The Next Big Thing?

Trends Shaping Nordic Innovation

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Nordic co-operation

Nordic cooperation is one of the world's most extensive forms of regional collaboration, involving Denmark, Finland, Iceland, Norway, Sweden, and three autonomous areas: the Faroe Islands, Greenland, and Åland.

Nordic cooperation has firm traditions in politics, the economy, and culture. It plays an important role in European and international collaboration, and aims at creating a strong Nordic community in a strong Europe.

Nordic cooperation seeks to safeguard Nordic and regional interests and principles in the global community. Common Nordic values help the region solidify its position as one of the world's most innovative and competitive.

Content

Special Focus: Climate Change – Impacts for Nordic Industry, Technology, and Innovation

Photo: Karin Beate Nøsterud/Norden.org

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The challenge and what is at stake

Arguably the first attempt by a major national government to understand climate change and the urgency of addressing it, was a UK government review[50] lead by a former chief economist of the World Bank, Sir Nicholas Stern, and released in October 2006.

The Stern review explained that the main cause of climate change was the emission of greenhouse gases arising from the burning of fossil fuels and activities related to land-use such as deforestation and agricultural production. It explained that actions taken over the next 10 to 20 years would have a profound effect on climate in the second half of this century and into the next. It made headlines when it published a conservative estimate stating that if not addressed, the overall cost of climate change to the global economy would be equivalent to a drop in global GDP of 5% per annum each year, now and forever. Taking into account a wider range of risks and impacts, it estimated that the costs and damages could rise to over 20% of GDP per year. The good news however was that if action were taken in time to reduce greenhouse gas emissions and avoid the worst impacts of climate change, the impact could be limited to around 1% of global GDP per year. The review called for concerted efforts on behalf of all nations to take immediate action to avoid disruption to economic and social activity on a scale similar to that experienced due to the great wars and the economic depression of the first half of the 20th century.

The Stern review indicated that while it would be difficult to avoid an increase in concentration of greenhouse gases to double pre-industrial levels by 2035 leading to a global average temperature rise of over 2°C, the long-term effect of inaction would be a temperature rise in excess of 5°C, equivalent to the change in average temperature from the last ice age to the present day.

The IPCC[51] agrees that a rise in average surface temperature of the planet by as little as 2°C above pre-industrial levels will have serious consequences for nature, society and the global economy due to dangerous and unpredictable climate change associated with such a rise in temperature.

[50] http://www.hm-treasury.gov.uk/sternreview_index.htm
[51] http://www.ipcc.ch/

The Nordic countries have independently verified these findings. A study commissioned by the Nordic Council of Ministers and carried out by CICERO, the Oslo-based Centre for International Climate and Environmental Research[52] and COWI of Denmark, entitled "The Nordic region will feel the heat", examines the impact of a 2°C rise in temperature by 2100[53] on the natural environment in terms of phenomena such as sea-levels, snow and ice, the warming of the arctic region and the extinction of species, together with the impact on industrial sectors such as agriculture, forestry, fishing, energy and tourism. The impact is dramatic and it looks in-creasingly likely that this estimate may be too conservative.

In February 2009 MIT News[54] reported findings of a team of scientists at MIT indicating that:

> "warming could be double previous estimates" and that this "… increases the urgency for significant policy action."

Their latest estimate suggests that surface warming of the Earth by 2100 will lie between 3.5°C and 7.4°C with 90% probability. This corresponds to an expected rise of 5.2°C rather than 2.4°C indicated by previous studies. Other studies seem to support this view. The EDGAR[55] project for monitoring global man-made emissions has recently reported that emissions are growing much faster than anticipated. They find that the increase from 2000–2005 is about 15% whereas the increase from 1990 to 1995 was only 3%. The consequences of not implementing climate change policies may be even more dramatic than their work indicates.

The prevailing opinion among scientists is that to limit climate change to less than 2°C by 2100, it will be necessary to implement measures that ensure among other things a reduction of 60–80% of 1990 levels of greenhouse gas emissions by 2050. This forms the basis for discussions on binding targets and many countries and cities have made legally binding commitments to achieving targets by 2020 an 2050. These targets are very important for innovation, because without them there is no level playing field

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[52] http://www.cicero.uio.no

[53] http://www.cowi.com/menu/news/newsarchive/nature/Pages/thenordicregionwillfeeltheheat.aspx

[54] David Chandler, MIT News Office 19 May 2009 http://web.mit.edu/newsoffice/2009/roulette-0519.html

[55] The European Database for Global Atmospheric Research at http://edgar.jrc.ec.europa.eu

and companies that eschew investment in new technologies to achieve these targets may gain short-term advantages over those who do not.

The Stern review led to the creation of the Office of Climate Change in the UK, which has in turn been upgraded to the Department of Energy and Climate Change[56]. Since then many governments and international organizations have conducted their own independent assessments of the impact of climate change, and they have subsequently put in place structures and measures to address what is now seen as one of the most important challenges facing humanity today.

The IPCC[57] won the Nobel Peace Prize in 2007 along with Al Gore for its efforts to disseminate knowledge about climate change and encourage measures to counteract such change. Al Gore made a significant contribution to communicating the dramatic effect of global warming on the natural environment and the fact that we are already experiencing climate change in dramatic ways in his film "An Inconvenient Truth". Other initiatives such as the "Planet under Pressure" series for TV produced by the BBC continue to develop this theme.

More than 190 countries have now signed the UN Framework Convention on Climate Change[58]. This recognizes that the climate system is a shared global resource and sets out a framework for inter-governmental efforts to tackle the challenge. Climate change is now a key item on the political agenda of all advanced industrialized countries. The trend is to see this as an opportunity for new business and job creation and to address not only a defensive approach aimed at limiting costs and climate change, but also the creation of new jobs and growth on the basis of the new technologies, new industries and the services they will require.

The transition to a low-carbon economy is an important component of U.S. economic recovery in the wake of the recent financial crisis. Some estimate that the transition provides an opportunity to create over 5 million new jobs in the coming years in the US alone[59], and many business analysts believe that the economic leaders of tomorrow will be the companies that manage their resources efficiently and take the lead in devel-

[56] http://www.occ.gov.uk/

[57] www.ipcc.ch … International Panel on Climate Change

[58] http://unfccc.int/2860.php

[59] See The Council on Competitiveness, Energy Security, Innovation & Sustainability Initiative and Harvard

Business Review, "Forethought: Climate Business, Business Climate," October, 2007.

oping and commercializing innovative clean technologies[60]. The EU has responded with a raft of mutually reinforcing policies and initiatives called the "Climate and Energy Package". These include the SET-Plan for Strategic Energy Technologies[61] and the EU-ETS system for trading carbon to which all Nordic countries belong[62]. In many ways this represents a global race to occupy "green space" in what is seen by many as a new industrial revolution.

Sweden played an important role in setting the agenda at EU level when it hosted the Summit of European Ministers in Gothenburg in 2001. It put forward a vision of a sustainable Europe by 2030 that is now shared by all the EU member states and is commonly referred to as "The Gothenburg Agenda". Norway has identified limiting the rise to less than 2°C as one of its major policy priorities for the future. Denmark will host COP15, one of the most important ever global events on climate change in Copenhagen from 7–18 December[63] this year. The transition towards a sustainable growth model has gained considerable political momentum and Nordic countries are well placed to provide continuing leadership by demonstrating to the world how to achieve this goal.

Climate and energy

The main cause of climate change is the emission of greenhouse gases from the burning of fossil fuels. This is why strategies to address climate change are for now primarily formulated in terms of energy. The measures taken include measures to encourage:

- Increased energy efficiency by private and industrial consumers
- Increased use of renewable energy sources
- Smarter two-way distribution systems, connected across national borders
- Reduction of emissions, e.g., via carbon capture and sequestration

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[60] See The Council on Competitiveness, Energy Security, Innovation & Sustainability Initiative and Harvard
Business Review, "Forethought: Climate Business, Business Climate," October, 2007.

[61] http://ec.europa.eu/energy/technology/set_plan/set_plan_en.htm

[62] The EU-ETS http://ec.europa.eu/environment/climat/emission/index_en.htm

[63] http://en.cop15.dk/

Peter Drucker pointed out that "every social and global challenge of our day is a business opportunity in disguise". [64] Far from being a burden, the transition to a low-carbon economy should be seen as an opportunity for business in sectors where the Nordic countries already have an edge.

Each Nordic country occupies a strong position in one or more areas of renewable energy production. In Iceland it is geothermal energy, in Norway it is hydro- and solar power, in Finland bio-energy from wood, whereas wind power dominated in Denmark, and hydropower and the use of solar panels in Sweden. These positions of strength provide strong arguments for foreign direct investment in the Nordic countries, especially for the re-location of energy intensive industries from regions with a high climate footprint to regions where it is much lower. There has already been some migration of businesses relying on computer centers, to areas where the climate is colder, where cooling can be achieved by using locally-derived air, water or ice rather than by energy intensive methods.

The Nordic countries already have a significant position in areas such as wind-energy, solar and geothermal power as well as bio-fuels derived from trees and bio-gas derived from agricultural, industrial and domestic sources of organic waste. This is guided by a vision of the future in which in principle all houses and buildings become both producers and consumers of energy, drawing from and feeding into smart electricity networks, where most energy is produced locally from a mixture of different sources, and where many tasks that once required energy from the grid are carried out using direct approaches to heating, drying and cooling. This last issue is very design intensive and provides challenges for architects and urban designers and not only for engineers working in the energy sectors.

Most electricity in Norway comes from hydro-power and is therefore carbon-neutral. However, Norway is a major producer of oil and therefore has an interest in technologies for carbon-capture and storage. Developments in this area could provide many benefits in terms of climate change mitigation. It has been known for a while that some rocks have a voracious appetite for carbon and readily absorb carbon dioxide. Geologists have known for some time that when peridotite is exposed to

[64] In a conversation with David Cooperridge in 2003 reported in the article available at http://www.aacsb.edu/publications/Archives/JulAug08/32-39%20Sustainable%20Innovation.pdf

the air it can react quickly with carbon dioxide to form carbonates such as limestone or marble. Some scientists have observed that natural outcrops of peridotite in places like Oman absorb considerable amounts of atmospheric carbon. They believe that it is possible to increase the rate of absorption by a factor of up to 100,000 times or more and that this process could be used to capture carbon on a scale that would have a significant impact on climate change. Of course it is early days yet, but some scientists harbour hopes that volcanic basalt in Iceland could be used for the same purpose. This is an example of where research may be required to investigate climate technologies that could provide a significant return in the long-term.

Nordic Energy Research has carried out studies to develop NORIA – the Nordic Research and Innovation Area[65]. This work includes a series of Nordic Energy Perspectives on issues such as district heating, energy imports, renewables and electric cars. It includes studies on the national energy innovation systems of the Nordic countries and on the international dimension of research cooperation with countries such as Russia and China. The main focus is on research and on the commercialization of projects developed within the publicly funded research program. A broader innovation agenda needs to be developed however – one that goes beyond transferring technologies from the lab and into the field to leverage existing capabilities, not only for the Nordic but also for other world markets. The newly established (2008) Top Reserach Initiative established by the Nordic Council of Ministers with NordForsk, NICe and Nordic Energy Research deals with several of these questions.

Binding targets for the Nordic countries in terms of renewable energy production and greenhouse gas emissions, whether at national or city level, are ambitious, and all available solutions should be considered. There is a tendency only to promote the results of public research projects, but this is to ignore most of what is available at any given time. McKinsey Consulting has identified 250 technologies for the reduction of greenhouse gases in the US[66] alone. It points out that 80% of these are already available today. Research is being conducted in the Nordic countries into energy and energy solutions and a website has been established

[65] http://www.nordicenergy.net/section.cfm?id=3-0&path=142

[66] Reducing U.S. Greenhouse Gas Emissions: How Much at What Cost? conducted by McKinsey & Company and published jointly with the Conference Board in November, 2007, available at: http://www.mckinsey.com/clientservice/ccsi/greenhousegas.asp

to promote Nordic Energy Solutions on both a regional and international basis[67]. Arguably the urgent issue is not so much in the creation of new component technologies but in the application of existing ones, in particular the integration of available component technologies in existing industrial systems. It would be of considerable interest to extend the work already performed by Nordic Energy Research, with a more explicit innovation focus.

Innovation is not only about research. Research is important and research policy has to position itself in the context of much larger innovation processes. The successful large scale adoption of Nordic climate solutions, not only in the Nordic area but in other world markets requires consideration of a range of issues such as:

- Strategies for adoption and integration into energy systems
- The role of the public sector as an early user of new technology
- The role of public procurement in creating new markets
- Business models based on economics, pricing, incentives and service
- Emerging economy business opportunities and engagement strategies
- Export readiness and adequate financing

It is important to understand how the creative burden and intrinsic risk of innovation remains a challenge for companies long after the basic technology has been demonstrated, from one market to the next. This is the key to understanding how the public sector can support innovation as distinct from the discovery of new science or technology on the basis of traditional R+D.

When one talks about solar energy and solar panels the focus of the discussion tends to be on the relative merits of different technologies. In reality, mainstream consumers have only a passing interest in this. They care more about issues such as:

- Can they afford it in terms of initial and recurring costs
- Does it require frequent maintenance, and if it breaks down what can they do and how much will it cost?
- Will it meet their needs or complicate their lives? Will it look nice?
- Can they replace it with something better one day?

[67] http://www.nordicenergysolutions.org/

From this perspective, innovation is not just about the technology but also about the possibility of integrating it into the architecture of the house or building so that it looks good. This requires collaboration with designers and architects and not with scientists in national research laboratories. It is risky work, fraught with uncertainty. It requires time, and money and patience before success is assured. Support for innovation should include support for these activities as well. Perhaps one of the most important areas that is often ignored due to the focus on technology, is the basic business model. In many cases solar energy installations require a substantial initial outlay and adoption is limited to those who can afford it, with or without the benefit of incentives, grants or tax-relief. In principle the user is rewarded with lower ongoing energy costs, but in reality the benefit will tail off if the system fails or is badly maintained. Some companies have adopted business models that make their products much more purchase friendly. In an age of open innovation when technologies can sometimes be licensed from anywhere around the world, there will be many companies competing with similar technologies or solutions with comparable levels of performance. The business model will be a major factor in enabling one to succeed at the expense of the others.

Sun Edison of the US[68] has developed a business model where it:

- Owns and finances the solar installation
- Operates the installation and monitors performance
- Charges the consumer on a monthly basis for the power consumed
- Carries out all repairs and maintenance

This business model means that there is essentially no barrier to entry for the consumer. The model is easy to understand. The provider has every incentive to make sure that the system works and is well maintained. The provider has a predictable long-term revenue stream for the future. This kind of a business model leaves the provider ideally placed to deal with revenues from feed-in of surplus energy supplied to the grid. In effect, rather than building a giant solar array in the desert, Sun Edison has distributed it across the roofs and buildings of thousands of houses and

[68] http://www.sunedison.com

buildings and has thus changed the economics of the solar power industry both from a provider and a consumer point of view.

Let's look at another example. This will illustrate how the design of the consumer or user experience provides the key competitive advantage. One of the big issues with electrical vehicles is the cost and capacity of the battery, combined with the burden on the owner of regular charging. In many cases the battery is an integral part of the car and a user has to "plug in" the car for charging overnight. Alternative business models exist. For example, Shay Agassi of World a Better Place[69] has developed a business model in which the battery is separate from the car and users simply replace depleted batteries with ones that have already been charged. This process only takes a minute. It totally changes the experience for the user. In principle the user should not even have to pay for the battery, but only for the charge, in effect reducing the cost of the car. As battery technologies improve the user is not required to invest in a battery upgrade, but simply buy a better charge. The provider is given more freedom in terms of when and how to charge the batteries and can thus contribute to better load balancing. Charging could be done during off-peak periods for traditional electricity grids or, for example, when supply is running at a peak due to high winds at wind-farms. One of the first testbeds for World a Better Place is Denmark, where the Danish government and DONG, the largest national power supplier, are working on how to implement the business concept of World a Better Place in Denmark.

Although the major players in the US car industry have received a lot of criticism in recent years and GM, historically one of the most successful innovators, has essentially been taken over by the US government, it is worth recalling that the growth of General Motors was largely due in no small part to its ability to innovate in management, marketing and sales. GM segmented the market in terms of user and ability to pay. It developed the idea of a product range that would cater to every user and every purse. It was the first in the US to use colour and styling as a differentiating factor and imported the best designers from Europe to help achieve this goal. Banks considered cars as dangerous toys for sports enthusiasts and refused to finance them so GM developed hire-purchase and insurance products for their customers. They developed dealer systems for distribution. They developed the market for second-hand cars

[69] http://www.betterplace.com/

and techniques such as trade-ins which in turn created a ladder of aspiration whereby young dives would buy-second hand. As their incomes increased they were able to afford more expensive models on the basis of trade-ins and tailored finance.

GM did not always get it right but many lessons can be learned from its glory days – that success is not just an issue of technology, but will respond to a creative and experimental approach to:

- Adoption strategies
- Pricing and payment, and consumer finance
- Consumer- and provider-side incentives
- Design in terms of engineering, performance, installation and maintenance
- Design of the product-service mix and the customer experience
- Maintenance, recovery and recycling

These two examples are intended to illustrate that innovation is just as much about the business model as about the technology. Once technologies are available, the battle for the consumer shifts very quickly beyond the mere possibility of renewable energy to options, finance and the consumer experience.

It is important for the public sector to understand that the incentives they put in place to encourage the adoption of new technologies are an important part of the business model of an industry in its early stage of development. Many technologies already exist and many more are in the pipeline. The job of the public sector is less to champion technologies and more to create favourable conditions for achieving high-level goals in the best way possible. To do this it is necessary to have a view of innovation that extends far beyond the development and dissemination of new technologies.

The role of cities

Cities contribute more than two-thirds of global greenhouse gas emissions, and according to the CCI or Clinton Climate Initiative[70], they consume 5%

[70] http://www.clintonfoundation.org/what-we-do/clinton-climate-initiative/

of the world's energy and produce 80% of the world's GHG emissions. Cities therefore have a key role to play in the climate-change agenda.

The CCI addresses climate change on various fronts – one of which is energy efficiency in cities. The "Large Cities Climate Leadership Group" started in 2005, as a coalition of leaders from 18 of the world's largest cities committed to climate change, became partners with the CCI in 2006 and, having expanded to 40 members, changed its name to C40[71]. Copenhagen and Stockholm are involved in this work which includes advocating measures such as LED street lighting, the retro-fitting of buildings to reduce energy use, waste management and the systematic measurement of emissions. Members of the C40 published action plans. Copenhagen for example aims at 20% reduction of GHG emissions by 2010[72] and Stockholm aims for a 60–80% reduction by 2050. To put this in perspective, Toronto is aiming at an 80% reduction by 2050[73] and Melbourne at zero-emissions by 2020[74].

In 2008, London set-up a city-wide waste and recycling board that brings together stakeholders in the waste industry, with a focus on recovering energy from food waste and the recycling of plastics. It has created a brokerage service by which waste-producers such as food manufactures and retailers are linked with recyclers and energy users. The initiatives can ultimately be self-financing or even money-saving. The London board has stated that "the total energy that can be supplied by waste is £504m or 10 per cent of London's gas and electricity bill". It is easy to say "do the math", but the math is complicated and more effort needs to be made to demonstrate fully what is often a sound financial and business basis for initiatives that can be good not just for the city, but for emerging new business sectors and the planet as a whole.

Norway intends to be a zero-emissions country by 2020. Norwegian cities have an important role to play and can set an example to the world. Arguably all major cities and towns have a role and should put in place plans to achieve declared climate goals, not just through savings and efficiencies, but also by creating jobs and employment using climate change as a catalyst for innovation and creativity.

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[71] http://www.c40cities.org/

[72] http://www.kk.dk/sitecore/content/Subsites/Klima/SubsiteFrontpage/HvadGoerKoebenhavnsKommune/KoebenhavnsKommunesklimaplan.aspx

[73] http://www.toronto.ca/changeisintheair/

[74] http://www.futuremelbourne.com.au/wiki/view/FMPlan/S2G3P1ZeroCarbonCity

There seems to be an emerging link between climate change initiatives and creativity that will be of considerable interest to agencies intending to promote inward investment. Fast Company is a U.S. publication on design, innovation and creativity in the broadest sense, and has recently identified the 13 most creative cities in the world[75]. The only European city currently featuring in the list is Malmø in Sweden. It is ranked at No. 8[76] and its position is based on its policies for creating eco-friendly neighbourhoods by transforming tenements and old shipyards. Fast Company notes that "much of Western Harbour now runs solely on renewable energy, including wind and solar, while organic waste from the area is turned into biogas. In Augustenborg, roof gardens reduce runoff and insulate homes, while a carpool system, pedestrian- and bike-friendly roads help cut vehicle use. The city expects to reduce its CO2 emissions by 25% between 2008 and 2012, blowing past the Kyoto Protocol's 5% target." It is clear that public administration has the potential to generate a considerable impact on climate-security. The city of Malmo is a good example of how this can happen. It is worth noting that the champions of innovation in this context are not just the captains of industry but, also the visionary leaders in public administration. They have their own specific learning and research, combined with a need to experiment with innovative climate measures that have a much more explicit systemic dimension than those that affect many players in the private sector.

It is interesting to note that Taipei[77] is ranked No. 6, 2 places ahead of Malmo. The city encourages the private sector to build composting facilities and recycling plants. It promotes trade in secondhand goods and has introduced new methods of kitchen-waste disposal. For example, there is a pilot project that involves converting food waste into pig feed. The result is that it has already reduced the volume of city waste by over 60%. Fast Company reports that it wants to achieve "zero landfill" and "total recycling" by 2010. This very goal is in advance of the UN trash target by 30 years. It is clear that these goals will not be reached without innovative approaches to the management and organization of the city's affairs.

The examples of Malmo and Taipei raise issues of interest for industrial clusters. It is clear that cities with policies such as these, as well as

[75] http://www.fastcompany.com/cities/2009
[76] http://www.fastcompany.com/magazine/135/fast-cities-malmo-sweden.html
[77] http://www.fastcompany.com/magazine/135/fast-cities-taipei-taiwan.html

being attractive places to live are attractive places for climate related businesses to operate.

This is not just an issue for city administrators, but also the companies that supply cities with services. The market for such companies comprises not only the visionary Nordic cities, but also the visionary cities of the world, and programs to support innovation might one day help such companies to expand beyond their home base, and to address the markets for city-oriented services throughout the world.

The networking of public administration in this way makes a lot of sense. Innovation is not the preserve of private industry. The public sector is under great pressure to innovate. The cost of provision of infrastructure, education, health care and other services increases much more quickly. Innovation in organization and management, combined with services, needs to become a core capability of a modern well-run city. The public sector needs to continuously reinvent and improve the business model of modern society – the business model that links the services provided by the state with the taxes and other revenues that pay for them. They create the demand for climate technologies, and have a very important role as users in user-led innovation initiatives. They need to consciously develop a capability for innovation and can help each other by establishing:

- *Common Measurement Tools:* Cities need to measure overall energy consumption and emissions. These data will act as a support for climate related decision-making, benchmarking among peers and the branding of the city as a modern, progressive venue for living and working.
- *Expert Assistance:* Exchanging and demonstrating good practice in the development and implementation of programmes to reduce energy use and lower greenhouse gas emissions by focusing on building efficiency, cleaner transport, renewable energy production and waste management, combined with water and sanitation systems.
- *Public Procurement:* They can work with vendors to lower production and delivery costs, while encouraging climate friendly building materials, traffic and street lighting, buses and waste disposal trucks, combined with waste-to-energy systems.

It is worth considering a greater and more explicit role for public administration in the innovation game. This should give consideration to capac-

ity and know-how building related to the public sector's role in terms of climate and energy related innovation, such as in the fileds of energy management and public procurement. The key questions include how to exploit procurement to:

- Achieve targets for 2020 and 2050.
- Support innovators and entrepreneurs with new, high-risk ideas.
- Enable the early stage growth of small and medium-sized enterprises.

Measures to support the peer group learning among public sector professionals could be of particlar value:

- Appoint 2020 or 2050 officers at region or city level, responsible for meeting the corresponding climate targets. Their job could be to maintain a vision for the region in terms of the acheievement of targets and ensure that data are acquired to track and report on progress. They could maintain a portfolio of relevant projects and work, together with providers of technology and know-how who want to be involved.
- Benchmark regions and cities
- Reward top performers such as the top 20 most sustainable cities, towns and villages.

One of the issues policy makers like to address when considering research and innovation is the role of risk. The state assumes risks that the private sector would normally eschew. It could be interesting to examine the concept of risk and the rationale behind public intervention in light of the public commitment that public administration sometimes makes in the pursuit of climate and related sustainability goals. Risk is not just technical or scientific, but socio-political and financial. The basis for the public funding of climate related innovation may need to be expanded to include the risk of not meeting targets necessary to avoid the worst effects of climate change. This would have the effect of:

- Demonstrating the possibility of reaching targets
- Maintaining local momentum to achieve results with high impact
- Maintaining international momentum and solidarity for a project that requires a concerted global effort from all nations.

Land-use, food, agriculture and forestry

Forestry is an important sector for several Nordic economies, and in particular for Finland and Norway. It plays an important role in the dynamics of climate change. Although forests by themselves are an important carbon sink and mitigate climate change, deforestation alone is responsible for up to 20% of global carbon emissions. According to the World Watch Institute, agriculture and land-use accounts for 30% of current man-made emissions, and its impact is comparable to that of the transport and industry sectors combined.

A recent report by the UNEP[78] highlights the potential of the world's forests and farmland to help absorb man-made atmospheric carbon. The report proposes that reducing the rate of deforestation by 50% by 2050 and maintaining it at this level until 2100 would provide benefits equivalent to a reduction of emissions by 12%. The report also claims that the agricultural sector could become virtually carbon neutral by 2030 if sustainable management practices were followed. Reducing the rate of deforestation and adopting better land use practices could lower global emissions by up to 30%.

Norway has therefore established an international climate and forestry initiative[79] with the aim of reducing global GHG emissions. This is closely linked to the UN-REDD programme for Reducing Emissions from Deforestation and Forest Degradation in Developing Countries[80] and part of a series of international initiatives such as the World Bank's Forest Carbon Partnership Facility[81], the Global Environment Facility Tropical Forest Account[82], and Australia's International Forest Carbon Initiative[83].

The World Watch Institute has recently sought to highlight the role of food and farming in the dynamics of climate change[84], in particular the role of the soil in carbon sequestration. The author points out that science and policy communities in Europe and elsewhere have focused most of their attention to date on improving energy efficiency and scaling up

[78] http://www.unep.org/pdf/BioseqRRA_scr.pdf
[79] http://www.regjeringen.no/templates/Tema.aspx?id=548491&epslanguage=EN-GB
[80] http://www.un-redd.org/
[81] http://go.worldbank.org/9IGUMTMED0
[82] http://www.gefweb.org/default.aspx
[83] http://www.climatechange.gov.au/index.html
[84] EWP179 "Mitigating Climate Change Through Food and Land Use", www.worldwatch.org

renewables, but that "any strategy that seeks to mitigate global climate change without reducing emissions from agriculture, forestry and other land uses is doomed to fail". The report claims that innovations in food production and land use that are ready to be scaled-up today could reduce CO^2 emissions by the equivalent of some 25% of global fossil fuel emissions. They outline a five-fold plan to achieve this. It calls for the incorporation of terrestrial emissions into climate investment and policy, and the promotion of voluntary markets for greenhouse gas emission offsets from agriculture and land use "while working out rules for regulated markets".

In Australia 27% of human-induced greenhouse gas emissions are generated by activities such as livestock, crop-production and land clearing. It has set up a national carbon accounting system[85] to account for carbon emissions related to land-based sectors such as agriculture and forestry. It publishes national greenhouse accounts[86] with a break-down according to region and industrial sector. The Nordic countries have not come this far, but it would make sense for them to examine the feasibility and benefits of doing so.

Food, farming and land-use in general are of importance for all economies. It would therefore be useful to investigate the overall role of these sectors in the Nordic region.

- What is the role of land-use change for climate change mitigation and adaptation in the Nordic countries?
- How could the Nordic region achieve carbon neutral agriculture by 2030?
- Can it do this while meeting the growing need for food, feed and fiber?
- How will this affect global supply chains, food security, and the distribution of related industrial activities and patterns of trade?
- What role will technologies play in providing workable options?
- What are the implications for future land-use policies?
- What is the impact on agri-business activity?
- What measures need to be taken to support innovation?
- How should this shape the future research agendas related to land-use, environment, tourism, agriculture and forestry?

[85] http://www.climatechange.gov.au/ncas/index.html
[86] http://www.climatechange.gov.au/inventory/index.html

Water, fisheries and the marine environment

Climate change has caused an observable increase in the frequency and intensity of extreme weather events. It has caused changes in the patterns of precipitation of rain and snow that have increased flooding and changed the large-scale hydrology of certain regions. It will have a big impact on the Arctic region in terms of the retreat of glaciers, permafrost and sea ice. There is even a fear that the associated release of GHG from peat-bogs and tundra could increase warming by even greater levels than previously anticipated.

The UNEP report on "Climate Change and Water"[87] explains these changes and how they come about in some detail. Temperature changes will affect agricultural yields and bio-diversity as well as the spread of disease and parasites related to intensive agricultural and fish production. We expect an increase in species extinction. We also expect a natural reduction in forestation, and sea level rise will affect marine eco-systems, with consequences for fisheries and associated patterns of human habitation and industrial activity. Coastal wetlands and estuaries are among the most biologically productive in the world. Climate change will have an increasing impact on aquaculture, the migration of invasive species, and will heighten the risk to stocks from disease and harmful algal blooms. The impact on marine eco-systems is due to:

- Acidification arising from increased levels of CO^2 in the atmosphere
- Surface water and coastal area temperature changes due to warming
- Weather patterns including increases in storm frequency, rain, run-off and sea ice occurrence

The sea has an important role in carbon sequestration. The main contributors are kelp and phytoplankton, which essentially represent the forests and savannah grasses of the sea. CO^2 dissolves more readily in cold water than in warm water so the effects of acidification could be expected to be greater in the more northerly waters of the Nordic region. Although we can easily monitor terrestrial forests by satellite, the seas are much less accessible. They may play a bigger role in the future in terms of carbon sequestration on the basis of geo-engineering or on the basis of kelp forests associated

[87] http://www.ipcc.ch/ipccreports/tp-climate-change-water.htm

with modern sustainable fish farms. They may play new roles in industry, in the production of bio-fuels, cosmetics, food and medicine.

Given their extensive coastline, the importance of fishing and sea-food as an industry, combined with their privileged relationship with the Polar Regions, there is arguably a need for the Nordic countries to increase their investment in:

- Basic science to promote understanding of the impact of climate change on marine and industrial eco-systems as well as on key global resources such as the arctic region.
- Innovation, technologies and strategies to help industries from fishing to tourism which may be poorly suited to adaption.
-
- Support for innovation based on the sustainable exploitation of marine resources, not just in terms of food, but also in relation to non-food or food-related sectors such as bio-fuels.

Other sectors

Climate change affects many sectors in addition to energy, agriculture, forestry and fishing. All sectors are to some extent energy intensive and thus all have to develop a response in terms of energy efficiency. Many sectors will have to adapt to changes that are imminent and unavoidable. Many sectors see the greening of the economy as a branding opportunity that will allow them to establish a superior position in terms of product placement. We will briefly look at the implications of climate change for sectors such as manufacturing, retail, logistics and IT.

In April 2009 Aberdeen released a series of reports on green product development[88]. Based on surveys which the city had carried out in 2008 they found that:

- 50% of consumer packaged goods providers regarded the ability to achieve product differentiation via green product development was the single greatest challenge they faced.

[88] www.aberdeen.com

- 54% of industrial machinery manufacturers found that their main challenge was to provide increasingly energy efficient systems
- 78% of automotive manufacturers had some kind of a green initiative in place.
- 81% of high-tech and electronics manufacturers had a green product development program in place

Transport is responsible for 71% of oil consumption and for 26% of CO^2 emissions. Logistics account for an estimated 10-15% of the final cost of finished products. Businesses are therefore increasingly seeking to cut costs by reducing fuel consumption and time spent in queues. In addition to reducing costs, industries are now concerned with their carbon footprint as part of a significant trend that considers greenness as an important differentiating factor in the provision of goods and services. The public sector has an important role to play in terms of traffic management, the planning of logistics hubs and freight corridors. Cities have taken numerous initiatives to "green" transport and supply chains[89]. Green–powered vehicles also have a role to play.

Postal operators and express services, for example, often represent the largest vehicle fleets in any given country and are particularly reliant on fast, low-cost solutions. Whereas battery power and hybrid systems already work well for personal transport and certain kinds of vehicle fleets, bio-fuels will also play an important role. A range of programmes are currently addressing logistics at European level. For example, since 2003, the EU financed Marco Polo program[90] has been established to promote innovative transport solutions. Estimates from before the financial crisis suggest a 50% growth in volume of world trade between 2005 and 2020. This figure may have to be revised but there is no doubt that supply chains have become longer and more complex. There is a need for international co-operation on logistics issues.

Iceland has been highly innovative in offering itself as a venue for the smelting of aluminium and for the processing for food of fish caught in northern waters. Smelting is very energy intensive but Iceland can

[89] "A review of green logistics schemes used in cities around the world" by Nikolas Geroliminis and Carlos F. Daganzo of Department of Civil and Environmental Engineering, Institute *of Transportation Studies, University of California, 416 McLaughlin Hall, Berkeley, CA 94720, USA …http://www.metrans.org/nuf/documents/geroliminis.pdf*

[90] http://ec.europa.eu/transport/marcopolo/home/home_en.htm

achieve this in a carbon neutral way using electricity generated from geothermal sources. An argument is emerging that this not only brings jobs to the region but also makes a significant contribution in the fight against climate change. Smelting has grown rapidly in China in recent years where it is fuelled by energy from coal. Were it not for Iceland, China would probably be producing much more aluminium, but with a negative impact on the environment. The Economist recently asked[91] "if electricity is going to be made anywhere, it might as well be made where it does the least damage to the environment". Having said that smelting has become a controversial issue, and environmentalists have objected to the fact that bauxite is often transported over long distances prior to processing. Finding ways to reduce the carbon footprint of the marine transport of bauxite to Iceland would help to address these concerns.

This example illustrates a broader strategy of greening entire supply chains by harnessing the natural advantages of the Nordic region. The region offers a range of zero-carbon energy alternatives for energy intensive industries, as well as the opportunity to exploit natural sources of heat and cold for greenhouse agriculture or the operation of server-farms for data-intensive industries. The focus of Nordic innovation on low-carbon energy intensive industries should encompass issues such as the greening of the whole supply chain and not just the energy required for processing. It should look at the challenge of greening transport and distribution networks, together with reducing the impact of activities on the local environment on the basis of architecture and design. The argument made by the Economist that countries such as Iceland should "use its plentiful clean energy for the benefit of the planet" is one that extends to the whole of the Nordic region. The greening of the global supply chain in terms of the intensive use of energy is one that would help the region build upon its existing natural and technological advantages, by explicitly addressing issues that we have in common with the greening of the supply chain as a whole.

McKinsey, the global consultancy firm, has written extensively on how IT can cut emissions[92] by measuring the impact on greenhouse gas emissions of the manufacture, distribution and use of IT. It estimates that

[91] Based on an article entitled "Testing metal" from the 29th Sep 2008 edition of the Economist.

[92] McKinesy "How IT can cut emissions", http://www.mckinseyquarterly.com/PDFDownload.aspx?ar=2221

despite the fact that ICT will continue as a major source of greenhouse gas emissions, the changes it will bring about can promote emissions reductions of as much as 15% of current levels. Major IT industry related companies in the Nordic region, such as Ericsson and Nokia have made considerable commitments to reducing the emissions relating to their equipment.

Retail is almost totally ignored in the innovation literature, but it has its own very specific forms of innovation, and can be a powerful force in transforming the capabilities of small and medium sized companies in the value chains where it is an active participant. It currently functions as an important lever in the greening of supply chains.

High profile examples in Europe include Siemens and Philips. Philips launched its EcoVision program in 2005 to improve the energy efficiency of its products and operations. In 2007 20% of EcoVision sales were of products that typically demonstrated a 20% energy saving over their predecessors. In 2008 this figure increased to 23%. That year it released almost 80% more new green products that the year before. Siemens has made a significant commitment to green product development and, according to a recent Reuters Report[93] it expects to increase revenues from its green product portfolio from €19B in 2008 to €25B in 2011 despite the worldwide slump that has already affected its order flow.

Wal-Mart is now the world's largest company. In 2008 it sold $245B worth of goods. It has become famous – or perhaps notorious – for its policy of squeezing suppliers to get the best price for its customers. Most recently it has started to adopt a sustainability agenda that will involve a social and environmental assessment of all of its suppliers. It has announced that those who do not or will not measure up to its criteria for sustainability will not be retained. Its 2009 sustainability report[94] announced targets of 100% renewable energy and zero waste. Although it is one of the largest solar panel installers in the US it has to date only achieved levels of 1% renewable energy consumption. On the other hand it has already achieved a 57% reduction in own-waste sent to landfill. It has undertaken initiatives in the area of organic clothing and food, sustainable sea-food, fuel efficient vehicles and building efficiency. It has established energy efficiency and performance inititives with its suppli-

[93] http://www.reuters.com/article/GCA-BusinessofGreen/idUSTRE52N2AX20090324
[94] http://walmartstores.com/Sustainability/7951.aspx

ers, as well as improvements in packaging and the use of renewable material inputs. To achieve these goals it has established a series of "sustainable value networks"[95] involving dedicated structures and human resources addressing themes such as alternative fuels, logistics, waste, packaging, food agriculture and fisheries.

The need to address climate change has created a new service industry based on the trading of carbon credits. All 27 EU countries are part of this system, together with Iceland and Norway. Many other countries are preparing to join in as well to what could eventually become a global carbon market. However, this kind of trading is not necessarily limited to carbon. It can be used to commoditise other environmental (and therefore social) goods. Lots of examples are provided on the website of the Eco-System marketplace[96].

Many new sectors are currently emerging either as a direct or indirect result of the urgency of climate change mitigation. These are linked to better resource exploitation, recycling, the processing of organic waste or urban sewage, the generation of clean water, bio-gas and compost, technologies for the retro-fitting of buildings and renewable construction materials. They include broader knowledge-based bio-economy sectors related to the greening of retail, bio-polymers, the reduction of pollution and the application of the most advanced areas of S+T such as synthetic-biology for food, medicine, energy and the production of bio-polymers and other industrial feedstock.

Finland has 1,200 cleantech companies, of which about 200 belong to the 4–centre cleantech cluster called "Cleantech Finland"[97]. The sector is growing globally at between 5–15% a year. The cluster was set up to help Finnish companies establish contacts with international markets. The NETS project[98] financed by the Nordic Innovation Centre in Oslo provides a platform to support the commercialisation of clean-technologies developed in the Nordic region.

These lists are not exhaustive. They are intended to illustrate how climate change has created complex ripples throughout local and international supply chains. The conclusion is that traditional approaches to understanding innovation may not be adequate to bring about the changes

[95] http://walmartstores.com/sites/sustainabilityreport/2009/en_threeKeyGoals.html
[96] www.EcosystemMarketplace.com
[97] www.cleantechcluster.fi/en
[98] www.nordiccleantech.net

required on a scale necessary to achieve the challenge of keeping global warming below the 2°C threshold prior to 2100. More integrated value chain approaches may be required.

The specific challenge of climate-related innovation

Innovation is a challenge for all companies in today's more or less global open-market economy. The meaning of innovation for a company usually boils down to winning clients or customers in a competitive market-place. The time scale for achieving this is usually of the order of months or years. However, the climate innovation challenge is not the property of any company, but belongs to society as a whole. The Stern review and subsequent reports conclude that if we do not keep global warming below an average of 2°C the consequences for national economies, marine and terrestrial eco-systems and patterns of human habitation will be quite drastic. Improved data and model revisions over the last years tend to indicate that the impact of current emission levels on climate change and all of its consequences could be even greater than previously thought. The risks involved are of a different order than those involved in terms of the levels of innovation required in the normal course of events. Success requires cooperation by all major participants and their supply chain partners, not just in the Nordic countries or in Europe but eventually all around the world. For this reason it may be necessary to "force" innovation by setting binding targets for the reduction of greenhouse gas emissions. These targets are then broken down on a sectoral basis with the current focus being on energy.

The various approaches by which the public sector steps in to actively encourage innovation in key areas through legislation and by using the leverage of its enormous spending power, can be thought of as "forced" innovation. This is a situation where real pressure to innovate is applied to all companies in the category in question, in response to a situation where innovation is no longer an option but a necessity. It is likely that there will be more of this in the future.

Compliance is not usually associated with innovation, but compliance forces innovation. One example of a public intervention carried out to force innovation provides an interesting model for other countries and

regions to consider. The Japanese "Top Runner" programme for energy efficiency is applied in connection with machinery and appliances[99]. On a category by category basis the programme identifies the most energy-efficient models already available on the market. These are referred to as the "top runner" models in that category. The government then stipulates that the current efficiency of the top runner model should become the standard within a stated period of time, such as five years. This approach constantly ratchets up the performance of industry with each new generation of targets. The advantage of this approach is that innovation laggards within a given category know that the goals are achievable because they are based on existing best-in-the-class models. They also know that they have a specified period of time such as five years in which to catch up or face exclusion from the game. On the other hand innovation leaders also know that the market will have caught up with them in five years time and this gives them the incentive to continue to innovate and exceed what will become the norm in five years time. Compare this with the usual approach by which minimum standards are set and where industry has little incentive to do more than simply comply because exceeding the standard will not earn them any extra recognition.

Another important approach was championed in 2006 by Esko Aho, former Prime Minister of Finland. The "Aho Report" entitled "Creating an Innovative Europe" became an important European contribution under Finland's Presidency of the European Union[100]. It focused on the creation of innovation friendly markets and emphasizes the potential role of governments in the creation of lead markets for important areas of innovation. What this amounts to in practice is that governments will be using their systems of public procurement to encourage innovative products and services. The European commission has taken this on board and has adopted this approach as an important element in achieving the Lisbon agenda. Lead Market initiatives[101] have now been established in sectors such as e-health, construction, recycling, renewable energy and renewable raw-materials. GPP or Green Public Procurement is the application of environmental non-price criteria by the public sector to purchasing deci-

[99] Go to http://www.eccj.or.jp/index_e.html to find out more about the programme and download the report at http://www.aid-ee.org/documents/018TopRunner-Japan.PDF for an evaluation.

[100] http://ec.europa.eu/invest-in-research/action/2006_ahogroup_en.htm

[101] http://ec.europa.eu/enterprise/leadmarket/leadmarket.htm

sions. It enables the public sector to pay more than the lowest prevailing price for a product or service, in order to capture an environmental or social benefit. The most straightforward examples involve the purchase of bio-fuel fleets. However, public procurement can achieve even more by supporting the innovation process in more direct ways. For example, it might be used to purchase hydrogen-buses or new types of electric vehicles which may not yet have reached mainstream markets. Such early purchase of an advanced technology allows the company to earn early revenues from their investment in research and development. It improves their financial standing and their ability to continue investing in the innovation process. It demonstrates the feasibility of the technology or solution in question and provides user feedback and market-learning experiences that are essential for a successful launch. Public authority spending in the EU amounts to about 16% of EU GDP or about €2,000B each year. The greening of public procurement rules at EU and national level is seen as a means of substantially reducing unsustainable production and consumption patterns, and could serve to introduce new environmental technologies to the market.

Only 7 EU countries have made a substantial commitment to GPP. These include Denmark, Sweden and Finland. The EC has proposed that all governments in Europe should aim at 50% GPP based on common criteria by 2010. Ten priority sectors have already been identified for the introduction of GPP on the basis of their potential impact on climate change, among other things. These are construction, food and catering services, transport and transport services such as “clean vehicles”, energy, office machinery and computers, clothing, uniforms and other textiles, paper and printing services, furniture, cleaning products and services, and health sector equipment. GPP has a role to play not only in helping innovators and creating lead markets, but also in demonstrating that green need not be expensive. It helps to mainstream quality initiatives such as eco-labelling or energy-labelling.

The Nordic region has already established a lead in the area of GPP. Perhaps it should maintain and extend this lead in order to achieve global pre-eminence in the use of procurement to support innovation. It can achieve this by becoming more involved in user-driven innovation, by acting as a first client for new products, and by helping to build lead mar-

kets in areas of importance to the environment and society as a whole. It is worthwhile considering measures whereby:

- All governments open up their procurement markets
- All administrations develop procurement strategies that favour climate friendly solutions
- They set aside funding for smaller companies
- They set aside budget funds for the purchase of innovative high-risk solutions so as to participate in their demonstration and assessment
- They benchmark progress towards 100% green procurement
- They, as in Finland, develop innovative municipalities whose missions are to act as "living laboratories" for climate mitigation strategies and green procurement practices
- They create a new research discipline related to the use of public purchasing power to accelerate all stages of the innovation cycle, from research to demonstration and full scale market deployment

To date two approaches have been mentioned regarding "forced innovation". The need to force derives from the urgency of the climate change issue and the acceptance of legally binding targets for emissions and renewable energy production. The two methods involve firstly, the use of programs such as the Top Runner program in Japan, and secondly, the use of green public procurement. Both have been discussed to some extent in the literature on innovation. A third approach attracts less attention and this might be a good opportunity to examine in further. This is the "Wal-Mart" approach whereby supply chain leaders put pressure on those further down the hierarchy to share the burden of becoming green.

One issue of interest to innovation researchers in the future could be the extent to which major retailers and branded goods producers work with their supply chain partners, the nature of this cooperation and the possible need for measures to support small and medium sized enterprises to manage the transformation required.

It is important for the Nordic region to address climate issues in the market as quickly as possible. The risk is that by waiting they will lose their competitive edge to the suppliers of Wal-Mart as low-cost economies become high-value suppliers of climate friendly goods.

In a recent book[102], Amar Bhidé stresses that the application and commercialisation of science and technology is a far more important part of innovation than the underlying process of scientific discovery. This observation is borne out by marketing experts who know that most new products or services introduced to the market fail. On the basis of 25 years' experience in bringing new technology products to the market, the Eco-Stategy Group recently claimed that the main reasons for product failures in the market-place are:[103]

- Poorly defined or incorrectly defined target markets
- Badly positioned product
- That product benefits not understood by the target customer.
- That the product fails to address important customer needs.
- That the product costs too much or the total cost of ownership is out of line with perceived benefits

Amar Bhidé also points out that the greatest benefits of innovation accrue to the users of an innovation and not to the original inventors. His arguments suggest that in exploring the systemic dimension of innovation to achieve a sustainable, climate friendly mode of economic progress, it is worthwhile paying attention not only to value chain issues, but also to the benefits that accrue to consumers in terms of energy savings, carbon credits, resource efficiency, compliance, branding and efficiency. When addressing climate change, it is worthwhile paying attention not only to scientific and technological innovation, but also to the creation of innovation related market intelligence and to innovation in marketing and sales which is essential if the promise of new jobs and business opportunities is to be kept.

In most periods in economic history it is not always entirely clear from where the next "new idea" will come from or how important it is likely to be. Nordic, European and even global policy trends indicate that factors such as carbon markets, climate change, renewable energy and industrial feedstock, recycling and the efficient use of energy, water and other natural resources, will assume increasing importance in the years to

[102] "The Venturesome Economy – How innovation sustains prosperity in a more connected world" published in 2008 by Princeton University Press, ISBN-13 978-0-691-13517-5.

[103] www.sustainablelifemedia.com/content/story/strategy/top_ten_reasons_why_new_green_products_fail

come. These sectors are essential components of an emerging sustainable economy. The global transition will affect not only existing companies and start-ups, but also the entire value chains to which they belong. This requires innovation at system level and on an unprecedented scale. Policies may need to pay more attention to issues such as the sourcing and adoption of new technologies if change is to be achieved on a scale sufficient to meet national and international energy and climate security goals.

The impacts and cross impacts of climate change on society and on the environment have been closely examined. However, relatively little work has been done on the impact of climate change and its policies on the industrial and trade systems at national, regional or world level. What has been done has mainly been qualitative in nature, but it has served to indicate the complexity that must be addressed, and provides a starting point for further analysis. The economic impact of climate change has been limited mainly to the costs of damages, mitigation or adaptation, and the costs associated with disasters, sea-level rise or the increased burden of health care. Relatively little has been done on the upside on the part of industry in terms of new business oppportunities, either regionally or globally. Studies of this kind that not only deal with the market place for energy or global carbon trading, but which also examine the ripple effects within supply and value chains, can play an important role in understanding the specifics of the innovation challenge faced by small and medium sized companies competing in nascent markets and with global opportunities.

Innovation researchers in the US have already started to look at the systemic impact of low-carbon technologies on the economy, by investigating how these changes will affect the entire production value chain. In a report entitled "Job Opportunities for the Green Economy - a state by state picture of occupations that benefit from the green economy"[104], US based PERI - the Political Economy Research Institute of the University of Amherst, worked with Duke University's Center on Globalization, Governance & Competitiveness to map out the value chains of the following five low carbon technologies and products:

- High-efficiency energy LED lighting
- High performance energy efficient windows
- Anti-idling technology for heavy duty trucks

[104] http://www.peri.umass.edu/fileadmin/pdf/other_publication_types/Green_Jobs_PERI.pdf

- Concentrated solar power
- Systems for recycling pig waste

This is not intended as an exhaustive list, and work is ongoing on other applications. However, they are examining how these different climate solutions are manufactured and how the benefits of this activity are distributed throughout the value chain. One example that will be especially meaningful for the Nordic countries is that of wind turbines. According to their report, a wind turbine contains 8,000 components manufactured by tens if not hundreds of suppliers. As demand increases among the turbine manufacturers, so does business for the producers of each one of these components. The report follows the links in the value chain of US based wind turbine manufacturers to determine the overall potential for growth that they represent. In particular they show that growth in these obvious environmental technologies has considerable benefits for sectors not normally associated with environmental conservation.

The methodology used is based on the provision of:

- A working understanding of each technology, broken down into its primary materials and components
- A view of the value chain that includes materials, component manufacturers, assemblers, and the distributors linked to each technology
- A view of the types of labour involved in manufacturing and installation
- A list of firms and a depiction of the market structure in which they operate

Other studies focus on the traditional skill sets that will be needed to make this happen. The transition is not concerned only with high-level scientific and technical jobs, but also with highly-skilled vocational jobs in areas such as the construction trades, pipe-fitting, metal-working and electrical jobs. All of these other sectors are part of the systemic change that the Nordic countries want to bring about.

Arguably, the Nordic countries lag behind in their understanding of how the transition to a low-carbon economy will benefit the economy. As a consequence, there is also a lag in terms of knowing how best to accel-

erate the change and optimize the distribution of benefits. Future innovation policies could benefit from a more systemic approach addressing not only the high-end knowledge needs associated with climate-related R+D, but also issues such as the benefits accruing to end-users, complementary skills and supply chain dynamics.

Eventually it will be possible to propose a coherent set of interventions that go beyond R+D to address innovation needs. This may require:

- Roadmaps for proof of concept, demonstration, large-scale demonstration and commercialisation, together with impact on jobs and economic growth
- Global market mapping of needs, magnitude, growth prospects, regulations, incentives, goals and targets, together with the extent of market fragmentation and conditions for penetration
- The opportunities presented in the form of emerging as well as developed economies
- The financing needs at different stages of new market development technology adaptation, demonstration and deployment
- The global market readiness of Nordic companies, the appropriateness of their capabilities, and the cost of adaptation to new skill-needs and new markets
- The need for business services, e.g., on the basis of a network of international innovation centres

Some work has already been done on more business and innovation oriented issues. For example, CICERO has published reports on the business implications of the Kyoto Protocol[105], in addition to pro-poor Climate Adaptation[106]. The Nordic Innovation Centre has supported projects dealing with how to build Nordic strongholds within environmental technologies[107] such as the use of wood as the basis of a bio-polymer industry. The NETS project[108] in particular will support the commercialization of Nordic environmental technology businesses in five key sectors. These

[105] Report 2001:05 by Torvanger and Asbjørn. http://www.cicero.uio.no/media/1690.pdf

[106] Report 2003:02, "Pro-Poor Climate Adaptation: Norwegian development cooperation and climate change adaptation - an assessment of issues, strategies and potential entry points" by Eriksen, Siri and Lars Otto Næss http://www.cicero.uio.no/media/2465.pdf

[107] http://www.nordicinnovation.net/article.cfm?id=1-834-804

[108] Nordic Environmental Technology Solutions

include bio-polymers derived from wood, clean-water technologies, and green nanotechnology as applied in the construction industry.

The Nordic Environmental Action Plan for 2009–2012 could be further developed by explaining how it will be used to create jobs, markets, and opportunities for entrepreneurial new companies. Arguably, the system would benefit from complementary work using:

- A value chain approach
- The potential for local job creation both directly and throughout the value chain
- The potential for exports to emerging markets

There is a need to create new technologies to address climate change issues, but many already exist and no time should be wasted in releasing these to the market and onto a trajectory of innovation by means of continuous improvement. Climate change is as full of opportunity as it is of urgency, but we are not yet as skilled in measuring and understanding the opportunities presented as we are at understanding the danger. We can help to address this by considering a supply or value chain approach to innovation in all related sectors.

Much of the discussion of global change is conducted in very broad general terms on the basis of global models and simulations. Local governments and administrations must now learn to understand climate change from a very local point of view, not so much in terms of its effect on the planet but in terms of its impact on local environmental and industrial systems. Much work remains to be done to adapt existing tools for use by policy makers and non-climate scientists so that they can explore answers to the questions that they need to ask rather than those that drive scientific inquiry. This is no small task and it should not be forgotten in the discussion of climate-related public sector innovation needs.

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