory are:

**For companies:** Participation to other programmes; Positioning of the project (Axis 1, 2 or 3) and pertinence of this choice (by stakeholders); Expressed objectives of the project (by stakeholders); Concerning implementation of the project: lists of tasks; Duration of the project and measure of satisfaction concerning duration

**Economic and Social Impacts:** Impacts in terms of economic development: List of main economic developments and rates from 1 (not at all) to 3 (a lot). Regarding for instance improvement of product, gain market share; Economic and social impacts: questions on the creation of new jobs and types of job created (technicians, employees, managers...) and creation of indirect jobs.

For **local authorities**: Evaluation of new activities developed: list presented and notation from 1 (Not at all) to 3 (a lot). For example, improvement in valorisation of image, innovation involved in public management, change management...

For **academia**, also evaluation of new activities developed and evaluation, regarding reinforcement of skills, knowledge transfer.

**Added value** of experimentation is also measured through questions on participation to the project enabling to acquire new knowledge in several areas (i.e user-centered innovation, collaborative project management, technological innovation) and specific questions on perception of user-centered innovation through various activities (i.e experience exchange, new working methods...). **Success** of the initiative is also measured through will to participate to its next steps and it what form (partnership, project manager, sponsor) and what axis. On their **comprehension of the programme**, participants were asked to classify objectives priority from 1 to 5. They were also asked to evaluate

from 1 to 4 administrative procedures put in place in support of the programme and to specify whether they had received all due subventions from ERDF of the Region.

#### 5.4 KEY FINDINGS OF THE EVALUATION

Results in terms of collaboration between public sector and academia are very positive and flexible but some tensions of economic finality versus social finality. Theoretical approach sometimes not widely understood.

Results of the first surveys show that an increased number of stakeholders are interested in participating to the initiative, with a growing number of economic actors and academia manifested interest. Paca Labs initiative enabled to foster the development of new forms of innovation and changes in organisation of innovation landscape. It plays a structuring role, be it from existing links or through newly created networks under the initiative. Implication of local authorities is a win-win situation. The evaluators witness the creation of "active territories" and structuring of new territorial innovation systems. Barriers identified: Difficult to bring about change and participative and mediation approach within public entities, temporality and valorisation problems

The latest evaluation carried out in 2012 shows that the programme and its objectives are considered pertinent by the participants and corresponds to their expectations. The programme enabled the diffusion of the user-centered approach, the development of partnerships and fostered knowledge transfer dynamics. Administrative and payment procedures could be simplified, and reflexion on the duration of projects, international component and definition of objectives per axis were held. Finally, the programme enabled to improve products and services development, however economic impacts are not yet significant. This raises questions on the positioning of axis, duration of projects and reflexions on business models.

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# 6. Energy performance regulation in the Dutch residential building sector

#### Compiled by Kincsö Izsak

#### January 2013

## 6.1 SHORT DESCRIPTION OF THE MEASURE

The Dutch Energy Performance Regulations were introduced in 1996 with the objective to reducing energy consumption in buildings originating from heating, hot water production, lighting, cooling and ventilation. The regulations mainly address the construction sector, where certain requirements have been set such as minimum insulation levels or maximum permitted energy use. Setting stricter requirements was expected to encourage energy-saving innovations such as in the area of ventilation, insulation, heating, domestic hot water, energy re-use, and energy generation or solar energy solutions. A speciality of the Dutch regulation was that it allowed for differentiating the energy produced for instance by photovoltaic energy systems in the calculations, thus fostering the use of more innovative systems.

The energy performance is based on calculating the energy performance coefficient, which is outlined by two national standards. It is the manufacturers that need to respond to the building regulations and produce innovative solutions to meet these requirements. The government does not impose product quality requirements directly on upstream materials and components manufacturers.

The Dutch regulations meet also the criteria of the European Energy Performance of Buildings Directive introduced in 2003 that obliges the EU MS to implement energy regulations based on the concept of energy performance.

The innovation system in the Dutch residential building sector is known as a complex system of inter-organisational collaborations and is of a project-based nature. Since every construction project is unique, there is little incentive for contractors to invest in innovation if they cannot reach an economy of scale. Moreover, the practice of selecting the tender that offers the lowest cost hinders innovation since there is little scope to change design specifications.

Private commissioning of new constructions represents only 15% of the buildings thus client demand for innovation is restricted focusing more on productivity gains rather than specific customer-oriented solutions. As it is known the construction sector in the Netherlands is subject to a "strong path-dependent development trajectory whereby old routines are too pervasive to make changes in the techniques applied" (Beerepoot M. and Beerepoot N., 2007). Thus, government regulation through norms and standards is supposed to take the place of the absent user demand.

## 6.2 THE EVALUATION METHOD

A study by Beerepoot M. and Beerepoot N. analysed the effect of the above presented Dutch energy performance policy on innovation in 2007. The analysis is based on data from a database of 350 energy performance calculations submitted to several Dutch municipalities for an 8-year period from 1996 to 2003 in connection with applications for building. The data in these calculations allowed for identifying the technologies used for insulation, space heating, hot water production and ventilation. Three types of technologies were distinguished:

- (1) Technologies that represent the 'state of the art' in 1996, when energy performance regulations were introduced in the Netherlands.
- (2) Technologies that show an improvement on the 1996 'state of the art': *incremental innovations*.
- (3) Technologies that are new to the Dutch residential construction sector compared to the 1996 'state of the art': *really new innovations*.

The authors used correlation analysis and logistic regression analysis. Correlations were explored between introducing and tightening up the energy performance regulations and the use of improved and new energy technologies in residential buildings.

The authors constructed an explanatory model in order to ascertain the relative influence of the energy performance regulations in relation to other factors that influence technological development in the residential building sector. Advancing and restricting variables for the macro-context were included in the database such as national gas prices per year for domestic use and economic growth. Subsidies and financial incentives remained constant in the period of assessment.

A model for evaluation research introduced by Mayer & Greenwood (Vall and Leeuw, 1987) and a framework for explaining the diffusion of innovations in new office buildings as developed by Vermeulen and Hoven (2006) were used as a basis.

The framework of Vermeulen and Hovens puts forward explanatory variables for the macro-context, consisting of the 'macro-economic situation', 'market demand in terms of environmental awareness in society' and 'energy price developments'.

Figure 14 Research model of the effect of energy performance policy on innovation



Source: Beerepoot M. and Beerepoot N. (2007)

## 6.3 INDICATORS USED

The baseline for the evaluation method was provided by the database on energy performance calculations.

The indicator used is the type of technologies introduced for insulation, space heating, hot water production and ventilation in the buildings.

A Guidebook on evaluating energy efficiency policy measures (Vreuls, 2005) recommends the use of further indicators to assess the effect of regulations on innovation such as the level of adoption of practices.

The specific indicators may include the

- share of architects that apply energy-efficient techniques and constructions in their design;
- share of builders that adopt energy-efficient techniques during construction;
- share of producers that produce energy-efficient building equipment.

The Guidebook suggests identifying a reference situation in order to assess the effects of regulations. This 'baseline' should state the situation in the absence of the measure. The baseline should preferably be determined ex-ante, but it is often defined ex-post. To determine the baseline ex-ante it is suggested to use surveys among designers, design specifications in approved permits, on-site audits, scenarios and simulation (Vreuls, 2005).

## 6.4 FINDINGS OF THE EVALUATION

- The study found a strong correlation between energy performance regulations and 'incremental' energy-saving innovations in hot water technologies in the Dutch residential building sector during the 1996–2003 period.
- The study demonstrates that energy performance policy in the Netherlands did not contribute to the diffusion or development of 'really new innovation' in hot water production technologies during the 1996–2003 period.
- As a result of the complex nature and defensive character of the building process, builders are generally unable to be flexible in using different technologies so as to comply with the energy performance standard.
- Energy regulations might not target the right level of the value chain in the construction sector. It would be more effective to target manufacturers of energy technologies directly and encourage them to innovate.

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7. Survey and interview-based evaluation of the Dutch Small Business Research Initiative scheme

#### Compiled by Nelly Bruno

October 2012

## 7.1 SHORT DESCRIPTION OF THE MEASURE

Launched in 2005 following a pilot phase, the Dutch Small Business Innovation Research (SBIR) programme is inspired by the US SBIR programme in which federal agencies spent a set percentage of their annual extramural research and development (R&D) budgets in contracts or grants to small businesses. The Dutch government uses SBIR to provide incentives for companies to develop and market innovative solutions to societal issues. SBIR is a way for the government to solve specific societal problems or accelerate a desired transition. In the Netherlands SBIR has turned out to be particularly beneficial to early-stage and small and medium-sized enterprises (SMEs), due to its simple, fast procedure, accessible registration and low administrative costs.

Three SBIR variants exist: a departmental SBIR, the STW Valorisation Grant and the TNO-SBIR programme. A noteworthy difference is that the departmental SBIR and the TNO-SBIR award contracts to companies and the STW Valorisation Grant awards grants. In general, the SBIR approach has three objectives: 1) solving societal issues and concerns, 2) stimulating innovation among SMEs, and 3) valorisation of public knowledge. Each SBIR variant places different emphasis on each objective.

Through the SBIR programme companies get the opportunity to develop innovations on a contractual basis (100% financing, no subsidy). Because it is pre-commercial procurement (R&D) these contracts do not fall under the European procurement directives. However, the tendering procedure still has to be transparent (nation wide publication), objective (clear criteria and procedures) and discrimination on basis of nationality is not allowed (companies from other countries should be able to compete). IPR belongs to the company, but the government can receive royalty free non-exclusive licenses in general interest. The SBIR-projects consist of three phases. Only if phase 1 has been concluded successfully, an invitation for the phase 2 tender is made: Phase 1: innovation feasibility study. Phase 2: R&D. Phase 3: marketing the innovation.

#### Key figures on the Dutch SBIR, June 2011

- SBIR used by seven ministries;
- Total budget spend on SBIR is over €69m;
- Over 30 SBIR procurements started;
- Over 370 contracts closed;
- About 750-1000 man-year innovation development in SMEs;
- 20 completed phase 2 contracts;
- 65% of supported companies make business from their SBIR development within a year;
- New industry policy developed in the Netherlands

Source: Dutch Ministry of Economic Affairs, Agriculture and Innovation, June 2011

The fact that SBIR consists of several phases limits the risks for the government, because only the best and most viable projects will receive

funding for the development phase. Furthermore, the government encourages entrepreneurs to look for partnerships with an external party who would be interested in financing the market introduction of the innovation. So that at an early stage an external party has an interest in the innovation's success and will take care of the economic viability of the innovation.

## 7.2 THE EVALUATION METHOD

The programme was subject to a first external evaluation in 2010, performed by Technopolis Group. The objective of the evaluation was to assess the functioning (design, implementation and results) of the three SBIR variants and to make recommendations for improvements. As the SBIR instrument had started only recently, it was too early for an impact assessment or an analysis of the cost-effectiveness of the SBIR variants because the effects and impacts of SBIR were not yet clear. Therefore, the evaluation had its focus on input and process aspects.

Main questions for the evaluation were:

- 1. How do the three SBIR variants work (design, implementation, results)?
- 2. What are lessons for improvement of their operations?
- 3. What is the value added of the SBIR variants within the wider R&D policy mix?

Methods used for this evaluation included data analysis of the SBIR calls, study of documents and literature (including a short comparison with SBIR in the United States and the UK), interviews and surveys.

**Preparation and data analysis:** The following information was mapped (when available):

- Financial information (SBIR budget per call, per project)
- Number of applicants (companies / researchers) in the different calls
- Number of winners and dropouts in the first phase and (then) in the second phase
- Characterisation of the applicants and winners (size, age)
- Characterisation results of the first phase
- Characterisation results of the second phase
- Estimation of flow to the third phase
- Estimation results of the third phase
- Number of new companies with SBIR

Further documents as the SBIR manuals, reports and monitoring reports, the information on the website of the AgNL were screened. This preparation and data analysis was used as an introduction to the other tools.

**Interviews with stakeholders:** This included interviews with relevant ministries (12 interviews), implementing organisations (11) (AgNL, Defence, TNO, STW), participants (28) and other stakeholders (4).

**Surveys among participants and non-selected applicants:** There were two surveys distributed among the companies that have submitted proposals for the departmental SBIR and the TNO SBIR. Given that STW recently launched a survey regarding the companies that had submitted proposals for the STW grant their results were used for this evaluation. The response rate to the surveys was of 31.4% (22 replies out of 70 survey requests). 43% of respondents have submitted a proposal for feasibility study but have not been commissioned by TNO. The participants were in different phases of the SBIR programme: 10% of the respondents had completed Phase 3, 10% had already completed phase 2 but were not involved in Phase 3, 14% were working on the implementation of Phase 2.

**International benchmarking:** The Dutch SBIR variants were compared with the SBIR programmes in the U.S. and in the UK.

**Analysis and final report:** The results from the above components were combined and analysed in order to reply to the evaluation questions.

The following Figure 15 displays the approach adopted for the evaluation of the Dutch SBIR programme.

Figure 15 Approach adopted for the evaluation of the Dutch SBIR



Technopolis Group, 2010

#### 7.3 INDICATORS USED

- Replies to the survey on a set of evaluation issues (design, process, implementation, results, etc.)
- Number of calls (Phase 1 & Phase 2)
- Budget of the calls (Phase 1 & Phase 2)
- Number of proposals (Phase 1 & Phase 2)
- Number of applicants (Phase 1 & Phase 2)
- Number of contracts awarded (Phase 1 & Phase 2)

## 7.4 Bibliography and Further information

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Roos A. (Dutch Ministry of Economic Affairs, Agriculture and Innovation), 'Pre-Commercial Procurement in The Netherlands: SBIR', Presentation 24 June 2011

Other information:

http://www.agentschapnl.nl/

## 8. Austrian Federal Programme to incentivise Thermal Renovation

#### Compiled by Kincsö Izsak

January 2013

## 8.1 SHORT DESCRIPTION OF THE MEASURE

In 2009 the Austrian Federal Government launched a programme for thermal and energy-efficient renovations with a support of  $\pounds$ 100m. The initiative was continued in 2011 with a further annual  $\pounds$ 100m planned to run till 2014. This thermal renovation programme provides private entities and companies with a non-refundable subsidy up to 20 percent of the total costs or a maximum of  $\pounds$ 5,000 per property for renewing the insulation, for changing windows to energy-efficient windows, or changing the furnace to a newer and more energy-efficient heating system. In the field of private housing, the following measures can be funded: insulation of outer walls; insulation of the rooftop or the ceiling; insulation of the lowest ceiling or the floor of the cellar; renovation or exchange of the windows and exterior doors.

It was expected that the programme would result in

- New investments from private organisations and companies;
- Securing and creation of new jobs;
- Thermal renovation of households;
- Greenhouse gas reductions over the lifetime of the investments.
- Inducing knowledge and innovation.

## 8.2 EVALUATION

The thermal renovation programme has not been officially evaluated, however a study from the Austrian Institute of Economic Research (WIFO) reviewed the first phase of the programme in 2010. This study investigated the implementation process and the outcomes of the programme through a review of supported projects both in private households and for businesses. It also explored the effects both on the environment and on the economy.

The programme was very positively evaluated. The study found that a  $\notin$ 61m funding in 2009 generated  $\notin$ 485m investment, thus it had a leverage effect of 1:8. The thermal renovation was and is not only good for the environment, but it strengthened businesses and employment.

There was also an impact on innovation in the field of renewable materials and resources, since the measure promoted using the latest technological developments in the field of thermal remediation. Nevertheless the effects on innovative activities have not been quantified and only anecdotal evidence exists.

#### 8.3 INDICATORS USED

The indicators used in the study of WIFO include:

- Number of projects in each province
- Type of supported projects
- Investment costs of projects
- Evolution of employment

## 8.4 KEY FINDINGS OF THE EVALUATION

The 2009 thermal renovation programme resulted in:

- Around 40,000 individual measures in nearly 14,000 buildings and applicants, with around €485m investment.
- An average apartment size of approximately 95 m<sup>2</sup> represents a volume of about 1.3m m<sup>2</sup> floor space redeveloped that is equivalent of about 0.5% of the total floorspace of Austrian housing stock.
- It is assumed, however, that there is a deadweight of investments meaning that projects were also carried out that would have been anyway realised.
- In terms of employment it was estimated that the programme created or saved around 28,000 full-time jobs.

The sectoral analysis revealed the sectors affected by the programme are: primarily in the construction industry, the non-metallic mineral products business services, but also sectors such as trade, transport, wood and metal products.

## 8.5 Bibliography and Further information

WIFO (2010). Thermische Gebäudesanierung nutzt Umwelt und Wirtschaft Erfahrungen mit dem Sanierungsscheck 2009 und Perspektiven fur eine Fortsetzung

More information:

http://www.sanierung2012.at

 $\underline{http://www.bmwfj.gv.at/EnergieUndBergbau/Energieeffizienz/Seiten/NeuerSanierungsscheck.aspx}$ 

www.umwelt-bauen.at

## 9. Mid-term review of the Finnish Demand- and User-driven Innovation Policy Action Plan 2010-2013

#### Compiled by Johanna Castel

January 2013

## 9.1 SHORT DESCRIPTION OF THE MEASURE

Demand- and user-driven innovation is considered by the Finnish government as a privileged way to find new sources of competitive advantages, bolster innovation policy effectiveness and broaden fields of action, remove obstacles to diffusion of innovations and facilitating the market entry of new products and services, tackle societal challenges and better consider user needs. To foster demand for novel goods and services and a broad based innovation approach, the Ministry of Employment and Economy set in 2010 the Action Plan for Demand- and User-driven innovation policy. The Ministry's vision of demand-driven innovation policy is expressed in the Action Plan and articulated into four areas, namely Competence development, Regulatory development, Development of public sector operating models, Incentives for demand-driven innovations.

The Action Plan is running since 2010 until 2013 and is branched into seven areas of innovation policy, each area being associated with one to four policy measures, their background and rationale as well as timeframe for action.

Figure 1: The seven areas of the Action Plan and related measures

1.Demand- and user-orientation as a source of competitiveness - building competencies and the knowledge base: Actions on the research and education systems: funding, internationalisation, networking, strengthening of research institutions roles; Actions to address societal challenges and to improve awareness.

2. Innovations by bolstering demand: Public sector influence on behaviours through procurement of innovations, innovation friendly regulation or improved national standardisation system and awareness to its benefits, promotion of lead markets to compensate for Finland small domestic market, particular attention to the impacts of the above-mentioned tools and how to measure them. It also refers to the development of funding models in order to introduce investment-intensive innovations.

3. Innovations in public sector renewal – aiming at a forerunner position: Through promotion of Public-private partnerships and more generally viewing the private sector and markets as partners, public procurement or the development of new operating services to improve quality, efficiency and productivity of the sector. To encourage these actions, a group for innovative forerunner cities will act as pioneers. The social and health care sectors will be privileged sectors for the development of innovations.

4. Incentives for grassroots initiatives: Through open access to public sector information and generalisation of contact points, foster citizens' engagement (vouchers, interactive electronic portal)

5. *Efficiency from user-driven innovation tools and methods*: Development of innovation platforms such as Living Labs, Promotion of the role of design (i.e design thinking, service design) and creation of a dedicated entity, exploit ICT potentialities

6. *Diffusing innovations through networks*: Dissemination of innovation through networks and cooperation among different actors at different levels (local, regional...)

7. Assessing the impact of the demand- and user-driven innovation policy action plan: selfevaluation during implementation/ external final evaluation; development of indicators to monitor activity.

Source: Framework and Action Plan, Ministry of Employment and the Economy, 2010

Prepared by the Demand-driven innovation group in the Ministry of Employment and the Economy, in consultations with various stakeholders, this strategy document is a cross-cutting policy action plan encompassing several sectors and involving, among others, Tekes, VTT, the National Consumer Research Centre and the Forum Virium Helsinki.

## 9.2 EVALUATION

As set in the 2010 Action Plan, the Demand- and User-Driven Innovation Policy Action Plan is internally evaluated during its implementation. The Interim Report was published in 2012 and examines two years of policy implementation. Desk research, case studies and consultations are the tools used to conduct this less formalised review distinguishing it somewhat from a formal evaluation process. According to advisors at the Ministry of Employment and the Economy, the review was not systematically planned nor were specific methods pre-defined to conduct the review. The analysis was performed by the Enterprise and Innovation Department as an empirical and pragmatic exercise. As there is a single entity responsible for information, the department was present in steering groups and progress review groups of the measures analysed. No specific scientific method has been developed to do so.

The goal of the review was to answer the following questions: Is the Action Plan participating to the renewal of the Finnish innovation Policy and transition towards a greener economy? Is this Action Plan contributing to resolve challenges inherent to the public sector and is bringing about the needed change? What are the levels of implication of stakeholders (SMEs, administrative branches...)? What is the progress to date of the initiative? What are its successes but also difficulties encountered? What are the next steps to ensure successful implementation of the Plan?

It is presented as a review of the implementation of the action plan, its successes, difficulties and lessons learned, as well as detailing the next steps for the implementation of the Plan. The detailed overview on progress is branched into the seven areas set in the Action Plan. This review is mostly based on qualitative indicators and presents results and achievements to date, referring to policy measures associated to each area of the action plan.

The action plan objectives are translated into concrete measures, but some liberty was given to the actors in some extent for the materialisation of these objectives. It can therefore involve different ways to measure progress. The review could rather be seen as an activity report as well as an occasion to promote good practices and highlight progress made, through various channels. A consequent list of structures created, events organised, funding granted, themes of research programmes or creation of networks or interactive platforms, reforms of policy or programmes related to demand-oriented innovation policy measures issues is presented in the document.

This analysis also relies on evaluation of programmes that resulted or are in the line with the action plan, such as based on the evaluation of the use of government aid granted for standardisation (2011). An impact assessment of regulation and other policy measures was also conducted externally (commissioned by the Ministry of Employment and the Economy), including seven case studies (in Finland, at the European level and beyond) on impacts of regulation on innovation. This benchmarking exercise revealed that policy measures should be considered more broadly and involving stronger cooperation among public actors. Analysis of the matching of the Action Plan objectives with the objectives, actions and regulatory processes of various administrative sectors, such as inclusion of basic principles of innovation friendly regulation at an early stage in the legislative drafting process were also looked at. Compliance with the European Union plans, especially progress on the adoption of a lead market approach was checked.

Since most of these actions are still in the making, it is quite difficult to find detailed information on their impacts. A two-year implementation review is a short-term period when most actions are still at start-up phases. Indicators to measure broad based innovation activity are under development and would most likely serve as a basis for the external ex-post evaluation. These tools are the Community Innovation Survey, as well as an assessment conducted on the frequency of user innovation and the results of a project currently led by VTT on the development of indicators for broad-based innovation activity. However, impacts are mostly measured in terms of public actions and not really in terms of impacts to the private sector. A broader impact analysis was however considered as too early to be done, but it is under discussion. There is also some uncertainty about having an external ex-post evaluation. By the end of 2013, it is most likely that a wrap-up and assessment will follow from a policy point of view. Lessons learnt and recommendations will be led internally, considering a systemic approach to innovation (Vilén, 2013).

#### 9.3 INDICATORS USED

The indicators used for progress made in the first area that concerns knowledge and competencies development are

- production of policy guidelines,
- introduction of a broad based innovation approach in strategies and plans,
- networking actions and intensification of related research (research programmes led),
- number of publications, events and research seminars held around demand-oriented innovation policy,
- communication activities (contests, dedicated websites).

For the second area, the creation of trial projects and their follow-up is one of the indicators used to measure progress in the second area, as well as the number of call for proposals from research institutions in related areas. Listings of initiatives to follow the EU lead market approach were scanned. Finally, the report provides an analysis of funding models (i.e demonstration funding) implemented since the validation of the Action Plan. However, there is no comparison with previous funding granted.

The third area's review mostly regards analysis on progress on the Forerunner Cities Group. For public procurement, the report mentions the development of tools and services to support procurement of innovation, number of financed innovative procurements from TEKES, organisation of seminars and events and preparation for the establishment of a sustainable procurement advisory services, as well as research projects launched on the subject. The fourth area encompasses a list of achievements in the field of digital technologies and study on governance. For the fifth area, actions in the field of design and reform of financial instruments and national design programmes are the main indicators used. For the sixth area, activities of dedicated networks were scanned. The seventh area of the Action Plan is referring to impact assessment of demand-side innovation policy measures. Finland Community Innovation Survey questions could constitute indicators (Innovations in goods introduced to the market, Process innovations introduced, Marketing innovations introduced, Collaboration with other organisations). A study on frequency of user innovation, encompassing self-motivated innovation activity of users and user communities and a study on development of indicators to measure broad based innovation activity are underway. However, there is no evidence than the studies and tools mentioned served as a basis to this interim report.

#### 9.4 KEY FINDINGS OF THE EVALUATION

The review is overall very positive. Many key national actors adopted the principles of demand- and user-driven innovation activity, materialised in their presence in policy definitions, strategies with the example of Tekes strategy, and some of the research programmes of strategic centres of excellence. The report notes high cooperation among actors.

It is however considered difficult to bring about change in public sector activity, changes still as initial stages and most SMEs still lack awareness on benefits of the policy. The review revealed a great need for a more systemic approach to the process. Tools and structures for the management of renewal are too recent and related methods are not yet development. The lack of knowledge and interest on foresight is also an important issue to act upon. The next steps set take these challenges into account and advise to act on actions to foster public sector renewal, increasing information on the innovation impacts of regulation, as well as presenting planned actions to tackle them.

In terms of impacts on innovation activities for companies, there is not much information apart from the awareness of SMEs on the benefits of user-driven innovation activity and that increased actions from networks such as the Centre for Economic Development, Transport and the Environment, and the Centre of Expertise programme OSKE could activate. Some actions that enhanced businesses innovation capacities are the funding from Tekes of around 30 innovative procurements. It also launched a project for promotion of design in SMEs, as well as dedicated increased funding to demonstrations, funding for 2010-2011 reaching €50m. Finally, actions undertaken on public procurement witness a greater implication to foster innovation in public procurement. It was however assessed that these actions are not sufficient and than more services should be provided to promote the issue, as well as to encourage debate on their centralisation, as well as on key strategic application areas.

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Demand Side Innovation Policies, OECD (2011) <u>http://www.oecd-ilibrary.org/science-and-technology/demand-side-innovation-policies\_9789264098886-en</u>

Demand and User-driven Innovation Policy: Framework and Action Plan, Ministry of Employment and the Economy (2010) <u>http://www.tem.fi/index.phtml?l=en&s=2382</u> Interim report 13 April 2012: Demand- and User-driven Innovation Policy Action Plan 2010-2013, Ministry of Employment and the Economy (2012). http://www.tem.fi/index.phtml?l=en&s=2382

Other information:

Interview with Kirsti Vilén, Ministerial Adviser at the Ministry of Employment and the Economy, Finland, Monday 14<sup>th</sup> January 2013.

# 10. "Health Checks" of the UK Small Business Research Initiative scheme

#### Compiled by Kincsö Izsak

#### December 2012

### **10.1 SHORT DESCRIPTION OF THE MEASURE**

The UK Small Business Research Initiative (SBRI) was first launched in 2001 by the Department for Trade and Industry (later Technology Strategy Board) and a second-phase followed up in 2009. The primary objective of this initiative is to help government act as a lead customer and to foster the procurement of research and development for identified key challenges thus delivering breakthrough improvement in public sector services.

The programme starts with the identification of a challenge where a governmental organisation is seeking a solution. This is based on the so called 'innovation procurement plan' that each governmental department develops as part of its commercial strategy. The government departments then can contact the Technology Strategy Board (TSB) and in collaboration they launch the process of pre-commercial public procurement. Following this, the open competition is launched and SMEs pitch their ideas to the clients. Selected projects are then fully funded to the proof-of concept stage, and those who meet the expectations are funded. The awarded contracts cover 100% of firms' costs.

The role of TSB is to provide support to public sector agencies to choose and shape competitions and gain the maximum value from SBRI. The first SBRI projects focused on the defence and health sector and are now also extending to other areas. Since launch in April 2009 there have been 82 SBRI competitions run with 26 separate public sector organisations and over £60m of contracts issued. It has resulted in 570 contracts involving 24 government departments and agencies and with the participation of 2,100 companies. 74% of the support went to SMEs at various lifecycle stages from pre-start-up to mature company, however, the spending of overall procurement budgets on SMEs could be improved.

In 2011-2012 new partners adopted SBRI including the Environment Agency, the Welsh Government, WRAP, NHS London, NHS Midlands and East, and the National Centre for the Refinement, Reduction and Replacement of Animals in Health. The Ministry of Defence continues to be a major user of SBRI, and use by the Department for Environment, Food and Rural Affairs is increasing.

#### **10.2 THE EVALUATION PRACTICE**

To date there has been no publicly available official evaluation of the UK SBRI scheme performed, nor was the impact of the first phase of the scheme assessed. Nevertheless, reports have been published on its progress and several authors analysed the benefits and shortcomings of the scheme. There have been also studies on the experiences of specific government departments participating in the SBRI, for instance three pilot schemes in defence, heath and constructions were assessed in 2008.

It would be too early to say the wider impact of the scheme and explore what

innovations have been generated through the lead customer role of government departments that were commercialised elsewhere. The Technology Strategy Board plans to run an evaluation in 2013.

The results of the scheme have been explored by Connell (2004, 2010), in the Richard report (2008), in the report of NESTA (Bound, Puttick, 2010) and in the framework of the PRO INNO Europe INNO Partnering Forum's<sup>10</sup> peer-reviews.

These assessments are primarily based on qualitative research methods such as case studies, interviews and surveys among the project participants, moreover using peer-review methodology. The UK scheme has been often compared to its inspiration model the US SBRI.

In the beginning, the focus of the assessment was on the value created for the companies who participated in the scheme. Later on this shifted towards an approach that also looks at the impact on the public sector and the government departments who commissioned the innovations (Bound, Puttick, 2010).

The report of NESTA was called as a 'health-check' rather than an impact assessment. The authors looked at a sample of SBRI competitions and analysed the experiences of both the participating companies and public sector bodies with the aim to understanding the achievements and problems of the scheme. 7 competitions were investigated as case studies and over 30 qualitative interviews were conducted involving government departments and agencies, companies, universities and other organisations part in seven case study competitions.

The INNO Partnering Forum peer-review set up a review team in 2010 composed of four visiting organisations: Enterprise Ireland, NL Agency, manager International Innovation (chairman), Tekes, Finland and VINNOVA, Sweden. The review team conducted an interview series with the SBRI implementing departments, and enterprises participating in the programme.

#### Results of the first phase

The first phase of the SBRI was seen as less successful. As several reports found few departments took use of it and the supported projects were academic-oriented, mostly for policy research rather than technology development. The large share of the supported initiatives remained general procurement rather than real innovations (Connell, 2010). One exception was the Biotechnology and Biological Sciences Research Council that had a small, but successful programme for several years. The firms interviewed by the group of Connell stated that they did not regard the UK public sector as a customer for innovation in general.

A key barrier was the attitude in the public sector. The government departments were focused on scientific policy advice and academic research and they saw innovation not as their responsibility, but that of the private sector. The IPR was another issue that was unclear. An important change introduced in the scheme in 2004 was requiring departments to use 2.5% of their external R&D budgets to procure "Innovation Contracts" with companies, particularly SMEs.

<sup>&</sup>lt;sup>10</sup> http://www.proinno-europe.eu/partnering-forum

## Results of the second phase

The second phase of the scheme turned to be very promising. The NESTA report found that the reformed scheme is on the right track.

The reformed UK SBRI has become very popular both among companies and public sector organisations. The success of the scheme lies in its 100% funding that allows the immediate start of projects without their being held up finding private matching funding. The benefits of being involved in the scheme are also that the initial backing of the government gives confidence to private investors. The TSB has done an excellent job in developing the SBRI process and marketing it to departments, and the experience of running competitions has led to considerable support from individuals in sponsoring departments who see it as a very useful way of addressing unmet departmental needs.

## **10.3 INDICATORS USED**

The ex-ante indicator specified is the government departmental compliance with the mandatory target to procure at least 2.5% of their extra-mural R&D from small firms.

It was suggested that the target for the total percentage would need to be very much higher than 2.5% - between 10 and 15% - to have any realistic value. (Connell, 2008).

The Technology Strategy Board uses a "dashboard" to monitor the SBRI programme. This records competition data including overall:

- The number of competitions
- When they open and close
- Number of public sector bodies using SBRI

For each competition:

- Sponsoring Public Sector body(ies)
- The number of applications received
- The number of contracts awarded
- The value of contracts awarded

An analysis of applications received and contracts awarded by:

- Size of organisation
- Age of organisation
- Location of organisation (Region)
- Industry Sector`
- Who made applicant aware of competition?

## **10.4 KEY FINDINGS OF THE EVALUATION**

The structure and management of the scheme is seen as a factor for its success. Its characteristics such as 100% funding, that collaboration is not mandatory have been contributed to an accelerated implementation and popularity of the scheme among SMEs.

The SBRI helped outreaching to new groups of companies that generated new ideas and collaborations.

It was highlighted that there would be a need for more clarity regarding the SBRI process and to better distinguish the SBRI from other innovation competition management tools.

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## 11. Evaluation of the Transportation Science and Technology (S&T) Programmes of Natural Resources Canada's Energy Sector

## **Compiled by Nelly Bruno**

### December 2012

## 11.1 SHORT DESCRIPTION OF THE MEASURE

In 2006, transportation-related demand accounted for 12.2% of Canada's gross domestic product (GDP). The Transportation Energy S&T Sub-sub Activity consists of six programmes that are multi-sectoral and interdepartmental and are aimed at developing clean and efficient energy technologies for the transportation sector. The programme's activities encompass: basic to applied research and development (R&D); support for the development of codes, standards and policy; development and demonstration of technologies; and process development. The Transportation Energy Activity is thus an example of a mix of demand-side and supply-side policy measures.

The programmes are intended to achieve environmental and economic impacts through a series of collaborative relationships among their partners (public and private S&T performers). The S&T performers include public sector laboratories, academic and private sector laboratories/technical groups, as well as implementer and user communities and various standards-setting groups. Out of the six programmes, the CTFCA is the programme focusing in particular on demonstration projects and the development of standards, codes and regulations:

- Advanced Fuels and Transportation Emissions Reduction (AFTER) Programme (\$12.1m of NRCan funding over 2002-2007): expected to lead to the development of new fuel and engine technologies designed to reduce emissions and produce a cleaner environment, on top of creating new markets and increasing hydrocarbon sales and oil sands crudes.
- Canadian Lightweight Material Research Initiative (CLiMRI) (\$7.1m): intends to develop and implement lightweight and high-strength materials in transportation applications for the purposes of reducing greenhouse gas emissions through improved vehicle efficiency.
- Particulate Matter (PM) Programme (\$5.8m): intends to strengthen the scientific basis for policy and regulatory decisions affecting transportation-related emissions of particulate matter and its precursors.
- Technology and Innovation (T&I) Transportation Programme (\$6m): its objective is to advance the development and implementation of promising new technologies to achieve long-term mitigation of transportation's contribution to climate change thereby strengthening Canada's technology capacity for a more efficient transportation system.
- Hydrogen Energy Economy (HEE) Programme (\$31.4m): focuses on using hydrogen from renewable sources on applications such as automobiles and stationary power generators, fuel cells and other H2-powered.
- Canadian Transportation Fuel Cell Alliance (CTFCA) (\$31.4m): has two components, which are: to demonstrate the greenhouse gas reductions

and evaluate different fuelling routs for fuel cell vehicles; and to develop the necessary supporting framework for the fuelling infrastructure, including technical standards, codes, training, certification and safety.

## 11.2 THE EVALUATION METHOD

Published in 2010, the evaluation covers the six programmes of the Transportations S&T Sub-sub Activity and thus different interventions tools, from support to basic research to the development of standards. The methodology used was similar across the programmes and examined issues related to the programmes' relevance/rationale, results and success and cost-effectiveness. The evaluation methodologies included:

- Document Review: programme's documentation, plans and performance reports, policy documents, technical publications...
- 61 interviews: programme managers, project leaders, industry stakeholders and partners;
- 25 in-depth case studies of a sample of projects;
- Detailed review of 19 projects.

Since there was no up-to-date policy or strategy that outlined federal transportation S&T objectives and priorities linking the programmes together, the evaluation used the multiple policy statements on energy S&T as the basis for the examination of the relevance and success evaluation issues.

### 11.3 INDICATORS USED

All programmes had performance reporting mechanisms, usually involving written reports and meetings to share information and, in one case, a website (no longer accessible). The majority of information reported was focussed on projects, with the exception of financial information. Financial information generally varied within and across the programmes with respect to quality and availability; and expenditure data was seldom reported. The six programs as a whole did not report on their performance frameworks. Annual reports tended to convey information regarding the technical achievements of individual projects and often did not make the linkages to the desired outcomes. This made it difficult for the reader to use the annual reports to understand progress towards achieving program objectives. This was not the case for project reports produced by private sector project proponents.

The programs' performance frameworks themselves were found to have two issues related to performance reporting. First, the performance indicators were not used to report performance information. Secondly, the frameworks themselves either had too many indicators or gaps in identification of indicators (e.g., that failed to bridge the gap between research outputs and program outcomes; or that did not identify how the results of the program would be provided to key stakeholders).

Apart from the number of publications and patents, at least three types of actual and potential impacts could be compiled from the programmes: GHG reductions, economic activity generated, and cost savings generated. The main indicators used for the evaluation were thus:

- Amounts of programme's funding (from different sources);
- Average funding per project;
- Scientific outputs: number of publications, patents, participations to conferences...;

- Cost savings to Canadians resulting from better efficiencies (reduced fuel consumption);
- Revenues and sales generated;
- Greenhouse gas reductions;
- Cost effectiveness of programmes (computation of leveraged amounts).

## **11.4 FINDINGS OF THE EVALUATION**

All of the programmes were found to be **relevant** to federal priorities, NRC priorities, and the needs and priorities of stakeholders.

The programmes produced **research outputs** such as better information, as well as improved fuels, materials, and technologies. With respect to actual impacts for Canadian society, the programmes supported new manufactured products, infrastructure and policy. These impacts are influenced by external factors and players, but the evaluation evidence shows that the programmes are key determinants of some of these impacts. The impacts include better air quality, safer equipment, reduced fuel consumption as well as economic impacts such as revenues for Canadian firms and savings for consumers and transportation companies. In terms of attribution, the programmes are not the sole contributors to these impacts (see in the Annex of this case study for an overview of the context and results model of the programmes). The data indicates that the six programmes built knowledge and expertise, and tested and showcased technologies, but they did not commercialise the R&D results. The programmes rely on publications and partnerships with the automotive supply chain for technology transfer<sup>11</sup>.

Overall, the Transportation Sub-sub Activity was delivered in a **cost-effective manner**. The table in the Annex of this case study provides estimates of the percentage of cash and in-kind funding leveraged from funding sources outside the Government of Canada for each of the programmes from 2003 to 2007. Interestingly but not surprisingly given its closeness to the market, the programme with the highest leverage effect is CTFCA, with 51% of funding leveraged from other sources.

Among the **CTFCA achievements** in particular, the programme successfully showcased refuelling demonstration projects; evaluated various hydrogen fuelled vehicles for commercial and private use; and delivered the national supporting framework to enable the development of the fuelling infrastructure such as technical codes and standards, training, certification and safety. The CTFCA was successful in developing collaboration with a wide section of the hydrogen and fuel cell community concerned with on-road demonstrations and fuelling technologies. The evaluation shows the effectiveness of the CTFCA's performance in having established a technical forum that allowed industry-government(s) collaboration on hydrogen technologies. This forum brought together people from various backgrounds (e.g., universities, government, utilities, consortia and associations, as well as other nongovernment organizations) to examine industry concerns and needs related to hydrogen fuelling stations.

<sup>&</sup>lt;sup>11</sup> Even when the programmes are successful in developing new technology, introducing change requires substantial time and resources. Even where proven technologies exist, the lead time for introducing them on the vehicle market is on the order of 5-10 years and involves substantial investments.

According to the evaluation, had the CTFCA Programme not existed such linkages would not have occurred; some projects would have continued but at a slower pace or would not have been undertaken at all; and projects with large public good benefits would likely not have been undertaken or would have been delayed (e.g., bus demonstrations). Alternative sources of funding would have been required, but would have been more difficult to obtain due to the lack of the government's presence. Moreover, some development work would likely have moved to countries where government funding was available, resulting in a loss of Canadian expertise. Less foreign involvement would likely have occurred and the Canadian hydrogen infrastructure, including regulations, would have varied from province to province with no national system. Buy-in from industry and end-users would probably also have been lower. As regards the other programmes, key outcomes on incrementality are summarised below for the sake of comparability:

- AFTER: the case study and interview data indicate that the incrementality of the programme is project-specific.
- CLiMRI: Interview data indicates that there are private sector laboratories which could in theory carry out CLiMRI type projects had the Programme not existed.
- HEE: Without public sector involvement, hydrogen R&D is of sufficient importance that some of it would probably have continued, but at a slower pace and reduced scope. The amount of collaboration would have decreased, given the role NRCan plays in bringing stakeholders together and the likelihood of results taking place would also have diminished.
- PM: Had the programme not existed, some of the research would likely have been carried out by each of the five partner federal departments separately, with each department focussing more on its own interests. The research would also be reduced in scope as PM is a small priority for any given department.

#### 11.5 Bibliography and Further information

Natural Resources Canada, Evaluation of the Transportation S&T Sub-sub activity (2010),
# Annex

#### **Context and results model**

To illustrate the types of results that the Sub-sub Activity has contributed to, a Context and Results model has been designed. It portrays the types of results throughout the impact chain, as well as contextual factors that surround the Programmes and their projects. In terms of attribution, the Programmes are not the sole contributors to the impacts. However, some of the projects would not have gone ahead without NRC's contribution, while others would have gone ahead but with reduced scopes.

- Contextual factors identified as key drivers of these programmes include: 1) environmental concerns about GHGs and black carbon; 2) health concerns related to emissions; 3) scarcity of non-renewable energy sources (fuel) and rising fuel prices; and 4) international agreements related to the environment and emissions.
- The second column of boxes represents the Programmes that lead to the results and the contribution of the project partners.
- The next set of columns illustrates the impact chain, going from research outputs to actual impacts for Canadian society.

Figure 16 Context and Results Model, Evaluation of the Transportation S&T Sub-Sub Activity, Canada



#### Financial leverage effect of the programmes

Table 3 Estimates of Funding Leveraged from Non-GoC sources per Transportation S&T Programme (\$K)

Programme	Years	Leveraged Amount	Total Cost	% Leveraged	
CTFCA	2001-2008	32,867	64,795	51	
HEE	2001-2008	28,199	66,883	42	
CLIMRI	2003-2007	5,619	13,379	42	
T&I Transportation	2003-2008	2,567	11,358	23	
AFTER	2001-2007	4,327	24,036	18	
Particulate Matter	2001-2007	2,229	18,247	12	
Total Leverage		75,808	198,698	38%	

Source: Natural Resources Canada, Evaluation of the Transportation S&T Sub-sub activity (2010), based on a) OERD financial records; b) programme annual reports; and c) programme financial project databases.

# 12. Monitoring the Future City Initiative in Japan

#### Compiled by Johanna Castel

#### January 2013

#### 12.1 SHORT DESCRIPTION OF THE MEASURE

The Future City Initiative is a project led by the Regional Revitalisation Office of the Japanese Government. It is one of the 21 projects set under the New Growth Strategy formulated in 2010 by the National Policy Unit, a government structure of the Cabinet Secretariat, reporting directly to the Prime Minister. These national Strategic Projects are articulated in two categories and seven subcategories:

- *'growth boost led by demand-side policy measures'* encompassing green innovation, life innovation, Asia and tourism-oriented nation and local revitalisation and
- *'growth boost led by supply-side policy measures'* encompassing science and technology IT oriented nation, employment and human resources and financial sector. The Future City Initiative is comprised under the green innovation projects.

The goal is to "forge a city that everyone would wish to live in and in which everyone if full of vitality". The Initiative witnessed a serious shift in goals in the aftermath of the earthquake that hit Japan and forced the country to reconsider its policy strategies. This shift is materialised in the adoption of a Strategy for Rebirth of Japan launched in December 2011, and the Innovative Strategy for Energy and the Environment launched in 2012, integrating the 21 National Strategic Projects as the basis and foundation of the Japan Revitalisation Strategy. Wider cooperation between initiatives is another key objective emerging from these strategies, where government wishes to make full use of the comprehensive special zone system and review of regional revitalisation systems. A revised policy mix in regard of policy priorities (Strengthening Green Innovation Strategy) and financial constraints is also evoked. At the level of the initiative, it was materialised in its scaling up and in the classification of selected cities in the disaster area/ not in the disaster area.

The Future City initiative is an echo to previous initiatives led in similar areas, such as the Eco-model city programme launched in 2008. Some of the cities selected in 2008 are also part of the Future City Programme. Eleven cities have been selected as Future Cities at the end of 2011 and recently presented their action plans. The Future City concept aims at the promotion of an open source innovation strategy. The identified goals of the initiative are to create:

- Human-centred cities;
- Green low carbon cities;
- Smart cities;
- Sound material-cycle cities;
- Resilient cities.

The aim of the Initiative is also to create environmental, social and economic value. An important aspect of the project is its dissemination goals. A platform for International Knowledge was created in the form of an international forum held on a yearly basis and a database gathering good practices in Japan and

abroad. At the regional level, it launched the "Future Cities we want" platform and the LOCARnet network.

#### **12.2 THE EVALUATION METHOD**

The National Policy Unit is the structure in charge of monitoring and reporting on progress of the initiative. It is the unit that continuously follows up the projects and releases periodical updates, however without specifying their frequency. The latest release dates from February 2012 and is encompassing the 21 National Strategic Projects.

The review of the Future City progress is rather brief. It indicates that 11 cities have been selected, of which 6 are located in affected areas and that the initiative was "scaled up and promoted". The International Forum on the Future City Initiative is an occasion to present progress of the 11 selected Future cities in the form of good practices, or at the regional level during the high level seminar on environmental sustainable cities organised on a yearly basis.

An important work of monitoring, evaluation and research was made on the concept of Future City itself. A Study Group led the evaluation and research. The expert review panel presented the summary of the concept in a document entitled "Promoting the Future City Initiative".

No feasibility study or ex-ante evaluation as such have been realised before the implementation of the initiative. However, a sound analysis of challenges, comparative advantages of Japan and a benchmark of overseas situations were conducted in 2010. Main challenges identified were the declining population and low birth rate, ageing, as well as environmental and energy concerns. In terms of data sources for the definitions of markets and the identification of key sectors, the National Policy Unit gathered demographic data. Less tangible aspects such as 'traditions' are also mentioned. Comparative advantages were identified for environmental and energy technologies, urban management, but also in tradition, culture, etc. Some comparisons were also made with Sweden, China and at the regional level within Japan. Roles in the development process of different stakeholders were also defined (i.e., for cities: setting a goal and further planning, development of an action plan and roadmaps, and preparing the implementing structure).

In terms of impact assessment, the initial strategy document points out that the outcomes are more likely to be measured qualitatively. Assessment criteria would be environmental, social and economic value created. The expected outcomes of the initiative are rather broad: to achieve a regional revitalisation through innovation in the socioeconomic system and the realisation of a sustainable social economy. In the end, an improved quality of life is the desired impact of the initiative. Benchmarking from eco-cities all over the world is a key tool in the initiative as its final goal is to disseminate good practices. To facilitate this benchmarking process, desk research and the above-mentioned maintenance of the database on good practices in Japan and abroad, as well as events and seminars are used. Via a bottom-up, joint effort for the provision of information on good practices ('tsunagari'), a sustainable change is aimed at.

A research project was also launched to establish a methodology to evaluate mid- to long-term environmental policy options toward Asian low-carbon societies, supported by the Environment Research and Technology Development Fund of the Ministry of the Environment (Japan) from 2009 to 2013.

#### Governance and levels of evaluation

The importance of constant evaluation and monitoring is mentioned in some official documents. The need for strong governance and collaboration between national and local governments was highlighted in the "Promoting the Future City Initiative" document, providing a framework for future promotion and networks of Future Cities.

In terms of project management, three areas are defined in the scheme to promote the Future City Initiative: at the level of the initiative (effective promotion of the Initiative), at the level of the individual cities (Management of all projects) and at the project level (monitoring progress of projects). The initiative will most likely be evaluated at all these three levels. Evaluation of all projects will be particular challenging as each selected city developed its own objectives (although closely following guidelines) in the selected proposals, taking into account local specificities (such as capabilities and areas to capitalise on).

The selection criteria of cities also constitute a good basis for the evaluation. The selected cities had to demonstrate they could tackle environmental and ageing population challenges as well as a potential to increase their originality and their comparative advantages. They should also have the intention to disseminate their good practices. The evaluation of projects was divided in three phases: the Theme evaluation, Comprehensive evaluation, and hearing. All the 30 cities applying to the scheme went through the first two phases. In the third phase, 18 applications remained, which was further decreased until the final selection of the 11 cities.

Although the previous Eco-model city programme is different to the current Future City Initiative, it is quite interesting to describe the way the projects were evaluated.

Evaluation method Eco-model city Programme, 2008

An "eco-model city follow-up map" was created to enable to summarise progress of initiatives, their results and areas for improvements. Grades from S, A, B, C were awarded to each project.

"S" The status of progress is extremely outstanding, and the city is a leader in its region and is ahead of national systems, etc.

"A" The status of progress is outstanding, and the city is implementing advanced projects ahead of schedule...

"B" The status of progress is good, and the city is implementing projects on schedule, etc.

"C" The city needs to further promote projects, and it appears that there are delays in the progress of projects...

A similar approach was followed for the Future City programme assessing the projects as not on target, on target, or exceeding target. According to policy officers of the programme, the way to evaluate impacts of the programme is still under discussion with experts. The only element known is that the indices/targets set by each Future City in their respective Future City Plans will be considered.

#### 12.3 INDICATORS USED

To measure progress, although not specifically mentioned in dedicated documents, indicators used are divided into the three aspects of value created.

- To estimate economic value, the GDP and indicators to measure the establishment of self-sustaining economic circulatory system such as public-private collaboration or the development of intellectual clusters are mentioned.
- To assess environmental value created, several tools and indicators were mentioned in the available documents in English, such as cut in Co2 emissions, Sustainable building and discussion about the use of the Comprehensive Assessment System for Built Environment Efficiency (CASBEE) at city level, which 24 Japanese local governments adopted as an environmental measure to encourage green construction. Geographical indicators are also implicitly used, especially for the aim of creating "Compact Cities".
- To determine social value created, one of the objectives was to improve quality of life with a human-centred approach. The indicators mentioned were the level of resident participation to community projects, number of community projects, level of cooperation and support. On networking and dissemination, the participation to and use of global network and success of the International Forum were mentioned as potential indicators.

Since cities are free to determine their action plans, in line with the guidelines from the Future City Initiative, evaluation will be based upon the objectives set at the initial stage of the project.

Some projects set quantitative targets, which would serve as the basis for evaluation. However, it is not systematic for all selected cities. Project summaries are presented as follow:

- Future Vision
- Assignments and goals to incorporate in the future vision:
  - Environment
  - Super aging society
  - Other
- Solutions for the issues and the policy towards achieving the goal
- Policy for comprehensive creation of three values (Environment, Economy and Society).

#### Figure 17 Example of Kitakyushu project



Source: Kitakyushu Project Summary

#### 12.4 KEY FINDINGS OF THE EVALUATION

The update of progress for the 21 National Strategic Projects published by the National Policy Unit of the Government of Japan in February 2012 states that despite difficulties and barriers caused by the earthquake, most of the measures are proceeding on schedule and will achieve their targets by 2020. Of which, the Future City initiative is following a sound progress and promotion.

A recent policy assessment published by the Cabinet office encompasses the Future City initiative. There is information about budget, goals, context and policy requirements. However, there are no information on impacts, effects of the measure on innovation as it is considered too early to measure impacts since the projects started in 2012.

The measure is however expected to produce world-class best practices for future technology, encourage development of futuristic city environment and create the ground for a sound socio-economic innovation system and foster the use of advanced technologies in city planning and implementation of projects, according to the Cabinet office policy assessment.

#### 12.5 Bibliography and further information

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Integrated assessment model for low carbon growth policy and the importance of GHG Emissions Reductions in Cities, Director General of the Global Environment Bureau, Ministry of the Environment of Japan, presentation at the LoCARNet first annual meeting, October 2012.

The following publications can be found at:

http://www.npu.go.jp/en/policy/policy04/index.html

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- Strategy for the Rebirth of Japan, National Policy Unit, December 2011
- Interim Report on Strategies to Revitalize Japan, National Policy Unit, August 2011
- Major achievements based on the Implementation Schedule of the New Growth Strategy, National Policy Unit, June 2011.
- Realising the New Growth Strategy 2011, National Policy Unit, 2011
- Promoting the "Future City Initiative', Regional Revitalization Bureau, Cabinet Secretariat, March 2011
- 21 National Strategic projects, National Policy Unit, 2010

More information on the Initiative:

http://futurecity.rro.go.jp/en/

Email exchanges with FutureCity policy officers at: g.futurecity@cas.go.jp

# 13. Cost-benefit analysis of the Warm up New Zealand programme

#### **Compiled by Nelly Bruno**

#### January 2013

#### 13.1 SHORT DESCRIPTION OF THE MEASURE

The Warm Up New Zealand: Heat Smart programme (WUNZ:HS) started in July 2009 replacing a number of existing programmes. It is a multi-year programme funded by the New Zealand government that provides funding for insulation retrofits and clean, efficient heating grants for New Zealand households. With a budget of \$340m the programme provides partial funding for the purchase and installation of eligible products by approved providers that undertake to assess, advise, provide finance or access to finance, and install insulation and clean heating devices. The underlying objectives are:

- Helping New Zealanders to have warm, dry, more comfortable homes;
- Improving the health of New Zealanders;
- Saving energy;
- Improving New Zealand's housing infrastructure through the uptake of cost effective energy efficiency measures; and
- Stimulating employment and developing capability in the insulation and construction industries.

Although not explicitly stated but through the increased domestic demand, the capabilities of the sector should improve and energy be saved through eco-innovations.

Under the programme, the government aimed to retrofit more than 188,500 New Zealand homes over a period of four years; it was originally expected that there would be 38,750 installations (27,500 insulation and 11,250 clean heating) by the close of the 2009/10 year, but applications were considerably more than this; in total, 64,291 (57,908 insulation and 12,658 clean heating) houses received installations (EECA (2010) Annual Report 2009/10; EECA personal communication).

#### **13.2 THE EVALUATION METHOD**

In 2010 the Ministry of Economic Development parent organisation, tendered a contract to carry out a full cost benefit analysis of the programme, which was completed in October 2011. The bid was won by a consortium including academics from He Kainga Oranga and Victoria University, and consultancy firms Motu Economic and Public Policy Research and Covec. The overall cost benefits analysis was made of different components analysing the impact of the programme on 1) Metered household energy use, 2) Health services utilisation and costs, pharmaceutical costs and mortality, 3) Industry & Employment.

The first study primarily used a fixed effects OLS estimator with standard errors clustered by treatment/matched control pairings to analyse changes in total **energy use and electricity use** as a result of receiving an insulation or heat pump retrofit under WUNZ:HS. It pairs homes that received a retrofit under the programme with control homes that are similar in age, size, quality and location via anonymised matching by a third party organisation. Anonymised data was collected from the Ministry of Health for the people who live at these homes including health outcomes and demographic information. Anonymised energy use data for these addresses was also collected from energy companies. Analysis of the relationship between receiving a retrofit and health or energy use outcomes was then possible at both the individual level and household level. From the initial list of homes that received treatment under the programme between June 2009 and May 2010 (46,655), the final usable data set included 255,672 treatment and control households and 973,710 individuals.

The **health analysis** included both individual and household level data. Individual level analysis utilised negative binomial models to analyse the impact of participating in WUNZ:HS on hospitalisation rates and mortality rates for recently hospitalised older people. At a household level the team utilised a fixed effects OLS estimator with standard errors clustered by treatment/matched control pairings to analyse hospitalisation and pharmaceutical use costs.

In addition a separate assessment of the **impact of the programme on industry and employment** was carried out. It is concerned with the effects on producers only, ie the change in producer surplus as a result of the programme and the change in employment. This required consideration of the impacts on total quantity, costs of production, labour requirements, sales prices and profits. The research for this study is based on data collected from phone interviews and email correspondence with a number of firms that produce and install insulation, in addition to an analysis of data provided by the administration. Employment impacts have been estimated from employment requirements for production and installation, as obtained from companies surveyed. Multipliers have been used to estimate the impacts on employment elsewhere in the economy (indirect and induced effects). The proportion of this total that is additional at the national level has been calculated as a range on the basis of company estimates of the proportion of new staff that were previously unemployed (at the top end) and from literature on the impacts of wage subsidies (at the bottom end). Producer surpluses have been estimated as the total revenue obtained from using a resource minus all opportunity costs of production. The calculation includes: (1) the wages paid to additional workers (assumed to be a transfer payment at the national level) and (2) estimates of marginal surpluses in production and installation.

When health and energy results were combined with an analysis of industry impacts and employment changes a **final cost benefit analysis** was carried out.

#### **13.3 INDICATORS USED**

The main outcome measures are the following:

- Ratio of benefits to costs for programme as a whole;
- Measurement of programme costs;
- Changes in employment due to programme;
- Changes in electricity and gas use due to programme;
- Changes in hospitalisation rates and mortality rates;
- Changes in hospitalisation and pharmaceutical costs per household;
- Additional annual consumption and employment from the programme (in insulation and clean heating sectors);
- Additional producer surplus (in insulation and clean heating sectors).

#### **13.4 FINDINGS OF THE EVALUATION**

It is noteworthy that not all companies provided data for the analysis. Some refused to provide any on the basis that they had no incentive to and/or that they were concerned about its confidentiality and the risk of release. This was despite the offer to sign confidentiality agreements.

According to the analysis, the insulation subsidy is a statistically significant factor in predicting insulation consumption. The regression analysis suggests that, for every subsidised home, there is additional insulation consumption of 127 m2 and that 85% of the quantity of insulation installed in subsidised houses is additional to that which would have been installed under business as usual, ie. without the subsidy. However, there is a reasonably large uncertainty range, from 41% to 129% at the 95% confidence level. As regards the impact of the programme on **additional consumption and employment and the increase in producer surplus**, the overall results are provided in the figures below.

Table ES4 Additional Annual Consumption and Employment from the Programme (2009-10)<sup>(1)</sup>

	In (underfl	sulation oor & ceiling)	Clea	Clean Heat		
Scenarios	Additional consumption (million m²)	Additional FTE jobs <sup>(2)</sup>	Additional Consumption (`000 units)	Additional FTE jobs		
Low	3.2	29 - 198	5.1	4 - 26		
Central	6.6	56 - 376	10.7	8 - 55		
High	10.0	82 - 555	16.3	12 - 84		

<sup>(1)</sup> Analysis is for 51,600 houses for insulation and 12,658 for clean heating; <sup>(2)</sup> FTE = Full-time Equivalents; employment impacts include direct and indirect effects.

Table ES5 Total Additional Producer Surplus in 2009-10 (\$ million)

Scenario Estimate	All Insulation	Clean Heating	Total
Low	16 - 23	5	21 - 28
Central	35 - 53	10	44 - 62
High	52 - 80	16	66 - 94

As regards **changes in total energy use and electricity use** as a result of receiving an insulation or heat pump retrofit under WUNZ:HS, it was found that there was a 0.96% reduction in average annual household electricity use as a result of receiving an insulation retrofit and 0.66% reduction in annual total metered energy used. Other key findings included a 1.92% increase in electricity use as a result of heat pump installation and a 0.75% increase in total metered energy used.

The study team found that there was **no statistically significant change in hospitalisation rates** as a result of participating in WUNZ:HS but that there was a statistically significant 27% **reduction in mortality** for participants aged 65 and over who had recently undergone a cardiovascular hospitalisation. It was estimated that this on-going benefit could be valued at \$439.95 per year per treated household. At a household level they found that there was a statistically significant saving of approximately \$64.44 in total hospitalisation costs per year for a household that received some combination of ceiling or floor insulation under the WUNZ:HS programme. Pharmaceutical savings were small but highly statistically significant for insulation, and not statistically significant for heating.

The results of the overall final cost benefit analysis were highly favourable. Under the preferred scenario, (additionality assumption of 85%, 4% discount rate) it was estimated that WUNZ:HS will have a net benefit of \$951m, and a highly favourable benefit cost ratio of 3.9:1.

#### 13.5 Bibliography and Further information

Grimes A., Young C., Arnold R., Denne T., Howden-Chapman P., Telfar-Barnard L., Preval N., <u>Warming Up New Zealand: Impacts of the New Zealand</u> <u>Insulation Fund on Metered Household Energy Use</u>

Grimes A., Denne T., Howden-Chapman P., Arnold R., Telfar-Barnard L., Preval N., Young C., <u>Cost Benefit Analysis of the Warm Up New Zealand Heat</u> <u>Smart Programme (revised)</u>, Final report for the Ministry of Economic Development, revised June 2012

Telfar-Barnard L., Preval N., Howden-Chapman P., Arnold R., Young C., Grimes A., Denne T., <u>The impact of retrofitted insulation and new heaters on</u> <u>health services utilisation and costs, pharmaceutical costs and mortality</u>, Final report for the Ministry of Economic Development, October 2011 Covec, <u>Impacts of the NZ Insulation Fund on Industry & Employment</u>, Final report for the Ministry of Economic Development, October 2011 http://www.healthyhousing.org.nz/research/current-research/evaluation-of-warm-up-new-zealand-heat-smart/

# Appendix C Market analyses

Overview of market studies
Smart textiles
Industrial Laser
3D printing
Car sharing
Smart grids
Sustainable construction

## 1. Smart Textiles

#### 1.1 The smart textiles market

The textile industry's main activities consist in yarn spinning, fabric manufacturing, finishing of dressing and coating of fabric and textiles (see Figure 18 for a graphical description). The industry is structured in:

- upstream activities (producers of natural and synthetic fibres);
- downstream activities (clothing, upholstered furniture, household items, floor coverings, industrial applications)

The CEN/TC 248 Committee working on standardisation defines smart textiles as "functional textiles, which interact with their environment by responding to it. This response can be either a (visible) change in the materials properties or result in communicating the environmental trigger to an external read out."

Another definition of smart fabrics and interactive textiles (SFIT) is that they are *fibrous structures that are capable of sensing, actuating, generating/storing power and /or communicating.* 

In statistical terms, smart textiles are classified as "technical textiles", identifiable under the industry classification NACE, Section C – Manufacturing, Division 13 – n.e.c: not elsewhere classified, Group 13.9 – Manufacture of other textiles, Class – 13.96 – Manufacture of other technical and industrial textiles.

#### Figure 18 Textiles Industry Opportunities



Source: Technopolis Group based on CTT Group, 2008: Technology Roadmap for the Canadian Textile Industry, p.  $_{\rm 37}$ 

The 2010 Europe Innova Sectoral Innovation Watch Report on Clothing and Textiles has deemed intelligent clothing and smart materials as an area of huge growth potential in the textiles sector. According to the Canadian Technology Roadmap for the Textiles Industry (2008), European countries are some of the most technologically advanced in the production of technical textiles (see Figure 19).

Figure 19 Level of technological development of the technical textiles market in selected countries



Source: CTT Group, 2008: Technology Roadmap for the Canadian Textile Industry, p. 37.

Intelligent textile materials and systems are a relatively new market segment, offering new growth avenues for textile companies.

According to the 2011 smart textiles market vision building exercise of the FP7 project SYSTEX, the market players in the field of smart textiles are mainly SMEs and university spin-offs (see SYSTEX, 2012).

If we take patent applications as an indicator for innovation, available data from the European Patent Office on textiles (IPC: D, without D21 (paper)), shows that in terms of absolute numbers, the number of patent applications has decreased on average annually by 8.3% between 2005-2009. Applicants from the EU-27 still apply for the majority of patents with 54% in 2009, followed by Japan (13.6%), South Korea (11.5%), an the U.S.A. (10.7%). In 2009, China had a small share with 2.3% however its average annual patenting growth rate at the EPO is 25% since 2005 - by far the highest of all countries. Within the EU27 countries, Germany has the highest share of patents with 47%, followed by Italy (21%) and France (10.4%). While the total number of patent applications fell in absolute numbers, Germany and France increased their relative shares by around three percentage points between 2005-2009. According to Europe Innova (2010), important markets for smart textiles are:

- Health;
- Customer clothing sector;
- Leisure and Sports;
- Defence

possibly also

- transportation,
- construction,
- agriculture and
- packaging

However, at the moment, there are very few indicators that are publicly available for describing the evolution of the market for smart textiles specifically. The European textile industry association Euratex mentions its growing significance but in statistical terms, data is rarely made available at the four digit level of NACE. Most indicators available on Eurostat capture the overall textiles market features, but do not go as in-depth as the specificities of the smart textiles market. A helpful indicator could thus be the industry production index, available for the manufacture of other technical and industrial textiles (see Figure 20). Since 2005, the Manufacturing of technical and industrial textiles has been experiencing high volatility, albeit generally decreasing. After a drop by 20 percentage points in 2009 (in comparison to the previous year), the industry production index recovered in 2010, but fell again in 2011.

Figure 20 Industrial Production Index for the Manufacturing of Technical and Industrial Textiles Industry in EU (% change versus previous year)



#### Source: Eurostat

Most of the remaining indicators are not available at the level of the technical textiles sector, but only for the overall textiles sector. The following graph shows the industry evolution of the turnover index for the textile industry in the EU, with a major drop of 15% of the 2008 turnover in 2009, and a slow recovery path since 2010 (Figure 21).

Figure 21 Industry Turnover Index for the Textile Industry in the EU (% change versus previous year)



Source: Eurostat

Figure 22 Employment in the manufacture of textiles and wearing apparel sectors



Source: Eurostat

The development of the gross employment in the textiles and wearing apparel industries has been constantly negative since 2005 in the EU27 (Figure 22). The biggest drop in employment was registered in 2009, when both industries' gross employment diminished by over 12% in comparison to 2008. The employment numbers have continued to drop by milder rates since then.

Figure 23 shows the trade balance for textiles, clothing and footwear in EU27 in billion Euros. It is visible that the imports from China and India have been increasing tremendously since 2006. The EU27 has been exporting more to markets in the United States and Japan, while further major export partners are other EU Member States, with the volume of intra-EU exported goods increasing since 2009.

Figure 23 EU27 trade balance intra-EU and with selected countries for textiles, clothing and footwear (in bn Euro) (1)



Source: Eurostat International Trade Database

(1) The graph shows the overall trade balance computed as volume of imports subtracted from the volume of exports for the following specific sectors: Textile yarns, fabrics, made-up articles, N.E.S. and related products; Articles of apparel and clothing accessories; Footwear.

A further dimension of the market for smart textiles is the **final consumption** of clothing and footwear articles, available on Eurostat (see Figure 24). While the indicator showed a drop by around 4.5% in 2009, the consumption started to mildly recover since then. The demand for the smart textiles market could be further assessed when taking into account further drivers mentioned in the next section.





Eurostat

#### 1.1.1 Applications for smart textiles

The functions that smart textiles can accomplish range from acting as sensors, actuators, to providing data processing, communication or energy generation. Smart Fabrics and Interactive Textiles interact with several industries: Textiles engineering, ICT, Electronics & Electricals, Sensors & Actuators, Material Sciences, Microsystems & Nanotechnology (see Figure 25 for application fields for the future).

The FP7 project *SYSTEX* – *Coordination action for enhancing the breakthrough of intelligent textile systems* has identified several lead markets where smart textiles applications are deemed as "high potential growth markets for the future"<sup>12</sup>. These markets are **the medical**, **sports & wellness**, **automotive & transport** and **protective clothing**. For example, intelligent textiles can be integrated in smart clothing and / or mobile devices, which can serve for personal health management for instance. They can also be used for personal wearable applications such as protection/safety and emergency signalling, for instance for fire-fighters equipment.

<sup>12</sup> See SYSTEX, 2011: Vision Map, <u>http://www.systex.org/content/successful-investigation-smart-textiles-landscape-markets-projects-vision-and-roadmap</u>

Figure 25 Future opportunities for the smart textiles market

Fields of business	Smart textiles applications for the future						
Clothing	Sensor integrated clothing for communication between automobiles and pedestrians						
_	Energy generation and energy storage in clothes						
	• Ambient assisted living: Intelligent functions for adjusting the clothes to the environment and personal profile (air permeability, temperature, humidity etc.) or as personal movement support costume for assisting aging or disabled persons						
	Protective work clothing ie. For fire-fighters						
	Sports products						
Housing	• Self-cleaning (or in need of minimal cleaning) furniture and cushion covers, carpets, tapestry, curtains; electro chromic textile surfaces for decorations						
	• Wellbeing and health monitoring through smart textiles in the building;						
	• Intelligent lighting systems for distribution and use of daylight; automatic sun protection						
	<ul> <li>Energy savings and/or climate adjustments through smart textiles;</li> </ul>						
Production / Logistics	Calculating the ecological footprint of the textile production value chain and improvements towards more sustainable processes						
	<ul> <li>Design for recyclable textiles and resource efficient textile production</li> </ul>						
	• Material structures based on textiles (e.g. 3D printing for components manufacturing)						
	Switching from decentralised production to centralised production with digitised workflow						
	Textile packaging of food products						
Energy	<ul> <li>Installing textile solar cells that contain threads with photovoltaic properties on facades and car roofs</li> </ul>						
	Textile materials to be used for biomass and bio fuel production						
Healthcare	• Development of new textile products and fibres to counteract allergies and health threats, such as filters of pollen and pollutants (e.g. for mouth- and respiratory protection)						
	• Development of conductive yarns and functional sensor textiles for controlling wellbeing (for car drivers, aged persons, risk groups)						
	Textile filters for liquids and gases for the separation of bioactive substances						
	Clothing fitted for the needs of the elderly and for disabled people						
Agriculture/ farming	• Introducing new agricultural production surfaces in previously infertile grounds or on the sea surface (aqua farming) or in cities (vertical farming)						
	Recovery of potable water with efficient preparation systems for households and communities						
Mobility	• Textile solutions for automobile construction (e.g. for increasing the comfort level of seats, adjusting the heating, massage functions)						
	Textile lighting within the car for a better ambiance						
	Integrated textile systems e.g. for weight reduction and energy efficiency of the vehicles						
	• Textile transport lanes for stairs or pedestrian roads e.g. in airports or railway stations						

Source: Technopolis Group based on Forschungskuratorium Textil e.V., 2012.

Further examples of prototypes of smart textiles (see Lymberis, Paradiso, 2008):

- Wireless-enabled clothes or accessories with embedded textile sensors for monitoring electrocardio, respiration, electromyographic, and physical activity.
- Sensorized clothes including woven textile sensors for ECG and respiratory frequency detection
- Further framework projects (FP6 or FP7) focus on: biosensing textiles for health management, protection e-textiles (micro or nanostructured fiber systems for disaster wear, targeted at fire-fighters and rescuers),

contactless sensors for body monitoring incorporated in textiles; stretchable electronic "motherboard" in textiles (STELLA)

The SYSTEX Project Database of demonstrators<sup>13</sup> contains more examples of such prototypes that have been developed by the project partners. Among them are:

- Stretchable and washable electronics
   <u>http://www.systex.org/demonstrator/stretchable-and-washable-electronics</u>
- Communicating textiles that monitor the physical state of a person through the clothes
- <u>http://www.systex.org/demonstrator/communicating-textiles</u>
  PROeTex Firefighter uniform

http://www.systex.org/demonstrator/proetex-firefighter-uniform

#### 1.1.2 The need for new business models for smart textiles

Following the 2010 Europe Innova Sectoral Innovation Foresight on the Textiles and Clothing Sector and the SYSTEX project vision building exercise, the following streams of new developments could be indentified as potential new business models for smart textiles:

- E-commerce: producers can sell their products directly to customers. One barrier is the customers' need to try on clothes before purchasing EU sponsored projects for improving the availability of technologies for this purpose exists (e.g. E-Tailor programme and the e-T Cluster programme for virtual prototyping and design).
- The challenge of transferring from a mass production type of business model that focuses on quantity to customized production, which focuses on quality and made-to-measure production processes (see Europe Innova, 2010, p. 40).
- Vertical integration (large portion of the supply chain have common ownership or belong to the same organisation). According to the SYSTEX project, the smart textiles market has tended to develop the forward form of vertical integration, as the smart textiles companies tend to control the distribution centres and retailers where products are sold (see SYSTEX, 2012, p. 47).
- Business to business strategic partnerships are becoming a trend (SMEs prefer to produce for larger original equipment manufacturers who have better access to distribution networks and better bargaining power, rather than directly to retailers).
- Complex value chain, as it also includes nanotechnology or ICT, materials and electronics companies. The bargaining power is relatively small among value chain members.

#### 1.1.3 Existing platforms and associations

 European Apparel and Textile Confederation (EURATEX) - <u>http://www.euratex.eu/</u>

<sup>&</sup>lt;sup>13</sup> See SYSTEX, Demonstrators / Prototypes: <u>http://www.systex.org/demonstrators</u>

- European Technology Platform for the Future of Textiles and Clothing
   <u>http://www.textile-platform.eu/</u>gm
- European Textile Services Association <u>http://www.etsa-europe.org</u>
- European Network of Textile Research Organisation <u>www.textranet.net</u>

#### 1.2 Barriers for the development of the smart textiles industry

The smart textiles industry has been characterised as complex and lacking industrialisation maturity (Lymberis, Paradiso, 2008). Reasons for this statement are the fact that clothing industries are not sufficiently engaged, and core modules / technologies (e.g. interface, connectivity, sensing, skin contact, transmission, manufacturing and usability) are not sufficiently developed, neither tested nor certified. In addition, the research community is fragmented.

The FP7 project SYSTEX vision map identified several barriers to smart textiles industry:

- Strategic barriers: Lack of standardization, lack of regulations for the new products, lack of coordination and collaboration among the value chain partners; financial constraints among SMEs to carry on development.
- Business barriers: high production costs and high selling costs; less consumer acceptance of smart textiles due to high prices; lack of HR with specific expertise to carry development in multidisciplinary areas; lack of understanding of customer requirements.

#### 1.3 Drivers of the smart textiles industry

#### • Demand side drivers:

- Increased consumer needs and demands for better quality of life and
- The ageing population and increased number of people suffering from chronic diseases that need constant monitoring and care. The population in general is also more health-aware.
- Changes in consumer behaviour between generations
- Internal Business drivers
  - Need for a diversification of customer base
  - Increased competition in established businesses
  - Need for higher profitability
  - Increased spending by local and national governments on smart textiles
- Sector drivers
  - Rejuvenation of established industries like textiles, ICT and electronics
  - Faster developments in the related industries like nano-, micro- and electronic industries
  - Emergence of specialized markets like continuous monitoring, neonatal care, fire-fighters equipment

### 2. Industrial laser

Being first produced in 1960, a laser is a device that emits light (electromagnetic radiation) through a process of optical amplification based on the stimulated emission of photons. The term "laser" originated as an acronym for Light Amplification by Stimulated Emission of Radiation. The first use of lasers in the daily lives of the general population was the supermarket barcode scanner, introduced in 1974. The laserdisc player, introduced in 1978, was the first successful consumer product to include a laser but the compact disc player was the first laser-equipped device to become common, beginning in 1982 followed shortly by laser printers. The days of the laser being a technology in search of an application have now clearly ended. More commonly, press releases regularly announce new capabilities that only laser technology can deliver, such as:

- Medicine: Bloodless surgery, laser healing, surgical treatment, kidney stone treatment, eye treatment, dentistry;
- Industry: Cutting, welding, material heat treatment, marking parts, non-contact measurement of parts;
- Military: Marking targets, guiding munitions, missile defence, electrooptical countermeasures, alternative to radar, blinding troops;
- Research: Spectroscopy, laser ablation, laser annealing, laser scattering, laser interferometry, laser capture microdissection, fluorescence microscopy;
- Product development/commercial: laser printers, optical discs, thermometers, laser pointers, holograms, bubblegrams;
- Laser lighting displays: Laser light shows;
- Cosmetic skin treatments: acne treatment, cellulite and striae reduction, and hair removal...

#### 2.1 The laser market

Focusing on industrial lasers only, Figure 26 shows the history of industrial laser revenue since 1970<sup>14</sup>. It appears clearly that industrial lasers have experienced a strong growth rate since the early 1990s, impacted however by the 2008 economic crisis.

<sup>&</sup>lt;sup>14</sup> Belforte David A., 2012 Annual Economic Review and Forecast, January 2013, http://www.industriallasers.com/articles/print/volume-28/issue-1/features/2012-annual-economic-review-and-forecast.html



#### Figure 26 Industrial Laser Revenues since 1970

Source: Industrial Lasers Solutions analysis and forecasts (2013)

According to the analysis of Industrial Lasers Solutions (ILS), following this recession, the industry however defied the experts' predictions of a long, slow recovery, and experienced booming sales of solid-state lasers for face plate applications in hand-held devices and fiber laser for marking/engraving and sheet metal cutting. By end 2011 equipment suppliers to the global industrial laser market were enjoying one of the best revenue producing years in the technology's history, with strong double-digit growth across the board in all laser types and all the applications that they serve.

As shown in Table 4 a steep decline of activity appeared however as of the third quarter of 2012, notably because of slowing markets in Europe and the impact of a sudden and deep cutback in exports to China, the single largest market for industrial lasers and systems. The China situation seemed to have a greater impact on laser equipment suppliers located in Europe, where they were already experiencing the fallout of collapsing economies throughout the Euromarkets, and in Japan, where a drop in orders from China caused a 20% drop in laser system sales. Turkey was one of a few bright lights in an otherwise gloomy marketplace. Product suppliers in the U.S. did not begin to feel the impact until late in the fourth quarter of 2012, as this country's manufacturing economy was in the midst of one of the best growth periods in its history. The effects of recession were being felt and reported throughout the 27 country Euromarket and in the UK. Worse, the impact of this situation had spread to Central and Eastern Europe, two regions that had in 2011 been cited as among the strengths of the European laser market. Generally, industry participants and observers are opting for a reasonable growth 2013 first quarter, as 2012 backlogs are reduced, followed by three quarters of flat or low growth rate sales and shipments.

	Laser Revenues (\$m)				Laser S	System F	leven	ues (\$m)	<b>\$m</b> )			
	2011	2012	%	2013	%	2011	2012	%	2013	%		
CO <sub>2</sub>	988	1016	3	1008	-0.8	4100	4244	4	4300	1		
Solid State	424	453	7	450	-0.7	1611	1665	3	1695	2		
Fibre	495	576	16	616	7	1164	1350	16	1465	8		
Other	84	90	7	103	14	200	216	8	240	11		
Total	1991	2135	7	2177	2	7075	7475	6	7700	3		

Table 4Revenues from laser and laser systems<sup>15</sup>

Source: Industrial Lasers analysis and forecasts (2013)

Fibre lasers were the winner in the growth-rate race in 2012, showing a 16% increase in laser revenues, mainly at the expense of high-power CO2 lasers, which lost market share by as much as an estimated 10–15%. Fibre lasers indeed increasingly penetrate into markets held by other laser types, as that laser's high efficiency, compact footprint and low maintenance costs are proving attractive in buying decisions when the fibre competes directly with other laser power sources. In 2011, high-power fibre laser sales grew at a fast pace and began a serious penetration into the market for sheet metal cutting. This situation intensified in 2012 as evidenced by the dominant presence of fibre-laser-powered metal cutters at all the major trade shows featuring fabricated metal product processing equipment. In 2012, high-power fibre lasers are estimated to have taken up to 20% of the market from equivalent power CO<sub>2</sub> lasers.

In the markets where fibres have been eroding sales of solid-state lasers, the fibre continued to be the laser of choice among marking system integrators; however, solid-state laser retained market share and actually increased this slightly in microprocessing applications, where it is preferred as a processing laser in the manufacture of hand-held communications devices. Excimer and diode lasers, the latter a fast-growing product in the manufacturing world, continue to show strong growth that started in 2011 and increased their market share by 7% in 2012. They are finding niche markets where they are the lasers of choice in semiconductor and microprocessing applications and for the high power diodes in macro applications in the auto industry.

According to data from Optech Consulting (2011), the world market for laser and laser systems for materials  $processing^{16}$  in particular was estimated to  $\notin 2.2b$  for laser sources and  $\notin 7.2b$  for laser systems in 2011, following the uneven evolution over the last decades.

<sup>&</sup>lt;sup>15</sup> ILS forecasts are based on documented reports from four dozen public corporations, including the market leaders, all of whom are obligated to publish their quarterly financial reports, along with company officer guidance statements that project future business, enhanced with other published comments and direct interviews and market assessments.

<sup>&</sup>lt;sup>16</sup> A "laser system" is a system or machine including a laser. A "laser source" is a laser.



Figure 27 World Market for Laser Systems for Materials Processing by Year (in Euro Billion)

The sales of high-power laser metal cutting systems are a significant portion of total laser system revenues. System revenues have been growing at a slightly faster pace than laser revenues in the past few years as the selling price of laser units has decreased because of increased competition in the marketplace, while the selling price for the laser system has not reflected this cost factor. In 2012, sales exceeded \$5 billion or 60% of the total.

Looking closer at geographic markets, Figure 28 provides a view of where industrial lasers were installed in 2012. China is considered to be the largest market for laser marking and metal cutting systems, and East Asia to be the largest market for microprocessing and semiconductor processing equipment. As home to much of the production of smart phones, computers, and support equipment and tablets, East Asia is the major user of solid-state, excimer, and other lasers that produce the components for these products. A slowdown in the Chinese economy would have a negative impact on worldwide laser sales. European countries, led by slow-downs in Italy, Spain, and the Central European nations, slipped two points to 30%. Only the continuing strength of the German market kept this percentage from slipping even further. The brightest performance in an otherwise slowing market was in North America, where manufacturing boomed in an otherwise slow economy. The industries that seemed to defy global manufacturing slowdown are: aerospace, transportation, energy, agriculture and heavy equipment, and medical devices. Laser products used ranged from low-power laser marking units to high-power laser metal cutters and welders.

Figure 28 Global system installations (ILS, 2013)



2012 Total: \$7.5 billion

The BRIC (Brazil, Russia, India, and China) nations have been targeted by several laser product suppliers as expanding markets in 2013 (ILS, 2013). ILS looks to the BRIC nation markets as a near term opportunity to expand sales of industrial laser products, acting as a relief valve for the slowing 2013 international markets. There is no sentiment for market loss through the appearance of new non-laser competition, so the industry is prepared for an anticipated strong fourth quarter in 2013, followed in 2014 by a return to double-digit revenue growth.

Box 1 POLYBRIGHT - FP7 Project on Extending the Process Limits of Laser Polymer Welding with High-Brilliance Beam Sources, http://www.polybright.eu

Starting with the **development** of the high power diode lasers in the mid 90's the laser welding of polymers enjoyed a continuous increase of its application fields and became an established process. It became over the last decade a strong competitor for the conventional joining technologies and significantly raised the industrial interest. Main factors contributing to the successful evolution of this technique lay within the process related benefits such as: contactless processing, high flexibility in time and product, high automation degree and precisely controlled and localised energy input.

Nowadays, based on the development of novel laser sources new opportunities arise for this versatile joining technology. The main objective of the EU-funded POLYBRIGHT research project gathering 18 partners from nine countries over the years 2009-2012 (EC budget of  $\in 6.6m$ ) was to **break new paths for laser beam welding of advanced polymeric materials**.

The project covered the **whole process chain** for laser based plastic part assembly and included laser companies, optics suppliers, material and processing specialists as well as machine suppliers. To benefit from current developments in the field of high brilliance laser sources, the main focus was the application of diode lasers and fibre lasers in the Near-Infrared (NIR) spectral range as well as beam shaping and scanning techniques. The projects aimed for challenging the limits of conventional polymer joining processes as well as related existing production systems and equipment.

Projects **outputs were a significant improvement of the process performance** and the development of innovative system technology concepts in order to reduce the investment cost for laser polymer welding systems. Key innovations of the PolyBright project are high brilliance mid-IR-wavelength fibre and diode lasers with powers up to 500 W, high speed scanning and flexible beam manipulation systems, such as dynamic masks and multi kHz scanning heads. The developed machine equipment and the new laser process approaches were validated by end users from medical, consumer good and automotive industry.

It was expected that PolyBright would **open new markets** for laser systems with a short term potential of over several 100 laser installations per year and a future much larger market share in a multi billion plastic market. PolyBright would thus hence establish a comprehensive and sustainable development activity on new high brilliance lasers that will strengthen the EU's laser system industry.

#### 2.2 Drivers and barriers for the laser industry

#### 2.2.1 Main drivers for the development of the laser industry

- Positive impact of the laser technologies on the manufacturing productivity allowing a reduction of costs and an increase in production scales<sup>17</sup>;
- Wide array of laser applications, e.g., the majority of microtechnology products are enabled by laser manufacturing.
- Near-ideal production line equipment type (in particular diodepumped solid-state lasers), since laser run off standard single-phase

<sup>&</sup>lt;sup>17</sup> See for instance Sherk J. (The Heritage Foundation), "Technology Explains Drop in Manufacturing Jobs", The Backgrounder No. 2476, October 12, 2010

electricity, require no external plant water supply, nor do they produce any hazardous waste, the latter often a by-product of plasma and wet etch technologies.

- Energy efficient production: the laser puts the energy in the right shape at the right time at the right place.
- Laser based manufacturing enables new "green" products like lightweight structures and use of new materials.
- Laser based processes avoid waste and toxic materials.
- Strong potential for development with additive manufacturing, e.g using laser sintering (see following section).
- Globalisation and an increasingly competitive business environment: pressure to provide new products and services individually tailored and based on cutting-edge technology with higher quality, distinctive features and better prices.
- Market opportunities opening in BRIC economies.

2.2.2 Main barriers/challenges for the development of the laser industry

- Slowdown in the Asian economies would have a negative impact on worldwide laser sales;
- Global supply of high-skill workers not keeping up with demand<sup>18</sup>;
- Volatility in raw material prices;
- Significant upswings and downswings in demand, driven by changes in customer preferences, purchasing power, and events such as quality problems;
- Policy uncertainties, e.g., unclear energy and carbon emissions policies, national protectionism, labour market and education policies, Intellectual Property arrangements;
- Manufacturing will be called upon to provide solutions for new societal needs and the challenges of the ageing Europe and a culturally more diverse society; need to design more sustainable products and services to improve environmental performance and to extend the lifecycle of products through recycling and to the substitution of hazardous substances and materials.

#### 2.3 Applications and future opportunities for lasers

As already stated, lasers are employed over a wide range of applications from scientific research, biomedicine, and environmental sciences to industrial materials processing, microelectronics, avionics, and entertainment. Industrial laser applications can be divided into two categories depending on the power of the laser: material processing and micro-material processing. In material processing, lasers with average optical power above 1 kilowatt are used mainly for industrial materials processing applications. Laser systems in the 50-300W range are used primarily for pumping, plastic welding and soldering applications. Lasers above 300W are used in brazing, thin metal welding, and sheet metal cutting applications. Micro material processing is a category that includes all laser material processing applications under 1 kilowatt<sup>19</sup> (for the

<sup>&</sup>lt;sup>18</sup> The McKinsey Global Institute projects a potential shortage of more than 40 million high-skill workers by 2020.

<sup>&</sup>lt;sup>19</sup> The use of lasers in Micro Materials Processing has found broad application in the development and manufacturing of screens for smartphones, tablet computers, and LED TVs.

production of semiconductors, flat-panel displays, printed circuit boards, and solar cells).

Figure 29 is a three-year summary of laser revenues broken down by applications in which they are used (ILS, 2013). Metal Processing is the largest segment, representing more than 70% of total laser revenues. Whereas this sector grew 6% over 2011 sales, it is estimated by ILS to only grow 2% in 2013, translating into a potential loss of at least \$325m in system sales, as the fabricating sector experiences a slowdown in 2013. Within the market segment CO<sub>2</sub> lasers dominate, but fiber lasers, which grew 30% in this sector at the expense of CO<sub>2</sub> lasers, are becoming a factor. In 2013, fiber lasers are estimated to grow 7% versus the 1% decline in CO2 sales. Marking/Engraving is the second largest laser application in terms of revenues and the largest in terms of unit numbers sold. Laser marking growth is assured because more government and industry standards are in place to factor in laser as the marking source, especially in the area of 2D bar code matrix marking. Laser activity in the Semiconductor/ Microprocessing markets continued to lay the ground work for substantial revenue increases in the coming years as microprocessing is thought to be a growth area for the rest of the decade. This sector is home to one of the fastest growing laser types: ultra-fast pulse, which produced a 60% growth in 2012 and looks to be continuing a double-digit growth for the next few years.

Figure 29 Laser Revenues by application sector
Laser revenues by application
Metal processing
2011



Source: Industrial Lasers analysis and forecasts (2013)

According to ILS forecasts, application segments that will sustain and in some cases drive growth in 2013 are: metal processing, which will represent about 70% of industrial laser revenues with CO2 representing 43% of total laser revenues and fibre lasers 13%. Laser marking/engraving is an application that is driven by company and government regulations and standards for traceability and security, thus even in a slipping economy, this support for annual revenues will keep this application as the number two revenue producer. Fibre lasers will dominate the laser-marking sector at about 75% of total laser marking revenues in 2013. Additionally, fibre lasers for marking will represent about 13% of all industrial laser revenues for 2013. Microprocessing applications revenues in 2013 will show the largest increase (12.2%) over 2012 sales, with diode-pumped solid-state lasers and ultra-fast pulsed lasers producing over 40% of the revenues in this category. This sector is one of the

most active in terms of advanced laser material processing technology, and it is the target for fiber laser suppliers in Europe and Asia.

#### 2.4 Existing platforms and associations

LaserLab Europe is the Integrated Initiative of European Laser Research Infrastructures. Currently in its third implementation phase, the Consortium now brings together 30 leading organisations in laser-based inter-disciplinary research from 16 countries. Together with associate partners, Laserlab covers the majority of European member states. 20 facilities offer access to their labs for European research teams. Given the importance of lasers and their applications in all areas of sciences, life sciences and technologies, the main objectives of the Consortium are:

- To maintain a competitive, inter-disciplinary network of European national laser laboratories;
- To strengthen the European leading role in laser research through Joint Research Activities, pushing the laser concept into new directions and opening up new applications of key importance in research and innovation;
- To offer transnational access to top-quality laser research facilities in a highly co-ordinated fashion for the benefit of the European research community;
- To increase the European basis in laser research and applications by reaching out to neighboring scientific communities and by assisting the development of Laser Research Infrastructures on both the national and the European level.

In particular, as highlighted during the recent analysis of European research infrastructures within the ERA<sup>20</sup>, the cutting edge field of 'attoscience' (the science and technology of ultrashort laser pulses) was promoted through a Joint Research Activity involving LaserLab and became an important component of the Extreme Light Infrastructure (ELI), which is one of the ESFRI selected research infrastructures. Europe is now a protagonist worldwide in this emerging field, due in large part to these initiatives.

Photonics21 is the European Technology Platform for photonics uniting the majority of the leading Photonics industries and relevant R&D stakeholders along the whole economic value chain throughout Europe. Presently, Photonics21 has more than 1700 stakeholders. Photonics21 undertakes to establish Europe as a leader in the development and deployment of Photonics in five industrial areas (Information and Communication, Lighting and Displays, Manufacturing, Life Science and Security) as well as in Education and Training. Its mission is the coordination of the research and development activities in Europe among all the contributing partners from education, basic research, applied research and development to manufacturing and all relevant applications<sup>21</sup>. The platform represents photonics research & innovation priorities at European level and aims to implement a common photonics strategy for Europe.

 $<sup>^{20}</sup>$  See here Analyses of FP7 supported Research Infrastructures initiatives in the context of the European Research Area by Costas Fotakis, Final report, 2010

<sup>&</sup>lt;sup>21</sup> See also on Euractiv, Laser lobby bids for billions in EU research cash, http://www.euractiv.com/innovation-enterprise/laser-lobby-bids-billions-eu-res-news-507683

# 3. 3D Printing - Additive Manufacturing

As reported by McKinsey (2012), additive manufacturing (AM) refers to a wide set of emerging technologies, including 3-D printing<sup>22</sup>, that build up solid objects from the bottom-up from small particles by adding material layer by layer, as opposed to subtractive manufacturing methodologies. It emerged in the mid-1980s after Charles Hull invented what he called stereolithography, in which the top layer of a pool of resin is hardened by an ultraviolet laser.

Additive manufacturing is used to build physical models, prototypes, patterns, tooling components, and production parts in plastic, metal, and composite materials. AM systems use thin, horizontal cross sections from computeraided design models, 3D-scanning systems, medical scanners, and video games to produce parts that can be difficult or impossible to produce any other way<sup>23</sup>. This process avoids the up-front costs, long lead times, and design constraints of conventional high-volume manufacturing techniques like injection molding, casting, and stamping. AM technologies - selective laser sintering, fused deposition modeling, and stereolithography - are used over a range of products, materials, and sizes, with no single technology capable of covering the entire range. The additive process requires less raw material and, because software drives 3D printers, each item can be made differently without costly retooling. The aerospace, automotive, and industrial plastics industries are the primary applications, although AM is used increasingly in customised consumer goods such as jewelry, prosthetics, and dental implants.

With recent developments in the synthesis of end-use products from multiple materials (including metals, plastics, ceramics, etc.) and its inherent environmentally-friendly nature, AM has emerged as a transformative technology in innovation-based manufacturing<sup>24</sup>.

#### 3.1 The 3D printing market

Engineers and designers have been using 3D printers for more than a decade, but mostly to make prototypes rapidly and cheaply. As the technology is getting better more things are being printed as finished goods. According to the Wohlers Report (2012)<sup>25</sup>, around 28% of the output of 3D printers is now

<sup>&</sup>lt;sup>22</sup> 3D Printing is actually a subset of Additive Manufacturing. ASTM International defines Additive Manufacturing as the "process of joining materials to make objects from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing methodologies." [Standard Terminology for Additive Manufacturing Technologies, ASTM F2792-10, June 2010.]

 $<sup>^{23}</sup>$  The layers are defined by software that takes a series of digital slices through a computer-aided design. Descriptions of the slices are then sent to the 3D printer to construct the respective layers. Powder can then be spread onto a tray and then solidified in the required pattern with a squirt of a liquid binder or by sintering it with a laser or an electron beam. Some machines deposit filaments of molten plastic. However it is achieved, after each layer is complete the build tray is lowered by a fraction of a millimetre and the next layer is added.

<sup>&</sup>lt;sup>24</sup> Campbell T., Williams C., Ivanova O., Garrett B. (Atlantic Council), Strategic Foresight Report - Could 3D Printing Change the World?, October 2011

<sup>&</sup>lt;sup>25</sup> Published annually, the Wohlers Report covers all aspects of additive manufacturing, including its history, applications, processes, manufacturers, and materials. It documents developments in the past year, covers R&D and collaboration activities in government, academia, and industry, and summarises the state of the industry in countries around the world. It also tracks the growth of personal 3D printers. The final part of the report concludes with 19 trends that are expected to shape the future of the technology and industry.

final products rather than prototypes, and this is expected to rise to 50% by 2016 and 80% by 2020. Some 6,500 industrial AM production units were shipped to manufacturing customers in 2011, nearly twice as many as in 2005. Less than 30% of AM-produced components are used as parts or in fit and assembly; the majority are used as functional models, prototypes, and casting patterns, or for presentation models. By 2015, the report states that the sale of AM products and services will reach \$3.7 billion worldwide, and by 2019, surpass \$6.5 billion. The compound annual growth rate (CAGR) of additive manufacturing was 29.4% in 2011, whereas the CAGR for the industry's 24-year history is 26.4%. The AM industry is expected to continue with a strong double-digit growth over the next several years.

Figure 30 Sales Forecast for Additive Manufacturing Products and Services Worldwide



Figure 31 Estimated revenues (in \$ million) for Additive Manufacturing



products and services worldwide

Source: Wohlers Report (2011), New Industry Report on Additive Manufacturing and 3D Printing

3D printing is indeed increasingly regarded as announcing the third industrial revolution<sup>26</sup>. The printing of parts and products has indeed the potential to transform manufacturing because it lowers the costs and risks. As there are barely any economies of scale in additive manufacturing, the technology is ideally suited to low-volume production. It also allows the mass customisation of finished parts. Millions of dental crowns and shells for hearing aids are already being made individually with 3D printers. Weight savings are part of the attraction of 3D-printed parts. Aerospace companies are at the forefront of adopting the technology, because airplanes often need parts with complex geometries to meet tricky airflow and cooling requirements in jammed compartments. According to the MIT Technology Review (2011) about 20,000 parts made by laser sintering are already flying in military and commercial aircraft made by Boeing, including 32 different components for its 787 Dreamliner planes. These items are not mass-produced (Boeing might make a few hundred of them all year) and they are also not critical to flight.

With the ability to produce small runs locally, 3D printing technology reduces the barriers to entry to bring the product to the market for individual entrepreneurs, which are generally cut off from traditional manufacturing techniques due to a lack of capital to invest in making the quantities of a product required to sell each one cheaply.

As direct metal AM is breaking longstanding technology acceptance barrier related to materials, the recent emergence of desktop-scale 3D printers is eliminating cost barriers. Thanks to expiring intellectual property and the open-source (and crowd-source) nature of these projects, AM technology can now be purchased for around \$1,000. Because of this low price point, interest in 3D Printing has skyrocketed as more and more hobbyists are able to interact with a technology that, in the past, was relegated to large design and manufacturing firms.

#### 3.2 Drivers and barriers of the 3D printing industry

#### 3.2.1 Main drivers for the development of the 3D printing industry

Additive manufacturing can be a truly transformative force for manufacturing flexibility by cutting prototyping and development time, reducing material waste, eliminating tooling costs, enabling complex shapes and structures, and simplifying production runs. The main drivers for the development of the 3D printing industry can be summarised as the following<sup>27</sup>:

- Technology that lowers entry costs to manufacturing business: cheaper and less risky route to the market for businesses.
- Assembly lines and supply chains can be reduced or eliminated for many products. Designs, not products, would move around the world as digital files to be printed anywhere by any printer that can meet the design parameters.
- Products could be printed on demand without the need to build-up inventories of new products and spare parts.
- A given manufacturing facility would be capable of printing a huge

<sup>&</sup>lt;sup>26</sup> The Economist, A third industrial revolution - As manufacturing goes digital, it will change out of all recognition, says Paul Markillie. And some of the business of making things will return to rich countries, Apr 21st 2012

<sup>&</sup>lt;sup>27</sup> See in particular the Foresight Report published by the Atlantic Council, 2011

range of types of products without retooling—and each printing could be customised without additional cost.

- Production and distribution of material products could begin to be deglobalised as production is brought closer to the consumer.
- Manufacturing could be pulled away from "manufacturing platforms" like China back to the countries where the products are consumed, reducing global economic imbalances as export countries' surpluses are reduced and importing countries' reliance on imports shrink.
- The carbon footprint of manufacturing and transport as well as overall energy use in manufacturing could be reduced substantially and thus global "resource productivity" greatly enhanced and carbon emissions reduced: Process using about one-tenth of the material required in traditional manufacturing. Savings in material costs: for instance, in the aerospace industry metal parts are often machined from costly high-grade titanium. Titanium powder can be used to print things like a bracket for an aircraft door or part of a satellite. These can be as strong as a machined part but use only 10% of the raw material, according to researchers at EADS<sup>28</sup>.
- Reduced need for labour in manufacturing could be politically destabilizing in some economies while others, especially aging societies, might benefit from the ability to produce more goods with fewer people while reducing reliance on imports.
- Utmost geometrical freedom in engineering design: complex designs do not cost any extra to produce, possibility to produce scooped-out shapes that minimize weight without sacrificing strength. Consequently, new opportunities exist for design in industries as diverse as automotive, aerospace, and bio-engineering.
- Possible to create functional parts without the need for assembly, saving both production time and cost.
- AM offers reduced waste; minimal use of harmful chemicals, such as etching and cleaning solutions; and the possibility to use recycled materials.
- Potential for products to be produced quickly and cheaply on 'printers' located in offices, shops and houses.
  - Allows replacement components to be produced in remote regions, improving logistics on humanitarian relief and military operations.
  - Way to reduce the environmental impact of shipping massproduced goods across oceans to get them in consumers' hands
  - Reduction of storage needs
  - Reduction of global economic imbalances
  - Use of local materials that are more appropriate for local consumption, including recycled materials
- Innovation-based manufacturing through AM could change economic power centres toward leaders in design and production of AM systems and in design of products to be printed, leading to a boost in innovation, design, IP exports, and manufacturing in Europe and OECD countries. This would also drive developing countries more rapidly toward becoming less dependent on others.

<sup>&</sup>lt;sup>28</sup> The Economist, Additive manufacturing - Solid print - Making things with a 3D printer changes the rules of manufacturing, Apr 21st 2012

# 3.2.2 Main barriers/challenges for the development of the 3D printing industry

According to McKinsey (2012) and the Atlantic Council (2011), AM still faces some barriers/challenges that are likely to impact its development:

- Competitive advantages may be shorter-lived than ever before.
- Shift in work-force requirements, with likely reduction in traditional manufacturing jobs, creating social pressure.
- In their current embodiments, AM processes are still limited for mass production purposes.
  - Compared with traditional casting, AM is still far less accurate and an order of magnitude slower.
  - AM is expensive to operate: capital costs for high-volume applications can be high, and powders used in AM can be 200 times as costly as sheet metal.
  - Need for better materials to use in printing and greater uniformity in production quality. Most AM processes use proprietary polymers that are not well characterized, and are weaker than their traditionally manufactured counterparts.
  - In some AM processes, part strength is not uniform—due to the layer-by-layer fabrication process, parts are often weaker in the direction of the build.
  - AM process repeatability is in need of improvement; parts made on different machines can often have varying properties.
- AM technologies that achieve mainstream success will need to have potential for mass customisation, enable larger printer sizes and a broad technology base, and exploit new materials. For now, only a handful of plastic and metal compounds can be used in 3-D printing<sup>29</sup>
- Need of experience to improve the technology: so far, manufacturers do not have enough data to predict exactly how a part will turn out and how it will hold up, or how production variables—including temperature, choice of material, part shape, and cooling time—affect the results.
- Ideas can be copied even more rapidly with 3D printing, so battles over intellectual property may intensify: need for new policy related to intellectual property and "part piracy," perhaps through the development of new digital rights management solutions (e.g. if everyone is a designer, who is held responsible when their designed part fails?). Trademarks, copyrights, liability, and patents may all come into play.

AM is on track to become a truly transformative technology with strong repercussions across the society. As stated by the Atlantic Council (2012), "it is thus crucial that technologists and policy makers begin a significant dialogue

<sup>&</sup>lt;sup>29</sup> "In laser sintering, for example, the material must be able to form a powder that will melt neatly when it is hit with a laser, and then solidify quickly. The compounds that meet the necessary criteria can cost 50 to 100 times as much by weight as the raw materials used in conventional manufacturing processes, partly because they're in such low demand that they're available only from small specialty suppliers. As demand increases with new applications, however, supplier competition should pull prices down dramatically. And the list of available materials is slowly expanding."

Freedman D.H., MIT Technology Review: Layer by Layer, With 3-D printing, manufacturers can make existing products more efficiently—and create ones that weren't possible before, December 19, 2011

in anticipation of these challenges to our current global economic status quo. While the future is certainly hard to predict, prescience and advanced planning are necessary in preparation for the disruptive technology of Additive Manufacturing".

#### 3.3 Applications and future opportunities for 3D printing

Initially, AM was referred to as "rapid prototyping," and was primarily used to quickly fabricate conceptual models of new products for form and fit evaluation. As material properties and process repeatability improved, AM technologies' use has evolved to creating parts for functional testing, to creating tooling for injection molding and sand casting, and finally, to directly producing end-use parts. The technology has proven to have a variety of applications across a number of industries. "While the technology is still in its infancy, innovators have proven how versatile it can be, such as using 3-D printers to make bicycles out of nylon, concrete, chocolate, and even transplantable organs that will one day save human lives." Industrial success stories of using AM for part production include<sup>30</sup>:

- Automobile components: While AM is not yet suitable for mass production, it is increasingly used to create components for high-end, specialised automobiles. For example, engine parts for Formula 1 racing cars have been fabricated using direct metal laser sintering.
- Aircraft components: Low-volume production found in the aerospace industry makes it a market primed for disruption from AM. EADS has developed the technology to the extent that it can manipulate metals, nylon, and carbon-reinforced plastics at a molecular level, which allows it to be applied to high-stress, safety critical aviation uses. Compared to a traditional, machined part, those produced by AM are up to 65% lighter but still as strong as those would be. The development of AM is an activity that spans the entire EADS group, with early applications in the production of fixtures and tooling for Airbus, and flying applications being implemented by Eurocopter and Astrium. EADS' UK research facilities have the lead in the group's AM activities.
- Custom orthodontics: stereolithography is used to fabricate molds from 3D scan data of each patient's dental impressions.
- Custom hearing aids: laser sintering to quickly fabricate custom hearing aids based on 3D scans of impressions of the ear canal.

A 2010 Ganter report<sup>31</sup> identified 3D Printing as **transformational technology** in the Technology Trigger phase of the Hype Cycle<sup>32</sup> (i.e., only 5-10 years from mass adoption). The 3D printing revolution is occurring at both the high end and the low end, and converging toward the middle. One end of the technology spectrum involves expensive high-powered energy sources and complex scanning algorithms. The other end is focused on reducing the complexity and cost of a well-established AM process to bring the technology to the masses. According to the Atlantic Council (2011), major advances will

<sup>&</sup>lt;sup>30</sup> Campbell T., Williams C., Ivanova O., Garrett B. (Atlantic Council), Strategic Foresight Report - Could 3D Printing Change the World?, October 2011

<sup>&</sup>lt;sup>31</sup> Jackie Fenn, "Emerging Technology Hype Cycle 2010: What's Hot and What's Not,"

http://www.gartner.com/it/content/1395600/1395613/august\_4\_whats\_hot\_hype\_2010\_jfenn.pdf

<sup>&</sup>lt;sup>32</sup> Jackie Fenn, "Mastering the Hype Cycle: How to Choose the Right Innovation at the Right Time," Harvard Business School Press, Cambridge, MA, 2008
continue to be made in both directions in the next five years. "Direct metal" processes will continue to advance as process control and our understanding of fundamental metallurgy improves. These cutting-edge technologies will gain broader acceptance and use in industrial applications as the necessary design and manufacturing standards emerge. On the other hand, the quality and complexity of parts created by the desktop-machines will continue to improve while the cost declines. These systems will also see broader dissemination in the next 5 years—first through school classrooms and then into homes. While these two technical paths will continue to develop separately—with seemingly opposing end goals—we can expect to see a convergence, in the form of a small-scale direct metal 3D printer, in the next few decades.

#### 3.4 European research and innovation stakeholders

The Global Alliance of Rapid Prototyping Associations (GARPA), and its annual meeting, the Global Summit were formed to encourage the sharing of information on additive manufacturing, rapid prototyping and related subjects across international borders. As a part of this sharing, GARPA members from around the world participate in activities that include technical presentations at industry conferences, the publication of application case studies, business meetings, social events, and the formal and informal exchange of information. This is an umbrella organisation with member groups and associations in Australia, Canada, China, Denmark, Finland, France, Germany, Hong Kong, Ireland, Italy, Japan, Korea, Netherlands, Portugal, South Africa, Sweden, United Kingdom and the United States.

# 4. Car sharing

## 4.1 The car sharing market

Carsharing is defined as *organised collective use of passenger cars* (Gossen, Scholl, 2011). This mode of transport is based on a new economic model that implies that car owners such as firms or organisations provide passenger cars to a pool of registered users who can share or rent the use of the cars at different times and different locations. Usually, the cars are rented for short periods of time (less than a day) and for short distances, especially for improving the mobility of city dwellers.

The global market for car sharing is concentrated in 27 countries and five continents, with a total of 1,788,027 subscribers and 43,554 cars shared in 2012. There were 0.7 million subscribers for car sharing services in Europe in 2012, with 20,464 cars available for such short-term rentals (see Figure 1). According to forecasts by Frost & Sullivan (2012), the number of subscribers is expected to reach around 15 million and the supply of car sharing vehicles to increase to 240,000 in Europe by 2020.

Continent	Members of car sharing services	Nr. of vehicles	Member-vehicle ratio
Asia	160,500	6,155	26.1
Australia	25,500	1,080	23.6
Europe	691,943	20,464	33.8
North America	908, 584	15,795	57.5
South America	1,500	60	25.0
Worldwide	1,788,027	43,554	41.1

Figure 32 The rise of car sharing globally

Source: Shaheen, Cohen, 2012.

The car sharing market has been steadily growing and expanding, with new players entering the market in the past years. While in 2006 there were around 346,000 worldwide members sharing 11,696 cars mostly located in Europe, the landscape was changed in 2012. The North American market expanded its membership base, with over 51% of worldwide members located there, out of the total 1,788,027 members. The number of vehicles available for sharing is almost four times as big in 2012 as in 2006 (see Figure 32).

# Figure 33 Evolution of the global car sharing market (2006-2012) (in percent of worldwide membership)



Source: Shaheen, Cohen, 2012.

The car sharing market can be split in three sub-segments, according to the type of business model.

- **Electric vehicle car sharing** implies the provision of electric cars for short term renting, based on the existence of infrastructure for charging the electric vehicles in the respective city.
- **Corporate car sharing** has been defined by the provision of passenger vehicles provided by traditional car sharing operators (CSOs), but increasingly also directly by vehicle original equipment manufacturers (OEMs), leasing companies, transport operators and parking management companies (see Figure 3).
- **One-way car sharing.** BMW's Drive Now, Car2Go and Quicar are recent market players in Europe whose services includes the rental of passenger cars based on pay per minute, with gas costs and parking included in the price of using the car. The users can locate the nearest available cars in their city by using smart phones, and park them anywhere in the city after use.

# Figure 34 Car sharing Market Players



Source: Frost & Sullivan, 2012.

## 4.2 Main drivers of the European car sharing market

- **Demographic:** the ageing population and the shrinking child-birth rates in Europe impact the demand for car purchases negatively
- **Geography:** the trend towards further urbanisation implies that communities will locate in more compact areas, with more options for transportation modes alternative to cars.
- **Operating costs:** The global recession has taken its toll on the automobile industry, with lower demand for cars around the world. The rising fuel prices and the high parking and maintenance costs are expected to have a negative impact the use of cars as preferred transportation means, as car ownership becomes costlier. An online survey conducted by the carsharing company Zipcar in 2011 on 1,045 adults found that 78% of the Millenials (aged between 18-34 years) agree that it can be difficult to own a car because of high costs (see Zipcar, 2011). So do 76% of the respondents aged 35-44 years. The share of adults belonging to the latter age group is also the highest to admit that they also consciously decided to drive less in 2011 (61%).
- Environmental concerns: a more environmentally aware population is changing its the driving patterns. The same 2011 survey commissioned by Zipcar showed that over 53% of the respondents aged between 18-44 want to protect the environment and are driving less (Zipcar, 2011).
- **Changing consumer preferences**: The existence of alternative transport modes, combined with a shift in attitudes towards cars from status items to functional items, as well as changing work/life patterns are further factors leading to a diminishing demand for car ownership. According to the 2011 Zipcar online survey, over 70% of the respondents aged 18-34 would drive less if there were more options for public transport, car sharing or carpooling in their area (Zipcar, 2011).

## 4.3 Barriers

- on-street parking regulations and limited parking space available
- traffic congestion in urban areas
- low awareness of the existence of car sharing services

# 5. Smart grids

Smart grids can be defined as "an upgraded electricity network enabling twoway information and power exchange between suppliers and consumers, thanks to incorporation of intelligent communication monitoring and management systems" (EC JRC, 2011, p. 10).

The Smart Grid Conceptual Model shown in Figure 1 is based on the original US National Institute of Standards and Technology's (NIST) proposed model. It was adapted to the European context by the EC Smart Grid Task Force. It portrays the complexity of the smart grid value chain, which comprises all steps from generation to consumers (and back) (see EC JRC – US DOE, 2012).

Figure 35 Smart Grid conceptual model and adaptation to the EU context



Source: EC JRC – US DOE, 2012, p. 6.

Due to the complexity of the European market structure, the market players are very diverse and can roughly be clustered in the following categories:

- Energy companies / electric utilities (e.g. EDF, E.ON, Enel Group, Endesa, GDF Suez etc.)
- Actors performing regulated activities due to the unbundling of the transmission and distribution of electricity in the European market:
  - Distribution System Operators (e.g. Enel Distribution, Enexis, Iberdrola, CEZ Distribuce, Endesa, etc.)
  - Transmission System Operators responsible for the transmission of electric power on the main high voltage electric networks. They provide grid access to electricity market players (generating companies, traders, suppliers, distributors and connected customers). E.g.: Austrian Power Grid AG, Elia System Operator SA (Belgium), Swissgrid ag, RTE – Reseau de transport d'Electricite (France), etc.
- Service providers
  - smart appliance manufacturers

- aggregators who mediate interaction between different grid users
- IT companies
- Universities, Research Centres, Public Organisations
- Consumers and prosumers (consumers of energy that can also be producers).

The available data and research show that the market for smart grids is set to grow by 2020 (see Figure 3), when Smart Grid investments are estimated to reach  $\in$ 56 billion in EU. Other markets such as the US and Chinese ones are also estimated to invest heavily on the implementation of smart grids.

Country/ Region	Forecast Smart Grid investments (€/\$)	Funding for Smart Grids development (€/\$)	Number of Smart Meters deployed and/or planned
EU	€56 bilion by 2020 (Pike Research, 2011)	€184 million - FP6 and FP7 European funding for projects in JRC catalogue (EC JRC 2011). €200 million from European Recovery Fund, ERDF, EERA (EC JRC – US DOE, 2012)	Over 40 million already installed (EC JRC 2011) 240 million estimated to be installed by 2020 (Pike Research, 2011)
USA	\$338 ( $\bigcirc$ 238) to \$476 ( $\bigcirc$ 334) billion by 2030 (estimated investments for implementation of fully functional smart grids)	\$9.6 billion in 2009 (US Recovery act; includes Federal and private sector funding).	8 million in 2011 60 million by 2020 (EC JRC – US DOE, 2012)
China	<pre>\$101 billion (€71 billion) planned to invest in smart grid technology in 2009-2020 (EC JRC 2011, p. 13)</pre>	<ul> <li>\$7.3 billion (€5.1 billion)</li> <li>Smart Grid Stimulus</li> <li>Investments granted in</li> <li>2010</li> <li>(EC JRC 2011, p. 13)</li> </ul>	360 million smart meters planned to be rolled-out by 2030 (EC JRC 2011, p. 13)

Figure 36 Smart Grid current and estimated investments

Source: EC JRC – US DOE 2012 and EC JRC 2011.

According to the JRC survey within its catalogue of smart grid projects (EC JRC, 2011), the major investors in smart grids developments are the Distribution System Operators (DSOs). By 2011, their total investment in projects amounted to  $\mathfrak{C}_3$  billion in Europe (ibid, p. 31).

According to a 2012 market research by Frost & Sullivan, advanced metering infrastructure (AMI), integration of distributed generation, sensors and advanced transmission technologies and electric vehicles are the fastest-growing segments in the European smart grid market (see Frost & Sullivan, 2012).

The smart meters rollout has already received a big push from the European Commission's 2009/72/EC directive concerning common rules for the internal market for electricity. The directive set Europe's goals to achieve 80 per cent smart meter coverage by 2020. As Figure 4 shows, there are already emerging hotspots for smart metering in Europe, and their instalment is forecasted to grow by 2020. Italy, France, UK, Germany, Poland, the Netherlands, Sweden and Belgium are expected to reach some of the highest rates of deployment of smart meters in Europe.



## Figure 37 Emerging Smart Metering Hotspots in Europe

Source: GreenTech Media Research, 2011. http://www.greentechmedia.com/research/report/the-smart-grid-in-europe-2012

## 5.1 Drivers

The International Energy Agency Smart Grids Technology Roadmap 2050 identifies several factors behind the rationale for future smart grids investments (see IEA, 2011). They are broadly summarised as follows:

- **Future demand and supply of electricity.** The global consumption of electricity is expected to increase by 150% between 2010 and 2050, as electricity is the *fastest-growing component of global energy demand* (IEA, 2011).
- **Supporting sustainability.** Smart grids can contribute towards reaching energy policy goals and EU2020 targets by reducing CO2 emissions, and increasing the use of renewables. The EU2020 goals set as objective that 20% of total energy (heat, transport, electricity) need to be sourced from renewables;
- **Electricity system features.** The use of renewable resources is projected to increase in Europe and globally, as a solution to reducing CO2 emissions (IEA, 2011):
  - In order to increase the use of renewable resources such as wind and solar, the infrastructure needs to adapt to **allow the use of intermittent energy sources**. Smart grids are designed to accommodate the deployment of such variations in energy sources, and manage the generation, transmission or demand of electricity accordingly.
  - In addition, electricity reliability and security are two factors that have received increased attention due to the increasing demands for electricity from customers. Smart grids are a solution to better cope with and **minimise energy outages**.

- **Managing peak demand for electricity.** The demand for electricity varies throughout the days, ranging from low consumption and underutilisation of the system at specific points in time, but also to very high levels of consumption that prove challenging to satisfy. The smart grid system would allow the management of peak demand by providing incentives to consumers to shift their consumption away from periods of peak demand.
- **Fostering competition** and reducing energy prices as well as operating costs.
  - **Cost reductions** can occur for network operators through remote operation of meters, lower reading costs, avoiding investment in peak generation.
  - **Lower energy prices** may be reached if the traditional business model of the utility companies is revolutionised by crossing-over to a more collaborative and service-based business model, where consumers can have a better overview of their consumption and pricing, and have the opportunity to switch between providers.

## **5.2** Barriers

The survey of smart grids projects conducted by JRC in 2011 (see Giordano et al, 2011) points to several barriers that the smart grids market faces in Europe. On the one hand, further investments for overcoming technological challenges and innovation are needed. On the other hand, further challenges are represented by the European electricity market features, where the specific segmentation of the market makes it unclear how the costs and benefits of smart grid investments should be shared between the market players. In addition, the European consumers have shown rather low demand for smart grid services so far.

- **Multidisciplinary cooperation** between organisations: establishing consortia of network operators, academia, research centres, manufacturers and IT companies.
- **System integration:** integrating different Smart Grid technologies and ICT. Ideally, using smart grid systems would transform the "one way transactions of the current electricity supply for passive consumers into a market platform for electricity supply and services among several heterogeneous and distributed grid users" (see EC JRC, 2011, p. 35). In this perspective, there are several challenges:
  - The physical infrastructure needs to be improved across the value chain, from electricity generation, to the transmission grid, and at the distribution level. Particularly the upgrading ICT infrastructure is key for sharing information, pricing and control signals among users and producers
  - The smart grids market needs to reach the point where transactions of electricity services of a wide scope are allowed between consumers, producers and prosumers (consumers of energy that can also be producers).
  - The creation of a "distributed collaborative market" that allows the integration of new technological components and the participation of new energy players (e.g. aggregators, who can be intermediaries of transactions between grid users). An example are the multi-sided platforms (MSP), which "provide goods or services to two or more

distinct groups of customers who need each other in some way and who rely on the platform to intermediate transactions between them" (EC JRC 2011, p. 38).

- **Regulatory challenges:** Distribution System Operators are major investors in Smart Grid systems; the current incentive system is not favourable for upgrading the grids to incorporating smarter systems; new incentive schemes are needed that facilitate the network operators' transition towards a service-based business model (see EC JRC 2011, 2011, p. 8). In addition, aggregators play an important role in setting up multisided platforms, but the costs and benefits sharing structure is currently not fairly structured between the market players.
- **Demand for smart-grid services in households.** Smart grids need smart users, as the former have strong potential for increasing consumer awareness and participation in the electricity market. However, according to a global survey performed in 2011, 75% of electric utility customers in 13 countries rated their relationship with their energy supplier as negative, showing the lack of trust between consumers and energy providers (see Ernst & Young, 2011). The survey also shed light on the lack of understanding of the smart grids' benefits for consumers (ibid). Thus, better communication of the costs and benefits of the smart grids system to consumers is needed. Ensuring the participation of consumers early on in the development of smart grid projects is key.
- The challenges of the ICT component. Interoperability, data privacy and cyber security are top requirements for a secure smart grid system. Standardization efforts are under way in Europe, and tackling these issues would reduce transaction costs for smart grid users.
- **Knowledge sharing:** dissemination of good practices among smart grids stakeholders is crucial, and efforts are needed for a common data collection structure and common definitions or terminology. In addition, the

## 5.3 Applications and future opportunities for smart grids

Figure 4 below explains in a nutshell the general functionalities of the smart grid systems, from supporting customers to oversee their usage of energy, to integrating renewable energy sources better into the energy distribution system.

Customer applications support	Smart meters / advanced metering infrastructure allow:	Grid applications drive:	Integration of renewables and distri- buted energy facilitate:	Data, IT systems integration and back- office allow:
<ul> <li>In-home display with real-time usage and pricing stats</li> <li>Usage aware applications</li> <li>Home automation</li> </ul>	<ul> <li>Report usage by time and outages in real time</li> <li>Remote disconnect</li> <li>Operational improvements for distribution companies</li> </ul>	<ul> <li>Automation of the grid</li> <li>Reduction in losses</li> <li>Remote monitoring</li> <li>More accurate balancing</li> </ul>	<ul> <li>Integration of back-up generators, storage, distributed solar</li> <li>Disconnection in case of network overload</li> </ul>	<ul> <li>Integration of front-end engineering, middleware and back-office systems</li> <li>Data collection and decision analytics</li> </ul>

Figure 38 Key smart grids components and applications

Source: Mckinsey & Co, 2010.

- 5.4 Example of existing platforms and associations in Europe
- EC Energy Smart Grids Task Force
   <u>http://ec.europa.eu/energy/gas\_electricity/smartgrids/taskforce\_en.htm</u>
- European Smart Grids Technology Platform
   <u>http://www.smartgrids.eu/</u>
- EDSO European Distribution System Operators' Associations for Smart Grids

http://www.edsoforsmartgrids.eu/

• European Network of Transmission System Operators for Electricity ENTSO-E

https://www.entsoe.eu

 European Smart Metering Industry Group – ESMIG <u>http://www.esmig.eu/</u>

# 6. Analysis of the sustainable construction market

The construction sector is characterised by a complex value chain. It includes both basic manufacturing and supply of construction materials and a range of knowledge-intensive services provided by private enterprises and public knowledge organisations. An illustration of the construction sector value chain is provided below:



Figure 39 Value chain of the construction sector (Ecorys, 2011)

According to an analysis by Global Construction Perspectives and Oxford Economics<sup>33</sup> the global construction market will grow from \$7.2 trillion in 2011 to \$12 trillion by 2020. By 2020, emerging markets will account for 55% of global construction (46% in 2011), and 16.5% of their GDP.

Construction is a complex sector with wide variations in buildings and energy consumption from country to country, from one climate zone to another and between types of buildings. Within the European economy the construction sector generates almost 10% of GDP and more than 50% of fixed capital formation mainly in micro and small enterprises, which produce about 80% of the total turnover of this industry. It is the largest single economic activity and it is the biggest industrial employer in Europe with 7% of the workforce (20 million jobs)<sup>34</sup>. According to the European Construction Industry Federation, the sector indirectly and directly affects some 44 million workers. Noticeably the overall construction sector in the EU27 grew considerably prior to the beginning of the financial and economic crisis both in terms of persons employed (just below 3% per year during the period from 2000 to 2007 with lower rates in Manufacturing of construction materials and higher rates in Professional construction services) and in terms of turnover (also just below 3% per year over the same period with lower rates in Onsite construction and higher rates in Professional construction services). Growth rates were

<sup>&</sup>lt;sup>33</sup> Global Construction Perspectives and Oxford Economics (2011), "Global Construction 2020: A global forecast for the construction industry over the next decade to 2020." 2011

 $<sup>^{34}</sup>$  ECORYS (2011), Sustainable Competitiveness of the Construction Sector, Final report to the European Commission, 2011

especially high in the EU12 with annual turnover growth rates close to double figures (about four times the EU15 average and almost doubling turnover levels in absolute terms from 2000 to 2007).

As reported by Ecorys (2011), the construction sector was however one of the hardest hit by the financial crisis (building and infrastructure works fell by 16 % between January 2008 and November 2011 across the EU-27). There have been severe drops in demand especially in the private residential market but also in other markets, e.g. the infrastructure market. Trends differ from one Member State to another. In some, the burst of the housing bubble was one of the triggers and has continued to significantly reduce activity in the sector. In others, the sector suffers particularly from the contraction of credit markets. Many of the companies that specialise in new private residential house building either have been declared bankrupt, have downsized dramatically or have shifted their attention to public housing and/or maintenance work. The constraints on public spending due to the crisis will put further pressure on investments in infrastructure works.

A current specific area of focus at the policy level is "Sustainable construction". The sustainability of a construction is measured throughout its life cycle and involves all the construction players. This multidimensional approach is not limited to the origin of the materials but focuses on every aspect of a building's performance. It includes: energy savings; CO2 emissions; the use of environment-friendly materials; the rational use of water; comfort; accessibility; costs; mobility; safety; health. According to the interim report of the Lead Market Initiative<sup>35</sup>, sustainable construction can be defined as a dynamic for developing new solutions involving investors, construction industry, professional services, industry suppliers and other relevant parties towards achieving sustainable development, taking into consideration environmental, energy, socio-economic and cultural issues. It embraces a number of aspects such as design and management of buildings and constructed assets, choice of materials, energy use, the physical and functional performances of building as well as interaction with urban and economic development and management. The very encompassing market area of sustainable construction involves environmental concerns (e.g. efficient electrical appliances and heating installations), users' health aspects (e.g. indoor air quality) and issues of convenience (e.g. related to elderly persons' independence). It encompasses developing sustainable solutions for residential and non-residential buildings as well as in infrastructure assets. The same report highlights that many technical solutions are already available for sustainable construction, but the demand is highly fragmented. Demand in Europe comes from various sources, private households, the business community and the public sector, which alone accounts for 40% of the demand for construction works (essentially infrastructure work). Residential and non-residential buildings are the main volume stream with about 80% of the total EU construction output. Buildings and new infrastructure represents 57% of the total activity. On average, construction expenditure per capita is 3 to 4 times higher in EU-15 compared to EU-12 but the growth rates are steadier in EU-12, especially for new construction and infrastructure work.

 $<sup>^{35}</sup>$  European Commission, Lead Market Initiative for Europe - Mid-term progress report SEC (2009) 1198 final

Buildings consume nearly 40 % of energy globally and consume over 50% of energy globally if construction materials are considered<sup>36</sup>. The construction sector is indeed the largest consumer of raw materials in the EU; construction and demolition activities also account for about 33% of waste generated annually (EEA 2010). Buildings also account for the largest share of the total EU final energy consumption (42%) with a further 5-10% being used in processing and transport of construction products and components, and produce about 35% of all greenhouse emissions.

#### 6.1 The sustainable construction market

## 6.1.1 Geographic markets

As the analysis of Ecorys (2011) shows, the construction sector in Europe is characterised by a high number of SMEs, a low level of cross-border activity and extensive use of subcontracting throughout the design and building processes. These traits are highly interrelated and give rise to a multitude of commonly disjointed, yet very competitive, price-based markets with severe implications for the individual enterprise's ability to absorb knowledge and information, utilise new technologies and take overall responsibility for the success of the final product or service. Three relevant market contexts can be mentioned:

- Leading designers, consultants and contractors operate in a global marketplace;
- The great majority of construction firms are not in competition with firms outside the EU;
- The smallest construction firms have competitors in the informal economy and the existence of this informal economy has implications for the development of a sustainable European economy, with good working conditions, etc.

Actors in the European construction market generally operate at the local, regional and in some cases, national level. While true of the construction sector in general, the above characterisation applies best to the principal markets for actual construction and maintenance activities. The small markets for knowledge-intensive services (design, management, planning concepts, and managerial and engineering services) are increasingly becoming internationalised if not globalised in many instances. The same is the case in the market for building materials, particularly on the supply side. Large multinational groups are already targeting an international market, especially in domains such as steel and glass. Even within onsite civil engineering and building work, international markets exist today for expert manual work teams who travel from construction site to construction site offering their unique competences at handling highly specialised construction functions and materials (for instance in relation to tunnel drilling or bridge building). Moreover, the enlargement of the EU has caused a temporary internationalisation of the most labour intensive market, i.e. the market for building completion, which will presumably persist until wages align between new and old Member States.

Recent studies indicate that the growth markets worldwide in construction will

<sup>&</sup>lt;sup>36</sup> WBCSD (2010) Transforming the Market. Energy Efficiency in Buildings.

be in other markets than the EU with the exception of certain new Member States such as Poland and Romania. Forecasts from the Global Construction 2020 study (Global Construction Perspectives and Oxford Economics, 2009), expects emerging markets in India, China, Asia Pacific, South and Central America, Middle East and Africa and countries like Poland, Romania and Russia in Central and Eastern Europe. Although the EU currently still represents the largest construction market in the world, the Global Construction Study estimates that emerging markets will increase from 35% of total global construction output in 2005 to 55% in 2020. Activity is predicted to be significantly stronger in Central and Eastern Europe than in Western Europe. The energy and environmental issues have created a new dynamic among companies and stimulated various public-sector initiatives which have become key factors in market competition. The potential threat of public expenditure cuts will likely influence the infrastructure in the Czech Republic, Ireland, Spain and the UK negatively.

Some of the large actors in the different subsectors currently operate across European borders and even in international markets (e.g., architects and engineering companies), while other actors in the value chain mainly operate in national or local markets. As a result, the different actors face very different challenges with regard to competitiveness and innovation. For the three subsectors, the global competition conditions are outlined below<sup>37</sup>:

- Onsite construction: This subsector is still almost exclusively dominated by local or national competition, especially concerning small and medium sized construction and refurbishment projects. Few exceptions are apparent in large-scale infrastructure projects in which consortia and/or firms from Member States or even countries outside the EU compete for business in Europe. However, most construction projects are won by national and even local construction companies.
- Professional construction services: Primarily undergoing local and national competition. 10% of activities of European engineering companies and 15% of European architectural company activities are international. Some design work is outsourced to countries with lower labour costs. Nevertheless, most architectural and engineering activities for the European market also take place in European professional construction services companies. A small group of architect and engineering firms have established global operations. However, most of them operate local departments with local engineers or architects and primarily address the national markets were they are situated. However, for large-scale contracts in developing countries, small and large European operators do compete with Professional construction services from different countries around the globe.
- Manufacturing of construction materials: The global competitive situation varies depending on the type and nature of building materials supplied. For some building materials global competition is very pronounced. For instance, this is the case for products where labour costs represent a significant part of total production costs and/or where transportation costs and compliance with standards and certifications do not represent a major barrier to distributing or

<sup>&</sup>lt;sup>37</sup> ECORYS (2011), Sustainable Competitiveness of the Construction Sector, Final report to the European Commission, 2011

producing the product worldwide. Another factor that influences global competition of building materials is of course the availability of raw materials. For some building materials, such as windows, doors and steel products, access to quality raw materials is essential if manufacturers are to be competitive. Some EU countries are actively encouraging and supporting building materials suppliers in the quest to set up production plants in future growth markets such as China, Russia and South America.

The table below summarizes the markets of the three main subsectors.

Markets for Onsite construction	Markets for Manufacturing of construction materials	Markets for Professional construction services
<ul> <li>Primarily national, regional and local markets</li> <li>Large enterprises increasingly embrace international activities</li> <li>Residential housing, commercial buildings, maintenance and renovation, infrastructure.</li> </ul>	<ul> <li>Internationally, nationally and locally oriented depending on product type.</li> <li>Increasing focus on emerging markets outside the EU</li> <li>DIY, building material wholesalers, architects, engineers, housing associations.</li> </ul>	<ul> <li>Primarily national and regional markets</li> <li>Some international orientation – particularly from large engineering service enterprises and smaller niche providers</li> <li>Private housing (architects), public and commercial buildings (architects, engineers), infrastructure (engineers), facility services.</li> </ul>

Figure 40 Markets of the different construction subsectors (Ecorys, 2011)

According to the NorthPass study (2012)<sup>38</sup>, in Nordic countries, where lowenergy buildings already have penetrated the housing market to some extent, focus should be on disseminating information, finding new marketing channels and encouraging state and municipalities to promote low-energy construction by their actions. In these countries there already exists an interest in sustainable construction and also required products and expertise are available in the market. In the Baltic countries and Poland, the political, economic and social environment is different and the first stage should be raising the awareness about low-energy construction among people, introducing more successful examples to potential buyers and bringing lowenergy products and cheap solutions to the market. The state could take a more prominent role also in these countries by introducing regulations, allowing financing opportunities and by demanding more energy efficiency in public procurement.

## 6.1.2 Main products and services markets

According to the forecasts, 60% of the residential output will come from renovation activity in 2013. Non-residential construction is forecasted to see the slowest recovery; the output in 2013 will hardly reach the level of the early 2000s. The total non-residential building stock of the eight countries studied in the OTB study (2008) is 43% of the residential building stock in terms of floor area. The percentages differ by country, being from only 4% in

<sup>&</sup>lt;sup>38</sup> Northpass (Promotion of the Very Low Energy House Concept to the North European Building Market) (2012), Final Results Report

Switzerland to 57% in Finland and 31% at the European level<sup>39</sup>. The large differences observed between countries are, however, directly related to the population of each country, at least for the residential sector<sup>40</sup>.

Figure 41 Residential and non-residential floor areas per country (OTB, 2008)



Although the residential sector accounts for about 70% of the total building stock, the non-residential sector is not negligible. In all the countries, office buildings have often already been renovated and the degree of penetration of sustainable renovation seems to be higher than in other sectors, not least because of image. The shopping and leisure sector accounts for a large part of the non-residential sector, in terms of floor area and also in terms of energy use. This is also a complex sector because next to large chain stores, a large part of the market consists of small shops with a high diversity of activities.

Currently, both space heating and cooling as well as hot water are estimated to account for roughly half of global energy consumption in buildings (IEA, 2011). The importance of space heating and cooling varies by country and region depending on climate and income. In OECD countries, most energy in the building sector is used for space and water heating, while the energy consumption for cooling is generally modest. In hot countries, with little or no space heating needs, cooling is much more important and given the largely immature market for cooling in these countries, represents a significant source of future energy demand growth. OECD countries dominate the market for space and water heating, but not for cooling, or for individual technologies<sup>41</sup>. The global market for heating and cooling is very large, with the market for cooling worth as much as \$70b in 2008. As reported in OTB (2008), electricity use for major household appliances (white goods) and lighting also has a large share (60%) and this share increases regularly. Brown goods (small electrical appliances) consume about 40% of the total electricity used by European households. Although there is a strong increase in renewable sources, the

 $<sup>^{39}</sup>$  At the European level, only the cold and moderate climate zones were taken into account, and Switzerland was not accounted for in the data

<sup>&</sup>lt;sup>40</sup> OTB (2008), Building Renovation and Modernisation in Europe: State of the art review, Research carried out at the request of ERABUILD

 $<sup>^{\</sup>scriptscriptstyle 41}$  International Energy Agency (2011), Technology Roadmap - Energy-efficient Buildings: Heating and Cooling Equipment

energy supply still relies largely on fossil fuels. However, the use of combustible renewable and waste sources is high (more than 20%) in Austria, Finland, and in the residential sector in France. Electricity also has, as an energy source, a high share in all countries. District heating has a high degree of penetration in Finland, Sweden and Germany. The sustainability of the electricity production differs a lot by country. Austria, Sweden and Switzerland largely use hydropower (more than 50%). France, Sweden and Switzerland also use nuclear power (75%, 50% and 45% respectively). Except for hydropower, renewable energy sources are used in a very limited way for electricity production with biomass and waste being the most utilised and wind having the fastest growing share.

Figure 42 Energy use as a percentage of household energy consumption, WBCSD (2009)<sup>42</sup>



Several markets with potential were identified with the Lead Market Initiative<sup>43</sup>:

• Lower material use and waste: The construction activity intrinsically requires a lot of raw material per unit of production and Construction and Demolition Wastes are proportionally significant in quantitative terms. However, this leaves room for rationalisation and large improvement in the sector. Most of C&DW are today recycled or re-used principally in the form of embankment. A significant proportion could potentially be used as a substitute for newly quarried aggregates in certain lower grade applications.

<sup>&</sup>lt;sup>42</sup> The Energy Efficiency in Buildings (EEB) study was performed with the World Business Council for Sustainable Development (WBCSD) and sponsored by 14 multinational companies at a total cost of US\$15m over four years. The study's recommendations are based on a data inventory of the building stock in six of the world's largest economic regions (Brazil, China, EU, India, Japan and USA) accounting together for 70% of the world's GDP, and divided between residential and commercial and existing and new building types. Financially driven behaviors against energy-efficiency technologies were modeled to show costs and savings under multiple scenarios.

<sup>43</sup> European Commission (2007), Lead Market Initiative for Europe - Background document

- *Lower energy consumption*: Heating and lighting of buildings accounts for the largest share of energy use (42%) and produces about 35% of all greenhouse emissions. The European passive house market is in rapid growth with approximately 1000 new dwellings per year but this represents only 0,1% of the total new construction today. Still, many existing houses have not yet a roof insulation and double-glazing.
- *More comfortable, healthy, accessible indoor environment:* Incorrect air ventilation due to increased thermal insulation and air infiltration tightness as well as thermal bridges in the building structures are the origin of condensation of water and microbial growth, and a faster deterioration of building material.

Within the NorthPass project<sup>44</sup> two surveys were compiled with the view to examine the attitudes of individual builders and real estate experts in eight Northern European countries. In general, the individual house builders were interested in the opportunity to construct a house according to low-energy standards, even if extensive measures might not have been implemented yet. Many of the respondents in all countries stated that they would be willing to pay an extra investment cost for low-energy buildings but in many cases the amount was not remarkably high and it might not reach the actual extra investment costs estimated by the experts. According to the estimations, in most Nordic countries, energy efficient construction have already entered the market to a large extent as a remarkable percentage of the newly built houses are low-energy houses (for example in Finland 31% and in Denmark 25%). Also the very low-energy houses have entered the market to some extent: In Finland 8% and in Denmark 5% of houses built in 2011 were very low-energy houses. In the Baltic countries and Poland the situation is not as good, as there are only few or no very low-energy houses, and also low-energy houses have reached a market share of only few percentages. However, a promising market potential seems to exist.



Figure 43 Willingness to pay extra in order to build a low-energy house, NorthPass (2012)

## 6.1.3 Applications and future opportunities for sustainable construction

In terms of future opportunities for sustainable construction, one might distinguish between the different market segments (residential market, the

<sup>&</sup>lt;sup>44</sup> NorthPass (Promotion of the Very low-energy house Concept to the North European Building Market) (2012), Final report on results, Project of Intelligent Energy Europe

non-residential market and the infrastructure market) and the specific regional context. For all three market segments, the EC<sup>45</sup> highlights that innovation will have to respond to an increasingly differentiated ownership and usage of premises and facility services, as well as to sustainability issues and life-cycle considerations which will become important decision-making criteria. This includes a growing importance of retrofitting of buildings and infrastructure: land-use and resources constraint will lead to opt more often for retrofitting instead of (demolishing and) building new products:

- The residential market:
- The users' requirements will change more frequently than before. This behaviour should be anticipated in design and construction processes, for instance by separating the technical utilities from the main structure. Renovation will integrate new components and prefabricated products which can be installed and used rapidly;
- Accessibility and flexibility will be significantly improved in dwellings throughout their life cycle for all types of users and ages;
- There would be an increased emphasis on energy efficiency, environmental, water, health and safety issues in the selection of materials and structural components;
- The passive house concept will be more and more widespread even in warm climate conditions, as well as the integration of renewable energies;
- Building management systems would enable occupants to control a greater variety of functions for a better comfort (ventilation, air filtration, temperature, lighting, etc.). ICT will facilitate remote supervision and control of appliances, equipment and security systems;
- There would be a growing demand for improving the access to affordable and decent homes and for a more harmonious urban and social mix;
- The non-residential market:
  - The requirements for improved energy efficiency and the integration of renewable energies would influence both the building structure and its utilities;
  - Indoor air quality would be considered as a factor affecting comfort and work efficiency. This will require meeting different needs in terms of heating, cooling, ventilation, lighting and acoustic levels;
  - Business premises will more often be occupied by fast growing and changing organisations which will require business-related facility services. Requirements for adaptability and divisibility of the premises will stimulate the development of new structural and system technological solutions, which will be facilitated by the expansion of the wireless data transmission.
- The infrastructure market:

 $<sup>^{45}</sup>$  European Commission (2007), Lead Market Initiative for Europe – Background document

Investment will be assessed on a more strategic approach towards the long term functional characteristics of the infrastructure and the associated life-cycle costs.

In relation to the increased focus on climate change, the market for ecoefficient buildings, which is populated by a huge variety of concepts (sustainable buildings, green buildings, passive houses, low-impact buildings, low-energy-buildings and zero-energy buildings), will be a major area for construction companies to invest in technology and innovation.

Figure 44 On-site technologies that are expected to have the greatest increase in market adoption over the next ten years



In the construction stage this could include new ways to design buildings composed of materials with low embodied energy (low energy for transportation, low energy for manufacturing and building products etc.) or design buildings with low service frequency (i.e. high level of physical durability, easy maintenance of buildings, physically adaptable to change of use) and the minimisation of waste, basically in the construction phase and in the demolition phase (reduction of the quantity of materials used but also a high level of physical durability, easy maintenance of buildings, and low barriers to physical adaptability to change of use.

Another technological element driving innovation in the construction sector is the use of IT in constructions, such as smart home technologies, smart construction or intelligent houses<sup>46</sup>. ICT is also important as a supporting technology that helps optimise production processes and logistics as well as it might form the basis for developments with regard to service innovation and new business models in the sector.

Another key technology for the Manufacturing of construction materials subsector is nanotechnology. The nano-based building products that are currently available on the market include concrete and cement products, nano paint and insulation materials. The market share of nano-based products is expected to grow. However, an important issue that may have a negative impact on the future development and use of nano-based products is the

Source: 6th annual survey practices of decision makers responsible for energy use in buildings led by the Institute for Building Efficiency, 2011

<sup>&</sup>lt;sup>46</sup> ECORYS (2011), Sustainable Competitiveness of the Construction Sector, Final report to the European Commission, 2011

uncertainty concerning the impact of nano particles on human health and the environment. Finally, innovation in other industrial sectors may contribute to the development of new building products. One example is the development and use of geotextiles for construction projects. Geotextiles have been used in the construction sector for decades, but textile-based materials are increasingly being explored from a design perspective as such products allow for the creation of innovative structures.

Some examples of areas of opportunity were identified in an INNOVA expert workshop in June 2009:

- Green smart technologies, i.e. technical devices designed to reduce the consumption of energy, automatic and intelligent systems which control heating, ventilation, sun blending, etc.;
- Ambient assisted living, including smart technologies to assist the elderly and other people with special needs; and
- Technical gadgets, including intelligent installations allowing people to improve their standard of living and quality of life.

The use of Building Information Modelling (BIM) is another key technological development in the sector. The purpose of BIM is to use three-dimensional, real-time, dynamic building modelling software to manage the entire building process and thus increase productivity in building design and construction. Through the use of such systems, a project's key functional and physical characteristics can be explored digitally before it is built. The use of BIM requires solid digital skills, increased focus on the building process as a whole and a higher degree of information sharing than what most architects and engineers are traditionally used to.<sup>47</sup>

Box. Examples of Integrated Climate-Friendly Design in Buildings

- Enhanced structures that can manage future winds, subsidence and heave.
- Heating, ventilation, and air conditioning systems that can be adjusted for new climates such as areas with increased heat waves.
- Passive cooling to avoid discarding heat that can worsen heat islands.
- Drainage systems, permeable paving and entrance thresholds that can handle more intense rainfall.
- Exteriors of buildings designed to reduce heat gain in the summer to better handle heat waves; insulation that allows poor households to stay warm during extremely cold winters; exteriors that provide the level of precipitation resistance needed for a new climate.
- Water usage efficiency to help tackle freshwater scarcity.

Source: ICLEI Resilient Cities Conference (2011) 48

The International Energy Agency (IEA), at the request of the G8, is developing a series of roadmaps for some of the most important technologies needed for achieving a global energy-related Carbon dioxide (CO2) target in 2050 of 50% below current levels. Within the IEA roadmap from today to 2050 dedicated to heating and cooling in buildings<sup>49</sup>, the key technology options have been narrowed down to those with the greatest long-term potential for reducing

<sup>&</sup>lt;sup>47</sup> ECORYS (2011), Sustainable Competitiveness of the Construction Sector, Final report to the European Commission, 2011

<sup>&</sup>lt;sup>48</sup> Institute for Building Efficiency (2011), Driving Transformation To Energy Efficient Buildings: Policies and Actions

<sup>&</sup>lt;sup>49</sup> The IEA roadmap on heating and cooling technologies is the first to be published for the buildings sector. Future efforts will look at the building shell, lighting and system issues.

CO2 emissions. According to the IEA (2011), R&D efforts should focus on reducing costs and improving the efficiency and integration of components. R&D into hybrid systems could lead to highly efficient, low-carbon technologies (*e.g.* integrated solar thermal/heat pump systems, CHP). According to IEA (2011) low/zero-carbon and energy-efficient heating and cooling technologies for buildings have the potential to reduce CO2 emissions by up to 2 gigatonnes (Gt) and save 710 million tonnes oil equivalent (Mtoe) of energy by 2050.

Figure 45 Buildings sector energy savings by 2050 by sector and end-use, BLUE MAP scenario, IEA (2011)



Most of these technologies – which include solar thermal, combined heat and power (CHP), heat pumps and thermal energy storage – are commercially available today such as Active solar thermal (AST). It can provide space and water heating, as well as cooling needs.

Solar thermal technologies provide heat that can be used for any lowtemperature heat application in buildings, incl. space and water heating, and cooling with thermally driven chillers. They include a range of commercial technologies and systems that are competitive for water heating in markets where low-cost systems are available, energy prices are not low and solar radiation is good throughout the year. However, for solar to meet a larger share of the building sector's space heating and cooling needs, costs will have to come down and performance improve. Cost reductions and improved performance are likely as there is substantial room for innovation and for improving existing technologies and applications, as well as commercialising emerging technologies such as solar cooling. Active solar thermal systems can be applied almost anywhere and do not require any energy infrastructure. They are either carbon-free or have very low emissions, associated with their electricity use for pumping and controls. Owners and operators of AST systems do not have to consider the risks of changing energy prices and potentially, carbon prices. An emerging application for AST systems is solar thermal air conditioning. Coupling solar thermal collectors with thermally driven chillers would enable systems to meet space heating and cooling, as well as hot water demands. The dominant technology of thermally-driven chillers is based on sorption. Solar cooling is attractive because solar radiation usually coincides closely with cooling loads, while many service-sector buildings also have simultaneous heating and cooling requirements. However, costs will have to come down and a wider range of technology packages will

have to be developed, particularly for single-family dwellings, before solar cooling is likely to be deployed on a large scale.

Figure 46 R&D Roadmap of the International Energy Agency for Active solar thermal systems (2011)

Active solar thermal

This roadmap recommends the following actions on R&D:	Milestones
R&D into the integration of solar thermal collectors into building shells and the development of low-cost multifunctional building components incorporating collectors. R&D into alternative materials for use in collectors	From 2011, deployment of new collectors between 2015 and 2030.
that can reduce costs and improve performance.	Single-family dwelling cost: 2020 -30% 2030 -50%
R&D for desiccant and sorption systems, and high-temperature solar collectors for solar cooling (reduced costs, improved performance, development of small-scale thermally-driven chillers).	2012-20
Development of systems and designs suitable for large-scale mass production that incorporate the latest materials.	2011-20
RD&D into customisable, optimal control systems capable of exchanging information with energy networks and building management systems. Optimising hybrid systems ( <i>e.g.</i> solar thermal/heat pump systems) to achieve very high efficiency heating and cooling systems, with large CO <sub>2</sub> emissions reductions.	2012-25

Combined heat and power (CHP): Traditional CHP systems are mature and a useful transitional technology, while micro-CHP, biomass CHP and even fuel cell systems (using CO2-free hydrogen) may emerge as an important abatement option:

Combined heat and power is the simultaneous production of electricity and heat (for space and/ or water heating), and potentially of cooling (using thermally driven chillers). CHP technologies can reduce CO2 emissions in the building sector today in a wide range of applications, depending on the fuel chosen, its overall efficiency and the avoided CO<sub>2</sub> from central electricity generating plant. CHP can reduce transmission and distribution losses, and improve energy security and the reliability of energy supplies, particularly when combined with thermal energy storage. There are several mature CHP technologies, including reciprocating engines and turbines. Newer CHP technologies that are not yet fully commercialised, such as fuel cells and stirling engines, are beginning to be deployed. Small-scale plants - so called mini-CHP or micro-CHP - can meet the needs of individual buildings or houses. There are a number of mature technologies available, as well as some that are not widely deployed and others that still require further R&D. Recent and future technological developments may expand the range of cost-effective applications for CHP in buildings. The main CHP technologies are: microturbines, fuel cells, reciprocating engines, stirling engines, gas turbines. Fuel cells, an emerging technology, provide a higher proportion of electricity than other CHP technologies. There remain challenges to the widespread uptake of CHP technologies in the residential sector, however, including their high first costs, scaling issues and regulatory and information barriers. In the service sector, some sub-sectors have proportionately larger water and space heating and cooling loads, with more stable loads throughout the year, which significantly improves the competitiveness of CHP solutions.

# Figure 47 R&D Roadmap of the International Energy Agency for Combined Heat and Power (2011)

#### Combined heat and power

This roadmap recommends the following actions on R&D:	Milestones
Development of PEMFCs and SOFCs (around 1 kW to several hundred kW class for residential use) with higher efficiency and durability, and lower costs. R&D on lower-cost fuel cell stacks (membranes, bipolar plates and gas diffusion layers) and balance of plant (inverters, controls, etc.), as well as reduced parasitic losses.	2015-20
RD&D to improve microturbine performance and efficiency, as well as reducing costs. Increase flexibility of systems to adapt to varying demand and electricity/heat demands.	2011-25
R&D to improve efficiency and costs of fossil fuel-fired reciprocating engines and gas turbines. Reducing local pollutant emissions, particularly for reciprocating engines.	2011-25
Development of large scale SOFC (hundreds kW class for commercial use) by establishing technologies for integration of cell- stack modules as well as R&D for hybrid fuel cell-gas turbine systems, with MW-scale capacities and very high efficiencies.	2015-25
Develop standardised CHP packages and operational strategies for different market sub- sectors and application profiles: provide professionals with simulation and optimisation tools.	2012-25

*Heat pumps* for cooling and space and water heating are mature, highly efficient technologies that take advantage of renewable energy:

Heat pumps provide space heating and cooling, and hot water in buildings. They are the predominant technology used for space cooling, either in simple air conditioners, reversible air conditioners or chillers. Heat pumps are highly efficient, although their overall primary energy efficiency depends on the efficiency of electricity production (or other energy source) they use. They are proven, commercially available technologies that have been available for decades. Annual sales of air conditioners were estimated to be worth more than \$70b in 2008<sup>50</sup>, with sales of room air conditioners in China alone estimated at 27 million units in 2009, a 35% increase over 2005 sales. Globally, an estimated 800 million heat pump units are installed (including room air conditioners, chillers, and heat pumps for space heating and hot water).

Figure 48 R&D Roadmap of the International Energy Agency for Heat Pumps (2011)

Heat pumps

This roadmap recommends the following actions on R&D:	Milestones
R&D into more efficient components and systems for heat pumps for	20% improvement in COPs by 2020; 50% by 2030
heating and cooling applications, as well as to reduce inst-costs for heat pumps for heating and cooling.	15% reduction in costs by 2020; 25% improvement by 2030
More efficient integrated heat pump systems (capable of simultaneous space/water heating and cooling) capable of meeting needs of low- energy buildings and interfacing with smart grids/home energy management systems.	Begin deployment in 2015, widespread deployment from 2020
Efficient low-temperature space heating systems and high-temperature space cooling systems integrated with heat pumps.	All new buildings capable of accepting low-temperature heating/high-temperature cooling by 2020 in OECD
Development of hybrid heat pump systems ( <i>e.g.</i> with solar thermal) with very high efficiency and CO <sub>2</sub> savings	Widespread deployment from 2020-25

*Thermal storage* includes sensible (hot water, underground storage) and latent ("phase change" ice storage, micro-encapsulated phase-change materials) and thermo-chemical storage. Thermal storage can maximise the

<sup>50</sup> See www.bsria.co.uk/news/global-air-conditioning-sales-reach-us70-billion-in-2008/

energy savings and energy efficiency potential of other technologies, facilitate the use of renewables and waste heat, and improve flexibility, helping to minimise the overall system cost.

The installation of larger-scale ice and chilled water storage is growing rapidly in some countries as utilities seek to reduce peak loads and customers seek to reduce peak load charges. Thermal energy storage will also be the key to solar systems providing a larger share of household space and water heating and cooling, when low-cost compact thermal storage systems or centralised largescale thermal storages systems become available. This will allow much larger solar systems than are used today, with surplus heat being stored until the winter enabling 100% of space and water heating needs to be met depending on system design. Sensible heat storage systems (e.g. hot and chilled water) and some latent heat stores (e.g. ice storage) are mature technologies. However, developments in advanced phase change materials (PCM) and chemical reactions are creating new application possibilities, such as PCMs embedded in building materials such as bricks, wall boards and flooring. Current R&D is focused on reducing the specific costs of high-density storage, which are still too high for many applications in buildings.

Figure 49 R&D Roadmap of the International Energy Agency for Thermal energy storage (2011)

#### Thermal energy storage

This roadmap recommends the following actions on R&D:	Milestones
Foster collaboration on basic science (thermodynamics and material development) and applied R&D (system integration, and centralised and building applications) for sensible, PCM and thermal-chemical stores.	2012 onwards
Invest in R&D to develop promising materials for compact thermal energy stores, particularly phase change materials and thermo-chemical stores. Validate stability of materials, performance characteristics and cycle life.	2012- 2020
Establish R&D collaboration with end-use technologies that will benefit from thermal energy stores (improved performance, reduced cost, greater CO <sub>2</sub> reductions). Key technologies are AST, heat pumps and CHP in buildings.	2013 onwards
Develop and demonstrate heating and cooling systems with integrated, advanced compact thermal energy storage systems (based on PCMs or chemical reactions) in order to optimise performance and identify pathways to reduce costs for compact thermal energy storage.	2015-25

Other technologies play an important, but the contribution is smaller and is thus not covered in the IEA roadmap. These include efficient fossil fuel technologies, such as condensing boilers, biomass and biofuels.

OTB (2008) also identified strategic research themes for the future of building renovation and modernisation: research on life cycle costing and value-added chain of construction products; post-occupancy evaluations; research on sustainable urban communities and citizen participation; overall environmental impact of buildings (LCA); impact of renovation on indoor air quality; research on standard solutions for the implementation of renewable energy in buildings and neighbourhoods; use of 3D modelling GIS techniques for renovation; practical research on (new) insulation techniques for solid walls; practical research on new or better components; practical and cheap concepts for continuous monitoring and control of HVAC equipment; impact of occupant behaviour on energy conservation measures; sustainable financial constructions for renovation; demonstration and scaling-up projects; efficient building regulations and policies for renovation; and process and organisation models for different stakeholders.

The UNEP/GEF guidebook (2012) provides a detailed description of

mitigation technologies and practices in the building sector (design, construction, operation, and demolition of buildings) in order to assist countries to carry out Technology Needs Assessments. Mitigation from the building sector can be defined as deploying and implementing design strategies, technologies and practices that:

- Reduce energy demand and consumption associated with the buildings

   from design, construction, hand-over, operation to renovation and end-of-life;
- Switch to low- or no-carbon fuels;
- Maximise opportunities for buildings to sequester carbon;
- Catalyse behaviour change towards sustainable lifestyles.

The following figure provides an overview of the mitigation typologies associated with specific technologies and practices. The annex provides summary sheets for each mitigation technology and practice: Contextual applicability; Critical application requirements; Feasibility for implementation; Financial requirements; and Contribution to triple bottom line

Figure 50 Typologies of mitigation technologies and practices – Building sector UNEP/GEF (2012)

No.	Mitigation typologies	Technologies and practices			
		Site selection			
Description	Passive solar	Design responsive to the sun			
Prerequisite	design	Design responsive to wind			
		Use of thermal mass materials			
1	Advanced passive	Renovation and innovative use of traditional building materials and techniques			
	solar design	Passive house design and technologies			
		Life cycle and integrated design process			
0	Technologies that enhance	Building envelope thermal insulation			
2	solar design	High performance building façade systems			
	periormance	Daylight harnessing technologies			
		Highly efficient heating, ventilation and air conditioning systems			
3	Active design	Efficient lighting systems			
		Water efficiency technologies			
4	Low carbon and carbon	Carbon-sequestration and low-carbon building materials and products			
	sequestration	Greening and building integrated greenery systems			
-	Onsite renewable	Solar technologies			
5	energy generation	Building integrated wind turbines			
6	Monitoring and occupants'	Energy management and performance improvement			
	feedback loop	Behaviour change catalysts			
7	Beyond	Community based energy services			
'	buildings	Sustainable community design and practices.			

Numerous demonstration programmes in Europe and elsewhere show the

significant potential for sustainable construction. Europe has notably launched various programmes such as ECO -BUILDINGS (more than 100 projects from FP5, FP6 and FP7 in many different European cities), CONC ERTO (18 projects from FP6 and FP7 covering 46 different CONC ERTO communities), SAV E projects, ERACO BUILD as well as a number of related national programmes. The Energy-efficient Buildings Public Private Partnership in particular is a joint initiative of the European Commission and the E2BA to promote research on new methods and technologies to reduce the energy footprint and CO2 emissions related to new and retrofitted buildings across Europe. E2BA is an initiative that span out of the European Construction Technology Platform (ECTP). It notably produced a list of projects supported under the FP7 research programme, ranging from cost-effective superinsulating materials and multifunctional vacuum-insulating panels using nanotechnology to intelligent energy-management systems. The projects demonstrate scientific and technological excellence, and discuss approaches for dissemination and exploitation of results. Projects aim at introducing new products and processes into the market and some of them are already demonstrating potential for commercialisation:

- Demonstration of Energy Efficiency in Buildings: BEEM-UP; E2ReBuild; School of the Future
- Improving the Energy Efficiency of Historic Buildings in Urban Areas: 3ENCULT
- ICT for Energy-efficient Buildings and Spaces of Public Use: ICT4E2B Forum; EnRiMa; Sporte2; REViSITE; TIBUCON; SEEMPubS; HESMOS
- New Nanotechnology-based High Performance Insulation Systems: NanoInsulate; NANOPCM; COOL-Coverings; NANOFOAM; AEROCOINS
- New Technologies for Energy Efficiency at District Level: FC-district; e-hub;
- PPP Related FP7 Projects: Clear-up; H2SusBuild; MESSIB
- Cost-Effective Demonstration of Very Low Energy New Buildings: BioBuild; BUILDSMART; DIRECTION; NEED4B; NEXT-buildings
- Energy saving technologies for buildings envelope retrofitting: EASEE; MEEFS
- Geo-clusters approach to support European energy efficiency goals: GE2O
- ICT for Energy-efficient Buildings and Spaces of Public Use: BEAMS; CAMPUS21; Cascade; IREEN; KnoholEM; S4EeB; SEEDS
- Materials for new energy efficient building components with reduced embodied energy: SUS-CON
- New efficient solutions for energy generation, storage and use related to space heating and domestic hot water in existing buildings: EINSTEIN; HEAT4U
- Operational Guidance for Life Cycle Assessment studies of the Energy Efficient Buildings Initiative: EeBGuide; SEAM4US
- Technologies for ensuring, monitoring and/or controlling a high quality indoor environments: CETIEB; INTASENSE.

6.2 Drivers and barriers for the sustainable construction industry

6.2.1 Main drivers for the development of the sustainable construction industry

The future development of the construction sector is situated in a complex duality between the sector's own internal dynamics and the sector's external framework conditions, which vary considerably among Member States. In particular it must be first emphasised that the construction sector is highly regulated at European and national level, in particular with respect to environment and to the materials in use. Builders, design services and specialist contractors have to observe building regulations. Their formulation, legislation and enforcement (control of application and building inspection) are Member States' competence, often with considerable power given to regional and local authorities according to the individual constitutional and administrative system. This responsibility is rather fragmented within various administrations.

There are also global challenges that can become enablers of sustainable growth in the medium term with the development of a range of services to address issues such as health and safety, energy efficiency, green building, disaster resilience, indoor climate, re-use/recovery/recycling and design to fit. If properly addressed, these challenges could also open up new market opportunities.

According to Ecorys (2011), a number of factors are likely to influence the future competitiveness of the construction sector (in a 10-year perspective) and to improve quality and productivity:

- Access to a qualified labour force;
- Access to finance and new financial models;
- Closer customer and end user relations and process innovation;
- Professionalisation of the clients;
- Access to applied R&D and technology transfer such as new technologies, materials, smart and eco-efficient solutions and buildings;
- New service models to complement actual construction, retrofitting and renovation activities;
- Modularisation and pre-assembling;
- Coordination across actors to achieve lean construction; and
- Orientation towards future growth markets outside the EU.

In the Delphi survey of the 2011 Eco-Innovation report, experts identified the strongest drivers of eco-innovation in the construction sector as being a good skills base and strong collaboration between research, experts and business. Additionally, the regulatory and policy framework are seen as having growing importance, especially concerning ambitious regulations and standards as well as government subsidies and incentive based programmes. Market drivers are among the relatively weakest determinants of eco-innovation in the construction sector: the prices of building materials and the competition for innovative building components are not currently considered strong incentives to eco-innovate. The relevance of both drivers is expected to slightly grow in the future.

Figure 51 Drivers to eco-innovation in the construction sector according to the Eco-Innovation Observatory Delphi survey (2011)

	Drivers	2010	2015	2030
Economic and	Competition for innovative building components	2,9	7	77
financial factors	High price of building materials (as an incentive to search for substitutes)	2,8	7	ิสส
Technological	Innovative technology development	3,2	7	77
factors	High research and development activity in the construction sector	3,2	7	ิสส
Environmental	Scarcity of materials for energy and resource-efficient technologies	2,6	Я	77
factors	Favourable geographical location (e.g. stable temperatures, ground composition)	2,4	7	Я
	Building planners skilled in sustainable construction (architects, engineers, etc.)	3,5	7	7
Socio-cultural	Strong collaboration between research, experts and business in the sector	3,4	7	7
	High level of awareness of building/home owners	3,3	7	77
Tactors	Handworkers skilled in sustainable construction (electricians, plumbers, etc.)	3,3	Я	я
	High level of acceptance of building/home users	3,3	7	ิสส
	Ambitious building regulations and standards	3,4	7	77
Regulatory and	Subsidies and programmes for sustainable construction	3,4	я	7
framework	Green public procurement	3,0	Я	77
In a memoria	Construction materials tax	2,5	7	Я

As highlighted by the WBCSD (2012) the energy transformation of the building sector in particular will require integrated actions from across the building industry, from developers and building owners to governments and policy-makers:

- Strengthen codes and labelling for increased transparency;
- Incentivize energy-efficiency investments;
- Encourage integrated design approaches and innovations;
- Develop and use advanced technology to enable energy-saving behaviours;
- Develop workforce capacity for energy saving;
- Mobilise for an energy-aware culture.

Figure 52 Drivers of organisation's energy efficiency decisions

How significant are the following in your organization's energy efficiency decisions?

2012 Global	Drivers of efficiency	2012 Europe	2012 UK	2012 Germany	2012 France	
1	Energy cost savings	1	1	1	1	Energy
2	Government/utility incentives/rebates	3	2			Security
3	Enhanced brand or public image	6				is #2 driver in Europe, China
4	Increasing energy security	2		2	2	
5	Greenhouse gas reduction	4		3	3	Increasing
6	Increasing asset value	5	3			asset value
7	Customer attraction/retention	7				4 <sup>th</sup> in France and
8	Existing government policy	8				

Source: 6th annual survey practices of decision makers responsible for energy use in buildings led by the Institute for Building Efficiency, 2011

Figure 53 Energy policies that would have the greatest impact on improving energy efficiency in buildings



Source: 6th annual survey practices of decision makers responsible for energy use in buildings led by the Institute for Building Efficiency, 2011

# 6.2.2 Main barriers/challenges for the development of the sustainable construction industry

As already recognised within the interim evaluation of the European Lead Market Initiative (2009), the construction market is facing significant challenges, not only in terms of its influence on energy and climate change, but also in terms of its impact on natural resources (energy, water and materials) and users' convenience and welfare (accessibility, safety & security, indoor air quality, etc.). This is particularly relevant for the existing building stock which has a significant socio-cultural value for the society and at the same time accounts for by far the most carbon emissions and the greatest energy saving potential.

Ecorys (2011) identifies the key challenges of the construction sector as the following:

- **Poor innovation performance** in the sector: There is a need to boost R&D participation, technology transfer as well as non-R&D based innovation through market and employee driven innovation, regrouping of firms in networks and clusters to address issues of scale.
- **Poor productivity levels**: Market and employee driven innovation is poorly deployed due to primary focus on cheapest price instead of the economically most advantageous proposal, but also because of poor deployment of enabling technologies, insufficient use of flexible work organisation practices. The sector is missing opportunities to add significant value to the economy, addressing the grand challenges as well as being more profitable.
- Narrow skill sets in large parts of the sector may hinder it in becoming more competitive and in meeting new demands for high performance construction products and services in the market. One issue is that generic skills associated with 21st century jobs and

occupations so far are only addressed and integrated in VET and CVET provisions in varying degrees. Generic skills such as problem orientation, problem solving, communication, design and entrepreneurial skills - are critical for cross-occupational collaboration in work teams and for exploiting value added creation at the firm level.

- **General macroeconomic environment**: During the financial crisis the sector has been impacted by severe drops in demand especially in the private residential market, but also in other markets. The infrastructure market has so far been the least affected due to already scheduled investments. However, public spending is also under pressure due to the crisis (targets are to reduce deficits by 50% by 2013 and the public revenues and costs should be balanced by 2016). Some countries have invested in stimuli packages as part of a post crisis strategy. It could, however, be argued that stimuli packages that do not contribute to increased productivity and innovation capacity and a greening of the economy will have limited effect.
- **Demographic change**: The ageing of societies will influence the future tax revenue of states, availability of workforce and will create new market opportunities for the sector.
- **Labour market conditions**: When the economy improves, the intra EU competition for skilled labour will likely return, and skills shortage and gaps could again become an issue for the sector in some countries.
- **Major drivers of structural change**: There are global challenges that can become enablers of sustainable growth in the medium term provided appropriate measures are taken now as this could result in the development of a range of technological services to address such issues as health and safety, energy efficiency, green building, good indoor climate, and renovation processes and materials, design to fit. If rightly addressed, these challenges could also open new market opportunities in developing countries for the sector.
- **Demand for convenience**: Increasingly clients and users are demanding better performance of constructions. Users expect convenient solutions in the short, medium and long term from the construction sector. Key demands include low maintenance, automation, flexibility, health improving features, optimal environmental integration, etc.
- Weak growth prospects in EU markets: As European construction markets are expected to grow at a slower rate than the emerging markets in, for instance, the BRIC countries, the sector will need to develop and maintain a stronger global perspective.
- **Fragmented industry structures**: The markets of the EU construction sector and the sector itself are highly fragmented with only very few large construction companies. The participation of enterprises in trade organisations is very low in most Member States, making it difficult to spread good practices. Moreover, poor value chain integration has a negative impact on the potentials of spill over innovation effects from collaboration. This is reflected in large differences between Member States in the competitive performance of the sector.
- **Growing international (global) competition**: The sector faces increased competition from outside the EU. The sector organisations have raised issues of unfair competition from state-owned enterprises benefitting from unlawful state aid in EU construction markets and

also fear unfair competition from third-country enterprises not respecting European employment, environment and competition laws. There is increasing evidence that in particular countries under budget pressures drive public infrastructure procurement in the direction of abnormally low offers from non-EU contractors. For example, the Chinese have positioned themselves in developing countries that have experienced a positive growth in recent years and thus invest heavily in infrastructure development. Similarly, competition is increasing in non-EU markets from international contractors due to state-aid, highly competitive labour costs and high skills and technological level.

- **Regulatory environment**: Following on from the above, the sector is faced with an increasingly stricter regulatory environment. The challenges concern not only the definition of the regulations but also the effective implementation of these at national level. In addition, standards and certifications lack harmonisation across Member States. The lack of adherence of competitors to the regulatory environment provides threats as it may unbalance the EU and global playing field for investors, developers and suppliers of construction products and services.
- Access to finance: The financial crisis, delayed payments by clients, ineffective financial management and limited profitability of parts of the construction sector have put strains on the access to finance for the sector. Equally, the significant decreases in the value of buildings in Europe and elsewhere have an enormous influence on the access to finance and investors for new construction projects. In particular, more speculative construction projects find it difficult to attract capital.

Figure 54 Top barriers to pursuing energy efficiency for the company/organisation



What is the top barrier to pursuing energy efficiency for your company/organization?

Source: 6th annual survey practices of decision makers responsible for energy use in buildings led by the Institute for Building Efficiency, 2011

In the Delphi survey of the 2011 Eco-Innovation report, experts identified the most significant barriers of eco-innovation in the construction sector as being related to socio-economic factors, especially to deficiencies in the knowledge base (e.g. lack of knowledge of planners and technicians) and social factors (e.g. risk averse attitudes in the construction sector and the lack of awareness of home owners). While a lack of demand for eco-innovative buildings (user-investor dilemma) were considered critical today, this was considered to have decreasing importance as a barrier in the future. Indeed, user demand is

expected to grow as driver over the next 20 years.

Figure 55 Barriers to eco-innovation in the construction sector according to the Eco-Innovation Observatory Delphi survey (2011)

	Barriers	2010	2015	2030
	Building materials are too cheap	2,6	Я	Я
	Building materials are too expensive	2,9	7	7
	Limited access to venture capital & other sources of finance for innovative projects	3,2	ы	И
Economic and financial factors	Price of materials for innovative technologies is too high	3,7	Ы	צצ
iniariciar factors	Lack of competition for innovative building components	3,3	Ы	И
	Limited demand for eco-innovative buildings (user-investor dilemma)	3,9	Ы	רבר
	Refurbishing too expensive	3,8	К	צצ
	Lack of innovative technology development	3,3	Ы	ИИ
Technological factors	Technological lock-ins (e.g. old energy infrastructures)	3,7	Ы	אא
	Low research and development activity in the construction sector	3,8	Ы	אא
Environmental	Scarcity of materials for energy and resource-efficient technologies	2,5	7	77
factors	Unfavourable geographical location (e.g. limited sunlight, extreme temperatures)	2,6	7	7
	Weak collaboration between research, experts and business in the sector	3,8	Ы	ЫЛ
	Lack of knowledge/training of handworkers (electricians, plumbers etc.)	4,0	Ы	ЫЛ
Socio-cultural	Lack of knowledge/training of building planners (architects, engineers etc.)	4,0	Ы	ЯЛ
factors	Lack of awareness of building/home owners	3,9	מא	ההה
	Lack of acceptance of building/home users	3,7	Ы	אא
	Risk averse attitudes in the construction sector	3,9	Ы	אמ
Regulatory and	Lack of subsidies and programmes for sustainable construction	3,5	Ы	ИЛ
policy	Unambitious regulations and standards	3,6	И	ИИ
framework	Monitoring and certification underdeveloped	3,7	Ч	ИИ

Source: EIO Delphi survey (2011); average results of 128 responses; results in bold are above 3; Legend: experts rated all factors from 1 to 5 where 5 was the highest importance. The symbols indicate:

Legend: experts rated all factors from 1 to 5 where 5 was the highest importance. The symbols indicate: א lower / higher importance by less than 0.5 compared to the 2010 rating; א lower / higher importance by more than 0.5 and less

According to the WBCSD (2012), several barriers stand in the way of rapid progress towards energy-efficient buildings worldwide. They range from market and policy failures, through professionals' inadequate knowledge and understanding, to the behaviour of building users. They claim that measures that have a substantial impact are unlikely to meet normal financial investment requirements and are therefore unlikely to be implemented. In addition there would be several structural obstacles that significantly inhibit the likely take-up rate even of financially attractive investments:

- A lack of transparency about energy use and cost, resulting in a limited focus on energy costs by all those in the building value chain, with viable investment opportunities overlooked and installed technology not operating at optimal levels;
- Public policies that fail to encourage the most energy-efficient approaches and practices, or actively discourage them;
- Delays and poor enforcement of policies and building codes, which concerns all countries;
- Complexity and fragmentation in the building value chain, which inhibits a holistic approach to building design and use;
- A lack of adequate offers today (affordable and quality energy-efficient solutions for new constructions and retrofitted works, adapted to local contexts);
- Split incentives between building owners and users, which mean that the returns on energy-efficiency investments do not go to those making the investment;
- Insufficient awareness and understanding of energy efficiency among building professionals which limits their involvement in sustainable building activity and results in poor installation of energy-related equipment.

As reported by the IEEB (2012), multiple barriers to energy efficiency in buildings exist, creating the 'efficiency gap.' These barriers prevent actors from making cost-effective investments in energy efficiency and are reported in the figure below. At each stage in a building's lifecycle, barriers range from split incentives that prevent investors from valuing energy efficiency to awareness issues that accrue from lack of information about building performance. They also vary in importance between countries. For example, awareness and technical barriers play a bigger role in less-developed energy efficiency markets, whereas market and finance barriers are likely to be the biggest challenges in markets that have more experience pursuing energy efficiency opportunities.

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Market	<ul> <li>Price distortions prevent consumers and investors from valuing energy efficiency.</li> <li>Split incentives – transactions where economic benefits of energy savings do not accrue to those who invest in energy efficiency, as when building owners pay for investments in energy efficiency, but occupants pay the energy bills.</li> <li>High transaction costs.</li> <li>Externalities associated with fossil fuel consumption are not priced; imperfect competition.</li> <li>Dispersed and diffuse market structure with multiple locations and small end users.</li> <li>Multiple industries – construction, efficiency, energy industries – are involved in building efficiency, posing a multi-sectoral challenge.</li> <li>Energy tariffs discourage energy-efficient investments.</li> </ul>
Financial	<ul> <li>Organizations rely on constrained internal capital and operational budgets.</li> <li>High up-front costs and dispersed operational benefits discourage investors.</li> <li>Perception that energy efficiency investments are complicated and risky.</li> <li>Financial institutions lack awareness of financial benefits. Perception remains that financial benefits from energy efficiency are non-existent or exaggerated.</li> <li>For building owners, a lack of external finance.</li> <li>For financial institutions, small transaction sizes may require bundling of buildings or improvement measures to make them suitable for financing.</li> </ul>
Techinical	<ul> <li>Lack of affordable energy efficiency technologies (or know-how) suitable to local condition.</li> <li>Insufficient capacity to identify, develop, implement, and maintain energy efficiency investments.</li> <li>Lack of firms that can aggregate multiple projects; lack of implementation firms that can deliver cost-optimal energy efficiency project.</li> </ul>
Awareness	<ul> <li>Lack of sufficient information and understanding on the part of consumers/tenants/building owners to make rational consumption and investment decisions.</li> <li>Lack of information about the performance of buildings.</li> <li>Energy information may not be provided or analyzed by end users, energy providers, or other implementing agencies.</li> <li>Benchmarks for performance may not exist.</li> <li>Perception that energy efficiency measures make buildings more expensive.</li> </ul>
Institution	<ul> <li>Governments, especially in developing countries, have limited technical capacity to design and implement energy efficiency policies, programs, building codes and standards.</li> <li>Inter-agency coordination to ensure policy coherence (at different levels of government, between various energy policy goals, or across scattered energy efficiency initiatives) is limited.</li> <li>Regulators pay limited attention to demand-side measures. Traditionally, policy packages rely on supply-side interventions.</li> <li>Energy providers are compensated by selling energy, instead of by delivering energy efficiency.</li> <li>Government and the private sector rarely work through partnerships that tackle energy efficiency in a collaborative manner.</li> </ul>

Sources: IEA Energy Efficiency Governance (2010)

EEI Survey, Institute for Building Efficiency (2011) Christiana Figueres, Executive Secretary, United Nations Framework Convention on Climate Change (2011)<sup>3</sup>

## 6.3 Main European stakeholders

The establishment of the <u>European Construction Technology Platform</u> was an important step towards improving the competitiveness of the construction sector through developing new research, development and innovation strategies. The platform currently has 130 member organisations spanning from SMEs to large companies, universities, research centres and associations. There are 26 national platforms. Their role is to address the future needs of the built environment, and in particular, the challenge of innovation and
industry transformation in the construction sector. The work of the ECTP has resulted in a vision for 2030 for the construction industry, a strategic research agenda and nine priorities:

- Technologies for Healthy, Safe, Accessible and Stimulating Indoor Environments for All;
- Innovative Use of Underground Space;
- New Technologies, Concepts and High-tech Materials for Efficient and Clean Buildings;
- Reduce Environmental and Man-made Impacts of Built Environment and Cities;
- Sustainable Management of Transports and Utilities Networks;
- A Living Cultural Heritage for an Attractive Europe;
- Improve Safety and Security within the Construction Sector;
- New Integrated Processes for the Construction Sector;
- High Added Value Construction Materials.
- Recently two extra priorities were added:
- Nanotechnologies for Materials in Construction;
- Technologies and Engineering for Innovative Added-value Services Offered by SMEs in the Construction Sector.

In order to help the construction industry reach the 20/20 targets and achieve energy neutral buildings and districts by 2050 the European Construction Technology Platform has set up the Energy Efficient Building European Initiative (E2B EI), steered by the Energy Efficient Buildings Association (E2BA) founded in 2008. This is a Europe wide industry driven research and demonstration programme for energy efficient buildings and districts, with the ambitious vision that all European buildings will be designed, built or renovated to high-energy efficiency standards by 2050.

The <u>European Construction Information Platform</u>: Explore Construction aims to support and increase the capability of the whole construction sector to adapt to new challenges. It provides all relevant information at European and National level, but also represents a bi-directional channel open to all the players in the construction industry, including all public institutions both at EU level and Member State/ Local level. This web portal wants to become a "one-stop information point" to create and access relevant information coming from the EC, and which could service any external contact relating to the construction sector.

The <u>Sustainable Construction Sector Group</u> provides:

- Information on local markets. More than 25 Enterprise Europe Network branches are building a knowledge and expertise centre on sustainable construction. They pool their knowledge on research, development and innovation as well as on standards and good practices in the Group's member countries and make it available through regional fact sheets.
- Access to European initiatives. The Sector Group functions as a gateway for SMEs to important European platforms in the sector, such as the European Construction Technology Platform (ECTP), to research funding programmes such as the European Commission's 7th Research Framework Programme, ERANET (ERACOBUILD) and EurekaBuild and to the European Commission's Lead Market Initiative.
- Partnerships. The Sector Group offers small companies a forum for

exploring business and innovation partnership opportunities and helps them to channel their offers and requests. As a crossroads of multiple disciplines and technologies, it also collaborates with other Enterprise Europe Network Sector Groups.

It also provides a "<u>Technology market</u>" on Sustainable Construction, where thousands of technology offers and requests related to sustainable construction are displayed.

<u>Eracobuild</u>, part of ERA-Net, started in 2008 with 31 Partners, from 16 countries as a strengthened and enlarged continuation of ERABUILD. The overall aim of Eracobuild is to develop deeper, more durable co-operation and co-ordination between national funding bodies across Europe, to increase the quality and impact of research in the construction sector and so its performance, and that of the assets it creates. The One Stop Shop "From demonstration projects towards volume market: innovations for sustainable renovation" was one of the successfully evaluated projects of the Eracobuild Joint Call 2009-12-10 on Sustainable Renovation. The objectives of this call were to support research and innovation in order to make the existing built environment more sustainable and to promote sustainable renovation activities for the building stock in Europe.

The <u>SCI-Network</u> is a network of European cities and other public authorities working together to find new, innovative and sustainable solutions for their public construction projects. Together with other expert organisations, the participating public authorities hope to:

- Identify the most sustainable construction solutions for their needs available on the market in Europe;
- Make sure their construction procurement practices and procedures are set up to best encourage new, innovative solutions.

The <u>Sustainable Construction Living Lab</u> is a network transversely representative of the construction sector, gradually integrating representatives of all relevant national and international Stakeholders: the European Institutions, Local Authorities, Utilities, Financial and Insurance Institutions, Real Estate Promoters and Agents, the Design Team, Contractors, Suppliers of sustainable construction solutions, the Building Owners and Users. Its mission is to contribute to mainstreaming sustainable construction. The Network will provide:

- Integrated, robust and effective construction solutions, which will enhance the energy environmental performance of buildings, by setting up and co-ordinating technical working groups that will bring together specialists representing the suppliers of the relevant components of sustainable construction (building envelope, systems, operation) as well as the contractor;
- Innovative solutions, by promoting technical working groups involving the collaboration between the relevant Stakeholders;
- Information on the sustainable construction solutions to be disseminated to a wide, interested public including laymen and professionals;
- Help to define and validate the incentives, which need to be implemented, in order for both, sustainable construction and sustainable refurbishment, to become common practice;
- Lobby action aimed at the relevant political Stakeholders, transversely representing the construction sector, that will contribute to putting in

#### place (at national and European levels) the incentives;

The <u>World Business Council for Sustainable Development</u> (WBCSD) brings together some 200 international companies in a shared commitment to sustainable development through economic growth, ecological balance and social progress. Members are drawn from more than 36 countries and 22 major industrial sectors. They also benefit from a global network of about 60 national and regional business councils and partner organisations. Their mission is to provide business leadership as a catalyst for change toward sustainable development, and to support the business license to operate, innovate and grow in a world increasingly shaped by sustainable development issues.

### 6.4 Sources of further information

**<u>Buildup</u>**: The European portal for energy efficiency in buildings

ECwebsiteDGenterprise:http://ec.europa.eu/enterprise/policies/innovation/policy/lead-market-<br/>initiative/sustainable-construction/index\_en.htmEnterprise:

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## Annex

# Summary Sheets: Mitigation Technologies and Practices – Building sector, UNEP/GEF (2012)e of traditional building materials and design

Renovation & innovative use of traditional building materials and design						
Associated technologies and practices	Contextual applicability	Critical application requirements	Feasibility for implementation	Financial requirements	Contribution to triple bottom line	
Earth-related building materials	Rural areas where suitable soil types are available.	Understand local soil types and characteristics. Produce, design and test the materials for their performance (including load bearing strength) to meet safe construction standards prior to mass application.	Overcome negative perceptions, e.g., renovation and innovative use of traditional building	Low-cost to no- additional cost for implementation.		
Traditional Chinese practices of building orientation and interior space organisation	Mainly in China, and other applicable areas in Northern hemisphere. Mainly in	Understand the logic behind the relevant principles of traditional Chinese practices of building orientation and interior space organisation for application that improve environmental	Re-educate and build capacity for local architects, engineers, builders and skilled technicians.	No-additional cost for implementation.	Appropriate to local climate conditions. Using locally available and accessible resources.	
Traditional building design strategies in the Mediterranean	Mediterranean region, and other hot and arid coastal areas.	performance benefits scientifically.	Initiate quality demonstration projects.		Creating jobs for	
Water cool building envelope	Hot and arid regions.	Require good technical knowledge and skill for water-proofing construction.	Foster collaboration between NGOs, government agencies and local communities.		with readily available skills.	
Wind tower	Hot and arid regions.	Require maintenance to keep water jar clean, refill water and prevent birds nesting.		Hequire Infancial arrangements for construction cost and maintenance.	Hesulting buildings that are contextually, socially and culturally familiar to the local users.	

Passive house design and technologies							
Associated technologies and practices	Contextual applicability	Critical application requirements	Feasibility for implementation	Financial requirements	Contribution to triple bottom line		
Passive solar building design All regions.	Design building responding to local climatic conditions, including but not limited to: – Orientation that is optimised for land form, sun path and seasonal and diurnal prevailing winds – Self shading design	Carry out research to identify appropriate design strategies, quantitative standards and construction details and systems to address local climatic conditions.	No additional cost for implementation.	Saving energy thanks to design optimisation for daylight and ventilation.			
Airtight construction	Temperate regions.	Compact form.     Require excellent     construction skills that pay     great attention to details,     especially at joints, edge     of doors, etc.     Put in place indoor air     quality measures, e.g.,     use low/no volatile organic     compound building     materials, proper flush-     out procedure prior to     occupancy.	design guidelines and standards to serve as springboard for large-scale adoption. Build capacity for local architects, engineers, builders and technicians.	Additional investment costs are required for delivering high-	Duilding occupants thermal comfort. Energy saving, resulting in avoiding additional energy demands that lead to additional investment to increase the		
High- performance envelope insulation		Insulate building envelope to stringent standards in order to limit thermal loss. Install triple glazing system for windows. Prevent thermal bridge through weak thermal insulation points, such as window frames and joints.	Organise training workshops for builders and skilled technicians to meet demanding skills, especial in airtight construction and high-performance envelope insulation. Extend capacity building and	builders and skilled technicians to meet demanding skills, especial in airtight construction and high-performance envelope insulation.	builders and skilled technicians to meet demanding skills, especial in airtight construction and high-performance envelope insulation. Extend capacity building and supportive	performance envelope insulation, triple glazing windows, airtight construction, heat-recovery ventilators, stringent construction details, etc.	capacity of local communal power infrastructure and power plants. Helping local construction workforce to upgrade
Ventilation with heat recovery	All regions. Transfer thermal energy from discharged air to incoming fresh air to make the temperature of incoming air closer to that of indoor air.		institutional setting to local manufacturers, in order for them to produce passive house components and materials locally.		technical skills, leading to better employment prospects.		

Lifecycle and integrated design process						
Associated technologies and practices	Contextual applicability	Critical application requirements	Feasibility for implementation	Financial requirements	Contribution to triple bottom line	
Inter- disciplinary and interactive approach	All regions.	Support from committed clients/developers / building owners. Form inter-disciplinary team, comprising client, architect, structural and civil engineer, mechanical and electrical engineer, quantity surveyor, energy consultant, landscape architect, facility manager, contractor (builder) and design facilitator, at the project's inception. Set high performance goals, lifecycle considerations and design targets as the ultimate objectives to direct the interaction and working relationship among the team members. Allow for iterative activity loops throughout each design stage – from conceptual to schematic to detailed design and documentation for construction.	Incentives from government, e.g., taking the lead by being supportive clients for publicly funded building projects. Changing mindset of main players in the building sector to adopt the practice with open mind and a spirit of tearnwork. Capacity building to raise awareness among the building sector's players and professionals. Demonstration projects as showcase of process to the industry.	requirements     u       Minimal additional cost is required during building design stage.     Addisonal cost re- eff building dasign stage.       Additional consultancy cost is required at the project's early design stage. This additional cost will be offset by savings created during the project's construction and/or operational stage.       Si consultancy cost is required at the project's construction and/or operational stage.       Si created during the project's construction and/or operational stage.	Providing methodologies and computational tools to deliver high performance buildings Addressing the scarcity of natural resources by effectively using building materials and components, and end-of-life considerations. Reducing overall lifecycle costs and social and environmental costs from building design, construction, operation and end-	
Lifecycle based decision making	Airiogions.	Make design decision based on lifecycle analysis, which takes into account building systems' embodied energy, performances, lifecycle cost, lifespan, end-of-life usage, etc.	Collection of lifecycle information of building materials, products, components, technological systems. Establish comprehensive data bank for lifecycle analysis through collaborations among local building regulators, research institutes, universities, building product suppliers and other building-related professionals.		of-life use. Strengthening the relationships among the building-related professionals by promoting teamwork and positive interaction. Providing a platform for cross-learning, knowledge sharing and innovation/	
Computer assisted design tools	Use computational simulation programmes as tools to assist design for decision making rather than just to verify design intention.	Training local workforce of energy specialists, experts on lifecycle analysis, and experts on computational simulation tools.		delivering sustainable built environment.		

	Building envelope thermal insulation							
Associated technologies and practices	Contextual applicability	Critical application requirements	Feasibility for implementation	Financial requirements	Contribution to triple bottom line			
Mineral fibre insulation		Be flexible for off-site and in-situ construction. Require good workmanship and foil backing to prevent the product from being exposed to vapour and water. Require good workmanship to prevent air leakage.	Availability of incentive and supporting policies.	Initial capital costs are required for the products and their	Providing thermal comfort to building occurants			
Cellular plastic insulation		Availability in form of rigid sheet or spray foarn. Spray foarm to be applied after electricity and plumbing services are installed, so all gaps are properly sealed.	Enforcement by building codes that safeguard minimum acceptable insulation levels for building envelope.	Installation. No maintenance cost is required for cellular plastic products.	Contributing to healthy living environment and better productivity at workspaces.			
Plant/animal derived insulation	All regions.	Require good workmanship and proper backing to prevent the products from exposing to vapour and water. Require good workmanship to prevent air leakage.	Avoid using cellular plaster insulation products that are associated with the use of ozone depleting agents in its production.	Avoid using ceilular claster insulation products that are associated with he use of ozone depleting agents in ts production. Replacement cost is required for mineral fibre and plant/animal derived insulation products.	Reducing energy demands for cooling and heating.			
Phase change materials (PCM)		Encapsulate PCM with paraffin, and mix with mortar for application on building environment.	Capacity building and training workshops for local professional and construction workforce.	insignificant cost for application of straw bales and air- gap in cavity wall.	Creating business opportunities and jobs.			
Use of raw natural elements as thermal insulation, e.g., straw bales, airgap in cavity wall, etc.		Overcome fire-hazardous or combustible materials (e.g., straw bales) by cladding them with metal sheets.						

High performance building façade systems							
Associated technologies and practices	Contextual applicability	Critical application requirements	Feasibility for implementation	Financial requirements	Contribution to triple bottom line		
High-performance solid wall system	Large range of products to meet various climatic contexts.	Design high wall-					
Cool paints	Hot climatic regions.	Avoid low wall-to- window for buildings in hot climatic regions.	Incentive and enforcement by building codes that safeguard minimum standards for thermal and daylight performances of building facade	Various financial requirements depending on the choice of façade	Contributing to lower heat gain and/or loss and thus reduce the		
Glazing systems, including – Low-emissivity glass – Double glazing and triple glazing filled with inert gas dry air, argon or krypton, or vacuum – Photochromic glass – Electrified glazing	Large range of products to meet various climatic contexts.	Integrate sun- shading devices for glazing areas exposed to sunlight. Provide airtight but operable windows. Carry out building envelope commissioning.	Availability of demonstration projects. R&D to determine material availability and types of façade systems that are appropriate to the local climatic conditions. Capacity building to upgrade local	Systems. Cost of solid wall systems islower than that of glazing systems (in most cases). Set appropriate window to wall ratio as a cost-effective measure.	Improving and/or heating loads of a building. Improving thermal comfort, and offering daylight and visual connectivity to external view for occupants.		
Double skin façade system	More effective for temperate regions. Less effective in hot climatic regions.	Facilitate nighttime ventilation for application in hot climatic regions.	Facilitate nighttime ventilation for application in hot climatic regions.	capacity building to upgrade local professionals' knowledge and to train a workforce with skills for designing, installing, operating and maintaining high			
Self-cleaning façade solution (TiO <sub>2</sub> )	All regions.	Apply to most building façade materials/systems.	façade systems.	Upfront investment to apply TiO <sub>2</sub> coating on the external surface of façade systems will reduce maintenance and cleaning cost during operation stage.	Reducing water consumption for façade cleaning and maintenance costs.		

Daylight harnessing technologies							
Associated technologies and practices	Contextual applicability	Critical application requirements	Feasibility for implementation	Financial requirements	Contribution to triple bottom line		
Light shelves (static and movable controlled mechanically or by sensors)	All regions.	Place on upper parts of windows/glazing systems above eye level. Design to allow diffused daylight, not sunlight, entering the building's interior. Apply in building interior spaces, which have more tolerance of some degree of fluctuation in illumination. Deploy in tandem with artificial lighting (controlled by lighting sensors) for more constant indoor lighting levels for office spaces or working/ learning areas. Avoid creating glare for neighbouring buildings. Utilise computational simulation tools.	Put in place relevant regulations to address: Adequate spacing between buildings in according to building height. Safety in relation to installation. Preventing glare and direct reflection to the neighbouring buildings. Availability of guidelines on daylighting design and methodology for daylighting computation. R&D to create a databank of local solar illumination, and suitable to local application. Capacity building in the areas of design and analysis tools for designers, installation techniques	Put in place relevant regulations to address:capital costs for products and their installation. These costs vary according to the technologies, design configurations, types of materials, etc.Adequate spacing between buildings in according to building height.etc.Safety in relation.External static installation.Preventing glare and direct reflection to the neighbouring buildings.of the technology, due to the simplicity of the technology and their combined use as sun shading devices.Availability of guidelines onRequire	Contributing to energy saving by reducing artificial lighting requirements and heat generated from artificial lighting.		
Sky lights	Mainly temperate regions.	Design to mitigate the problems of rainwater leakage, noise caused by rain, and heat gain/loss. Shade the skylights with other components of the same building, to cut down heat gain, in hot climatic regions. Apply to buildings' interior spaces, which have a higher tolerance of fluctuations in illumination. Utilise computational simulation tools.		local optimised performance level. hing to maintain the optimised performance level. hination, and echnologies should also be o local set aside for or or component replacement building of mechanical/ as of sensor-controlled light shelves and designers, in techniques workforce, tenance es for owners and anagement al.	Creating positive psychological impacts for occupants by connecting them with dynamic outdoor illumination.		
Light pipes	All regions.	Apply in building interior spaces, which have a higher tolerance of fluctuations in illumination. Deploy in tandem with artificial lighting (controlled by lighting sensors) to achieve the constant indoor lighting levels required in office spaces or working/learning areas.	and maintenance procedures for building owners and facility management personnel.				

Highly efficient heating, ventilation & air conditioning systems						
Associated technologies and practices	Contextual applicability	Critical application requirements	Feasibility for implementation	Financial requirements	Contribution to triple bottom line	
Heating systems (boilers, heat pump technologies)	Temperate regions.	Require efforts during design stage for coordination, selection and design to result in highly energy efficient				
Cooling systems (chillers, condensers, heat exchanger, desiccant wheels, automatic condenser tube cleaning systems)	Hot climatic regions.	HVAC. Avoid oversizing HVAC components, leading to in-efficient system. Plan for expansion rather than size it.	Set minimal performance in building codes for design and implementation of more efficient HVAC systems. Raise awareness	Additional investment costs can be minimal by not oversizing HVAC system at the early design stage. Additional costs are required for additional HVAC	Contributing to economic and environmental development through energy saving. Being catalyst for ESCO	
Ventilation systems (variable air volume system)	Various technologies applicable for various regions.	Divide building spaces/ rooms into zones, each equipped with their own thermostat, motorised damper and control system for zones and user controllability. Locate fresh air intake away from air exhausts, (potential) sources of pollution and odour. Shift peak load in cooling systems to utilise off-peak electricity. Use displacement ventilation to harness the natural buoyancy of	Paise awareness to prevent oversizing HVAC systems through demonstration projects with proven records of energy saving and thermal comfort performances. Capacity building and training workshop to upgrade professional knowledge and skills.	additional HVAC subsystems to enhance performance. Examples are the installation of automatic condenser tube cleaning systems, ice storage systems for shifting peak load application, etc. Additional costs are often recouped from energy saving and reduced maintenance costs.	for ESCO businesses to prosper. Contributing to better indoor living and working environment. Reducing sick building syndrome and indirectly enhance productivity.	

EFFICIENT LIGHTING SYSTEMS							
Associated technologies and practices	Contextual applicability	Critical application requirements	Feasibility for implementation	Financial requirements	Contribution to triple bottom line		
and practices Energy efficient lamps (T5/ T8 tubes, compact fluorescent lamps, high- intensity discharge lamps, light emitting diodes) Ballasts Light fixtures	All regions.	Use efficient lighting systems in association with natural daylight, further enhanced by using lighting sensors. Divide building spaces/room into zones requiring different lighting needs, which can then be independently controlled. Allow users to control the lighting requirement. Install motion sensors to automatically switch the light off, when there is no one in a zone. Install a dual lighting circuit system to allow alternate lights to be turned off at places and times, when having a brightly lit environment is not critical. Provide safe disposal of CEI s at the end	Reduce import tariffs on energy efficient lighting components. Initiating energy efficient lighting programmes, which provide or subsidise energy efficient lighting. Decisions can be made by individual building owners/ occupants. One-time small investment costs can be paid back through savings from electricity bills. Assist local manufacturers to make energy efficient lighting components and systems. Provide public education and campaign to raise	Initial investment required to purchase and install energy efficient lighting systems. Costs are normally paid back in a short time, e.g., approximately a year, through savings from electricity bills. Maintenance costs are negligible during the lifespan of energy efficient lamps and ballasts.	Contributing to economic and environmental development through saving energy. Consuming fewer resources, thanks to long lifespan. Improving health and living conditions for occupants. Creating business and employment opportunities, once local manufacturers can meet local demand.		
	of CFLs at the end of their life, in order to safely dispose of mercury contained in the lamps.	awareness.					

Water efficiency technologies						
Associated technologies and practices	Contextual applicability	Critical application requirements	Feasibility for implementation	Financial requirements	Contributions to triple bottom line	
Metering and water consumption information		Install meters at locations that are easy to access for reading. Protect meters from the weather. Install separate sub-meters for different units, or major uses (e.g., landscape irrigation, cooling tower, etc.) in large- scale buildings. Link data from all sub-meters to the building management system.	Availability of regulations on water metering. Demonstration projects with proven data related to water saving for complex metering systems in large-scale buildings.		Contributing to the environment through conserving water resources and indirectly reducing energy consumption. Ability to detect water leaks.	
Rainwater harvesting systems		Use non-corroding materials for components. Size storage tank based on roof catchment area and local rainfall data. Use collected rainwater for non-potable usage. Regular clean up of contaminants, dry leaves, etc.	Availability of guidelines for design and installations of rainwater harvesting system. Availability of guidelines for preliminary water treatment and/or water purification for drinking	Various systems require different initial investments, which in general, are low. Return on investment varies in according to specific systems adopted and the	Reducing the stress on the municipal storm water system. Reducing surface storm water runoff and cutting down peak discharge to urban drainage systems.	
Grey water re-use systems	All regions.	Separate grey water and black water piping systems. Disinfect the stored water to prevent cross contamination and growing of bacteria/fungi. Use the stored grey water as soon as possible. Require regular maintenance and check for leakage, replace treatment medium and prevent mosquito breeding and bacteria growth.	capilicable for regions with scarce water resources and limited communal water supply.) Availability of guidelines and regulations related to environmental health – i.e., prevention of mosquito breeding in rainwater/grey water storage tanks/ containers.	contexts. For example, ROIs for complex rainwater harvesting systems on high-rise buildings in a high-density urban setting are not as attractive as those for simple roof- gutter-tank systems of smaller buildings in rural settings. A budget should be set aside for maintenance, e.g., cleaning, repairing the systems, and replacing components.	Encacing end	
Hydro-pneumatic water supply systems		Require space on high level (roof) for the air-pressured water tank. Require sensor to monitor water level and pressure in the tank. Link the data to central building management system.			Engaging end users to conserve water, and instilling positive environmental- friendly habits and practices to the society at large.	
Water-saving devices (aeration technologies, dual flushing water closet, water-saving dishwashers, clothes washers, drip irrigation systems)		Add aerators to existing water taps or shower heads. Specify and equip buildings with dual-flush toilets and water-saving appliances. Programme drip irrigation systems to fit local weather requirements. Identify opportunities for zones (of plants with different water needs) for zone controls.	Raising awareness to buildings occupants, professionals, builders and public at large, by local governments and/ or NGOs. Introducing labelling system for water-saving devices.			

(	Carbon-sequestration and low-carbon building materials and products							
Associated technologies and practices	Contextual applicability	Critical application requirements	Feasibility for implementation	Financial requirements	Contributions to triple bottom line			
Carbon sink building materials and products (harvested wood products, bamboo products)		Enhance the products with lamination and/ or chemical treatment to reduce vulnerability to termite infestation, and to strengthen their water- and humidity-resistance.	Raising awareness through public educational campaigns. Establishing green labelling/carbon	Raising awareness through public No additional investment is con campaigns. required, as the rate materials and products are red substituted to for i the otherwise products are red	Substituting conventional carbon intensive materials and reducing demand for them in the market.			
Low carbon building materials and products (low-carbon bricks, green concrete, green tiles, recycled metals, locally available materials and products)	All regions.	Reduce or avoid wastage during process and application.	labelling schemes by government agencies or reputable NGOs. R&D to identify and develop new materials and products and their innovative applications.	conventional carbon-intensive ones. Savings from reducing transportation costs, by using locally available materials.	Promoting the use of locally available materials, and thus supporting local industries for employment opportunities and economic growth.			

	Gre	ening and building	integrated green	ery systems	
Associated technologies and practices	Contextual applicability	Critical application requirements	Feasibility for implementation	Financial requirements	Contribution to triple bottom line
Garden and landscape	All regions.	Maximise soft- scape where land is available.		No additional cost required, because it is a common practice.	Reducing heat gains for buildings in hot climatic regions. Reducing heat island effect in urbanised
Green roofs					areas.
Roof gardens, balcony gardens and sky terraces					Absorbing airborne particles and improving ambient air quality in urban settings. Nurturing and enhancing urban
		Design building	Incentives from local government,		biodiversity.
		structure to support additional dead loads.	such as cost sharing schemes.		Reducing rainwater and peak rainwater run-off.
Green façades/ walls	All regions, excluding extreme temperate regions, or hot and arid climatic regions. More suitable in densely populated urban areas.	loads. Provide good water proofing system and measures to prevent structural damages caused by root penetration or water leakage. Deter the risk of plants or tree branches falling from the buildings. Design, install and maintain irrigation, water storage and drainage systems appropriate to local climatic conditions. Select lightweight substrate and media for plants to grow on.	Capacity building, especially in the following areas: – Planning, designing skills and plants selection. – Installation technique, including water proofing and irrigation systems. – Maintenance procedures for building's owners and facility management personnel. – Manufacturing and supplying lightweight components.	Additional initial investment cost for the products, their installation and stronger structural elements. These costs vary from system to system and from region to region. Ongoing maintenance costs are required.	run-off. Absorbing carbon dioxide for photosynthesis. Creating biophilic value to building occupants and city dwellers. Providing alternative public spaces for leisure activities and fostering community ties in high-rise high- density urban setting. Reducing building cooling load, leading to lower energy consumption and thus cost savings to owners/tenants. Enhancing the buildings' marketability and value. Reducing the diurnal temperature fluctuation of the building roofs and facades, leading to reduction in materials' contraction and expansion, and thus prolonging the building roofs and facades' lifespan. Nurturing the prosperity of new supply chains and new job creation.

			Solar technologies		
Associated technologies and practices	Contextual applicability	Critical application requirements	Feasibility for implementation	Financial requirements	Contribution to triple bottom line
Solar thermal water heater	Most temperate and hot climatic regions.	Design building structure and roof to cater for additional dead load of the	Require strong institutional supports, especially incentivising policies and supportive financial mechanism, including:		
Combining solar water heating and space heating (combi- system)	Temperate regions.	system. Design for accessibility for maintenance and services. Bequire stability	<ul> <li>Reducing/removing subsidies for fossil-fuel-based electricity supply.</li> <li>Reducing/removing import tariffs on solar technologies' components.</li> <li>Clearly identifying power arid expansion plans (for</li> </ul>		Seen as prominent and promising
Combining solar heating and solar cooling system	Hot climatic regions.	and sufficient pressure of continuous water supply for automatic operation of solar thermal water heaters.	rural and remote areas) and communicating these plans to the public. This is necessary for calculating payback periods used in decision-making processes to invest and implement off- grid solar technologies, e.g.,	Requirement of investment costs of the products and their installation, and maintenance costs.	technologies to substitute fossil fuel based electricity. Contributing to improve quality of life and
Building integrated photovoltaic (bipv)	All regions.		Solar home systems and solar charging stations. – Setting up smart grids and incentivising feed-in tariffs as a platform to promote	PV technologies require more capital intensive to invest, compared	deliver healthy environment.
Solar home system		Located PV	on-grid application of PV technologies.	to solar thermal technologies.	Bring direct benefits to home
Solar charging station	Remote rural areas of all climatic regions.	Located PV panels exposed directly to sunlight. Mount PV panels to face the sun directly. Require periodic maintenance to clean the surface from accumulated dust and/or bird droppings, etc.)	<ul> <li>R&amp;D in priority areas, including:</li> <li>Local data of solar radiation, intensity and sunlight hours for various seasons.</li> <li>Locally most suitable, efficient and cost effective solar technologies and products for large-scale development.</li> <li>Viable business models and financial mechanisms for a reasonable return on investment.</li> <li>Capacity building in the area of technical knowledge, design technicians, and routine inspection and maintenance for building owners and facility management personnel.</li> </ul>	The costs of components vary, depending on the technologies and wither the products are produced locally or imported.	owners and communities (in remote rural setting). Creating business opportunities for remote rural community with solar charging systems.

		Building inte	egrated wind turbines		
Associated technologies and practices	Contextual applicability	Critical application requirements	Feasibility for implementation	Financial requirements	Contribution to triple bottom line
Horizontal axis wind turbines (HAWTs) Vertical axis	All regions, especially windy coastal areas. All regions, especially windy coastal areas. All regions, especially windy coastal areas. All regions, especially windy coastal areas. All regions, especially windy coastal areas. All regions, especially wind conditions va a wind turbine's of wind speed, rate wind speed, rate structure is stron en uph to within the additional de loads from the turbine's operation absorbent technot to prevent dama to building struct and to minimise noise penetrating building's interior. Put in place mea to deter wind turbine to deter wind turbine to maintenance is services. Applicable to bot grid-connected of off-grid settings.	Collect wind data in	Building up local wind mapping to understand wind speed, frequency and directions at different heights, times, and settings.		
(VAWTs)		of the building or installation site. Determine suitable wind turbine types and installation locations, in order	Putting in place supporting policies and financial mechanisms to make building integrated wind turbines commercially viable: – Reducing or removing subsidies for fossil fuel based electricity supply. – Reducing or removing import tariffs on wind turbine components. – Clearly identifying power grid expansion plans (for rural and remote areas) and communicating these plans to the public. – Setting up smart grids and incentivising feed-in tariffs as a platform to promote on-grid application of building integrated wind turbine	Initial investment	Contributing to reduce the need for fossil- fuel-based electricity.
Wind home systems (WHSs)		to maximise the potential energy generated from the turbines, by matching ambient wind conditions with a wind turbine's cut-in wind speed, rated wind speed, rated wind speed and cut- out wind speed. Ensure building's structure is strong enough to withhold the additional dead loads and vibration		feasibility studies and system design, the wind turbines, their installation, and additional strength of building structure. The cost components of wind building integrated wind turbine system	Opportunities for building owners to sell surplus electricity back to the grid. Providing local workforce new skills and employment opportunitios
		loads from the turbine's operation. Adopt vibration absorbent technology to prevent damage to building structure and to minimise noise penetrating the building's interior. Put in place measures to deter wind turbines from being damaged by lightning. Plan for accessibility for maintenance and services. Applicable to both grid-connected or off-grid settings.	Setting guidelines and standards to regulate the installation, to address: – Structural safety – Noise pollution control – Grid connection – Urban-scape design guidelines. Capacity building: – Technical knowledge to compute, simulate and select appropriate types of wind turbines at appropriate locations. – Installation skills and techniques for local workforce. – Maintenance procedures for building owners and facility management personnel. – Manufacture of micro wind turbines and related components, for long-term development.	Maintenance budget to be set aside for parts' replacement.	A mechanism for local green economy to prosper. Wind home systems contribute to social development by improving the quality of life to villagers in remote islands and rural areas.

Energy management and performance improvement						
Associated technologies and practices	Contextual applicability	Critical application requirements	Feasibility for implementation	Financial requirements	Contribution to triple bottom line	
Commissioning		Verifying performance against the targets set at the early stage of building design, ensuring that installations undergo onsite inspection, and that all technical systems tested and faults rectified. Engaging an independent commissioning agent during handover of complex and large- scale buildings to help eliminate hidden deficiencies. Providing building user guide, to explain the operational procedures and functions of complex technical systems.	Agreement between building developers and builders/ contractors. Providing institutional supports, such as legal requirements to mandate commissioning on contracts of certain complex building types. Commissioning of advanced technologies/ systems requires training operating/ facility management staff and educating potential users.	Building developer to invest a one-time cost for building commissioning	Ensuring good performance of technical systems, and improving their life cycle performances. Enhancing environmental health and comfort level. Reducing training and familiarisation costs for facility management staff. Saving from utility bills, and improving productivity.	
Building Energy Management System (BEMS)	All climatic regions. Most suitable for commercial buildings and large-scale	Most beneficial when considered and incorporated during building design stage. Require skilled personnel to operate and monitor the data from BEMS. Put in place user interface and manual-override functions for possible intervention in case of system breakdown and/or emergency situations.	Capacity building to train highly-skilled technicians to install and operate the system.	Require additional cost for installing, operating and maintaining the system.	Optimising energy usage to create energy savings. Offering early warning and detection of problems, and ease of problem diagnostics.	
Energy Performance Contracting (EPC)	mx-use complexes.	Require strong support from building owners. ESCOs to define clear baselines – existing energy consumption, patterns and rates, equipment inventory, occupancy, existing energy saving measures, etc based on spot measurement, metering, inspections and surveys. Devise technological interventions, measured against baselines for calculating potential savings from energy consumption in monetary terms and the payback period. Setting up project specific measurements and verification plan, maintenance schedule, expenses and payback. Carrying out post-installation verification, periodic performance verification, operational feedback and fine- tuning.	Availability of institutional supports, including: – Non-subsidised electricity price. – The availability of feed-in tariff. – Financial assistance from international and local organisations at the initial start- up phases.	Building owners are not expected to any additional investment cost for EPC, except for experiencing some disruptions during installing intervention technologies by ESCOs.	Providing opportunities to improve energy performance of large existing buildings. Providing opportunities for existing buildings' owners to upgrade old equipment and systems. Being a small- scale green financing mechanism that unlocks the financial bottleneck of large-scale implementation of energy- efficient and renewable energy technologies.	

Behaviour change catalysts							
Associated technologies and practices	Contextual applicability	Critical application requirements	Feasibility for implementation	Financial requirements	Contribution to triple bottom line		
Energy efficient appliances	All regions and contexts.	Requiring no special spatial or additional technical requirements for application, as the products are typically no different in terms of size and shape, compared to the conventional ones.	Availability of institutional supports, such as product energy labelling schemes.	Energy efficient appliances, in general, cost more than conventional ones. However, the additional cost can be recouped through energy savings during operation.			
Home area network (HAN)	For domestic application in all regions.	Connect electrical domestic appliances and systems (e.g., HVAC, lighting, refrigerators, washing machines, water heaters, televisions, computers, etc.) to smart meters.	Requiring more R&D and test bedding. Establishing a common set of standards and protocols for compatible integration of various HAN products and fine tuning them to be more user-friendly and appealing to end-users. Setting up demonstration projects, showrooms to raise awareness at the initial market penetration stage. Further R&D to bring down the cost. Availability of a simple form of electricity dynamic pricing.	Initial investment to purchase and install the related equipment. Additional operational cost to the energy used in the in-home display unit, and system/software upgrade.	Contributing directly to domestic energy savings. Being a catalyst for behaviour change toward a more sustainable lifestyle. Contribution towards implementing dynamic pricing of electricity, which in turn helps reduce		
Pre-paid meters	Most suitable for least developing countries	Require the credit and/or vending system set out by utility providers. Protect meters from the weather, especially rain. Locate meter away from potential contact with water or heat sources Position meter so it can be easily used and maintained.	Good collaboration and communication between power plant operators, utility providers, local government and local community. Online vending systems can only be implemented in communities where majority of households have access to internet.	Financial investment from a utility provider to lay the distribution infrastructure, install vending machines, and operate the system. Small upfront investment is often required for the consumers to purchase and install pre-paid meters in the homes.	peak demand, to alleviate energy shortages and the need for power infrastructure expansion.		

Community based energy services						
Associated technologies and practices	Contextual applicability	Critical application requirements	Feasibility for implementation	Financial requirements	Contribution to triple bottom line	
District heating/ cooling	All regions, and more feasible in high-density urban setting.	Set up centralised plants to produce heating/ cooling through boilers/ chillers, recover waste heat through co-generator, or tap into waste heat from nearby industrial processes or power plants. Deploy renewable and clean energy sources	Setting up		Being more thermally efficient in densely urban setting, compared to that of many isolated small systems in individual buildings. Optimising the operation of the centralised plant in terms of energy efficiency, renewable energy deployment and maintenance personnel.	
Combined heat and power generation (CHP)	All regions, and more feasible in rural lower- density setting, where accessibility to renewable and alternative energy sources area easy.	<ul> <li>(where possible) for thermal energy conversion.</li> <li>Utilise heating-cooling conversion technologies to address the different thermal requirements of a year.</li> <li>Setting distribution network of thermally insulated metal pipes and pumps to transfer thermal energy from the centralised plant to individual buildings within a community.</li> <li>Put in place leak detection systems and corrosion protections for underground piping.</li> <li>Use variable speed pumps with low noise generated to save pumping energy and prevent noise transfer through the thermal medium into the buildings.</li> <li>Install in individual buildings: heat exchanger, piping, valves and control system, e.g., thermostats, and meter.</li> <li>Require periodic maintenance, including leakage inspection, monitoring and reporting the system's performance.</li> </ul>	investment and financing mechanisms. R&D to identify energy sources, suitable system, technologies, and system capacity to serve the communities. Conducting user consultation to gain common understanding, expectations and cooperation, during feasibility study, design, construction, and operation stages. Capacity building to train local workforce with technical skills to install, monitor, identify faults, and repair the systems.	Require investor and master developer to invest initial capital to set up the systems, operational cost and maintenance cost.	Efficient in electricity generation with the use of the byproduct – i.e., heat. Creating opportunity to tap renewable or cleaner energy sources. The combination of a biogas anaerobic digester and a CHP co- generator offers better sanitation solutions for rural communities, reducing odour and flies, preventing water pollution due to waste dumping, and improved environmental health. Creating sense of community and strengthen social coherence within a community. Offering buildings' owners: - Savings on capital cost for installing boiler/ chiller plants, and thus saving on building spaces. - Savings on ongoing capital expenses to upgrade boiler/chiller plants. - Flexibility, monitoring ability and controllability of thermal energy usage.	

Sustainable community design and practices						
Associated technologies and practices	Contextual applicability	Critical application requirements	Feasibility for implementation	Financial requirements	Contribution to triple bottom line	
Sustainable community design and physical planning	Vicinus	Planning buildings layout of a community responding to local sun and seasonal wind characteristics, harvesting rainwater and enhancing local landscape ecology.	Involving as many stakeholders to appraise the status of existing conditions. Designating individual(s) as champion for sustainable community programmes. Identifying, together with stakeholders, key needs and objectives, through consensus building. Creating vision and	Financial support is required at the initial stage for a kick-off, usually related to planning and early stage implementing activities.	Planning with regard to local climatic conditions, including sun, wind and rain. Creating comfortable micro- climate for both communal spaces and individual buildings in a community. Being water efficient. Promoting native vegetation, and nurturing biodiversity.	
Sustainable community practices (building a sense of community, upgrading quality of life, developing skill sets gearing towards green economy)	planning and practices strategies applicable to various contexts of communities	Discuss with members of the community to understand existing lifestyles, daily activity patterns, and their wish list for improving the living experience in the community. Encourage all members of the community to participate in all communal activities. Empower members in all decision-making processes and instill a sense of ownership and pride.	workable roadmap. Developing a set of indicators to benchmark and monitor the progress. Identifying and communicating with supporting partners. Starting with the most feasible and economical activities. Monitoring and improving the activities as progressing. Continuing seeking feedback from all stakeholders and partners.	communities often require financial support by international agencies and/or local government. Successful community activities often find themselves a sustainable income stream generated from the return on investment.	Reducing and eliminating poverty for lower-income communities, while upgrading their skills for employability in green economy sector. Facilitating a sustainable local green economy, e.g., through eco- tourism, local food production, etc. Generating community ties and sense of ownership. Reducing crime. Improving quality of life.	

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