ECO-INNOVERA Systems Innovation Strategy

the way forward in research for eco-innovation

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1. Abstract

The present paper provides an introduction to the concept of systemic eco-innovation, primarily based on the transition theory, as a basis for developing guidance and suggestions for programming future research at the regional, national and European levels.

ECO-INNOVERA – boosting eco-innovation through cooperation in research - organized two joint calls-for-tender addressing among others paradigm change or systemic eco-innovation, prepared reports on various aspects of eco-innovation, and developed a research and innovation strategy. A number of workshops with experts from within the ECO-INNOVERA network as well as from outside, resulted in preliminary conclusions and recommendations for future research programming. The main conclusion throughout the strategy is that in order to successfully address complex challenges at a systemic level research programming needs to induce multi-phased, multi-stakeholder, cross-sectoral processes generating several competing alternative approaches and solutions in the technological and non-technological areas, which are capable to challenge vested economic processes and interests.

The conclusions and recommendations are preliminary; little practical experiences in programming research for systemic eco-innovation has been obtained so far. ECO-INNOVERA calls for integration of efforts through synchronization and cooperation between regional, national and European policy-makers, researchers and frontrunner economic actors and funders of research for further joint development of concept and implementation of systemic eco-innovation.

2. Introduction

ECO-INNOVERA[1] acts as a Europe-wide advocate for system innovation for sustainability, influencing and leveraging funding from national and EU programmes. It aims to boost eco-innovation through cooperation in research across the EU; promote an EU-wide approach for innovation with significant impact for sustainability; and identify and disseminate information on 'game changer' projects. Over the past years, ECO-INNOVERA promoted the understanding of system eco-innovation through funding projects and the development of a research agenda.

One of its tasks is to develop a Research and Innovation Strategy for ECO-INNOVERA. At this level, the ERA-Net functions as a project, intended to form a solid foundation for the better co-ordination of eco-innovation in Europe. The ambition of the consortium partners, however, goes beyond the project. The partners in ECO-INNOVERA consider that there is a unique opportunity to build a larger programme of activities, based on the intersection of interests of its partners, involving also other eco-innovation networks and platforms. The R&I strategy seeks to identify and prioritise value-adding activities for eco-innovation having faster and more significant impact in society. Moreover, it may be the start of a process by which the ERA-Net moves beyond a project into pro-active network for the European eco-innovation community.

In the framework of developing a strategy, ECO-INNOVERA identified six topics for further development:

1. Developing a common understanding of eco-innovation
2. A better understanding of national/regional programmes, leading to a research landscape for eco-innovation in Europe
3. Ex-ante assessment through common metrics for impacts
4. Value chains and business models
5. Systems thinking applied to different sectors
6. Developing a research agenda on system-innovation for advice to the European Commission

In the present paper we focus on "Systems thinking applied to different sectors". For the other topics, please refer to the website www.eco-innovare.eu.

[1] ECO-INNOVERA – boosting eco-innovation through cooperation in research and development, an ERA-net project funded through the EU 7th Framework Programme. Partners and associated partners are: Kommunalkredit (Austria), IWT and SPW (Belgium), MON (Bulgaria), MST (Denmark), Tekes (Finland), ADEME and ANR (France), Ministry BMBF, Ministry BMU and DLR (Germany), Regione Piemonte and Finpiemonte (Italy), ISERD (Israel), FNR (Luxemburg), Ministry of IenM and RVO (Netherlands), NCBiR (Poland), APA (Portugal), Ministry of Science (Slovenia), Ministry of Science and Ihobe (Spain), FORMAS (Sweden), BAFU (Switzerland), Tubitak (Turkey), and Technology Strategy Board (United-Kingdom).
Coordinator of ECO-INNOVERA is Pt-Julich (Germany). Website: www.eco-innovera.eu

Seeking to move from systems innovation as a high-level academic topic, mostly of interest to scientists for analytical purposes, to developing an understanding of the concept in specific contexts, some workshops provided the basis for conclusions and advise to the public owners of programmes for the future funding of research for eco-innovation. ECO-INNOVERA shares the results from these workshops on the concept and theoretical background of systemic eco-innovation, including a definition, and on how a systemic approach to eco-innovation could influence the expected impacts of research and policy in the complex areas of resource efficiency and the future smart city.

The conclusions and recommendations are a reflection of common insights acquired by the ECO-INNOVERA partner organizations in the course of the project. They are being presented to the benefit of European, national and regional funders of eco-innovation, and as a basis for future ongoing coordination and cooperation for effective programming of eco-innovation with faster and deeper impact in society.

3. The case for systemic eco-innovation

Eco-innovation has been defined in the Eco-Innovation Action Plan (COM(2011)899):

> *Eco-Innovation is any form of innovation resulting in or aiming at significant and demonstrable progress towards the goal of sustainable development, through reducing impacts on the environment, enhancing resilience to environmental pressures, or achieving a more efficient and responsible use of natural* resources.

The Eco-innovation Observatory (EIO) introduced a similar definition (EIO-2010):

> *"Eco-innovation is the introduction of any new or significantly improved product (good or service) process, organizational change or marketing solution that reduces the use of natural resources (including materials, energy , water and land) and decreases the release of harmful resources over the whole life-cycle".*

The definition is broad, and by implication so is the remit of ECO-INNOVERA. The sources of eco-innovation are diverse and may not require the development of new technologies. Eco-innovation can equally be the assembly or integration of a set of existing technologies employed in disparate sectors to meet a defined environmental challenge. For example, the development of carbon capture technologies draws on a set of commercially available technologies from the oil, chemical and power generation industries. (OECD 2011).

The EIO distinguishes between eco-innovation and eco-industries. Eco-industries form sector(s) originating in environmental technologies but also including "green products and technologies" and "green energy", that is serving markets for environmental goods and services. The introduction of environmental technologies is often being driven by environmental regulations. Eco-innovations are considered to be solutions that are novel to both a company and to the market, but may not be driven by an explicit requirement to reduce environmental impact (typically the driver is reducing costs of materials/energy in order to increase competitiveness). (EIO 2010) .

The terms eco-efficiency and eco-effectiveness are also sometimes used. In general terms, eco-efficiency approaches tend to work within the boundaries of an existing industrial system, and can be viewed as "doing more with less". Eco-effectiveness approaches imply change at a system level, and are associated with highly circular industrial systems based on a "waste is food" approach as introduced in the influential publication "Cradle to Cradle", referring to "industrial systems that emulate the healthy abundance of nature".

Literature approaches based on the OECD Oslo Manual definition focus on an analysis of eco-innovation in terms of its targets (the main focus of the eco-innovation), its mechanisms (how change is exerted on those targets) and its impacts (the effects of those changes on environmental conditions).

A useful typology, proposed in OECD (2009) and combining approaches of other authors, provides sub-structure to the targets and mechanisms of eco-innovation, and broadly distinguishes measures as either being primarily technological change or primarily non-technological change.

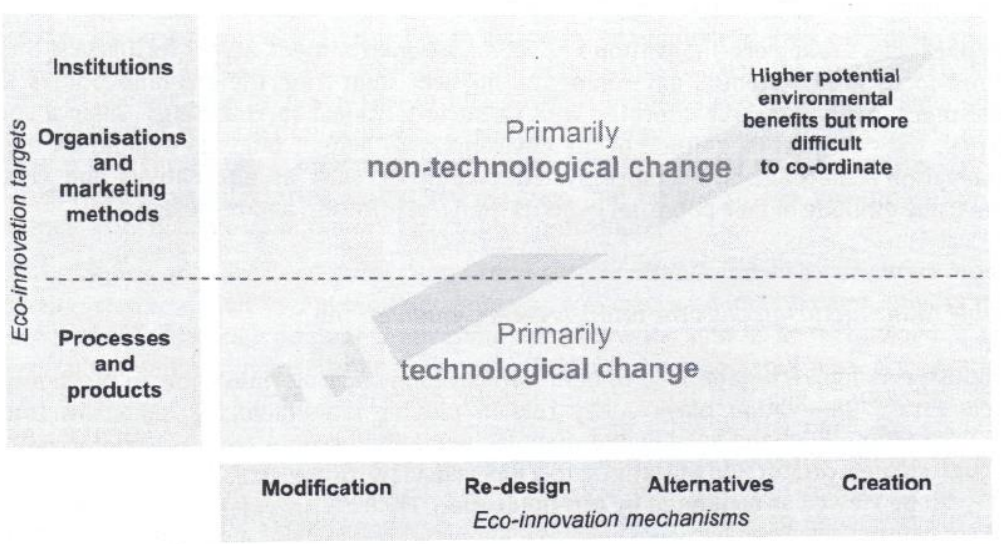

Figure 1: A typology for eco-innovation (OECD 2009)

The direction of EU environmental policy over the last 30 years broadly correlates to the direction of the arrow on this diagram, from measures focused primarily on pollution control/end-of-pipe technologies, through to cleaner manufacturing / full life cycle approaches through to measures intended to change fundamental patterns in consumption and production. Moreover, currently there is increased attention for the importance of innovation in so-called low tech sectors, creative industries, non-technological aspects of innovation and organisational innovation (Coenen & Lopez 2009).

It is widely recognized that technological innovation alone is not sufficient to put the European economy onto a sustainable path; to meet the magnitude of this challenge will require innovations which are more systemic in

nature, also involving social changes and measures to gain public acceptance. These more systemic types of eco-innovation will tend a) to be more complex, having several components on the above matrix and b) have significant components above the dotted line demarking primarily technological and non-technological change.

It should be recognized that many European companies are already implementing eco-innovation: the EIO cites a recent report in which 27% of innovating companies in the EU increased their material efficiency as the result of implemented changes (EIO 2011). For the vast majority of companies, the improvements were more modest and incremental. The EIO notes that there is an "eco-innovation gap" in terms of both the scale of eco-innovation activities (there being large differences between countries, sectors and companies) and the scope of eco-innovation changes, with a tendency towards more incremental rather than radical change.

Europe, as an industrialized economy, is an intensive user of resources with consumption averaging around 16 tonnes per year person (Eurostat 2011). While there have been relative improvements in material efficiency - material consumption increased by 7.8% in absolute terms between 2000-2007 at the same time as the economy grew by 35% - as yet the efficiency gains have not been sufficient to bring about a reduction in the overall use of natural resources. European policy – as articulated in the European Commission's Roadmap to a Resource Efficient Europe and the Eco-Innovation Action Plan – requires or implies an absolute decoupling in the use of natural resources. The current trajectory for eco-innovation improvements – even if the small proportion of companies achieving near Factor 2 improvements could be massively expanded – cannot achieve this objective.

The EIO estimates that targets for absolute reduction of material consumption ranging from Factor 2 (i.e. 50%) to Factor 5 (80%) will be necessary by 2050 if absolute decoupling of economic growth from material consumption is to be achieved and European policy objectives are to be met. (EIO 2012).

Examples of global challenges include access to clean water and affordable healthcare, poverty, employment, energy scarcities, and climate change as probably the most challenging of them all. Common to challenges of this magnitude and complexity is that they cannot be addressed by any single company, sector or government but rather required broad-based collaboration and synergistic actions across organizational, sectoral and national boundaries, including private-public partnerships. Global challenges thus call for system change at various levels of the economy and society.

The types of eco-innovation necessary to achieve such a transformation in resource use extend beyond the deployment of technological solutions alone to approaches which are more systemic in nature. Bleischwitz et al (2009) considered system innovation to be one of three distinct categories of eco-innovation. By this analysis, system innovations are concerned with technological systems, disruptive technologies and system changes and

associated with approaches such as life-cycle analysis, cradle to cradle, material flow analysis, closed loop, factor 4 or 10 amongst others. This implies rethinking the way the economy caters for the basic needs of society.

System innovations, according to Geels (2011) and others can be seen as "a change from one socio-technical system to another." The needs of a society in this model are met by 'socio-technical systems' – "a cluster of elements, including technology, regulation, user practices and markets, cultural meaning, infrastructure, maintenance networks, and supply networks" providing a basic function. Examples of needs and functions include, e.g.: food and food supply; shelter and construction materials; physical protection and clean cloths; mobility and public transport. Encouraging system innovation can be seen as structuring these transitions - in the image below this is the coalescence of smaller arrows into the larger arrows. The result is that the individual elements become aligned and stabilize into a new design, creating the momentum for a system shift.

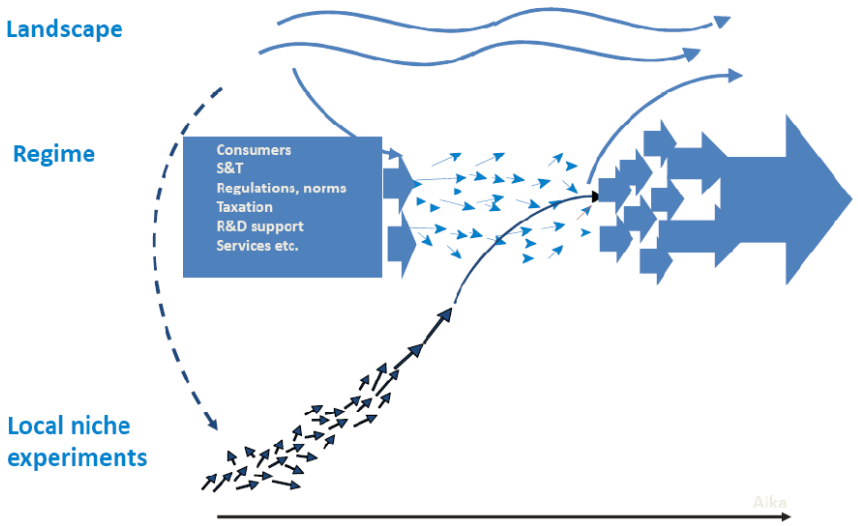

Figure 2: System level changes and innovations. Source: Finnish Tekes, after Geels (2011)

Systems innovation is a set of interventions that leads to a system-wide shift (in a sector, a city, an economy) to a more sustainable or ecologically sound path. The correct mix of policy interventions and research support - tailored to intervene at the tipping points and levers of a given system – has the potential to achieve a ***deeper*** level of innovation, ***faster*** than through a traditional, non-system approach. Furthermore, if the system is correctly defined and its potential interactions with other systems are well understood, the possibility of unintended consequences is reduced.

Process modification, product design, alternative business models and the creation of new procedures and organizational arrangements need to go hand in hand to leverage the economic and environmental benefits of such initiatives. This implies that as sustainable manufacturing initiatives advance, the nature of the eco-innovation process becomes increasingly complex and more difficult to co-ordinate. Although system innovation may have its

source in technological advances, technology alone will not make a great difference. It has to be associated with organizational and social structures and with human nature and cultural values. While this may indicate the difficulty of achieving large-scale environmental improvements, it also hints at the need for manufacturing industries to adopt an approach that aims to integrate the various elements of the eco-innovation process so as to leverage the maximum environmental benefits (OECD, 2009).

The overall objective of ECO-INNOVERA is to support innovation to reduce environmental impacts/resource use at a European level. Systems innovation is in the early stages of development outside of specialised academic circles; the thinking trickles down to practitioners slowly and difficult. ECO-INNOVERA aims to share understanding, connect active practitioners, and build and sustain the community for systemic eco-innovation for high-impact change to full decoupling. As a cross-cutting network with a remit to support eco-innovation, it can reasonably expect to have influence in shaping EU-wide policy and has the opportunity to occupy a distinctive space of high policy significance. At a national/regional level, network members provide links to national funding opportunities which can translate into practice.

4. General aspects of systemic eco-innovation

Thinking about systems innovation means embracing and understanding complexity. This means it is difficult, perhaps even counter-productive, to attempt to provide an inflexible or universal definition of system innovation. Instead, ECO-INNOVERA sought to identify some of the characteristics by which system innovation for sustainability can be identified, and which might provide some insight on the levers that can help bring about a system shift.

The key characteristics of systemic (eco)innovation were identified on the basis of a selection of case-studies that were known to ECO-INNOVERA partners (ECO-INNOVERA 2012). This resulted in the following characteristics:

1. Interdisciplinary, multi-faceted - combining behavior, technology, policy and economy;

2. Radical, transformative, providing alternative viewpoints to traditional policy thinking – thus creating significant change, using new approaches and applications

3. Collaborative - cross sector, involving different players, new entrants and new types of partnerships, including public-private partnerships;

4. Including whole value chains

5. Designed to work towards a shared eco or sustainability goal on complex challenges that they cannot be addressed by any single company, sector or government but rather require broad-based collaboration and synergistic actions across organizational, sectoral and national boundaries

A systemic eco-innovation also often implies significant adaptations or changes in other products or components. Increasingly complex innovations are often mutually interdependent and also have to be compatible with critical infrastructures, such as the Internet or electric grids. Systemic innovations thus require much created coordination during their development, commercialization and appropriation. This coordination also entails extra costs for the innovating company, for example related to development of new competencies, new business models, creation of standards and infrastructures to ensure interoperability and compatibility. Systemic innovations can have a large impact but they are also risky due the reasons mentioned above.

As to the impacts, systemic eco-innovations aim for the best performance on both economic benefits and environmental boundaries and social values, both intrinsic as well extrinsic ("eco-effectiveness").

To achieve actual system change for sustainability, a destabilization process is a crucial step. It follows a process moving from one socio-technological system to another and towards a new stable (and dynamic) equilibrium. In this process, novel supply and novel demand challenge the current dominating supply and demand structures. The transition theory suggests means for management of the destabilization process, the transition arena (Geels 2011).

5. Systemic eco-innovation for resource efficiency

Systems innovation comprises all approaches that aim at addressing all environmental, economic and social aspects of economy in an integral manner. In the first place, that may include the choice of primary and secondary resources, the use of these resources in manufacturing and business, the provision of processes, products and services to customers, the extended ownership and responsibility for products and materials after end-of-life, and the closing of the material chain through high-level re-use and recycling while maintaining the integrity of the material characteristics. The concept requires entrepreneurs to step beyond their usual area of influence by addressing their entire supply lines, their marketing, and their

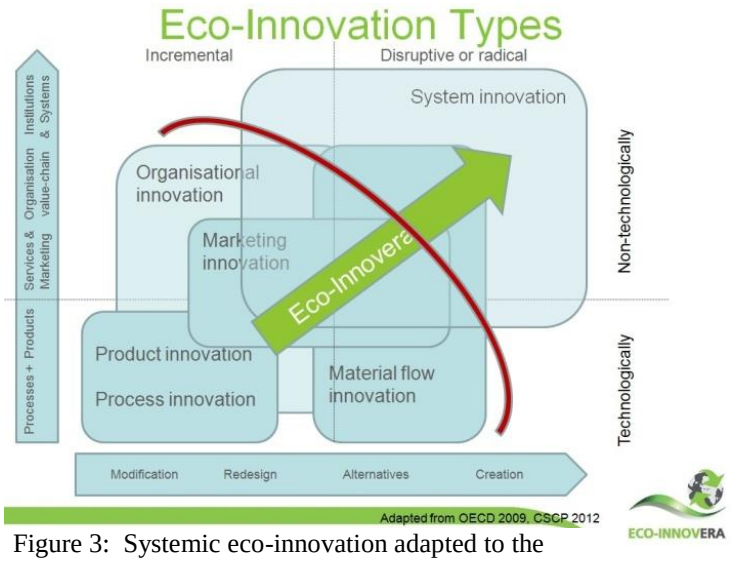

Figure 3: Systemic eco-innovation adapted to the Strategy of ECO-INNOVERA

business model, adapting the business strategy and enhancing internal competences to deal with challenges which are strange to entrepreneurship today. The red barrier in Figure 3 depicts the usual area of influence for entrepreneurs. That includes product and process innovation; innovation in marketing; material innovations or introducing new virgin materials; and some organisational innovations. Beyond the red barrier, we rarely find expertise, understanding and capacities among entrepreneurs or otherwise, who can actually deal with innovations that challenge the business model, substitute the use of the raw materials for recyclables or otherwise renewable resources.

A limited number of frontrunner entrepreneurs do so to their benefit; they develop industrial symbiosis, find new market niches for new sustainable products, services and processes, with new customers, using new sustainable resources. These frontrunners also meet many barriers of system level character: system related barriers to new approaches are all over the society, including in the education system and the user or consumer market. Experience shows that new technologies are not the main challenge. It is the way in which society values and adapts new approaches and technologies which require a change in behaviour, that poses the main challenge.

For policy-makers and research funders, such as in the ECO-INNOVERA community, the questions is therefore, to identify the policy interventions necessary to connect the research agenda of systemic eco-innovation to ongoing and planned initiatives in the field of a resource efficient economy. In the course of a set of expert-facilitated workshops, ECO-INNOVERA partners identified the most significant barriers and opportunities for systemic eco-innovation (ECO-INNOVERA 2014), which can be aggregated as follows:

- The EU definition of waste and resource needs streamlining, geared to the principle "there is no waste, only resource". Cross-sectoral approaches and industrial symbiosis involving mutually adapted practices and performances are likely to offer major opportunities for new integrated solutions, often leading to or inducing systemic changes.
- Resource efficiency includes materials, energy, water and the supplying eco-system and -services.
- Research is needed to enable business to re-use and recycle without significant loss of productivity, including development of new forms of entrepreneurship and business models which enable to raise funding even in cases where the innovation may lead to temporary disruption of the existing systems. Shift of profits and costs including change of social and cultural values and behaviour are inherent to system changes.
- Lack of awareness and training is a barrier to change, even more so in the case of systemic eco-innovation

- Social aspects and consumer behaviour are key areas for research, challenging also the current system of buy, throw-away, and buy more. A significant step could be made in the field of eco-design influencing from the start of the value chain having impacts also on consumer behaviour.

Key opportunities being identified for the further development of R&D topics and exploitation of results in support of systemic eco-innovation, include:

- Activities to involve stakeholders from different fields, during the entire process of design, innovation and innovation implementation enhance the chances for new approaches and solutions. Engagement of the design community leads to more efficient approaches to product design and use. Living labs are an example. Question remains how to tackle "big" problems with breaking them into silo's of segregate problem solving.
- The development of resource focussed communities needs research and policy-support (e.g. urban-farming, eco-industrial estates) , also building on open dialogues with all stakeholders
- The development of new networks for the exchange of products and materials will help the practical adoption at business level. Innovative marketing approaches foster awareness and motivation for new eco-innovative behaviour, practices and solutions.
- Identification of the pressure points and potential for change, including the key actors for change, and establish the right change arena for brainstorming, rethinking and redesign. Destabilisation of the dominant socio-technological regime offers niche opportunities for alternatives in the various institutional characteristics, including changes in governance, ownership, cultural implication, infrastructure, and supportive legislation.
- Learning from good and bad practices, and therefore creating an experimental space for radical novel approaches. Create case studies of systemic change, and aim to draw conclusions for their multiple value creation potential.
- Adapting the selection criteria for funding of research for eco-innovation in accordance with the above findings and recommendations.
- Enhancing education for future generations, which take a lead in the new challenges of the transforming system.
- Collaborating with eco-innovation partners and the European Commission to find best ways of triggering and supporting systemic eco-innovation, among others through funding front-runner small and medium enterprises that could influence, with their eco-innovations setting examples, different levels in society.

The above recommendations for future research aim to trigger a different type of research, more function-based, while acquiring and exploiting new insights in social values and consumer related patterns. The connecting factor

between the current and a possible future socio-technological system is the function being delivered to society, not the product or process.

6. Wrap-up

To achieve the expected impact in society and economy at a depth which is sufficient to enhance resource efficiency to the extent that European business does not overstep its rightful ecological footstep, aspects of society need to be subject of research which clearly goes beyond the realm of an individual entrepreneur, individual policy-maker, or even individual research programme. New understanding of system level barriers, including existing legislation, vested interests, and the potential of new business approaches, new education and competences, and new understanding of consumer behaviour are necessary. Publicly funded research should address such challenges, taking as a starting point the economic function delivered to society, the system analysis surrounding that function and challenge, describing systemic barriers that tends to limit innovation to business-as-usual, among others vested interests, as well as identify possible creative partners, researchers, and frontrunner entrepreneurs, aimed at generating new approaches to overcome these barriers.

ECO-INNOVERA expects a great potential for growth and employment within a circular economy for which systemic eco-innovation among others will open up new business opportunities for growth in services, remanufacturing and re-use.

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