

Environmental Innovation

Drivers · Challenges · Opportunities



A Report for **NUTEK**
The Swedish Agency for Economic and Regional Growth

By
Copenhagen Institute for **Futures** Studies
Institutet for **Fremtidsforskning**

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Sammanfattning

- » Denna rapport kommer att inledas med en kort analys av de trender som driver på behovet av miljöinnovation. Analysen kommer att följas av en beskrivning av risker, utmaningar och möjligheter inom miljöinnovation för små och medelstora företag. Rapporten avslutas med en presentation av scenarier för framtida miljöinnovation och vilka konsekvenserna kan bli för svenska små och medelstora företag.
- » Med små och medelstora företag menas privata företag med färre än 250 anställda inom tillverknings-, service- och handelssektorn. Dessa företag utgör mer än 95 % av den privata sektorn i Sverige samt inom EU och OECD.
- » Att hjälpa små och medelstora företag förstå deras enskilda såväl som kollektiva miljöpåverkan är avgörande för framtida miljöinnovation. Miljöinnovation kan definieras som "nya eller förändrade processer, tekniker, metoder, system samt produkter för att undvika eller minska miljöförstöring". Små och medelstora företag svarar för så mycket som 70 % av alla industriföreningar, vilket lämnar utrymme för stora möjligheter inom miljöinnovation med en förväntad marknad på flera biljoner dollar år 2050.
- » Under de närmaste 10 - 15 åren kan vi förvänta oss att se radikala innovationer som leder till förändringar inom det tekniska systemet. Under de kommande 20 - 30 åren kan miljöinnovationer leda till en teknisk revolution inom näringslivet – vilket, om så är fallet, kommer utveckla ett mer hållbart ekonomiskt system.
- » Det finns generellt sett tre typer av innovativa små och medelstora företag: de användardrivna, entreprenörerna och de forskningsbaserade innovatörerna. Enligt en dansk undersökning är 80 % av alla små och medelstora företag fokuserade på innovation i tillväxtsyfte. Innovation inom dessa företag uppstår vanligen genom nära kundkontakt, där företagen anpassar befintliga produkter till nya kunder och nya behov. Man kan därför tänka sig att större delen av all miljöinnovation som kommer från små och medelstora företag även i framtiden kommer att syfta till tillväxt.
- » Det finns två vedertagna modeller för miljöinnovation: "market push" samt "technology pull". Båda modellerna förklarar hur miljöinnovation kan utvecklas via utbud och efterfrågan genom faserna demonstration, kommersialisering och etablering. Båda modellerna har strukturella svagheter som kommer att påverka innovationen.
- » "Market push" innovationer hämmas av en brist på tydlig efterfrågan efter miljövänliga produkter från statens och företagets kunder samt från konsumenterna. "Technology pull" innovationer får hjälp av statlig finansiering när riskerna för företaget är som lägst. Olika lagar och regleringar begränsar finansieringen under demonstrations-, utvecklings- och försäljningsperioden, när företagets risker är som störst.
- » I framtiden kan miljöinnovation utvecklas på flera sätt. I rapporten presenteras fyra framtida scenarier för miljödriven innovation och vilka konsekvenserna blir för små och medelstora företag. Dessa scenarier undersöker följderna av attityden till ny miljöteknik: kommer den drivas av en önskan att begränsa miljöeffekterna eller kommer den med stora steg leda till nya former för innovation? Scenarierna utreder vilka konsekvenserna blir för små och medelstora företag om kraven på miljöinnovation kommer uppifrån (från regeringar och stora företag) eller nerifrån (från privata organisationer och konsumenterna).
- » Under de närmaste 15 åren kan vi få se fyra olika tendenser rörande miljöinnovation, vilka beskrivs i scenarierna. Scenarierna kan användas för att diskutera vilka former för innovation vi önskar se mer av och hur vi utvecklar strategier samt för en politik så vi kan uppnå bestämda mål. Följderna av det politiska agerandet såväl som de små och stora företagens agerande kommer påverka framtiden för miljöinnovation.

Executive Summary

- » This report will begin with a short analysis of the trends that are driving the need for environmental innovation. This analysis will be followed by a description of the risks, challenges, and opportunities of environmental innovation for small and medium-sized enterprises (SMEs). The report will conclude with a presentation of scenarios for the development of future environmental innovation and their consequences for Swedish SMEs.
- » The term small and medium-sized enterprises (SMEs) refers to private enterprises with less than 250 employees in manufacturing, service and trade industries. SMEs constitute over 95% of the private sector in Sweden and the broader EU and OECD. It is widely assumed that SMEs are responsible for as much as 70% of all industrial pollution, which means that the future opportunities within environmental innovation are large – with projected market sizes in the trillions of dollars by 2050.
- » Helping SMEs understand their individual as well as collective environmental impact is essential for future environmental innovations that will help prevent, mitigate, or remediate the impacts of business on the environment. Environmental innovations can be defined as “new or modified processes, techniques, practices, systems, and products that avoid or reduce environmental harm.”
- » Over the next 10 – 15 years, we can expect to see incremental and radical innovations leading to changes in technology systems. In the next 20 – 30 years, we may witness environmental innovations leading to a technological revolution within business, leading to a much more sustainable economic system.
- » There are generally three types of innovative SMEs: the user-driven, the entrepreneurial, and the research-based innovator. According to a Danish survey, 80% of SMEs are focused on incremental innovation. Innovation in SMEs typically occurs through close customer contact (either B2B, B2C, or B2G), where SMEs adapt existing products for new customers and new needs. The majority of SMEs tend to be risk adverse as they are unwilling to take the risks associated with potentially high-growth markets. Hence, it is likely that the majority of environmental innovations coming from SMEs in the future will be incremental ones.
- » There are two well-accepted models for environmental innovation: “market push” and “technology pull.” Both models explain how environmental innovation can be driven from R&D through to demonstration, commercialization and diffusion phases. Both have structural weaknesses that will impact environmental innovation.
- » Market push innovations are hindered by a lack of well-articulated demand for environmentally friendly products from government and business clients and general consumers. Technology-pull innovations are affected by State Aid regulations that provide funding for R&D phases, at a time when market risks for the company are lowest. State Aid regulations restrict funding during demonstration, scale-up and commercial sales periods, when market risks for the company are greatest.
- » In the future, environmental innovation can be driven in a number of ways. This report concludes with four future scenarios for environmentally driven innovation and explores their consequences for SMEs. These scenarios will examine the consequences of global attitudes towards new environmental technologies: Will attitudes towards new environmental technologies be driven by a desire to limit existing environmental impact or aggressively target new forms of innovation? The scenarios will also explore the consequences of a regime where the demands for environment innovation come from the top (governments, big businesses) or from below (NGOs, shifts in consumer demands) for SMEs.
- » In the next fifteen years, we could see environmental innovation trends in any of the four directions. We can use these scenarios in the present to discuss what forms of innovation we wish to see in fifteen years’ time and develop strategies and policies that focus efforts towards achieving those aims. The consequences of government policy and investment decisions will impact SMEs business decisions and resulting future forms of environmental innovation.

1. Introduction

This report will begin with a short analysis of the trends that are driving the need for environmental innovation. This analysis will be followed by a description of the risks, challenges, and opportunities that environmental innovation offers small and medium-sized enterprises (SMEs). The report will conclude with a presentation of scenarios for the development of future environmental innovation and its consequences for Swedish SMEs.

SMEs are essential when considering environmental innovation. SMEs refer to private enterprises with less than 250 employees in the manufacturing, service and trade industries. SMEs constitute over 95% of the private sector in Sweden and the broader EU and OECD, and their cumulative impact on the environment is large. In Sweden, SMEs contribute to three-fifths of economic turnover.¹ SMEs are often not the focus of environmental policy, because they are miniscule, as are their individual negative environmental impacts. Many in OECD countries are in service industries and have no visibly "dirty" industry practices. While SMEs' individual environmental impacts are generally small, they are large when aggregated. Although a largely unsubstantiated figure, it is widely believed that SMEs are responsible for as much as 70% of all industrial pollution.² However, SMEs, in general, are ignorant of their environmental impact. According to a recent survey of SMEs in Great Britain, only 15% of SMEs considered that their business activities could have an impact on the environment.³

The future opportunities within environmental innovation are large with projected markets sizes in the trillions of dollars by 2050. However, SMEs' low awareness of their environmental impacts coupled with often-weak policy and market incentives will make a transition to a more sustainable and environmentally innovative SME sector challenging in the future.

1.1 Environmental innovation

Innovation is the introduction of new processes, services, and products into the marketplace. Environmental innovations can be defined as "new or modified processes, techniques, practices, systems, and products that avoid or reduce environmental harm."⁴ Innovation – unlike research – seeks to achieve an expected desired outcome. Innovations can:

- » Be *incremental* – meaning that companies seek to reduce the impact of existing processes, products, and services.
- » Be *radical* – these are innovations that come from outside the mainstream that can lead to significant structural impacts. It normally requires several radical innovations to lead to the development of entire new product and technology classes.
- » Lead to *changes of "technology system"* these are changes that

occur due to technologically and economically related innovations that combine several radical and incremental innovations that lead to far-reaching changes in technology.

- » Lead to *technological revolutions*

Over the next 10 –15 years, we can expect to see incremental and radical innovations leading to changes in technology systems. In the next 20 – 30 years, we may even witness environmental innovations leading to a technological revolution within business, leading to a much more sustainable economic system. However, over the coming years, one must not lose sight of the benefits that incremental innovations have. According to recent research, the cumulative effect of incremental innovations can be equal to or much more significant than radical innovations.⁵

1.2 Innovation models

The two most influential innovation theories that will impact future developments in environmental innovation are: "market pull" and "technology push". According to market pull theory, changes in technology and business practices originate from market demands and rely upon corporate investments. Proponents of technology-push theory, however, maintain that new developments result from public policy and autonomous trends. Proponents of technology push models argue that technological change and innovation are due to public policies and autonomous trends. More often than not, both models impact innovation.⁶ The push-pull models are the principal mechanisms through which innovations can be driven from R&D through demonstration, commercialization and diffusion phases.⁷

2. Megatrends: driving environmental concerns, environmental innovation

Megatrends are long-term driving forces or development trends that influence almost everything at all levels of society. They have great importance now, and we are relatively sure they will also have great importance in the future. Examples are demographic development with an ageing population, technological development within biotechnology and nanotechnology, and globalization with a rising, global financial integration. The Copenhagen Institute for Futures Studies (CIFS) has identified 13 megatrends. Megatrends are often well known, and information about what they encompass is widely available. The

megatrends that are affecting the environment and which will lead to increasing demands for environmental innovation by all businesses, including SMEs, for the foreseeable future include population developments, growing prosperity and increasing global consumption, and technology developments.

Population developments: Over the next 22 years, the world's population is expected to grow, become wealthier, and more urbanized. Despite the fact that birth rates are largely declining around the world, the world's population is projected to continue to grow from 6.7 billion today to approximately 8 billion by 2030. Much of this growth will occur in non-OECD countries, while Europe's population is not expected to grow significantly.⁸ The world's population is expected to become increasingly urbanized with over 75% of the world's population living in urban areas in 2050 – up from 50% today.⁹ Along with increasing population growth, people around the world are growing wealthier. Global wealth has doubled since 1990. Over the next 22 years, global wealth can double again.¹⁰ Economic growth is expected to be particularly high in China and India. China and India's household wealth is expected to grow dramatically in the future. According to Barclay's Bank and the Economist Intelligence Unit, the average net worth for Chinese families is expected to grow from \$18 000 in 2007 to \$74 000 by 2017, while Indian families' is expected to grow from \$12 000 to \$57 000.¹¹

Growing prosperity and increasing global consumption: A growing global population combined with increasing global propensity means increased consumption that – without environmental innovation – will place increasing demand on an already stressed globe. Energy use among households in OECD countries is expected to increase by 1.4% annually, as are personal travel miles. According to forecasts by the International Energy Association, non-OECD countries' energy consumption is expected to surpass OECD countries by 2010 and be 30% higher than the West's by 2030. Growing prosperity will also increase global demand for consumer goods and foodstuffs in the form of meat, dairy and processed foods. It will also increase the demands and amounts of personal travel and household waste that will be generated on a global scale.¹² The recent announcement of a new class of vehicles aimed at the world's global middle class – Tata motor company's \$2 500 car, which has already spawned competition from Renault Nissan – is a perfect example of this trend.

Technology developments: In the future, technology developments will take two forms, development of new processes and of new products. These can be environmentally beneficial, ambiguous, or lead to

further environmental degradation. Many new innovations – such as biofuels and nanotechnologies – can lead to beneficial developments in certain areas, while leading to increasing environmental pressures in other. This is particularly the case with first-generation biofuels, which have led to increasingly stresses on land resources and questionable greenhouse gas emission reductions. Hybrid engines are another example of innovations that offer both energy reductions and also led to other environmental challenges in terms of battery disposal. Innovation will lead to number of new technologies and processes in energy, water, and waste reduction. Solar cells are becoming increasingly efficient. Currently over 20% of biotechnology innovations are used in industrial applications in Japan. In China, industrial usage of biotechnologies is, surprisingly, much higher than in most OECD countries.¹³

3. The areas in need of environmental research in the future and future growth of the market

The major challenges in defining the areas for environmental innovation are due to the environmental market's size and diffuse nature, which makes this market difficult to both define and isolate. Among the key challenges in the future will be developing innovative solutions to current and future energy, waste, and water challenges.¹⁴

Moreover, the challenges facing Sweden and Swedish SMEs in the environmental arena are no longer local. They are global. This includes not only environmental challenges, but business solutions as well. Swedish SMEs can both create environmental solutions that can be used in both the local and/or global marketplace. Vestergaard Frandsen's Lifestraw is an example of an environmental innovation from Scandinavia that will primarily be used abroad. Increasing competition from abroad will also challenge Swedish SMEs. On the next page, there is a list of the pressing environmental challenges from the 2008 OECD's *Environmental Outlook to 2030* report that presents the key environmental challenges over the coming twenty years:

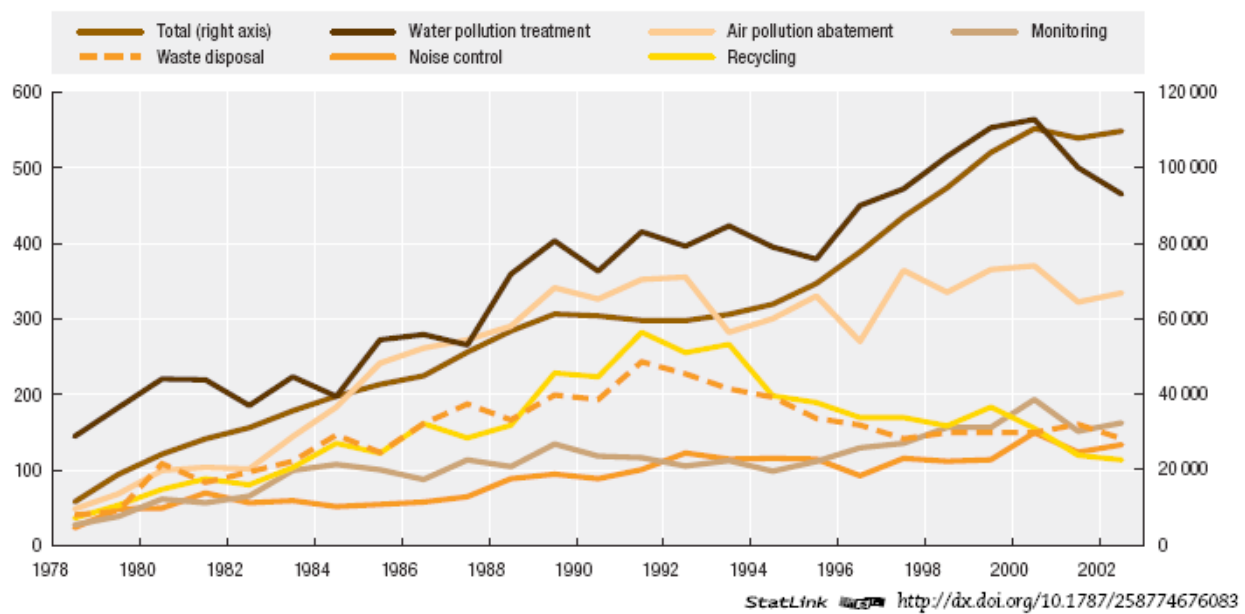
	HIGH (SIGNIFICANT IMPORTANCE/LOW CAPABILITY)	MEDIUM (OF IMPORTANCE/ MEDIUM OR GROWING CAPABILITY)	LOW (ENVIRONMENTAL RISKS THAT ARE BEING WELL MANAGED)
Climate Change	Global GHG emissions Adaptation to already changing climate	Declining GHG emissions per unit of GDP	
Biodiversity & renewable natural resources	Development of renewable energy sources Ecosystem quality Species loss Invasive alien species Tropical forests Illegal logging Ecosystem fragmentation	Forest management Protected Areas	Forested areas in OECD countries
Water	Water scarcity Groundwater quality Agricultural water use & pollution	Surface water quality and wastewater treatment	Point of source water pollution in OECD countries
Air quality	Urban air quality	PM & ground-level ozone Road transport emissions	OECD country SO ₂ & NO _x emissions
Waste & hazardous chemicals	Hazardous waste management and transportation Waste management in developing countries Chemicals in the environment and products	Municipal waste generation Developing country emissions of CFCs	Waste management in OECD countries OECD emissions of CFC

Environmental challenges will impact all business sectors to varying degrees, and environmental innovations will come from almost any sector. According to the UK Environmental Innovations Advisory Group (EIAG), even though some companies – such as environmental consultancies – can identify themselves as being within the environmental industry sector, many environmentally innovative firms cannot. The scale of the industry is often underestimated, and its needs likewise neglected.¹⁵ According to recent interviews conducted by the OECD for case studies of large companies around the globe, interviewed companies no longer saw a distinction between *environmental* innovation and innovation in general.

The need to take the environment into consideration into the innovation process may erase many of the distinctions between environmental and other industrial innovations (e.g. construction, manufacturing, etc.) This, in the future, may lead to a mainstreaming of environmental thought within the innovation process. The consequence

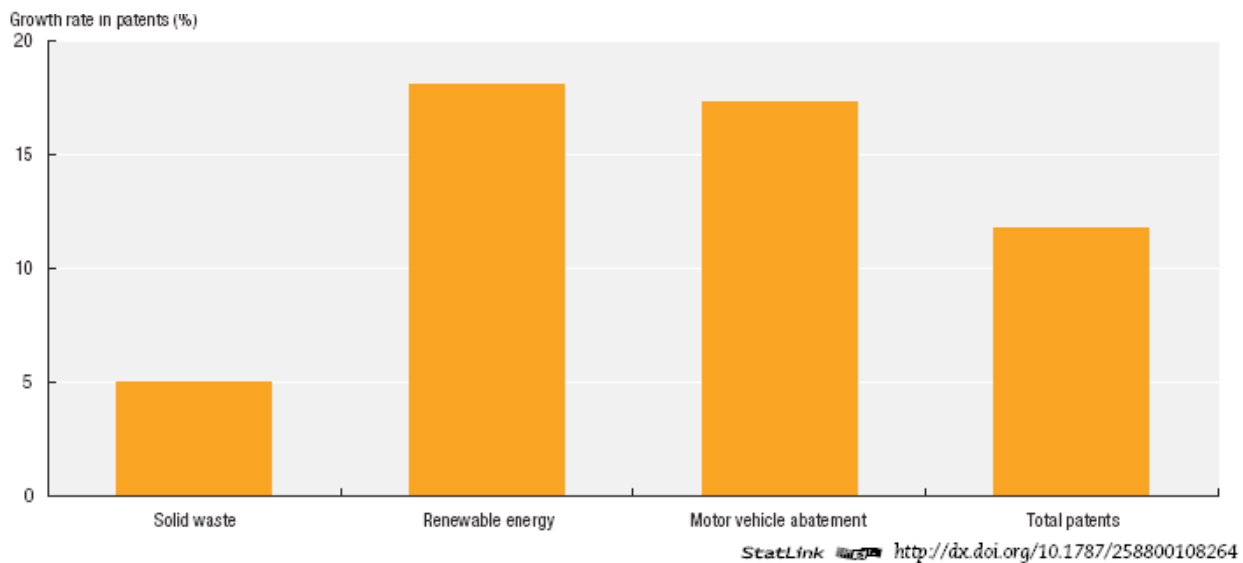
of this development for SMEs in the future would be that companies all along the supply chain would begin looking at the ecological footprint of their suppliers. Suppliers' customers could punish companies that do not attempt to reduce the ecological footprint of their products and services by purchasing from a more environmentally sustainable competitor. This future consequence, however, is dependent upon how deeply companies include environmental considerations in their supply chain management and innovation considerations.

On the next page, the two graphs present trends in environmental innovation patent taking (Fig. 1) and relative growth of environmental innovations compared to trends in innovation patenting in general (Fig. 2). The first graph shows that there has been a trend towards increasing environmental innovation in most areas, excluding waste disposal and recycling. Innovations within these industries seem to have peaked in the 1990s. The second graph shows that even though the total



Source: Data drawn from the OECD Project on Environmental Policy and Technological Innovation www.oecd.org/env/cpe/firms/.

Fig. 1. Environmental innovations and patent taking 1978-2002



Source: OECD (2007b).

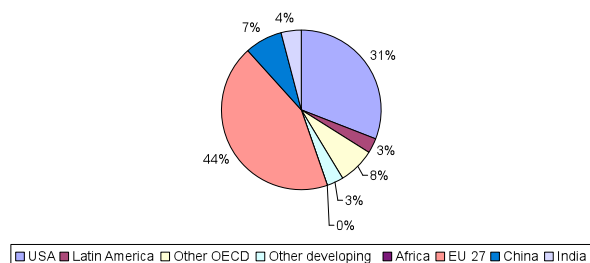
Fig 2. Growth rate in patents in selected environmental areas, 1995-2004

amount of environmental innovations are increasing, environmental innovations are increasing only slightly faster than the general pace of innovation.¹⁶

The global scale of the environmental industry is large. It was estimated to be as big as \$584 billion in 2004, and is projected to reach \$700 billion by 2010, which is triple the size of the global aerospace industry.¹⁷ The future of environmentally driven innovations is expected to be great. The Stern Report projected that the low-carbon energy sector would grow from \$100 billion to \$500 billion by 2050. Further analysis by Professor Dennis Anderson, Imperial College London, places the figure much higher at approximately \$3 trillion. Though speculative, these figures will in all likelihood underestimate the overall impact of environmental innovations. They do not, for example, include impacts of new vehicle technologies or integration of new innovative practices in businesses. They also ignore the possibilities of creating new brokerage services within mitigation services.¹⁸

Sustainable investment has grown significantly over the last two decades. Venture capitalists investments have grown from \$0.07 billion in 1990 to a high of \$1.6 billion dollars in 2006. If one includes investments conducted around the globe in sustainable energy by venture capitalists, on public markets, and through asset financing, the figure reached \$53.04 billion in 2006. This figure only includes investments in sustainable energy and does not factor in investments in the development of new business processes and products that reduce the environmental impacts of product and service production, consumption, and disposal.¹⁹

Fig. 3 Global Investment in Sustainable Energy in 2006
Source: SEFI, *New Energy Finance*, 2006



Although investment in environmental innovations has been growing over the last twenty years, it remains a relatively small portion of total R&D investment. In the largest OECD countries, environmental R&D has not risen above 5% of total governmental investments in R&D.²⁰

4. Sweden and innovation and the Danish experience

Sweden is ranked at the top of the European Innovation Scoreboard index²¹ and has been considered an innovation leader for years. Sweden has a good research environment that produces first class results at a relatively low cost compared to the rest of the world.

According to an IMD 2006 World Competitiveness report, Sweden is among the countries that produce the most scientific articles per capita. Sweden is in first place in medicine, second in natural science and technology. Articles by Swedish researchers are among the most cited in Western Europe. Sweden ranks fourth in qualified engineers.

Relative to its size, Sweden invests more in R&D than any other country. The Swedish investment in R&D is about 4% of GDP. The EU's goal that each country should commit 3% of GDP to R&D by 2010 was already met by Sweden in 2004. While Denmark ranks lower in R&D investments, it has, in general, reaped greater rewards from its R&D. This is, in part, due to the difference in the structure of the business environment between Swedish and Danish companies.

In Denmark the economic factors driving the economy come from its many SMEs who are able to develop niche markets for their products compared to Sweden, whose economy is shaped by big multinationals. As a result, most Swedish R&D investment is made in industry. About 75% comes from industry, with the state supplying about a quarter. About 20 large companies dominate R&D efforts within industry. In 2003, these made 68% of commercial R&D investments in Sweden. About 75% of commercial R&D investment was made in the pharmaceutical, automobile, and IT/telecom.²²

The Swedish paradox

The primary challenge for Sweden is that its export of high-tech goods is still below the OECD average, despite its large investment in R&D. This is sometimes called the Swedish paradox. The Swedish paradox may affect Swedish SMEs' ability to successfully market environmental innovations. Studies point to many possible explanations. One explanation is that Sweden has not had sufficient skills in converting the large R&D investments to commercially viable innovations. Another is that Sweden has had little luck keeping high-tech production in the country. The reason is that Sweden imports more high-tech products than it exports. Another possible explanation is that relatively few R&D-intensive companies are started in the country. One explanation is that Swedish universities and technical schools lack a culture that fosters academic entrepreneurs, something that is normal in, for example, the United States.²³

Innovation within SMEs: The Danish experience

A Danish survey on SMEs show that over 80% of SMEs are focused on incremental innovation.²⁴ One can therefore imagine that the majority of environmental innovations that will come from SMEs in the future will be incremental innovations. Innovation in SMEs typically occurs through close customer contact, where SMEs adapt existing products that they have not invented themselves for new customers or new needs. Large R&D intensive companies are typically best at developing radical innovations, while SMEs, to a large extent, are good at process-driven and user-driven innovation. The SMEs that participated in the Danish study stated that most innovations occurred within the sales-customer service, internal warehousing, education, and knowledge-sharing processes.²⁵

There are several explanations for this occurrence. First, it requires a deal of risk-taking on the part of capital investors to start new businesses. Second, it requires the necessary personnel. SMEs are often noted for not having a particularly high proportion of highly educated workers (only 4% of SMEs had more than 25% with high-level of education) and are not known for being particularly R&D intensive.

Larger organizations can afford to have long-term strategies and make mistakes. Where large organizations can develop a market and wait for it to mature, SMEs typically do not have that advantage. They need to be on an existing market that can support their innovation. Therefore, SMEs are typically focused on the short-terms, and innovations are typically incremental.⁷

5. Three types of innovative SMEs

In the future, as more companies begin to take the environment into consideration during their innovation process, it is important to understand the different types of innovative SMEs. One can identify three types of innovative companies. An innovative company is a company that has developed two or more new products or services in the last two years. The three types of innovative companies are:

- » The user-driven innovator (typically under 20 employees): the micro company
- » The entrepreneurial innovator (typically more than 30 employees): small to medium-sized
- » The research-based innovator (typically more than 30 employees): small to medium-sized

There is a class difference in R&D investments among these three types of SMEs, and there is no linear relationship between a business's size and the R&D investments it makes. There is, however, an exponential relationship up to a certain point. This means that SMEs can be described as going through a phase transition. If a company can manage this phase transition successfully, it can continue to grow.

5.1 The User-driven SMEs

The user-driven SMEs are typically small businesses with fewer than 20 employees. Employees are not generally highly educated. Innovation occurs through close relationships with customers and from the good ideas developed by the firm's relatively few employees. There is typically talk of incremental low-tech innovations that are usually focused entirely on the national marketplace, though they can be internationally focused. An example of this type of environmental SME is the Danish design company Mater.

5.2 Entrepreneurial SMEs

The entrepreneurial SMEs generally have more than 30 employees. They are typically high-growth in both revenue and employees, and the company is changing from a small to a medium-sized organization due its ability to develop successful products by its highly innovative personnel. The organization's innovation is based on its own ideas, which are developed by a relatively large number of its employees. The enterprise's growth means that there is a need for developing systems that support the innovation process throughout the organization. These systems include knowledge development and dissemination, which form the basis for the organizations growth and innovation in the future. An example of this type of SME is Mil-tek, a Danish waste reduction company.

5.3 Research-based SMEs

The research-based SMEs share many characteristics with large business organizations rather than other smaller organizations. The number of highly educated employees is larger, and they typically have larger revenues than the other types of SMEs, which permits a greater focus on research. The organization typically has more than 30 employees. They also have research budgets that typically permit them to develop both incremental and radical innovations. Innovations are developed by a number of employees, and the research-based SMEs tend to be more innovative. This innovative nature can be seen in their higher-level of idea generation, willingness to accept new ideas, readiness to take risks. An example of this type of firm within environmental innova-

⁷ These studies have been confirmed by analyses conducted during the OECD's study of Hungarian companies. OECD: SME Promotion: Increasing Competitiveness and Fostering Successful Entrepreneurship (Paris: OECD, 2006)

tion is IRD fuel cells.

6.1 Sector risks and SMEs

SMEs include businesses from a number of different sectors and industries, including agriculture, manufacturing, retail, and construction. As a result, the business risks from not pursuing environmental innovation vary considerably. Government program addressed at helping SMEs to become aware of the business risks associated with environmental issues will have to address their campaigns to the needs of particular business sectors.

6.1.1. Agriculture: SMEs within this sector are typically small – often one-man businesses. They are exposed to a high degree of physical risk concerning environmental factors (climate change, issues of water scarcity and pollution, etc.). According to varying studies, climate change will lead to a great deal of uncertainty year-to-year. The agricultural sector will be exposed to alternating periods of drought and heavy rainfall, where the sector increasingly will face periods of bounty and low yields. Agriculture is the sector that is most reliant on water, and farmers whose animal waste, fertilizers, and pesticide runoffs contaminate surface water and/or groundwater will face increasing regulations in the future. This sector is therefore considered to be at high regulatory, legislation, and reputation risk among a variety of studies measuring business risk resulting from environmental challenges.

As a result of these challenges, a number of innovations will need to be developed in the future. These could include the development of new financial and insurance policies, as well as new types of agricultural techniques. These include developing new types of crops (including some that are genetically modified) that are drought-resistant or that require less fertilizer and pesticides to grow. One could also expect that elevated consumer demand for food from the developing world and resultant rises in food prices will spur the demand for and acceptance of GMOs. New types of animal breeds will be developed and introduced into the marketplace. These could include artificial meats, new types of cows with kangaroo stomachs (to cut down on methane emissions), etc. There will likewise be a trend for increasing the amount of organic foods available to public consumption.

6.1.2. Manufacturing: is at medium risk for climate regulatory measurements, but at high risk for environmental regulatory measurements, especially concerning problems associated with discharge of liquid wastes, energy efficiency, and greenhouse-gas emissions. Manufacturing is influenced by consumers' individual needs and higher demands for clean, healthy and ethical manufacturing. As ecological footprint

ing across the supply chain comes into use by a growing number of manufacturers in the West, the issue of how one's suppliers produce a product will become relevant. For example, Indian steel companies consume about 10-80 cubic meters of water to produce a single ton of steel, while producing a ton of steel in the US consumes 5-10 cubic meters. So, should companies buy steel from India or the US?

Increasingly stringent demands are being placed on large-scale companies, which will in turn place stringent demands on their suppliers. SMEs that can supply big companies with specialized innovative solutions will have better chances at competing at the local and global level. While the focus is currently on large-scale manufacturers, it is not difficult to imagine that customers and governments in the future will place similar demands upon SMEs. This will create both risks as well as opportunities for SMEs. They can help create innovations that help to reduce GHG emissions and waste generation and increase the amount of goods that can be reused.

6.1.3. Retail: is at high risk of being exposed to the public demand for new innovations. The SME retailer will have little ability to influence enacted regulations, but they will develop increasing market opportunities by offering increasingly environmentally friendly products. In recent years we have seen several examples of companies like Tesco, WalMart, Whole Foods, which have installed solar panels and/or committed them to carbon labeling.

6.1.4. Consultancy: SME consultants will be in a low-risk zone for litigation, reputation, physical, and regulatory risks concerning both climate and the environment. However, consultancy will have a unique opportunity to create process innovation and facilitate learning in the areas of managing, certifying and helping companies in all kinds of different environmental and climate aspect.

6.1.5. Construction: Construction is considered at high risk for increasing regulation concerning both climate change and environmental issues. For example, the EU is planning to make passive-heated housing the standard for all new housing construction by 2016. Austria has already done so. Germany plans to do so by 2014 – as does the United Kingdom by 2013. SMEs who are not up to speed on the coming regulations, building techniques, etc., will be at an extreme disadvantage. SMEs – including designers, builders, and architects – will have to become highly innovative in order to ensure that new buildings are environmentally friendly as possible. For example, the insulating factors of all windows installed in these new structures will have to ensure the maximum amount of energy efficiency, or else the builder will look to-

wards the competition. Ventilation and furnishing emissions will become an increasingly important issue and designers and manufacturers of home furnishings will have to look at new materials for their products to ensure that new unexpected emission problems will not arise in the future.

6.2. Financial Risks for Environmentally Innovative SMEs

A study conducted by NUTEK indicates that innovations taken in the environmental sector are less profitable than those made in other sectors. This means that the environmental startup may have less likelihood for success.²⁶ If a number of environmental startups fail and if a general understanding that environmental innovations are less profitable than others develops, it will eventually have an effect on the stream of venture capital focused on environmental innovation.

There is already some analysis and discussion pointing to this possibility occurring. Many environmental firms have more in common with telecoms than they do with dotcoms. Dotcoms, which have been so successful at raising venture capital, have relatively shorter development-to-product launch phases than do environmentally innovative companies. Environmental innovations – particularly high-technology intensive ones – tend to be capital intensive and take up to fifteen years to reach the market. The long time frame places SMEs at great risk for changes in government policy and/or breakthroughs in competing technologies. Green City Denmark is an example of just such a phenomenon. Although a successful public-private partnership, this project went bankrupt when the 2006 municipal reforms cut its public funding support.

As a result, funding can be highly volatile. Last year the investment trends at first flowed to solar energy and then switched back to wind. There is doubt as to whether venture capitalists will have the nerve and patience to invest large amounts of capital into the sector. If oil prices remain high over the next several years, then the impetus for investing in environmentally innovative companies will remain. However, if oil prices were to drop dramatically, the funding available for environment innovation may likewise collapse.²⁷ This may lead to a structural barrier in the market pull model for technological innovations for SMEs.

6.3. Challenges for Environmentally Innovative SMEs

6.3.1. Customer communication

B2C communication will be a challenge for SMEs working with environmental innovation. According to a British analysis of consumer attitudes towards the environment and business conducted in the United Kingdom and the United States, consumers, in general, do not trust businesses to provide accurate information regarding the environmental

impact of their products and services. They want more independently verifiable information regarding businesses' environmental impacts.²⁸

The media continually bombards us with often-conflicting information as to what is the best thing to do as a conscious citizen. For example, one newspaper article has a story with a health expert recommending that individual wash their clothes at 60° Celsius in order to avoid dangerous molds and fungi. A few pages later, another article will have an environmental expert advising readers that they should not wash their clothes at temperatures over 40° due to the excessive energy required to heat the water to higher temperatures.

As a result, the environmental innovative firm that is trying to sell to the average consumer market will be challenged to give clear information as to the exact environmental benefit their product gives. This challenge will be further compounded by the analytical skills required to understand what is actually the correct thing to do when making a purchase. The results of carbon and other lifecycle analyses are often counter-intuitive, which can work both to the advantage or disadvantage of SMEs. Swedish SMEs that are selling to the local market will definitely gain an advantage from the buy-local movement, whether or not it is actually more environmentally friendly to buy the Swedish product or not. However, this movement will likewise challenge the Swedish SME selling its products or services abroad.

6.3.2. Difficulty of gaining market penetration and need for new business models

It is difficult for many environmental technologies to gain market penetration, because environmental technologies are often initially more expensive than conventional solutions. In addition, consumers are often uncertain about how effective the new solutions are compared to old solutions. Individual consumers also tend to expect much larger returns on environmental investments than do businesses or governments.²⁹ Environmentally innovative enterprises face a difficult challenge, which requires new financing and business models.

SunEdison is an example of a new business model within environmental products. Sun Edison installs solar cells on the roofs of large warehouse and stores like Walmart and Whole Foods (a chain ecologically oriented grocery stores). The companies do not pay for the installation or rental of the solar panels. They pay for the electricity that the solar panels generate. Each company agrees to 20-year contracts with SunEdison, and SunEdison owns the panels and is responsible for their maintenance and operation. All SunEdison's clients do is pay for what is of real value to them – electricity from alternative sources. By thinking in new alternative business models to what large companies use, SMEs can open new niche markets in the future.

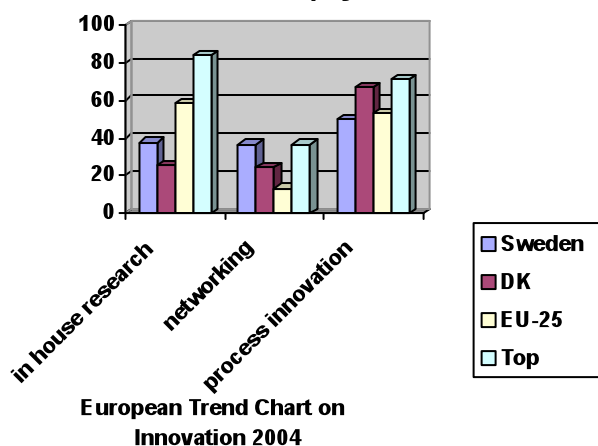
6.3.3 Losing touch with customer needs

A common problem for technical engineering companies is that they focus on quality and technological superiority of their products and run the risk of losing touch with the consumer's actual needs. This is a challenge that innovative SMEs in general and environmentally innovative SMEs in particular will face in the future. The challenges for these companies are to develop innovations that have meaning to the consumer and help them in their daily life and not just to create a technological solution that the engineers themselves think is good.³⁰

6.3.4 Creating a Supportive Climate for Innovation

As Sylvie Lemmet, Director, Division of Technology, Industry and Economics at the UN Environmental Programme, phrases it "We must be open to ideas and partnerships that do not easily fit the "business-as-usual mindset."³¹ In a survey done by SIFO, the majority of the Swedish companies point to better creative processes as one of the most important factors behind improved results from their investments. This will indeed be the case for SMEs as well.³²

EU Innovative firms 20-499 employees



Fostering new innovative ideas also means joining partnerships and participating in innovative networks. In a European survey done, in 2004 Sweden ranks high when it comes to networking but there is room for improvement. The Innobarometer survey from 2004 demonstrates that Swedish companies have some of the highest participation rates in innovative networks that include other firms, universities or

research institutes in the world. However, 62% of Swedish enterprises still do not participate in such networks. In a 2004 European survey on innovation, Sweden ranked first when it comes to networking, but didn't utilize the support programs of the EU to the full extent. Also, the in-house research was lower than the EU average and could be significantly improved. For SMEs, joining these networks and receiving support in the innovative process is important if they are to gain a foothold in the new green economy. The Danish Green City is an example of a private-public partnership intended to create a supportive climate for environmental innovation.

Environmentally innovative SMEs need to create a culture of adaptation to a changing socio-economic landscape and encourage employees to embrace change. They need to equip them with means to be a motor for change. SMEs need to undertake the requisite research and development and translate R&D efforts into appropriate innovations.

Expertise is important for ensuring that the support provided by governments meets the needs of SMEs and that the initiative is seen as credible and worthwhile. There is evidence to suggest that the most effective initiatives for influencing behavioral change in SMEs are delivered at a regional level and in collaboration with sector-specific business associations and organizations.³² Such support could be used to reward lead actors in order to direct the attention of SMEs towards innovation.

6.3.5 Poor planning for technical assessments

According to UKs EIAG, SMEs and larger companies often fail to integrate the technical assessment process for their environmental innovations into their business plans. Hence, they create unnecessary challenges when bringing products and services to market. As a result of this neglect, many businesses missed out on key markets, ran out of funding, or wasted resources and time on costly delays that could have been prevented with adequate planning that took the assessment process into account. While part of this problem is solely the responsibility of SMEs, the EIAG also concluded that the government could do much to improve the technical assessment process to make it user friendlier.³⁴

6.4. Opportunities for Environmentally innovative SMEs:

The focus on the environment and global warming will offer the SME a number of new potential markets. This means that those SMEs who can successfully exploit these new opportunities will be able to grow quickly and eventually make the transition from SME to larger enterprises. This transition will require different competencies from the organi-

zation and place new demands to the enterprise's leadership, which in many cases is often the organization's founder.

The future opportunities within the environmental market are large and varied. It encompasses innovation in wastewater, new material design and product that minimize energy consumption. It encompasses new innovation in process design and monitoring systems. Ranging from green lean production and lifecycle and supply chain analyses to Information and Communication Technology (ICT) based sensor, tracking and environmental monitoring systems design. In Japan over 20% of biotechnology applications sold are for industrial environmental applications China is also at the forefront of this trend, averaging 10%, which is above the OECD average.³⁵

The move towards a more diversely powered economy will mean an upswing of new innovation opportunities. The new technologies can become central to a variety of subsidiary innovations, which will require entire new industries of SMEs to cater to a market that has yet to overcome all its initial obstacles. SMEs will flourish in the niches and aftermarkets that will follow. For example, the rapid growth in popularity of hybrid vehicles is leading to widespread innovation in battery technology. A123, a company that was founded in 2001, used nanotechnology to make safer lithium-ion batteries for use in hybrid vehicles. The company now has over 1000 employees and has raised \$148 million in private equity.³⁶

6.4.1. Global markets

The global market for environmental solutions is in rapid growth. While the challenge for Swedish SMEs are often local, supply chains are becoming increasingly global, meaning that Swedish SMEs can develop environmental solutions that can be used abroad or face increasing competition on the home market. In China alone, the need for new solutions to tackle environmental problems are becoming increasingly pressing. So far, the Chinese have emphasized economic growth over the environment, but the consequences of this policy have now emerged. 40% of China's land mass is affected by acid rain. 16 out of the 20 world's most polluted cities are in China, and the World Bank predicts that the costs associated with air pollution between 1995 and 2010 threatens to cost China 5-13% of its GDP.³⁷ The Chinese government aims to make alternative energy an integral part of the modern Chinese economy. The country's inefficient production capacity must be modernized. This problem is not only facing China, but other BRIC and developing countries as well. Swedish SMEs can develop significant business opportunities by offering important skills, solutions and innovative products.

6.4.2 SME Customers

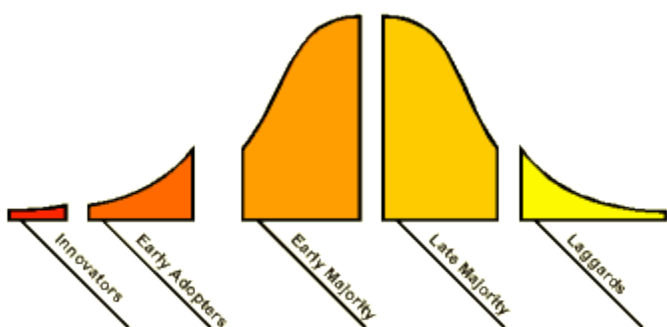
SME customers are varied: There are traditionally three types of SME customers with varying demands: these are B2G (Business to Government), B2B (Business to Business), and B2C (Business to Consumers). The demands that these customers will place on businesses in general and SMEs in particular will to a large extent determine which environmental innovations will succeed or fail. According to the analysis made by UK EIAG, the UK environmental industries have not been very successful at creating innovations that have achieved success on the market despite the fact that the UK has been one of the world's leading environmental research countries. Many challenges that innovators in the UK environmental goods markets have faced are due to the problem of poorly articulated demand within the UK and global supply chain.³⁸

One way to analyze future consumers would be to look at their attitudes towards technology. Geoffrey Moore, an American technology researcher who is a leader in SME entrepreneurial marketing, has developed a modified technology lifecycle that helps explain the challenges that technology innovations face in becoming successful in the marketplace. Using a modified definition of the innovation adoption theory developed by Everett Rodgers, he identifies five archetypes of technology customers that can be found business and among consumers.

These are the innovators, early adopters, early majority, late majority, and technology laggards. Innovators are those who pursue new innovations and technology products, as these are a central interest in their lives. Early adopters, though not technology enthusiasts, are those who tend to be imaginative and who can identify and appreciate the potential benefits that a technology may offer. They typically are willing to take risks and do not rely on others' references. Early majority have some of the early adopters' ability to relate to technology, but they are weary of passing fads and want to see a new technology or process succeed before investing in a new innovation. The late majority are those who wait for a new technology to become an industry standard before they begin investing in it. Members of both early and late majorities want solutions that will give an immediate benefit with little or no disruptions to current operations, while the innovators and early adopters are willing to accept technological teething problems in ordering to gain an early adoption comparative advantage.

It is important that companies develop marketing strategies tuned to the needs of each of these customer archetypes. The differences in the needs between the market segments create gaps or chasms that

The Revised Technology Adoption Life Cycle



have swallowed many an innovative company. Companies in innovative industries – SMEs in particular – who understand these differences, are able to gain traction for their products with the innovators and then make the leap to mainstream markets.³⁹

The challenge, however, for the future is due largely to the rapidly increasing pace of technological change, which has the risk of stretching the ability of innovators and early adopters to assist in the development of new technologies. The increasing pace of new environmental innovations – particularly those in energy and water, with innovation to market time frames – may lead to the market’s abandonment of potentially good, yet still immature technologies in the early development phase in the quest for latest new innovation.

6.4.3 The Advantages of a Strong Home Market

Like the rest of Scandinavia, Sweden is characterized by a large and growing concern for environmental issues. According to the latest Eurobarometer reports, Sweden ranked 2nd among countries where the environment was of great personal importance. More Swedes stated that they have purchased more locally produced products in the last month than did any other European country’s citizens. They are in general more optimistic regarding innovation than in other European countries.⁴⁰ This gives Swedish SMEs an advantage of having a relatively strong domestic market for environmental innovations than other European countries. Swedish SMEs could use this advantage to become a test-bed for environmental innovations that can then be exported abroad.

Table 2: SMEs Barriers to environmental innovation

Level	Barrier
System	Competing policy rationales (e.g. innovation and environment)
	Government information asymmetries
	Uncertainty and poor appropriability of sustainable innovation
Organizational	“Public-good” nature of ecological investments
	Systematic, interactive and strategic nature of environmental innovation
Managerial	Fragmented product development process in SMEs
	Lack of managerial and operational resources (including time, cost, skills)
	Failure of SME managers to act strategically
	Lack of top management commitment
	Lack of awareness, training, and motivation of employees

6.5 SMEs Barriers to Environmental Innovation

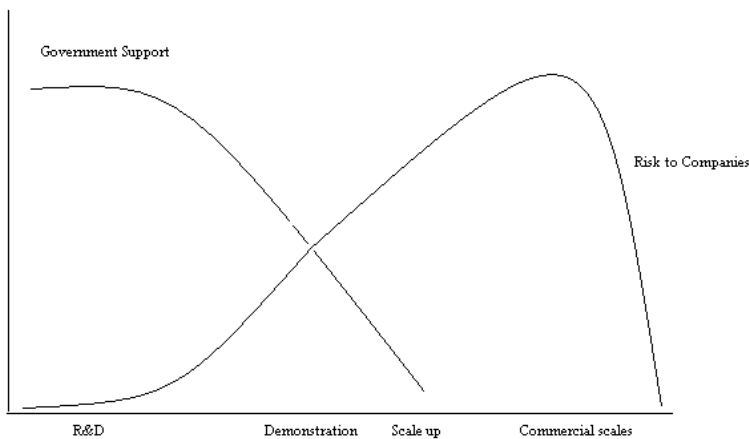
SMEs face a number of challenges in trying to innovate. According to an analysis of Welsh SMEs conducted as part of a broader EU project, researchers at the EcoDesign Centre have identified a number of SME barriers (described in Table 2) that hinder environmental innovation.

7. Role of government in helping SME and environmental innovation in the future:

The central issues for future government efforts are:

- » How does the government help SMEs create markets for innovations in the future?
- » How do the government best design programs to assist SMEs and their adoption of environmental innovation?

Governments can help SMEs create markets for innovations in the future by working with the European commission to reform State Aid rules for environmental innovation, reforming procurement processes, as well as providing grants, loans and other assistance to SMEs that are under the testing and certification procedures to help bring new products to market. The lack of government funding at key points during the innova-



tion process points to significant barriers in the government push model for technological innovation.

According to an analysis conducted by the UK EIAG, government assistance programs (technology push model) are overly focused on R&D and are not providing the right form of assistance to help companies, large and small, bring innovations to the market place.⁴¹ Most government programs are focused on R&D under the assumption that this is the aspect of the innovation process that is the furthest away from the market. This assumption, however, is wrong. R&D is relatively cheap and achieves its primary purpose with little inherent risk – generating knowledge. The real risk comes during the attempts to bring a product to market. As in the chasm example above, the largest amounts of money are spent on developing demonstrations and the scaling up for potential commercial sales before proving that the market will purchase their product or service. Increasing government support to business during the demonstration, scale-up and commercial sales periods, which are arguably the most risky for business – SMEs in particular – is important, but is limited by State Aid rules and current public procurement practices. This means that public finance is often lacking when a company's risks and needs are greatest.⁴²

In the future, governments can help SMEs predict future sales by reforming its procurement practices to create markets for environmental innovation. Companies receive little or no incentives to provide more environmentally friendly products beyond what is required by law in the procurement process. They are competing on price and quality. The costs of negative externalities are not typically included in the government's procurement analysis, which means that potentially innovative

ideas struggle to find a place in the market. The UK EIAG has proposed introducing forward commitments as part of the UK procurement to combat this problem.

8. Scenarios for future environmentally driven innovation

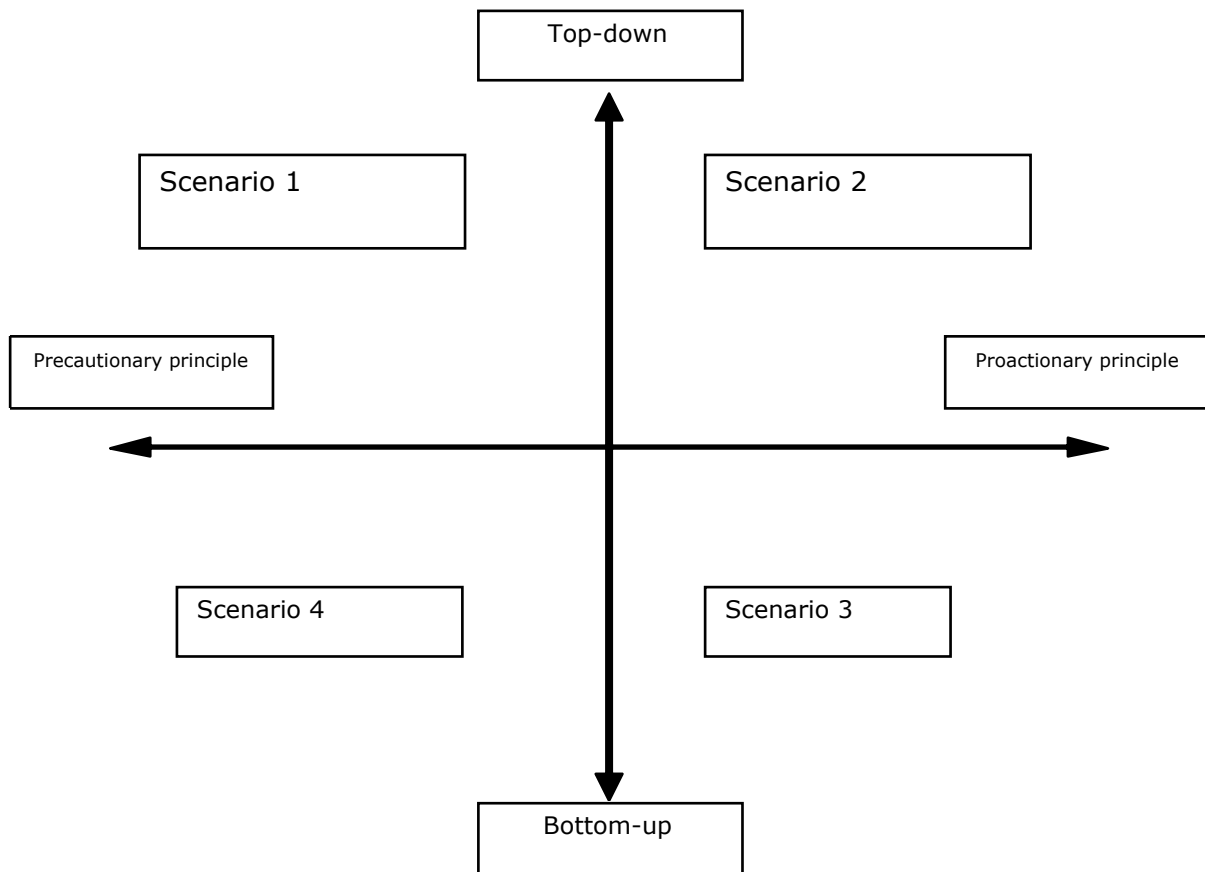
The future of environmental innovation is based largely on the responses that we in society take in the coming two decades. The following is short description of four "response scenarios" that explore what role environmental innovations may have for SMEs in the future. The four scenarios illustrated on the next page are inspired by a previous scenario project that CIFS completed for the Danish EPA⁴³ and by four scenarios published by Jamais Cascio from the Institute for Ethics and Emerging Technologies.⁴⁴

Scenarios are possible future images created with a basis in the driving forces and trends of today. The future is uncertain, and traditional extrapolations are unfortunately least applicable when we most need them, in periods of great change. The advantage of the scenario is that it is a useful tool for gaining an overview of the strategic landscape, when changes mean developments can no longer be described as business as usual, as in the case of environmental innovation. Scenarios help us understand the world around us, so that events and corporate decisions are not seen as isolated elements, but in the complex context they are a part of.

We develop scenarios by selecting two axes that describe the drivers that we, at the Copenhagen Institute for Futures Studies, believe will be affecting environmental innovation in the future. It is important to note that in each of the four quadrants, environmental innovations will occur, and that they will include innovations that prevent, mitigate, or remediate business impacts on the environment. In each of the scenarios, the emphasis among the three types of environmental innovations will shift, but all three types of innovation will take place.

The axes upon which the quadrant is divided represent broader social and political drivers that will influence how the environment is perceived by political leaders, corporate leaders, the general public and SMEs. The horizontal axis studies general political, social, and economical willingness to adopt environmental innovations. It is important to recognize that this does not reflect the pace of technological innovation. It reflects societies' willingness to accept and the businesses' ability to create new markets for their new tools and systems.

Moving from left to right, the precautionary side of the axis is based



upon the precautionary principle (do no harm) and describes a world where academia, governments, and NGOs want a measured approach to environmental issues. The technical assessment process is slow, and SMEs face many technical, social, political, and market barriers to environmental innovations that are deemed too risky. Academia, governments, NGOs, et al. are interested in ensuring that new innovations produce as few unintended consequences as possible. They are worried about possible future litigation risks, and insurance companies demand that they proceed slowly with the introduction of new business products. There is a broad consensus that the world does not want a repeat of what happened when the first generation of biofuels was introduced, which quickly went from being hailed as a green solution to being vilified for the environmental and social consequences. It is also a world where customers want innovations that help prepare the world for possible adverse events of climate change, for example.

The proactionary side of the axis is based upon the proactionary

principle and looks at worlds where many of the structural barriers regarding technical assessments and financing have been streamlined. Governments maintain a strong and lasting interest in funding and advising SMEs on how to bring their environmental innovations to market. The most radical, high-tech environmental innovations receive the most interest from government and business. Technical assessment processes ensure that products and services meet a minimum of environmental, health, and safety standards. The interest here is finding products that increase capabilities, but do not necessarily lower ecological footprints.

The vertical axis looks at where the impetus for environmental innovations is originating. Are environmental innovations being driven from the top, meaning that governments and major corporations are setting the innovation agenda (technology push innovation emphasized), or are they being driven from demands by made the broader citizenry, NGOs, innovative SMEs, etc. (market pull innovation emphasized)? The

bottom-up axis does not necessarily represent an idealist dream of cooperative interests; it could equally include a society of competing interests, where environmental issues can be neglected in favor of other issues (education, healthcare for the elderly, or international terrorism).

The Scenarios

1) Top-down-Precautionary – This is a world where governments and major corporations drive environmental issues and innovations. Climate change, water scarcity, waste removal, and water and air pollution are issues of concern. The focus is on strong environmental mandates and regulation aimed at increasing energy efficiency and lowering waste and environmental pollution. Carbon and ecological accounting is now required of businesses, but carbon and ecological labeling is not. Consumers assume that the government is taking care of the problem. New innovations are put through strict technical assessments. Consumers want environmental innovations that are either improvements on tried and true solutions or ones that have received the seal of approval from a relevant government authority. The focus is on incremental environmental innovation. SMEs also play a large role in environmental innovation, but their needs are neglected in favor of large corporations, and their environmental innovations are forced to react to environmental standards placed upon them by governments and their larger customers in the global supply chain.

Innovation is predominately technology push, and the user-driven SME with its focus on incremental innovations would prosper in this scenario. Entrepreneurial and research based SMEs would in general find this scenario more challenging. However, those SMEs who create radical innovation solutions would most likely find the Swedish government championing solutions that it believes provides the most benefit and the least risk of harm.

Despite the precautionary focus of business and governments, there are a number of areas available for future environmental innovations including improving energy efficiency, new financial mechanisms (tradable emissions/pollution quotas), and new urban developments.

2) Top-down-Proactionary – In this scenario, governments and major corporations are once again the principal drivers setting the environmental agenda. Climate change, water scarcity, waste removal, and water and air pollution are issues of concern. This world believes that the freedom to innovate is – in and of itself – an important factor for human development and prosperity. In this world, the door is opened to new environmental innovations (business processes, models, products, etc.) that meet the minimum requirements in health and safety. The spirit of the age is open to trying new innovations first and evaluating

their consequences afterwards. The Swedish government and the EU in general are in an innovation competition with other countries and regions across the globe. As a result, there is a general acceptance for genetically modified foods, bioengineering, geoengineering, etc.

Governments, large corporations and venture capitalists are all looking for the next big thing. Therefore, the most successful environmentally innovative SMEs would typically arise from the entrepreneurial and research-based SMEs who tend to develop the most radical environmental solutions. As a result, they garner the most financial, technical, and other forms of assistance.

3) Bottom-up-Proactionary – This scenario is the most complex of the four. It is a world with many competing interests. Environmental issues are important, but other policy issues are just as important. This is a world of ad-hoc coalitions forming over a variety of issues. Governments have been unable to come to agreements over how to effectively respond to the pressing environmental issues challenging the world. Treaties regarding climate change and other environmental issues are little more than statements of intent. Some states and regions push an environmental agenda, while others look to secure access to existing energy resources.

In this world, SMEs have to deal with a murkier business environment. On the one hand, the entrepreneurial and the research-based SMEs face more rapid and streamlined technical assessment processes. They thrive in their domestic markets where they understand the rules and local market place. However, the sheer variety of environmental approaches and legislation in other countries and regions makes it difficult for Swedish SMEs to export environmental innovations abroad.

4) Bottom-up Precautionary – This is a world where there is a broad social and cultural consensus regarding the environment's importance and the need to limit human impacts as much as possible. Local efforts are the primary focus, and the environmental innovations that gain the most traction are those that support local communities. In this scenario, governments are interested in local best practices and incremental solutions. In this scenario, the environmentally innovative SME is e.g. one that develops incremental solutions that increase energy efficiency and lower waste production and gas emissions. Citizens are actively involved and concerned about the environment. They serve as watchdogs, ensuring that governments and businesses live up to environmental standards and that they are lowering their ecological footprints. They are interested in the local consumption and locavore diets. The market for personal environmental solutions is large, where

such things as household rainwater collectors are commonplace. Carbon labeling is common, and the market choices are seen as the best way to choose the most environmentally friendly solution.

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Environmental Innovation: Drivers, Challenges, and Opportunities
A Report for **NUTEK**
The Swedish Agency for Economic and Regional Growth

By
Copenhagen Institute for **Futures** Studies
Instituttet for **Fremtids**forskning

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