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ORIGINAL PAPER

Eco-innovation for enabling resource efficiency and green growth: development of an analytical framework and preliminary analysis of industry and policy practices

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Abstract In order to meet great environmental challenges including climate change, more attention needs to be paid to innovation as a way to develop and realise sustainable solutions. This paper reviews the existing understanding of "eco-innovation" and proposes a framework that defines this concept from three aspects—target, mechanism and impact. The proposed framework is also applied to understand the evolution of corporate activities for sustainable production and analyse some good practices. Eco-innovation activities are very diverse and are occurring at different levels and scales. Although the primary focus of corporate practices tends to be on technological advances, some advanced industry players have adopted complementary organisational or institutional changes such as new business models and alternative modes of provision. It is therefore essential to capture both incremental and systemic (or radical) types of eco-innovation unlike most empirical research in this area.

1 Introduction: green growth emerged as new policy crossroads

In June 2009, the OECD Council Meeting at Ministerial Level (MCM) adopted a *Declaration on Green Growth* (OECD 2009a). The declaration invited the OECD to develop a Green Growth Strategy to achieve economic recovery and environmentally and socially sustainable economic growth.[1] The MCM Declaration broadly defines "green growth policies" as policies encouraging green investment in order to simultaneously contribute to economic recovery in the short term and help to build the environmentally friendly infrastructure required for a green economy in the long term. In terms of resource economics, such policies firstly need to guide industry to delink environmental degradation from economic or sales growth by reducing resource use per unit of value added (*relative decoupling*). At the same time, it would be essential to aim at further efforts towards achieving absolute reductions in the use of energy and materials to a sustainable level (*absolute decoupling*).

[1] For the latest development on the OECD Green Growth Strategy, see www.oecd.org/greengrowth.

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While industries are showing greater interest in sustainable production and are undertaking a number of corporate social responsibility (CSR) initiatives during the last decade, progress falls far short of meeting the pressing global challenges such as climate change, energy security and depletion of natural resources. Moreover, improvements in efficiency have often been offset by increasing consumption and outsourcing, while efficiency gains in some areas are outpaced by scale effects. Without new policy action, recent OECD analysis suggests that global greenhouse gas (GHG) emissions are likely to increase by 70% by 2050, whilst the G8 leaders agreed to aim for halving global emissions during the same period (OECD 2009b). The political and economic challenges for OECD countries are daunting.

Incremental improvement is not enough to meet such challenges. Industry must be restructured and existing and breakthrough technologies must be more innovatively applied to realise green growth. The OECD Directorate for Science, Technology and Industry (DSTI) is thus aiming to contribute to the development of the *OECD Green Growth Strategy* from a viewpoint of promoting the role of innovation for realising green growth and has been conducting a project on Green Growth and Eco-innovation since 2008.[2] Raising efficiency in resource and energy use and engaging in a broad range of innovations to improve environmental performance will help to create new industries and jobs in coming years. The current economic crisis and negotiations to tackle climate change should be seen as an opportunity to shift to a greener economy.

This paper presents part of the outcomes from the first phase of this OECD project, which took stock of the existing research and industry and policy practices and attempted to develop a conceptual framework for common understanding and further analysis. Firstly, the paper reviews the existing understanding of eco-innovation and propose a framework that defines the concept from three aspects. Secondly, the framework is applied to understand the evolution of corporate activities for sustainable production and analyse some good practices. Lastly, the paper envisions the potential of diverse approaches of eco-innovation captured by the framework with a particular emphasis on the role of systemic or radical innovation, and concludes by outlining the next phase of the OECD project that is planned for further in-depth understanding an advanced policy support.

2 Defining the role of eco-innovation for green growth

Much attention has recently been paid to innovation as a way for industry and policy makers to achieve more radical improvements in corporate environmental practices and performance. Many companies have started to use *eco-innovation* or similar terms to describe their contributions to sustainable development. A few governments are also promoting the concept as a way to meet sustainable development targets while keeping industry and the economy competitive. However, while the promotion of eco-innovation by industry and government involves the pursuit of both economic and environmental sustainability, the scope and application of the concept tend to differ.

[2] For more details on the OECD project on Green Growth and Eco-innovation, see www.oecd.org/sti/innovation/sustainablemanufacturing.

In the European Union (EU), eco-innovation is considered to support the wider objectives of its Lisbon Strategy for competitiveness and economic growth. The concept is promoted primarily through the Environmental Technology Action Plan (ETAP), which defines eco-innovation as "the production, assimilation or exploitation of a novelty in products, production processes, services or in management and business methods, which aims, throughout its lifecycle, to prevent or substantially reduce environmental risk, pollution and other negative impacts of resource use (including energy)".[3] Environmental technologies are also considered to have promise for improving environmental conditions without impeding economic growth in the United States, where they are promoted through various public-private partnership programmes and tax credits (OECD 2008).

To date, the promotion of eco-innovation has focused mainly on environmental technologies, but there is a tendency to broaden the scope of the concept. In Japan, the government's Industrial Science Technology Policy Committee defined eco-innovation as "a new field of techno-social innovations [that] focuses less on products' functions and more on [the] environment and people" (METI 2007). Eco-innovation is thus seen as an overarching concept which provides direction and vision for pursuing the overall societal changes needed to achieve sustainable development (Fig. 1).

The OECD is primarily studying innovation based on the OECD/Eurostat Oslo Manual for the collection and interpretation of innovation data. This manual describes innovation as "the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations" (OECD and Eurostat 2005, p. 46). This provides a good overview on where innovation occurs beyond technology spheres but does not shed enough lights on how it occurs and what it is developed for, which are essential to understand the nature of eco-innovation as it particularly concerns the scope of changes and the impact the changes can create for improving environmental conditions. Charter and Clark (2007, p. 10) provides an alternative useful classification of eco-innovation based on the levels of making differences from the existing state as below:

- *Level 1 (incremental)*: Incremental or small, progressive improvements to existing products
- *Level 2 (re-design or 'green limits')*: Major re-design of existing products (but limited the level of improvement that is technically feasible)
- *Level 3 (functional or 'product alternatives')*: New product or service concepts to satisfy the same functional need, *e.g.* teleconferencing as an alternative to travel
- *Level 4 (systems)*: Design for a sustainable society

In addition to the above two aspects, the concept of eco-innovation entails two other significant, distinguishing characteristics from that of ordinary innovation:

- Eco-innovation includes both environmentally motivated innovations and unintended environmental innovations. The environmental benefits of an

[3] The EU is discussing the renewal of the ETAP as the Eco-Innovation Action Plan from 2011. The new plan will reflect the extension of the eco-innovation concept by embracing non-technological aspects of eco-innovation such as innovation in business models and increasing attention to the diffusion and commercialisation stages of eco-innovation on top of research and development.

Field \ Target	Industry		Social infrastructure		Personal lifestyle
	Manufacturing	Service	Energy	Transportation / urban	
Technology	•Sustainable manufacturing •Innovative R&D (energy saving, etc.) •Green ICT •Rare metal recycling	•Innovative R&D •Building Energy Management System•	•Innovative R&D •renewable energy, batteries· •Superconducting transmission	•Innovative R&D (intelligent transport systems) •Green automobiles •Maglev	•Heat pump
Business model	•Green procurement •including BtoB• •Green servicizing •EMA •LCA	•Energy services •Environmental rating/green finance	•Green certification	•Modal shift	•Green procurement •Cool biz •Green finance
Societal system (institution)	•Environmental labeling system •Starmark •Green investment		•Top Runner Programme •PRS Act (Renewables Portfolio Standard)	•Green tax for automobiles •Next-generation vehicle and fuel initiative (METI)	•Telework, telecommuting •Work-life balance

Source: Ministry of Economy, Trade and Industry (METI), Japan.

Fig. 1 The scope of Japan's eco-innovation concept

innovation may be a side effect of other goals such as reducing costs for production or waste management (MERIT et al. 2008). In short, eco-innovation is essentially innovation that reflects the concept's explicit emphasis on a reduction of environmental impact, whether such an effect is intended or not.

- Eco-innovation should not be limited to innovation in products, processes, marketing methods and organisational methods, but also includes innovation in social and institutional structures (Rennings 2000; Reid and Miedzinski 2008). Eco-innovation and its environmental benefits go beyond the conventional organisational boundaries of the innovator to enter the broader societal context through changes in social norms, cultural values and institutional structures.

Synthesising the above considerations, the OECD project proposes that eco-innovation can be understood and analysed from three dimensions, namely in terms of an innovation's *1)* ***target***, *2)* ***mechanism*** and *3)* ***impact.*** Figure 2 presents an overview of eco-innovation and its typology:

1) **Target** refers to the basic focus of eco-innovation. Following the OECD/Eurostat Oslo Manual, the target of an eco-innovation may be:

a. ***Products***, involving both goods and services.
b. ***Processes***, such as a production method or procedure.
c. ***Marketing methods***, for the promotion and pricing of products, and other market-oriented strategies.

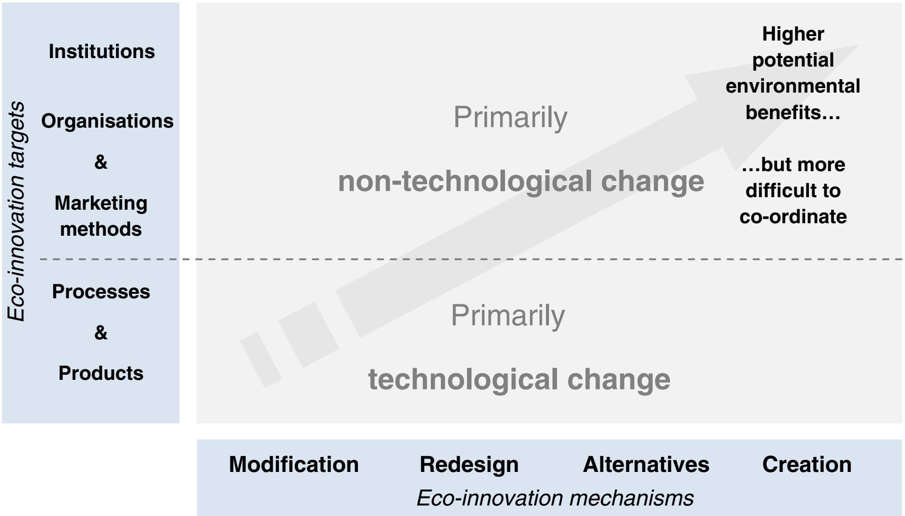


Fig. 2 A proposed framework of eco-innovation

d. ***Organisations***, such as the structure of management and the distribution of responsibilities.
e. ***Institutions***, which include the broader societal area beyond a single organisation's control, such as institutional arrangements, social norms and cultural values.

The target of the eco-innovation can be technological or non-technological in nature. Eco-innovation in products and processes tends to rely heavily on technological development; eco-innovation in marketing, organisations and institutions relies more on non-technological changes (OECD 2007).

2) **Mechanism** relates to the method by which the change in the eco-innovation target takes place or is introduced. It is also associated with the underlying nature of the eco-innovation—whether the change is of a technological or non-technological character. Four basic mechanisms are identified:

   a. ***Modification***, such as small, progressive product and process adjustments.
   b. ***Re-design***, referring to significant changes in existing products, processes, organisational structures, etc.
   c. ***Alternatives***, such as the introduction of goods and services that can fulfil the same functional need and operate as substitutes for other products.
   d. ***Creation***, the design and introduction of entirely new products, processes, procedures, organisations and institutions.

3) **Impact** refers to the eco-innovation's effect on the environment, across its lifecycle or some other focus area. Potential environmental impacts stem from the eco-innovation's target and mechanism and their interplay with its socio-technical surroundings. Given a specific target, the potential magnitude of the environmental benefit tends to depend on the eco-innovation's mechanism, as more systemic changes, such as alternatives and creation, generally embody higher potential benefits than modification and re-design.

3 Understanding sustainable manufacturing practices from the eco-innovation perspective

Industries have traditionally addressed pollution concerns at the point of discharge. Since this end-of-pipe approach is often costly and ineffective, industry has increasingly adopted cleaner production by reducing the amount of energy and materials used in the production process. Many firms are now considering the environmental impact throughout the product's lifecycle and are integrating environmental strategies and practices into their own management systems. Some pioneers have been working to establish a closed-loop production system that eliminates final disposal by recovering wastes and turning them into new resources for production, as exemplified in remanufacturing practices and eco-industrial parks.

This evolution of such sustainable manufacturing initiatives can be viewed as facilitated by eco-innovation and classified according to the dimensions proposed in the previous section. Figure 3 provides a simple illustration of the general conceptual relations between sustainable manufacturing and eco-innovation. The steps in sustainable manufacturing are depicted in terms of their primary association with respect to eco-innovation facets. While more integrated sustainable manufacturing initiatives such as closed-loop production can potentially yield higher environmental improvements in the medium to long term, they can only be realised through a combination of a wider range of innovation targets and mechanisms and therefore cover a larger area of this figure.

For instance, an eco-industrial park cannot be successfully established simply by locating manufacturing plants in the same space in the absence of technologies or procedures for exchanging resources. In fact, process modification, product design, alternative business models and the creation of new procedures and organisational 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.

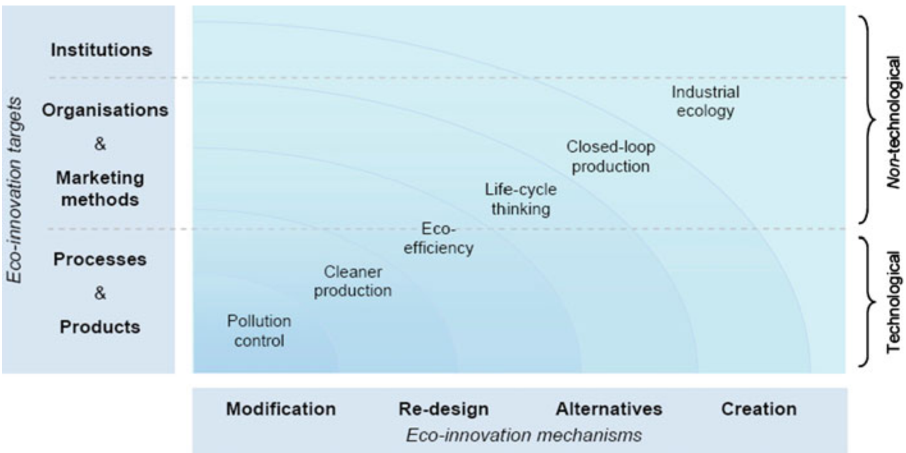


Fig. 3 Conceptual relationships between sustainable manufacturing and eco-innovation

Table 1 Eco-innovation examples examined through the eco-innovation framework

Industry and company/association	Eco-innovation example
Automotive and transport industry	
The BMW group	Improving energy efficiency of automobiles
Toyota	Sustainable plants
Michelin	Energy saving tyres
Velib'	Self-service bike sharing system
Iron and steel industry	
Siemens VAI, etc.	Alternative iron-making processes
ULSAB-AVC	Advances high-strength steel for automobiles
Electronics industry	
IBM	Energy efficiency in data centres
Yokogawa Electric	Energy-saving controller for air conditioning water pumps
Sharp	Enhancing recycling of electronic appliances
Xerox	Managed print services

OECD 2010

These complex, advanced eco-innovation processes can power possible "system innovation"—*i.e.* innovation characterised by fundamental shifts in how society functions and how its needs are met (Geels 2005). Although system innovation may have its source in technological advances, technology alone cannot make a great difference. It has to be associated with organisational 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. The feasibility of their eco-innovative approach would depend on the organisation's ability to engage in such complex processes.

4 Applying the eco-innovation framework for good practices

To better understand current applications of eco-innovation in manufacturing industries, a small sample of sector-specific examples were reviewed in light of the above framework. Examples from three sectors chosen for this preliminary review: a*)* the automotive and transport industry; b*)* the iron and steel industry; and c*)* the electronics industry. The examples draw mainly on the interaction with industry practitioners made during the first phase of the OECD project (Table 1). The examples are not meant to represent "best practices" but were selected to illustrate the diversity of eco-innovation, its processes and the different contexts of its realisation.[4] Following is an overview of the examination of each sector's general practices and examples according to the proposed eco-innovation framework. A few notable examples are illustrated in boxes.

[4] For detailed information on each example, see OECD (2010).

The automotive and transport industry is taking steps to reduce CO_2 emissions and other environmental impacts, notably those associated with fossil fuel combustion. Combined with the growing demand for mobility, particularly in developing economies, many eco-innovation initiatives have focused on increasing the overall energy efficiency of automobiles and transport, while heightening automobile safety. Eco-innovations have, for the most part, been realised through technological advances, typically in the form of product or process modification and re-design, such as more efficient fuel injection technologies, better power management systems, energy-saving tyres and optimisation of painting processes. Yet, there are indications that the understanding of eco-innovation in this sector is broadening. Alternative business models and modes of transport such as the bicycle–sharing scheme in Paris (Box 1) are being explored, as are new ways of dealing with pollutants from manufacturing processes of automobiles.

The iron and steel industry has in recent years substantially increased its environmental performance through a number of energy-saving modifications and the re-design of various production processes. These have often been driven by

In an attempt to reduce traffic congestion and improve air quality, the City of Paris introduced a self-service bicycle-sharing system *Vélib'* in the summer of 2007. The system consists of some 1 750 stations located in conjunction with metro and bus stations and open 24 hours a day year round, each containing 20 or more bike spaces. This amounts to about one station every 300 metres throughout the inner city, with a total of 23 900 bicycles and 40 000 bicycle racks.

Each station is equipped with an automatic rental terminal at which people can hire a bicycle through different subscription options. Subscriptions can be purchased for a small fee by the day, week or year and can be linked to the "swipe and enter" Navigo card used for the city's metro and bus system.

A subscription allows the user to pick up a bicycle from any station in the city and use it at no charge for 30 minutes. After that a charge is incurred for additional time in periods of 30 minutes. The payment scheme was designed to keep bicycles in constant circulation and increase intensity of use. To facilitate circulation, bicycles are redistributed every night to stations which have particularly high demand. Real-time data on bicycle availability at every station is provided through the Internet and is also accessible via mobile phones.

The start-up financing for the *Vélib'* project, as well as full-time operation for 10 years and associated costs, was undertaken entirely by the JC Decaux advertising company. In return, the City of Paris transferred full control of a substantial portion of the city's advertising billboards to this company.

The *Vélib'* system has been considered as a great success and taking bicycles is also becoming fashionable. Part of this success is due to the system's design, with its strong focus on flexibility, availability and, not least, ease of use. By October 2009, the number of annual subscribers has reached 147 000, and between 65 000 and 150 000 trips are being made each day. The system was extended to 30 neighbour boroughs in the suburbs by the summer 2009. Building on this success, the city is now planning to expand the project with about 4 000 self-service electric hire cars (named *Autolib'*) by the beginning of 2011.

Box 1 *Vélib'*: Self-service bicycle-sharing system in Paris strong external pressures to reduce pollution and by increases in the prices and scarcity of raw materials. While most of the industry's eco-innovative initiatives have focused on technological product and process advances, the industry's engagement in various institutional arrangements has laid the foundation for many of these developments. For example, the development of advanced high-strength steel was made possible through an international collaborative arrangement between vehicle designers and steel makers and enabled the production of stronger steel for the manufacturing of lighter and more energy-efficient automobiles (Box 2).

The electronics industry has so far mostly been concerned with eco-innovation in terms of the energy consumption of its products. However, as consumption of electronic equipment continues to grow, companies are also seeking more efficient ways to deal with the disposal of their products. As in the other two sectors, most eco-innovations in this industry have focused on technological advances in the form of product or process modification and re-design. Similarly, developments in these areas have been built upon eco-innovative organisational and institutional arrangements (see Box 3). Some of these arrangements have also been, perhaps unsurprisingly, among the most innovative and forward-looking. A notable example is the use of large-scale Internet discussion groups, dubbed "innovation jams" by IBM, to harness the innovative ideas and knowledge of thousands of people. Alternative business models, such as product-service solutions rather than merely selling physical products, have also been applied, as exemplified by new services in the form of energy management in data centres (IBM) and optimisation of printing and copying infrastructures (Xerox).

To sum up, the primary focus of current eco-innovation in manufacturing industries tends to rely on technological advances, typically with products or processes as eco-innovation targets, and with modification or re-design as principal mechanisms (Fig. 4). Nevertheless, even with a strong focus on technology, a

The introduction of new legislative requirements for motor vehicle emissions in the United States in 1993 intensified pressures on the automotive industry to reduce the environmental impact from the use of automobiles. In response, a number of steelmakers from around the world joined together to create the Ultra-Light Steel Auto Body (ULSAB) initiative to develop stronger and lighter auto bodies. From this venture, the ULSAB Advanced Vehicles Concept (ULSAB-AVC) emerged. The first proof-of-concept project for applying advanced high-strength steel (AHSS) to automobiles was conducted in 1999.

By optimising the car body with AHSS at little additional cost compared to conventional steel, the overall weight saving could reach nearly 9% of the total weight of a typical five-passenger family car. It is estimated that for every 10% reduction in vehicle weight, the fuel economy is improved by 1.9-8.2% (World Steel Association, 2008). At the same time, the reduced weight makes it possible to downsize the vehicle's power train without any loss in performance, thus leading to additional fuel savings. Owing to their high- and ultra-high-strength steel components, such vehicles rank high in terms of crash safety and require less steel for construction.

The iron and steel industry's continuing R&D efforts in this area also stem from its attempt to strengthen steel's competitive advantage over alternatives such as aluminium. The Future Steel Vehicle (FSV) is the latest in the series of auto steel research initiatives. It combines global steelmakers with a major automotive engineering partner in order to realise safe, lightweight steel bodies for vehicles and reduce GHG emissions over the lifecycle of the vehicle.

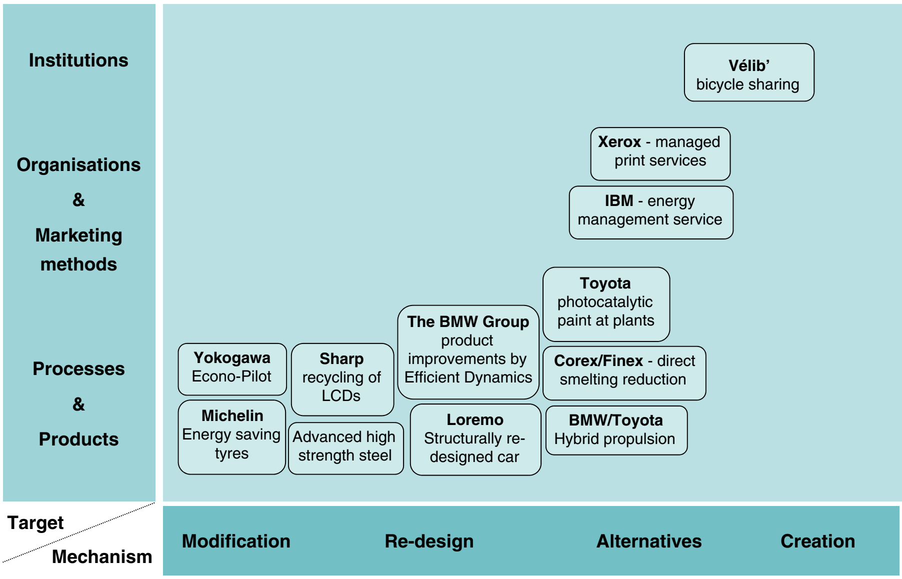
Box 2 The development of advanced high-strength steel for automobiles

Air conditioners function by driving hot or cold water through piping to units located on each level of the building. The amount of cold water varies according to the desired temperature relative to the outside temperature. However, conventional air conditioners operate at the pressure required for maximum heating and cooling demands. Based on research revealing that in Japan air conditioning consumes half of a building's total energy, Yokogawa Electric, a Japanese manufacturer, sought to create a simple, inexpensive and low-risk control mechanism that would eliminate wasteful use of energy. The resulting product, Econo-Pilot, can control the pumping pressure of air conditioning systems in a sophisticated way and can reduce annual pump power consumption by up to 90%. It can be installed easily and inexpensively, precluding the need to buy new cooling equipment. The technology has been successfully applied in equipment factories, hospitals, hotels, supermarkets and office buildings.

Image: Yokogawa Electric Corporation

Econo-Pilot is based on the technology devised by Yokogawa jointly with Asahi Industries Co. and First Energy Service Company. It was developed and demonstrated through a joint research project with the New Energy and Industrial Technology Development Organization (NEDO), a public organisation established by the Japanese government to co-ordinate R&D activities of industry, academia and the government. NEDO researches the development of new energy and energy-conservation technologies, and works on validation and inauguration of new technologies. After the demonstration and piloting of this technology, various functions were incorporated in the final product.

Box 3 Energy-saving controller for air conditioning water pumps



Note: This map only indicates primary targets and mechanisms that facilitated the listed eco-innovation examples. Each example also involved other innovation processes with different targets and mechanisms.

Fig. 4 Mapping primary focuses of eco-innovation examples number of complementary changes have functioned as key drivers for these developments. In many of the examples, the changes have been either organisational or institutional in nature, such as the establishment of separate environmental divisions for improving environmental performance and directing R&D, or the setting up of inter-sectoral or multi-stakeholder collaborative research networks. Some industry players have also started exploring more systemic eco-innovation through new business models and alternative modes of provision.

The heart of an eco-innovation cannot necessarily be represented adequately by a single set of target and mechanism characteristics. Instead, eco-innovation seems best examined and developed using an array of characteristics ranging from modifications to creations across products, processes, organisations and institutions. The characteristics of a particular eco-innovation furthermore depend on the observer's perspective. The analytical framework can be considered a first step towards more systematic analysis of eco-innovation.[5]

5 Guiding towards systemic changes

The above framework of eco-innovation implies diverse approaches to help realise resource efficiency and green growth through accelerating innovation, including both technological and non-technological changes. The approaches can be roughly categorised into *incremental innovation* and *systemic* (or radical) *innovation*. Incremental innovation primarily contributes to the relative decoupling of environmental impacts from economic growth, while the latter tends to have larger potential for helping to make absolute decoupling possible.

Facing the great challenges of climate change and environmental degradation, it has to be clear to government and industry alike that incremental improvement is not enough to fulfil their long-term commitment. Deliberate policy interventions could bring a new opportunity to create new entrepreneurs, industries and jobs, but existing industries must be restructured and existing and breakthrough technologies must be more innovatively applied to secure long-term competitiveness and economic growth. In parallel to investing in easy short-term win-wins such as subsidising eco-friendly vehicles, today's economic stimulus packages could also stimulate investments in technologies and infrastructures that help innovation and enable changes in the way we produce and consume goods and services in the long term.

Clear benefits of more systemic innovation have been well exemplified in the areas of general-purpose technologies. While the information and communication technologies (ICTs) urgently need to raise energy efficiency in existing products which are responsible for around 2% of global GHG emissions, one estimate indicates that the transformation of the way people live and businesses operate through the smart application of ICTs could reduce global emissions by 15% by 2015 (The Climate Group 2008). Biotechnology and nanotechnology could create environmental benefits mainly through the unique application in different sectors or

[5] A combination of this eco-innovation framework with the frameworks of system transition developed by some scholars (*e.g.* Geels 2005; Loorbach 2007; Carrillo-Hermosilla et al. 2009; Bleischwitz 2007) could further help understand the dynamic nature of radical changes created by eco-innovations.

Table 2 Application of technologies in different types of innovation

Incremental innovation	Systemic innovation
Existing (but improved) technologies in existing application	Existing technologies in new application
New technologies in existing application	New technologies in new application

the convergence with existing technologies. Table 2 highlights the basic distinction (though there is not clear line) between incremental and systemic eco-innovation based on the way which existing or new, breakthrough technologies are applied. Figure 5 provides the other way to highlight the distinction based on the evolution of manufacturing processes and products and services towards sustainable production which was explored in Section 3.

Needless to say, there are many barriers to enabling systemic innovation. Policy makers and industry are increasingly facing difficulties in investing in long-term future due to short political cycles and pressure from shareholders. Sector or technology-based approaches in conventional environmental policies may fail to take into account the full innovation cycle of environmental technologies and undermine opportunities for cross-sectoral application of new technologies. The market-based "getting prices right" measures such as carbon taxes and emissions trading schemes may not be enough to guide investment in promising technologies with high initial cost and much-needed green infrastructures.

6 Conclusions: agenda for the future eco-innovation analysis

In order to meet great environmental challenges such as climate change, much attention has been paid to innovation as a way to develop sustainable solutions. The concepts of eco-innovation are increasingly adopted by industry and policy makers as a way to facilitate more radical improvement in production processes and

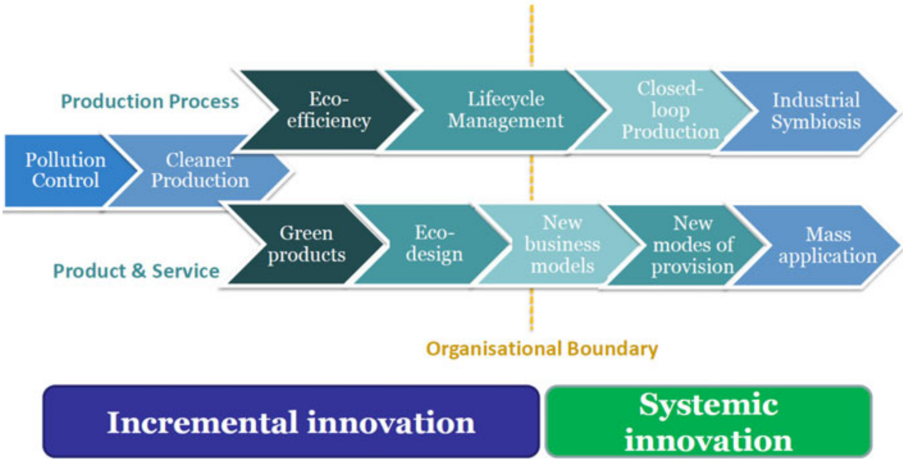


Fig. 5 Conceptual distinction between incremental and systemic eco-innovations

products and in corporate environmental performance. Eco-innovation can be understood in terms of its target, mechanism and impact.

From the perspective of eco-innovation, the primary focus of sustainable manufacturing practices tends to be on technological advances for the modification and re-design of products or processes. However, some advanced industry players have adopted complementary organisational or institutional changes such as new business models or alternative modes of provision, for example, offering product-service solutions rather than selling physical products.

As such, it is essential to capture both incremental and systemic (or radical) types of eco-innovation unlike the conventional economic and empirical research in this area. The former type of innovation mainly supports realising relative decoupling in the relatively short term, while the latter has potential for enabling absolute decoupling in the long term. Although improvements in eco-efficiency through incremental innovations have led to substantial environmental progress, the gains have often been offset by increasing consumption or outpaced by scale effects. In order for OECD countries to fulfil a potential post-Kyoto target of GHG emissions reduction, they will therefore need to engage in a broader range of eco-innovations.

Probably most needed for government is knowledge and competence to set balanced priorities between taking short-term "low-hanging fruit" and investing in long-term sustainable changes. The potential economic and environmental benefits of systemic innovation need to be identified, particularly where applications of new technologies can have highest benefits. To guide the processes of system transition and industry restructuring, visions and scenarios for further societal systems should be collectively developed and shared in different areas such as transport, housing and nutrition.

In this context, the OECD project on Green Growth and Eco-innovation moved to its second phase in 2010 and works in three fronts: *a)* case studies of new business approaches to eco-innovation; *b)* analysis and case studies of policies to drive eco-innovation; and *c)* empirical analysis of eco-innovation and the transition in industrial structures required to realise green growth. The first element is particularly relevant to the further development of the eco-innovation concept and framework as it will explore the potential of radical and systemic eco-innovation and learn how successes can be further extended and accelerated. This will be done by analysing the innovation processes of specific cases to be collected from member countries, including diverse aspects such as the source of the original idea, the business model, the role of partnerships and collaboration, the impact of policies in facilitating the innovation, the sources of funding and the potential economic and environmental benefits.

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