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Scoping Green Growth and Innovation in Nordic Regions

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Nordic co-operation
takes place among the countries of Denmark, Finland, Iceland, Norway and Sweden, as well as the autonomous territories of the Faroe Islands, Greenland and Åland.

The Nordic Council
is a forum for co-operation between the Nordic parliaments and governments. The Council consists of 87 parliamentarians from the Nordic countries. The Nordic Council takes policy initiatives and monitors Nordic co-operation. Founded in 1952.

The Nordic Council of Ministers
is a forum of co-operation between the Nordic governments. The Nordic Council of Ministers implements Nordic co-operation. The prime ministers have the overall responsibility. Its activities are co-ordinated by the Nordic ministers for co-operation, the Nordic Committee for co-operation and portfolio ministers. Founded in 1971.

Nordregio – Nordic Centre for Spatial Development
works in the field of spatial development, which includes physical planning and regional policies, in particular with a Nordic and European comparative perspective. Nordregio is active in research, education and knowledge dissemination and provides policy-relevant data. Nordregio was established in 1997 by the Nordic Council of Ministers. The centre is owned by the five Nordic countries and builds upon more than 30 years of Nordic cooperation in its field.

Stockholm, Sweden, 2012

Contents

Preface

This working paper is published as part of the ongoing project Regional Strategies for Green Growth and Innovation, commissioned by the Nordic Working Group for Third Generation Regional Policy. The ambition of "third generation regional policy" is to use the potential of each region in the best possible way and to integrate all Nordic regions and local communities into the global economy. The working group is composed of representatives from the national ministries responsible for regional policy. It was established by the Nordic Committee of Senior Officials for Regional Policy. One of the working group's priorities is to explore the potential of green growth for regional development, for which purpose this project was initiated in July 2011. Its main objective is to provide policymakers with a useful reference on regional challenges and opportunities to achieve green growth and innovation.

This working paper illustrates the relatively new and explorative nature of the green growth concept. First, it includes a literature review on green growth and related concepts, with particular focus on conceptualizing green growth and innovation from a 'territorial' or 'spatial' perspective; that is, focusing on the implications of the geographic, demographic and economic characteristics of specific regions within Nordic countries for their green growth performance and potential, e.g. urban versus rural experiences. This section includes an overview of national policies and strategies for green growth in each of the Nordic countries. Second, it presents a quantitative study using available data, intended to identify different regions' potential for and barriers against green growth and to produce visual representations in the form of maps. The paper's second part illustrates in particular that identifying and developing a quantitative approach to mapping green growth performance and potential at the regional level faces many challenges, and it remains a work in progress.

In order to provide a comprehensive overview of the opportunities and challenges of developing regional policy frameworks for green growth and innovation, and to elaborate on concrete initiatives supporting green growth and innovation, two case studies are conducted. These illustrate the utilization of green growth potential in an urban environment and a sparsely populated rural region, and describe the characteristics of economic sectors relevant to green growth and innovation. The first study involves the urban region of Skåne in Sweden and the regional and local initiatives to support the cleantech sector; the second involves the rural region of South Savo in Finland and the regional and local initiatives to develop bioenergy in the forestry sector. These qualitative, in-depth case studies incorporate and build on the findings of this working paper, and they will result in a second working paper.

The project will be finished by the end of 2012, by which time there will be two further deliverables: 1) the case study working paper, and 2) a shorter report that synthesizes the main findings of the project presented in the two working papers. The synthesis report will also include policy recommendations.

The authors would like to thank the representatives of the Nordic Working Group for Third Generation Regional Policy who have commented and provided valuable input on draft versions of this working paper. Furthermore, we thank Maria Lindqvist and Lisa Hörnström for their comments and advice during the working process.

Ole Damsgaard
Director

Stockholm, June 2012

Introduction

This working paper seeks to provide relevant stakeholders and policymakers with a useful reference on the territorial dimension of green growth in the Nordic countries; that is, the implications of the geographic, demographic and economic characteristics of specific regions within Nordic countries for their green growth performance and potential, e.g. urban versus rural experiences. It intends to show that a coherent and unified Nordic green growth approach is strengthened by the acknowledgment of relevant regional characteristics. This can provide insight into the geographic and spatial features that can ultimately secure Nordic countries' competitive advantage as economic and political leaders in green development, within the European Union (EU) and globally.

Because green growth is a relative newcomer in policy discourse, the first phase of this working paper relies on the work of multiple international organizations—namely, the Organisation for Economic Co-operation and Development (OECD), United Nations Environment Programme (UNEP) and EU—to provide an understanding of the green growth concept. This analysis starts with the context of the continuing economic crisis and then discusses the roles of eco-innovation and territorial perspectives in a green growth strategy. The discussion continues with a presentation of the Nordic approach to green growth, in both the Nordic region as a whole and in individual countries. This enables the identification of policy-making and investment activities that may ensure that the Nordic countries remain globally competitive while pursuing green development.

The second phase of the working paper will entail a process of data collection, and from it, a statistical and qualitative analysis to evaluate green growth performance and potential in the Nordic countries. Again, insight from the OECD's evaluation of green economic performance will be used as a basis. However, additional indicators will be used based on relevance and availability—in particular, the paper uses priority recommendations from the Nordic prime ministers' Working Group for Green Growth. The paper then introduces and evaluates numerous territorial dimensions of both green growth performance and potential, to the extent possible given the current availability of region-level data. This will suggest how best to take advantage of regional characteristics in a unified Nordic approach to green growth, and what further research and data collection are necessary for a complete overview of regional green growth potential in Nordic countries.

I. Scoping Green Growth

By Ryan Weber, Lise Smed Olsen, Aslı Tepecik Diş, Christian Fredricsson, Liisa Perjo, Haukur Claessen & Apostolos Baltzopoulos

Perspectives on green growth continue to evolve in the discourses of international institutions such as but not limited to the UNEP, World Bank, EU and OECD. In many respects, the OECD has most extensively developed its green growth framework, as shown by its keystone green growth report in May 2011, *Towards Green Growth* (OECD, 2011a), which elaborates on the need for a clearly defined green growth strategy as well as a policy framework to promote the transition to this new development paradigm. In May 2011, the OECD released the supplementary reports *Tools for Delivering Green Growth* (OECD, 2011b) and *Towards Green Growth: Monitoring Progress—OECD Indicators* (OECD, 2011c). In combination with these information sources, the research base of the OECD provides operational guidelines for green growth. Undoubtedly, the EU and national and regional policymakers in Europe also rely on this broader OECD framework when tailoring development strategies for local contexts.

Based on the extensive work of the OECD, the Nordic prime ministers' Working Group on Green Growth proposes to apply the OECD's definition of green growth as a basis for a Nordic approach. The OECD states:

"*Green growth means fostering economic growth and development while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies. To do this it must catalyse investment and innovation which will underpin sustained growth and give rise to new economic opportunities*" (OECD, 2011a, p. 9).

This sentiment is very much evident in the UNEP's approach to the green economy, according to which growth in income and employment is primarily driven by investments that reduce carbon emissions and pollution, promote clean energy resources and prevent the degradation of biodiversity or ecosystem functioning (UNEP, 2011a)[1].

The OECD also states, "A return to 'business as usual' would be unwise and ultimately unsustainable, involving risks that could impose human costs and constraints on economic growth and development" (OECD, 2011a, p. 9). The phrase "a return to 'business as usual'" draws on the unanimous understanding that green growth is contextualized by the current state of the world economy, in which national and regional economies are unevenly recovering from the worst economic crisis since the Great Depression. Europe faces the challenges of record unemployment, spiralling fiscal deficit, low growth and the "gross misallocation of capital" (OECD, 2011a; UNEP, 2011a). The latter refers to investments that have been directed mostly towards property, fossil fuels and structured financial assets with embedded derivatives. Furthermore, growth has been dependent on the accumulation, consumption and/or exploitation of finite resources, thus making both our current and future well-being increasingly vulnerable (UNEP, 2011a). However, the green growth perspective implies that this state of crisis also represents an opportunity for change.

Both the UNEP and OECD make clear that the concepts of green growth and a green economy are *not* intended to replace sustainable development; rather, green growth *embodies* sustainable development (UNEP, 2011a; OECD, 2011a). "The concept of green economy does not replace sustainable development; but there is a growing recognition that achieving sustainability rests almost entirely on getting the economy right" (UNEP, 2011a, p. 16). Likewise, green growth is one subset of strong sustainability[2] that is narrower in scope and entails an "operational policy agenda to achieve concrete and measureable progress at the interface between the environment and the economy" (OECD, 2011a, p. 11).

The aim of green growth is therefore principally the same as that of sustainable development—to achieve balanced, resource-efficient growth that does not degrade the environment. Yet, green growth extends a more direct focus on the conceptual, policy and monitoring tools necessary for innovation and investment that can give rise to competitive sources of economic growth.

It is also argued that green growth ultimately entails the implementation of an entirely new development paradigm based on the following two central elements. First, there is the need to optimize energy efficiency and renewable energy production to provide an environmentally sustainable supply of energy to the entire economy. Second, there is the need to seek new and enhanced competitive advantages based on local competencies and natural assets in order to implement the 'smart specialization' of the economy. Experts unanimously agree that no single solution

[1] While the OECD's work towards green growth is used as a conceptual basis for a Nordic perspective, the UNEP has also completed extensive work relating to the development of a global green economy. An introduction to this work is available in Annex 2.

[2] See Annex 1 on the distinction between strong and weak sustainability in the context of green growth.

can be applied to effect the transition of the regional, national and international brown economies to green economies. For example, while policy tools are often relied upon as the key instigators of socio-economic changes, social and economic inertia can be so strong that even highly favourable policies can still fail to change investment behaviour. For this reason, green growth requires diversity and complementarity in its mix of drivers. Components of the existing approach to development ought to be maintained and supported by policy and investment.

This conceptual perspective implies that a transition to green growth entails balancing the prioritization of new opportunities for growth, further enhancement of existing good practices and the phasing out of counter-productive activities. In this context, it is essential to emphasize that our modern knowledge-based economies depend on a continuous process of adopting new products, processes and ideas to drive growth, and this is particularly relevant in the Nordic countries. Through this process, labelled "Creative Destruction" by Joseph Schumpeter (1934), innovation advances the process of change, thereby placing it at the core of any development initiative. This includes sustainable development, which green growth embodies.

A strong capacity to innovate is considered essential for overcoming the inertia of existing socio-economic and technological norms. By coupling our existing approach to development through innovation and technology with a well-founded and comprehensive policy mix that enhances green development's competitiveness vis-à-vis the brown economy business environment, we seek to establish break-troughs in patterns of production and consumption (OECD, 2011a).

Eco-innovation and Environmental Technologies

The OECD's *Oslo Manual for Measuring Innovation* introduces four types of innovation:

Product Innovation: a good or service that is new or significantly improved, including significant improvements in technical specifications, components and materials, incorporated software, user-friendliness or other functional characteristics.

Process Innovation: a new or significantly improved production or delivery method, including significant changes in techniques, equipment and/or software.

Marketing Innovation: a new marketing method involving significant changes in product design or packaging, placement, promotion or pricing.

Organizational Innovation: a new organizational method in firms' business practices, workplace organization or external relations (OECD, 2005).

While Schumpeter distinguishes between "radical" innovations that bring about major disruptive changes and "incremental" innovations that continually advance the process of change, innovation in its current sense generally involves new and/or significantly improved advancements (OECD, 2005).

According to the definition in Chapter 34 of *Agenda 21* (UN, 1992), environmentally sound technologies are processes and products that protect the environment, pollute less and use resources more efficiently than traditional technologies. This definition refers to end-of-pipe technologies for treatment of pollution, product life cycles and integrated environmental strategies and management systems. Environmental technologies include closed-loop, circular production, whereby discarded residual by-products are used as new resources for production (OECD, 2009). Eco-innovation was first described as "Innovation that results in a reduction of environmental impacts, no matter whether or not that effect is intended" (OECD, 2009, p. 15). Thus, the term "eco-innovation" gained traction as a description of the contribution of firms to sustainable development, while they maintain their focus on improving market competitiveness.

To promote eco-innovation in the EU, the Environmental Technologies Action Plan (ETAP) was adopted in January 2004. This is a co-operative initiative between the European Commission (EC), member states and industry to overcome barriers hindering the development of environmental technologies. The ETAP has three objectives: to aid the transition from research to markets and to improve market conditions. It is implemented at EU and member state levels. According to the ETAP, there is potential to promote environmental technologies in all economic sectors because technologies vary in maturity (some are already in use while others are under development) and in scope (e.g. information and communication technologies cut across different application areas, while others are focused on a specific issue) (COM, 2004). Within the framework of the ETAP, member states have developed national roadmaps for eco-innovation (Barsoumian et al., 2011).

The definition of environmental technology in the ETAP is:

"*All technologies whose use is less environmentally harmful than relevant alternatives*" (EU Press release IP/04/117, 2004).

The development of environmental technologies is thus related to eco-innovation and may be considered a means to achieve it. Moreover, the role of procedural and organizational eco-innovation is now being further accentuated as a means to reduce environmental impacts substantially while maintaining economic performance as a priority. This is exemplified in the work of the Eco-Innovation Observatory (EIO), which began in 2010 as a three-year initiative by the EC's Director General of the Environment to develop an integrated information source on the current state and potential of eco-innovation. This takes place in the context of the Europe 2020 flagship initiative to achieve a "resource-efficient Europe" (EIO, 2011).

According to the EIO, the definition of eco-innovation is:

"*innovation that reduces the use of natural resources and decreases the release of harmful substances across the whole life-cycle*" (EIO, 2011, p. VII).

The EIO approaches eco-innovation as a pervasive phenomenon across all sectors and as relevant for all types of innovation. In part, this is because as sustainable manufacturing and initiatives advance, the process of implementation becomes increasingly complex, and firms must adopt a multidimensional approach to integrate the various elements of eco-innovation. According to the OECD, this advanced, multilevel notion of innovation is often referred to as "system innovation"—"innovation characterized by shifts in how society functions and how needs are met" (OECD, 2009, p. 16). This is paralleled by the EIO, which states that "the magnitude of the challenge also calls for systemic innovations […] Public acceptance and social changes are key in this process" (EIO, 2011, p. VII).

The deepening of eco-innovation through concepts such as "system innovation" and the "life-cycle" perspective not only legitimizes innovation in green growth but also accentuates its inherently holistic nature. On the one hand, this involves the well-rounded nature of activities targeted by green growth, encompassing all sectors and recognizing that technological innovation alone is not sufficient to enable the transition of Europe into a resource-efficient economy (EIO, 2011). Instead, these systematic innovations emphasize process innovation such as business models, work patterns, city and regional planning and transportation arrangements[3] (OECD, 2011a).

On the other hand, the fact that environmental limits to growth must be increasingly prioritized in any economy necessitates a more comprehensive (and complex) notion of innovation. In particular, this involves the recognition that products and processes needed to support green growth must in turn be driven by innovative policy and institutional structures, which are needed to facilitate eco-innovations that may not be economically competitive in the current market. This includes an entirely new scale of investment in eco-technology, as well as policy tools to create equitable market conditions for environmental technologies, such as emissions trading schemes, national renewable energy tariff programmes and the directed focus of EU Structural Funds towards drivers of green growth.

Territorial Implications of Green Growth Initiatives

Because of a strong focus on biodiversity protection, on revision of protocols for the exploitation of natural resources and on smart specialization in local and regional development, the pursuit of a green growth agenda requires an understanding of at least four key territorial implications with explicit Nordic dimensions. First, deeper understandings of the mosaic of spatial differentiation within the Nordic can provide great insight on the opportunities and constraints that different regions have with respect to green growth. While some processes seem to have a macro-scale (e.g. globalisation, core-periphery) component to them, others are much more localised. The most anticipated example of this is the nature and strength of urban-rural linkages in relation to the green economy; as many green production activities are located in rural areas while a vast majority of resource consumption takes place in urban settings. This is an increasingly important consideration in the Nordic countries as growth of just a few large urban centres continues to take place at the expense of the vast expanse of rural areas.

Second, green growth and its simultaneous dependence on exploitation of certain forms of natural capital alongside the preservation of other forms increases the importance of understanding territorial potentials of green activities. Further, green growth can introduce a new set of internal and external interactions that might boost regional competiveness and thus

3 For example, improvements to urban public transportation infrastructure are as much about organizational and institutional innovations as they are about technological improvements to the infrastructure itself.

specialization and differentiation. In this connection, part two of this paper provides a regional analysis of important natural resources (in particular, renewable energy resources) to show clear territorial dimensions that ought to shape the focus of regional green growth strategies. Likewise, the positioning and scale of key ingredients for the development of eco-innovation (i.e. location of tertiary education institutions and regional investment in R&D) is also shown to be especially present in particular regions of the Nordic countries. As such, the defining characteristics of these regions can become the territorial logics that have a role to play in defining regional strategies for green growth.

Another important example of territorial capital is the much-needed pursuit of increased renewable energy production and improved energy efficiency across all production and consumption sectors. In both cases, development is contingent on local conditions, in terms of both physical and monetary potential for improvement and the management of improvements. A classic example in this case is the development of wind turbines, where local debate over their impact on the landscape is often involved in the decision of whether to situate turbines in a given area. This indicates that proactive, decentralized governance institutions that prioritize development of green potential have a strong impact on the success of environmental investments.

Third, a key issue is the evolving and changing roles of small and medium-sized towns (SMTs) in generating greener growth in the Nordic countries. SMTs provide employment in rural areas, and some sectors exhibit notably strong local economic integration in and around such towns (Mayfield et al., 2005; Mitchell et al., 2005; Courtney et al., 2007). These observations support the European Spatial Development Perspective, which promotes a shift towards a polycentric system in which SMTs are hubs in a green growth process. For instance, the discussion of SMT's can be related to territorially-specific path dependencies in terms of the local knowledge development characteristics creating local specialization in terms of certain technologies over others; particularly where historical development of certain technologies are adapted or transformed for new uses within a green growth perspective. A high potential for benefits from early adoption are notable where many regions in the Nordic have become key players in the international market from innovative green products. These patterns appear to be due to a number of factors including natural resource constraints that promote adoption of renewable energy production at an early stage (i.e. wind energy in Denmark), and the high level environmental awareness that has been cultivated among the public and political realms.

A fourth example is the increased importance of biodiversity protection alongside natural resource exploitation, which emphasizes the need for new insight into land use functionalities for pursuing green growth. In particular, land use multi-functionality is important because it provides a basis to acknowledge the potential efficiencies of proximate or even overlapping land uses. In this way, the green economic development in Europe is shaped by new conceptualizations of urban and rural landscapes; where areas that were previously characterized by exclusivity and monoculture can physically and conceptually accommodate non-agricultural activities, such as clean energy production and green manufacturing plants. This not only implies increasing multi-functionality of non-urban areas, but also a higher degree of territorial dispersion of the new functions/activities put in place. This is because many new green activities are intrinsically dispersed from the spatial perspective (e.g. windmills), and/or linked to diverse agro-ecological conditions (e.g. biomass production).

In summary, green growth is intrinsically dependant on local conditions to a much greater degree than is the brown economy. (Centralized energy production from fossil fuels compared with local and decentralized energy production of renewable resources is a perfect example.) Labour markets (skills and costs of the work-force), governance structures, spatial development strategies and natural resource availability will increasingly influence economic productivity, and consequently territorial specialization on a wider scale. These combined elements reflect the necessity of a well-developed and long-term regional policy acknowledging territorial implications for green growth and delivering a balanced, flexible and dynamic economy in the Nordic countries.

Green Growth Policy Perspectives

OECD

The current global economy, particularly in Western Europe and North America, is strongly constrained by its multiple challenges. The economic crisis has left a trail of vulnerability and instability among national and international economies, resulting in reduced access to financial capital for investments and increased market volatility. The OECD characterizes these challenges from a green growth perspective as follows.

- Existing social, economic and technological inertia limits the effectiveness of green growth policies, even those with clear pay-offs. For example, existing technologies make it difficult for some new technologies to establish themselves in the market and achieve sufficient scale to effect significant change. Technological and skill lock-in naturally occurs in employment skill sets, which means that pursuing green growth requires appropriate frameworks through which to facilitate the reallocation of workers from contracting to expanding sectors. Likewise, the distribution effects of green growth policy could have negative effects on some populations, especially in the short term. For example, towns centred on energy-intensive industries or fossil fuel exploitation could face acute short-term losses. Targeted compensatory measures are needed for vulnerable areas.
- Many environmental externalities are under-priced or not priced at all. These need to be identified and eliminated in the short term to level the playing field for innovation, particularly in terms of energy production.
- Trade barriers can limit the development and diffusion of technology, which in turn limits potential pay-offs and therefore causes a disincentive to innovation.
- Green growth requires numerous infrastructure investments that are extremely intensive, and long-term capital investments that have even longer financial pay-offs. These include green technology for the development of water, transport and communication technology, but especially the investments needed to transform and establish a pan-European smart grid for energy (OECD, 2011a).

The implementation of any socially, economically or politically sustainable green growth strategy will hinge on overcoming such constraints with a comprehensive mix of instruments that draw from two broad sets of policies. According to the OECD, the first set includes framework conditions, such as core fiscal and regulatory policies that include tax and competition policies and that reinforce the economy and the preservation of natural capital. The second set includes policies that incentivize efficient use of natural resources, make polluting more expensive and eliminate harmful policies that encourage further natural resource exploitation. These policies indicate that some of the most effective tools are market based and emphasize the view that 'getting the prices right' is critically important for the success of green growth policies (OECD, 2011a).

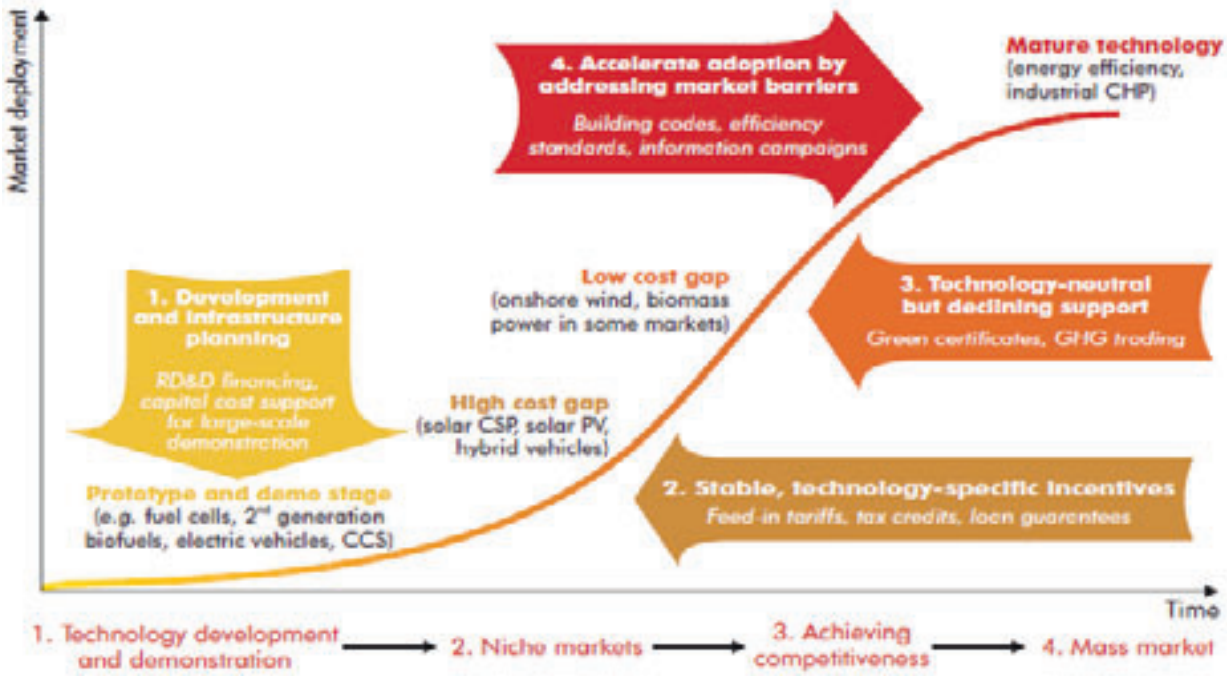
However, the OECD also makes clear that there is no 'one size fits all' solution to achieving green growth. For instance, just as regulatory and market-based policies cannot be implemented alone, financial support for green research and development (R&D) must be complemented by other types of policy support in order to withstand open market forces. This includes voluntary and information-based measures to strengthen market effects, which are precisely the types of policies that ought to be controlled and filtered by regional and local authorities, who are most in touch with their local constituents and are best able to consider local development conditions. In terms of a framework for green growth, however, the OECD reiterates that good economic policy with a long-term policy horizon is at the heart of any successful transition to green growth (OECD, 2011a).

Table 1 Policies to foster innovation (OECD, 2011b)

Policy challenge	Policy options
Insufficient demand for green innovation	- Taxes and market-based instruments to price externalities and enhance incentives - Demand-side policies, such as public procurement, standards and regulations, in specific markets and circumstances
Lack of innovation capability	- Broad-based policies to strengthen innovation
Technological roadblocks and lack of radical innovation	- Investment in relevant R&D, including thematic and mission-oriented research - International cooperation
Research and investment bias to incumbent technology	- R&D support, tax incentives - Adoption incentives/subsidies - Technology prizes
Lack of finance	- Co-investment funds - Market development
Regulatory barriers to new firms	- Regulatory reform - Competition policy - Front-runner approaches
Lack of capabilities in SME to adopt green innovation	- Access to finance - Skills development - Linking SMEs to knowledge networks - Improving information supply - Reducing regulatory burdens
Non-technological innovation	- City and transport planning - Regulatory reform
International technology transfer	- Development of capabilities - Trade and investment policies - IPR protection and enforcement - Voluntary patent pools and collaborative mechanisms

Technology development through innovation will continue to drive the products and processes that underpin green development. A policy mix to foster innovation is presented in Table 1. Figure 1 places these policies on a temporal curve to show that the policy mix has a clear temporal dimension. This time perspective reveals the conditions needed to nurture the development of green technologies at different stages of the innovation process. In doing so, it distinguishes four key policy dimensions that combine in a cohesive manner to facilitate green growth. First, core funding through national and European investment covers initial research and development, where support is needed for high-risk, fundamental research with a long-term perspective. Next, stages 2 and 3 in Figure highlight the need to incubate new technology in the common market by reducing the cost gap between capital investment and future financial benefit. Market-based support through technology-specific tariffs, certificates and tax incentives are most important. Once market viability is achieved, regulation and awareness-based campaigns are needed to transform the behavioural norms of consumers, thus creating a stable and secure market for green technologies.

Figure 1 Policies for supporting low-carbon technologies (IEA, 2010)



European Union

While the OECD emphasizes that overcoming green growth constraints will not be achieved by a 'one size fits all' policy solution, it also stresses that green growth needs to be incorporated into existing policy processes rather than created through stand-alone policy documents or agencies (OECD, 2011b). In adherence to this principle, the EU has not released any formal policy documents that focus directly on the concept of green growth. However, the fundamental elements of green growth are acknowledged in two of the EU's main strategies, and as mentioned above, the EU has established initiatives to support eco-innovation.

Europe 2020 reiterates the common understanding that the economic and financial crisis is a point of departure for the three mutually reinforcing priorities of "smart, sustainable and inclusive growth" (EC, 2010a). These priorities are rooted in five headline targets: increase employment to 75% of the working-age population; invest 3% of the EU's gross domestic product (GDP) in R&D; ensure that the 20-20-20 energy and climate targets are met (with the potential to elevate emission reductions targets to 30%); increase education participation to 90% of the population completing high school and 40% tertiary education; and finally, reduce the number of people at risk of poverty by 20 million (EC, 2010a). The principle of the green economy is firmly rooted in these goals, most clearly in the EU's commitment to increase resource use efficiency, adhere to the 20/20/20 energy and climate targets and invest 3% of GDP in R&D.

One of the seven "flagship initiatives"—a "resource-efficient Europe"—will be achieved primarily through three broad measures: promotion of renewable energy to increase its use to up to 20% of total energy consumption, modernization of the transport sector and improved energy efficiency (EC, 2010a). These measures in combination may also decouple socio-economic development from the consumption of natural resources in all aspects; in other words, they may achieve green growth.

Investing in Europe's Future (EC, 2010b) is the EC's fifth *Cohesion Report* and shows how regions and the cohesion policy can further the objectives of the Europe 2020 strategy. It maintains that headline targets of the Europe 2020 strategy will not be achievable through policies formulated at the EU or national levels alone. Instead, overcoming territorial disparities through the right mix of national, regional and local governing structures will play a critical role in defining and implementing policy measures based on territory-specific characteristics (EC, 2010b).

The report was the first of its kind since the Lisbon Treaty to include the goal of "territorial cohesion" alongside social and economic cohesion. It also "pays more attention to climate change and the environment" (EC, 2010b, p. xi) by emphasizing that if Europe is to achieve its 2020 target for renewable energy production it will require very different energy sources, ranging from solar and wind power to biofuels, depending on the local characteristics of regions. It also points to the significant potential for increased energy efficiency, particularly in urban areas (EC, 2010b).

The Nordic Council of Ministers

Since the adoption of the first sustainable development strategy by the Nordic Council of Ministers (NCM) in 2000, the Nordic countries have worked to create sustainable societies. The joint Nordic vision is to prepare a fossil fuel-free future. The main issue for the Finnish presidency in 2011 has been to address climate change at all levels.

The fourth Nordic Prime Ministers' Globalisation Forum was held in June 2011 in Kirkkonummi, Finland. Its main aims were:

- to highlight tangible areas in green growth where collaboration can generate synergies among Nordic countries;
- to discuss how to turn green growth into a policy objective for Nordic co-operation; and
- to determine how to enhance the Nordic region's green profile in an international context.

In line with the forum, the main green growth initiative from a pan-Nordic perspective has been the establishment of the Nordic prime ministers' Working Group for Green Growth[4] (NCM, 2011). The work of this group is to continue building upon the territory's already leading reputation for clean energy development, environmentally friendly behaviour by the general population, interregional co-operation and eco-innovation. Furthermore, their objective is to make co-operation a key priority through a unified vision, titled *The Nordics—leading in green growth* (NCM, 2011). These build upon the aforementioned ability of the Nordic countries to benefit from being a first mover in various aspects of green growth and to retain the lead in expected developments in the EU.

To achieve these objectives with existing territorial strengths, the working group is now recommending eight strategic priorities:

1. Developing Nordic co-operation on test centres for green solutions. In particular, developing improved energy technologies and using existing ones in smarter ways.
2. Working together in education, training and research for green growth to promote the long-term stability of green growth innovation.
3. Promoting flexible consumption in the integrated Nordic electricity market. Here, further investment towards a smart grid is necessary to meet the need for increased spatial and temporal flexibility of a low-carbon energy system. For instance, the traditional solution to energy shortages has been to draw on back-up capacity through conventional fossil fuel sources.
4. Working together on green technology norms and standards to take advantage of the region's strength in certain sectors. EU regulations could be further strengthened, especially regarding energy efficiency standards in the building and transport sectors. The key to this will be Nordic co-operation, to ensure that tightened regulations will be met by green business and that green firms will be able to approach the region as a single market.
5. Working together on green procurement in the public sector. Because of the characteristics of the Nordic welfare system, public procurement comprises 16% of GDP. Thus, the public sector not only is an important market player in environmental investment but also may be a major influence on consumer decisions in the private sector.
6. Developing techniques and methods for processing waste, to continue as a European leader in this sector.
7. Promoting the integration of the environmental and climate considerations into international developmental aid, especially given the relatively large donations from Nordic countries.
8. Co-ordinating and improving funding for green investment and companies to maintain Nordicleadership in green growth (NCM, 2011).

[4] It would be too exhaustive to acknowledge all Nordic initiatives related to the principles of green growth here. Therefore, the Nordic prime ministers' Working Group for Green Growth is introduced in the main text because of its overarching thematic coverage of the relevant issues. See Annex 2 for additional examples of Nordic institutions and initiatives that are central to the development of Nordic green growth.

While it is anticipated that the prime ministers' Working Group on Green Growth and its priorities will generate a common, unified strategy for the Nordic countries, the tangible policies and funding mechanisms that currently drive green development are largely constructed by the national and subnational policies of the individual countries. It is therefore relevant to identify the key green growth policy drivers in each Nordic country.

Denmark

Denmark has a national strategy on green growth, based on two political agreements. The first agreement was made in 2009 and enforced from 1 January 2010 (Danish Government, 2009). The follow up agreement, *Green Growth 2.0*, was adopted in April 2010 by the Danish government (Danish Government, 2010a). The green growth strategy was developed and implemented in close co-operation between the Ministry of Food, Agriculture and Fisheries and the Ministry of the Environment. Furthermore, the Danish government launched the *Action Plan to Promote Environmental Technology 2010–2011* (Danish Government, 2010b) to solve environmental problems in the areas of water, waste and air.

The main objective of the green growth strategy is to ensure better conditions for the country's natural environment while allowing competitive and innovative agriculture and food industries to develop. The green growth agreements are intended to ensure integration with the Danish Rural Development Programme 2010–2013, and thereby ensure that Denmark uses its full entitlement from the European Agricultural Fund for Rural Development. Moreover, Denmark will utilize the funds available under the 'health check' of the EU's Common Agricultural Policy. In addition to this funding, the Green Development and Demonstration Programme was launched by the Ministry of Food, Agriculture and Fisheries to implement the strategy. Moreover, the Danish Energy Agency runs Green Labs DK, which supports the establishment of large-scale test facilities for the demonstration of new climate and energy technologies, and the Energy Technology Development and Demonstration Programme, which supports innovation in clean energy technology. It has been established that the new Danish government will continue the Energy Technology Development and Demonstration Programme in 2012, and it will be implemented in public–private partnerships (Monday Morning for Nordic Innovation, 2012).

The Danish strategy for green growth is to a large extent focused on agriculture and food industries and on ensuring integration with the Danish Rural Development Programme 2010–2013. However, the European Regional Development Fund (ERDF), managed by the Danish Business Authority, is also utilized to promote green growth and innovation. While the *Operational Programme for the European Regional Development Fund in Denmark 2007–2013* does not focus on green growth to the same extent as does the Rural Development Programme, it provides recommendations for business cluster-related activities. These include developing various types of renewable energy in areas of strength, such as water, industrial biotechnology, mega wind turbines, biofuels, hydrogen fuel cells and wave and solar power. It is stressed in the programme that development of energy and environmental technology provides socio-economic potential such as new development opportunities for small to medium enterprises (SMEs) to strengthen business development and employment in regions outside the capital area and to increase production of renewable energy (Danish Business Authority, 2011). The Danish Business Authority further administers the Business Innovation Fund, which aims to generate growth, employment and exports, particularly in small and medium-sized enterprises. The aim of the fund is to promote growth, employment and exports by supporting business opportunities within green growth and welfare, as well as to support exploitation of new business and growth opportunities in less-favoured areas of the country.

Denmark has six regional growth forums, which have been established in partnership to develop strategies for regional development, monitor regional development and allocate regional development funds, including the EU Structural Funds. The regional development strategies of each growth forum concern renewable energy and/or cleantech as focus areas of the regions (Danish Regions, 2010).

Finland

The *Programme of Prime Minister Jyrki Katainen's Government* states that "economic growth must be ecologically and socially sustainable", that "this government strives for a Finland that is among the world's forerunners in environmentally friendly, resource and material-efficient economies and is a developer of sustainable consumption and production methods" and that the goals of sustainable development should be taken into account in all administrative sectors and in all economic sectors of society (Prime Minister's Office of Finland, 2011).

In 2009, the Ministry of the Environment established an environmental innovation panel to evaluate the need for eco-innovations and the role of regulation, national funding and EU measures. During its two-year working term, the panel sought new ways to improve the support for eco-innovation evaluation and implementation to secure the best possible conditions for a green economy. According to the panel, there is a need for eco-innovation in several sectors involving both process and product innovation. Moreover, the need for promoting innovations in services is highlighted in the panel's report. Several recommendations for further measures are introduced, for example to create more effective steering measures to promote innovation. After the report from the panel was published in March 2011, an environmental business programme to promote growth, business activity, innovation and internationalization was introduced by the Finnish government (Hämäläinen, correspondence November 2011).

Under the auspices of the Ministry of Employment and the Economy, the main institution involved with eco-innovation is the Finnish Funding Agency for Technology and Innovation, Tekes, which provides funding for applied R&D and has introduced environmental technology programmes and projects (Palmberg and Nikulainen, 2010). Tekes introduced the Green Growth Programme 2011–2015, which is concerned with identifying potential new sustainable growth areas, based on lower energy consumption and sustainable use of natural resources. It will be implemented in two phases. First, analyses will identify the impacts of climate policy control measures and scarcer natural resources and the long-term impacts of changes in consumer behaviour on the business community. Second, information from the analyses will be used in development projects by companies. More detailed information about the objectives, services and results of the programme is currently being prepared by Tekes (Suortti, correspondence November 2011).

Another significant fund that supports the development of environmental technologies is the Eco-innovation Fund of the Finnish Innovation Fund, Sitra (Palmberg and Nikulainen, 2010).

With regard to policy measures at the regional level in Finland, the Finnish Strategy for the EU Structural Funds 2007–2013 is not focused on the promotion of green growth as such. However, promoting innovation, networking and strengthening knowledge structures are main objectives, and it is noted that this may involve innovation in terms of energy efficiency and renewable energy (Sisäasiainministeriö, 2007).

The Centre of Expertise Programme (OSKE) is partly focused on environmental technologies. This programme is part of Finland's broader Centres of Expertise Programme (with 21 centres), co-ordinated by the Ministry of Employment and the Economy in compliance with the *Regional Development Act*. The programme supports regional strengths and specialization. Within the OSKE, the Cleantech Cluster has been identified as a good example of green innovation at the regional level (Suortti and Hämäläinen, correspondence November 2011). The Cleantech Cluster was ranked in the top three of the world's best green tech clusters by the international Cleantech Group in early 2010. By June 2010, the cluster had promoted the creation of more than 65 cleantech companies and more than 500 jobs. The Cleantech Cluster involves the Centres of Expertise in Lahti, Kuopio, Oulu, and Helsinki (Centres of Expertise, 2011; Cleantech Cluster, 2011).

Iceland

The Iceland 2020 strategy, launched by the Prime Minister's Office of Iceland (2011), presents a vision of innovation in the transition to a green economy, with a focus on eco-innovation. In line with this vision, some initiatives have been adopted to support innovation in public procurement following the *Government Policy for Ecological Procurement* (Government of Iceland, 2009), which has two main objectives. These are to reduce the environmental impact of governmental procurement and to improve the competitiveness of environmentally friendly solutions. Another approach to advancing the 2020 vision is expressed in the recent parliamentary resolution on strengthening the green economy of Iceland (Monday Morning for Nordic Innovation, 2012).

A committee to strengthen the green economy of Iceland consisting of 19 members of parliament representing all political parties was established to map the growth potential of environmentally friendly job creation and develop a policy proposal for Iceland. The committee released its policy proposal in September 2011, and suggested that the prime minister of Iceland rather than any particular ministry should be in charge of the green economy. The committee developed the vision, stating, "Iceland may become one of the leading nations in the world regarding green economy, focusing on clean natural environment, sustainable use of energy and education towards sustainability" (Jónsdóttir, 2012).

The policy proposal Promoting a Green Economy in Iceland includes 48 measures to make strengthening the green economy a priority of the government of Iceland. This applies to fields such as labour market policy and job creation, transport and public tendering. Innovation Center Iceland will shape methods to make all branches of Icelandic companies more environmentally friendly. This will

be made possible partly through the development of environmental technologies.

The Icelandic Parliament enacted a legislative proposal in April 2011 for the Regional Development Strategy 2010–2013 (Icelandic Parliament, 2011b). Its provisions include the need for an increased share of domestic, environmentally friendly energy sources in transportation and for the development of new ways to minimize or bind carbon dioxide (CO2) from power plant and industrial emissions (Icelandic Parliament, 2011a, p. 49).

There are indications in the report on the green economy of Iceland that co-ordination at the local level will proceed when the strategy has been formally approved by Parliament. The report states, "Consultation will be held with local authorities on the current laws for state-owned institutions (such as the Regional Development Institute) for the purpose of binding their activities more closely to the green economy" (Icelandic Parliament, 2011a, p. 20). Currently, there are no publically funded measures to support green innovation in regions (Árnason, correspondence October 2011).

The policy proposal to enhance the green economy was adopted unanimously by Parliament in March 2012, and it will be developed into an action plan.

Norway

In June 2011, the Norwegian Government launched Business Development and Green Growth—The Government's Strategy for Environmental Technology. This is to be implemented over a period of three years (Ministry of the Environment and Ministry of Trade and Industry, 2011). The strategy was developed by the Ministry of Trade and Industry and the Ministry of the Environment and is a central part of both environmental and industrial policy, with an overall objective to achieve sustainable development. The strategy is intended to support the Government's vision of Norway becoming a leading supplier of environmental technology solutions.

The strategy states that focus will be placed on the areas where Norway has special advantages over competitors to succeed: "Strategic national efforts will contribute to making Norway a pioneer of environmental policy and create jobs in the whole country" (Ministry of the Environment and Ministry of Trade and Industry, 2011, p. 12). The strategy document mentions examples of Norway's strengths in environmental technology involving solar energy and photovoltaic materials, CO2 management, hydropower, environmentally friendly marine engineering, and oil and gas production, as well as its strong competence in waste management, recycling and environmental monitoring.

To implement the strategy, the Government has launched the Environmental Technology Programme to run for a three-year period to support the commercialization of environmental technology. The programme will utilize and supplement existing measures to promote environmental technology. A major part of the funds allocation in 2011 is provided to the already-established Environmental Technology Scheme administered by Innovation Norway.

The development of innovation and sustainable development at the regional level is mainly implemented through a number of programmes operated by Innovation Norway, SIVA – The Industrial Development Corporation of Norway, and the Research Council of Norway. One example of this is the national programme Arena, which is intended to strengthen innovation in clusters. A project implemented through the Arena framework is Arena EYDE, which is a network of companies contributing to effective industrial solutions for environmental and climate challenges. Another related project is Arena Wind Energy, which is a cluster of industrial companies, power companies and the R&D environment that together intend to form a strong alliance to supply offshore wind energy from Mid-Norway (Arena Programme, 2009). The Norwegian Centres of Expertise Programme and the VRI programme are other examples of policy initiatives in some regions to support the development of green innovation.

Sweden

During the Swedish EU presidency in 2009, the Swedish Government decided to focus on "an eco-efficient economy" as an overall theme of several policy areas. Following the presidency, the Ministry of Enterprise, Energy and Communications (2010) published a document presenting 68 ways in which the Government supported or proposed to support green growth in Sweden.

During the period 2005–2010, the Swedish Environmental Technology Council, Swentec, was set up to assist the Government with the development and implementation of initiatives to support environmental technology. Swentec issued an action plan that served as a background document for the Strategy for Development and Export of Environmental Technology 2011–2014, launched by the Government in 2011. It has three main objectives: to ensure good conditions for the establishment and development of environmental technology firms in Sweden; to promote research, innovation and the export of Swedish environmental technology; and to facilitate the commercialization of innovations (Swedish Government, 2011; Winther,

2011). Swentec was terminated after the action plan was submitted, and it was not replaced with an equivalent organization.

In the Strategy for Development and Export of Environmental Technology, the Export Council, on behalf of the Government, analysed which export markets and sectors Sweden should prioritize. The following focus areas are recommended: sustainable urban planning, transport, energy, water, sewage and waste. According to this strategy, regional actors and organizations promote the export of environmental technologies and support the SMEs operating in these fields of work in a variety of ways. In particular, projects funded by EU Structural Funds support this development at the regional level. However, it is also highlighted that regional and local actors should be involved in the process of developing the environmental technologies sector. It is stressed that Swedish collaboration with international agencies, such as the OECD and EU, should be communicated to relevant actors on the regional and local levels. In this regard, regions and local actors should also support Swedish environmental technology companies and serve as "door openers" for export companies (Swedish Government, 2011). The funding is channelled through various organizations, for example: VINNOVA, the Swedish Governmental Agency for Innovation Systems, which provides funding for needs-driven research; the Swedish Agency for Economic and Regional Growth; and Innovationsbron (English: Innovation Bridge), which supports commercialization.

The Delegation for Sustainable Cities was initially set up by the Government for the period 2008–2010 and was subsequently extended to the end of 2012 to discuss ways to stimulate sustainable urban development. The delegates include architects, planners, technical consultants and export promoters. Furthermore, public funds under the Delegation for Sustainable Cities are managed by the Swedish National Board of Housing, Building and Planning. These funds are intended for development projects of new construction or reconstruction in urban districts or residential areas (Swedish National Board of Housing, Building and Planning, 2012).

The Government has defined the objectives and methods of implementation of the regional growth policies in the policy document A national strategy for regional competitiveness, entrepreneurship and employment 2007-2013 (Ministry of Enterprise, Energy and Communications, 2007). It is stressed that there should be a stronger focus on environment, climate and energy within the regional growth framework. Moreover, regional growth initiatives should facilitate environmentally driven business development and the incorporation of environmental concerns to strengthen the competitiveness of firms.

The Swedish Agency for Economic and Regional Growth has launched the Programme for Environment-driven Markets, which is targeted at SMEs to strengthen their potential competiveness in environmentally driven markets. The programme focuses on four key areas: networking and matchmaking, environment-driven business development, development of system solutions and support and co-ordination in public tendering (Tillväxtverket, 2011).

The Swedish Energy Agency, commissioned by the Government, manages the regional energy and climate strategies initiative. The county administrative boards are responsible for developing the strategies to reach the targets of the national energy and climate policy at the regional and local levels. Moreover, the Swedish Energy Agency is responsible for supporting the current 12 regional energy offices in Sweden, which have gradually been established since 2002. The regional energy offices are in many cases significant regional partners with regard to energy efficiency and regional climate initiatives (Swedish Energy Agency, 2012).

Finally, the Government has initiated a project whereby three counties have been appointed pilot counties for green development. The three counties of Norrbotten, Dalarna and Skåne were assigned to support and inspire other counties in Sweden in the energy and environmental areas. All three regions were selected because they were proactive and ambitious in the areas of climate issues, renewable energy and innovation (Swedish Government, 2010).

Summary of National Policy Perspectives

After providing brief overviews of the main public policies that are currently in place in each Nordic country, some similarities and differences may be noted. Table 2 provides an overview of the main institutions, strategies and programmes, including those implemented at the regional level. It should be noted that while the review of policy documents may not be exhaustive, it intends to provide an overview of the most relevant ones.

Table 2 Overview of main institutions and policy initiatives

Country	Main institutions	National strategies and programmes	Regional level implementation
Denmark	Ministry of Food, Agriculture and Fisheries Ministry of the Environment Danish Energy Agency Danish Business Authority—Regional Growth Forums	Agreement on Green Growth 2009; Green Growth 2.0 2010–2015 Action Plan to Promote Environmental Technology 2010–2011 Green Development and Demonstration Programme Energy Technology Development and Demonstration Programme Green Labs DK Business Innovation Fund	Danish Rural Development Programme 2007–2013 Danish ERDF Programme 2007–2013
Finland	Ministry of the Environment Ministry of Employment and the Economy Tekes Sitra	Environmental Business Programme Green Growth Programme 2011–2015 Eco-innovation Fund	Centre of Expertise Programme (OSKE) Finnish ERDF Programmes 2007–2013
Iceland	Parliament	Government Policy for Ecological Procurement Iceland 2020 Promoting a Green Economy in Iceland, 2012	Regional Development Strategy 2010–2013
Norway	Ministry of the Environment Ministry of Trade and Industry Innovation Norway Norwegian Research Council SIVA	Business Development and Green Growth—the Government's strategy for environmental technology 2011–2014 Environmental Technology Programme 2011–2014	Arena Programme VRI Programme Norwegian Centres of Expertise Programme
Sweden	Ministry of Enterprise, Energy and Communications Vinnova The Swedish Agency for Economic and Regional Growth Innovationsbron Swedish National Board of Housing, Building and Planning Swedish Energy Agency	National Strategy for Growth, Regional Competiveness, Entrepreneurship and Employment 2007–2013 Strategy for Development and Export of Environmental Technology 2011–2014 Programme for Environment-driven Markets 2008 Delegation for Sustainable Cities	Swedish ERDF programmes 2007–2013 Regional Energy and Climate Strategies

This overview of the main strategies and programmes indicates that Finland, Sweden, Denmark and Norway all have programmes to support the development of environmental technologies. The proposal of an Icelandic parliamentary committee—*Promoting a Green Economy in Iceland*—also includes plans to support environmental technology development. This may be expected to form part of the action plan currently being developed in Iceland after the adoption of the committee's proposal in March 2012. Environmental technology programmes, developed by the three EU member states as well as Norway, all refer to the EU's ETAP in formulating their strategies. The various current funding schemes in four of the Nordic countries support research, innovation, business development, demonstration projects and the export of environmental technologies.The main ministries responsible for green growth and eco-innovation initiatives in the Nordic countries are usually the Ministry of the Economy/ Enterprise (with the exception of Denmark, where the Ministry of Food, Agriculture and Fisheries had a prominent role in the development of the national green growth strategy) and the Ministry of the Environment. In Iceland, a parliamentary committee developed a proposal for a national green development strategy. In Sweden, Finland and Norway, national agencies for innovation and regional development have assumed responsibility for the administration of national programmes to support the development of environmental technologies.

The focus areas of the strategies and programmes vary slightly between the countries. One strategy that stands out involves the Danish government, which focuses on green growth potential in the agriculture and food industries. This strategy includes co-ordination with the EU Rural Development Programme in Denmark for the programming period 2007–2013. The Danish Environmental Technologies Action Plan, however, not only targets these sectors but also emphasizes the country's strengths in technologies for water, air pollution and waste. Similar focus areas are evident in the Environmental Technologies Action Plan in Sweden, which also emphasizes the country's strengths in sustainable urban development and transport. Finland has a general focus on cleantech, while Norway promotes its potential for solar energy, environmentally friendly technologies for marine engineering and oil and gas production. The policy documents refer to certain strong economic sectors in the Nordic countries, and to varying extents they refer to the fact that green growth and sustainable development must be generated by all sectors of society.

With regard to the relevance of the regional level in the implementation of green growth and eco-innovation initiatives, importance is clearly placed on the role of regions in Sweden, as it is specifically stated by the Swedish Government that regional growth policies should promote the development of environmental technologies and renewable energy. The importance of EU Structural Funds is highlighted for the development of environmental technologies and renewable energy at the regional level, and the funds play a similar role in such projects in Denmark. Moreover, green growth is prioritized as part of the regional development strategies of all regional growth forums in Denmark. The importance of the Structural Funds in Finland is less clear in this review, but further studies may reveal that the funds are also widely used for green growth-related projects there. There, the national Cleantech Cluster programme implemented in certain regions has been highlighted as a good example of support for eco-innovation at the regional level. Similarly, in Norway, certain national cluster initiatives implemented at the regional level involve eco-innovation projects, for example through the Arena programme. The ongoing strategy development in Iceland shows indications that it will include co-ordination with the regional and local levels.

Although some differences in policy perspectives between the Nordic countries are evident, they clearly also show similarities. The broad field of environmental technologies or cleantech seems to be an especially significant priority for all Nordic countries.

II. Green Growth Performance and Potential in the Nordic Countries

By Ryan Weber, Apostolos Baltzopoulos, Rasmus Ole Rasmussen & Asli Tepecik Dis

The previous section provides a conceptual basis for an indicator-based assessment of green growth performance, as well as an outline of green growth potential in the Nordic countries. Here, a clustering procedure using a selection of regionalized indicators will be used to identify relevant territorial dimensions of both challenges and opportunities for achieving green growth. The clustering exercise is also intended to delineate the limits of such analyses; that is, to determine if a more detailed version, with more robust indicators, may produce innovative and value-added results. The assessment of green performance and further potential, as well as the clustering findings, will provide a deeper understanding of green growth in order to guide policy in Nordic, national and regional institutions for promoting maximally effective development strategies based on local territorial characteristics.

First, a short commentary will identify the types of regional indicators available for measuring the performance and potential of green growth in Nordic regions. An introduction to the OECD's approach to measuring progress towards green growth then forms a basis for our own work. The collection of indicators will be introduced, mapped and analysed to show their visible territorial patterns. This territorial analysis will then be further refined by a basic clustering of selected indicators. Grouping regions into clusters based on the similarity of their territorial characteristics facilitates an analysis of the conditions that create territorial variance in key aspects of green growth. An analysis of the applicability of the cluster analysis to green growth policy will be discussed. Lastly, a first outline of green growth potential in the Nordic region will focus on the energy sector.

Performance versus Potential

It must be established at this early stage that analysis of regional *performance* in Nordic countries is categorically different from that of *potential*. Performance is viewed as *what* regions are doing—an overview of current development activity related to green growth. The goal is to use readily available statistics on the Nordic countries to provide an overview of activities. Potential, on the other hand, implies some notion of *future* opportunity that could be obtained and is not necessarily realized currently. For example, the fact that a certain region shows very strong and positive green growth performance actually demonstrates very little about its future potential. In contrast to performance, assessment of potential requires much more sophisticated statistical modelling. Without this, only very general inferences can be made, mainly based on sector-specific policy targets.

Monitoring Progress towards Green Growth and Innovation

The *de facto* measure of economic performance is GDP, which provides a concise and comparative indication, especially in relation to the notion of weak sustainability, according to which different forms of capital are interchangeable. However, at the heart of green growth is the notion of strong sustainability, whereby different forms of capital have an intrinsic, non-transferable value that contributes to long-term wealth, health and well-being. Accordingly, the concept of green growth calls into question the appropriateness of *only* using GDP as a measure of performance because GDP generally overlooks the contribution of natural assets to well-

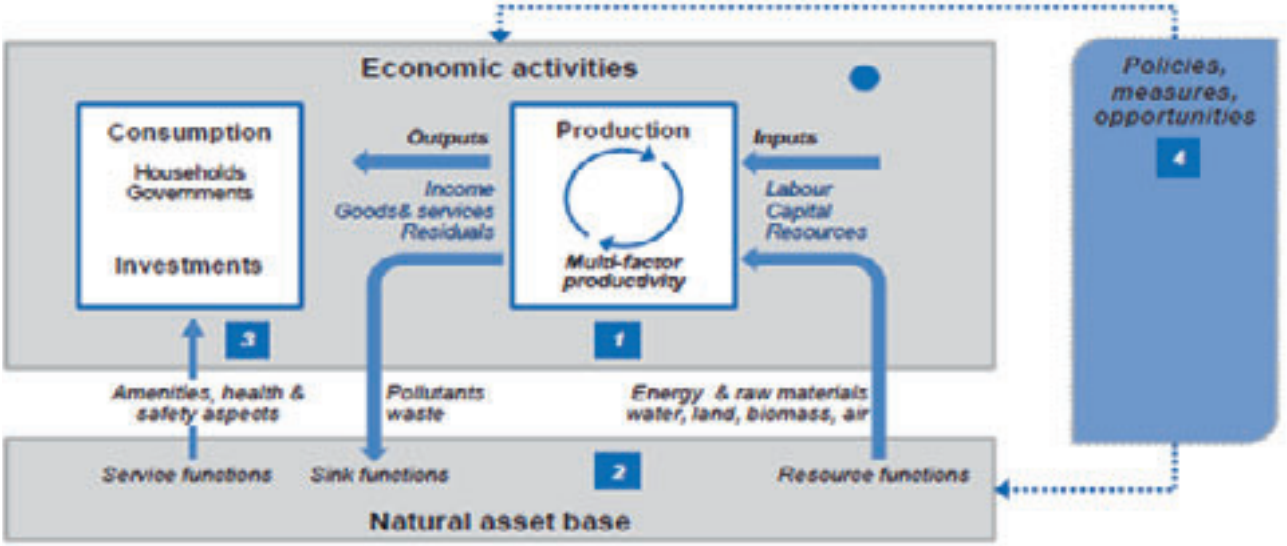
being (UNEP, 2011c). Accordingly, measurement of green growth must be based on a range of indicators of progress in addition to GDP: indicators that measure the *quality* and *composition* of the economy, how it affects people's wealth and welfare and how it relates to the preservation of the environment.

The recently released OECD report on monitoring the progress of green growth includes a proposed set of indicators intended as a point of departure for monitoring national progress towards green growth. In a Nordic context, some of these indicators have already been scaled down to the regional level. Therefore, where the statistical information permits, we can provide a preliminary measure of regional green growth performance.

As listed in Annex 3 and visualized in Figure 2, the OECD has grouped indicators to characterize a shift towards green growth. The four categories are:

1. *Indicators of the environmental and resource productivity of production and consumption:* Growth indicators covering the sphere of production account for volume of output per unit of services from natural assets. Changes in productivity can reflect several effects, such as the substitution of natural assets for other inputs and changes in industry composition or multifactor productivity. While it is difficult to distinguish between these effects (this is high on the agenda for developing more robust indicators), Figure 2 shows that the main idea is to capture the key aspects of a low-carbon, resource-efficient economy. As such, the indicators cover the production side of the economy and can be compared in relation to growth, which is captured by GDP.
2. *Indicators of the natural asset base:* Accounting for the production perspective alone is insufficient for assessing green growth, because it neglects the value of natural assets beyond their short-term economic benefit. Natural assets need to be maintained because a declining assets base represents a risk to future prosperity. This is therefore a central element of green growth.
3. *Indicators of the environmental dimension of quality of life:* Similarly to the previous notion of a natural asset value beyond purely economic utility, quality of life entails demands to maintain societies' asset bases. Health and well-being relate to factors such as pollution and the preservation of wilderness for recreation. These factors must be acknowledged when monitoring green growth. This is shown in Figure 2 regarding the "service functions" provided by the natural asset base for consumption activities.
4. *Indicators of policy responses and economic opportunities:* These account for opportunities arising from environmental considerations. They include the roles of 'green industries', trade in 'green products' and creation of 'green jobs' in contributing to growth. They also account for innovation and technology in terms of business practices, increased production efficiency and new consumption patterns that may not be overtly 'green' but still play important roles in the transition to green growth. Accordingly, regulations and management approaches (policies) are included in this group as tools to reduce negative effects on the environment. The OECD notes, however, that these components are challenging to pin down statistically, and more work is required to identify robust indicators of these opportunities and green growth policy responses (OECD, 2011c).

Figure 2 Relationship between the four groups of indicators (OECD, 2011c)



The OECD has already assembled the general components of these four spheres to measure green growth with a preliminary (draft) list of 22 indicators. These are presented in Annex 4.

In parallel, the EIO has devised a comprehensive Eco-Innovation Scoreboard (Eco-IS) to assess the performance of EU member states. It shows member states' performance in various dimensions of eco-innovation compared with the EU average, as well as their strengths and weaknesses, and it identifies barriers and drivers of eco-innovation (EIO, 2011). The central element of the Eco-IS is the use of 13 indicators to produce a composite eco-innovation performance profile. The Eco-IS indicators were also considered for our study.

Constraints on Measuring Regional Green Growth Performance

Use of the above indicator sets to complete a statistical analysis of regional green growth performance in the Nordic region presents a number of challenges:

- *Conceptual:* The broadness of the notion of green growth, encompassing such a large spectrum of economic activities and aspiring to an entire 'paradigm shift towards a new economic framework', means that it is not very conducive to the aggregation of indicators into a composite measure of performance or potential at the Nordic level. As will be shown by the analyses below, commentary is mostly limited to individual sectors—or connections between individual sectors—at such a scale. Because of the high number of region-specific variables and the complexities that characterize their relationships, it appears that comprehensive (multisectoral) green growth analyses may be preferable only when investigating the activities and opportunities within individual regions.
- *Applicability:* In numerous cases the OECD green growth indicators are either not applicable to a Nordic context or do not possess regional dimensions that will distinguish between Nordic regions. For example, OECD indicators include life expectancy as a socio-economic measure of growth, the availability of sewage treatment and drinking water as a measure of the natural asset base, and environment-related taxation as an indicator of green growth policy responses.
- *Consistency:* While there is no shortage of data regarding the economy and environment, it is difficult to conduct comparative analyses because of national differences in classifications, terminology and the currency and comprehensiveness of data accounts (OECD, 2011c).
- *Scale:* The OECD's collection of green growth indicators is based at the national level, whereas the analysis conducted in this project is dependent on regional statistics at the NUTS 2/3 level.
- *Inability to interpret statistics:* A continuing challenge highlighted by the OECD is the extreme difficulty of delivering quantitative and statistical appraisals of the environmental dimension of quality of life and of policy responses to green growth. For this purpose, case studies of specific regional examples have great value in characterizing the regional dimensions of green growth.

Selection of Indicators

The indicator analysis below mainly relates to the first two spheres of analysis presented in Figure 2, indicators of the economic characteristics of production and consumption, and those of the natural asset base.

Following the aforementioned work by the OECD and EIO, indicators were gathered based on internal assessment of the availability and relevance of each indicator to the Nordic context. As Table shows, this resulted in 24 indicators grouped into three themes:

1. *Socio-economic conditions:* The socio-economic conditions present in a region form the basis of any discussion of growth, including green growth. From this perspective, high-performing regions in terms of production, human capital and competitiveness (as represented by strong GDP, low unemployment, a low dependency ratio and a suitably skilled work-force) are better equipped to invest in a switch to a green economy.

2. *Innovation capacity and performance:* Transition to green activities in the Nordic region will continue to depend on significant innovations in both products and processes. To that end, the innovation performance and knowledge capital of a region provide useful insights.
3. *Natural assets (energy):* The degree of dependence on renewable energy sources, which is closely related to a region's natural resources and geography, to a great extent defines the sustainability of local production and consumption.

As an *ex post* assessment, it is clear that at the current level of availability of data on green growth, these indicators are severely limited in their ability to account for the actual composition of regional economies in the Nordic countries, or their governance based on institutional and policy frameworks. In this context, a number of shortcomings are notable:

- The manner in which green innovation and R&D is captured—by measuring the number of green patents as a percentage of total patents—is limited because "green patents" are defined to include only a subset of all innovations that drive a green economy in practice.
- This level of statistical aggregation is blind to the micro-foundations of very relevant mechanisms and trends. For example, the governance and firm dynamics that initiate the development of cleantech initiatives within regions are based on local conditions that can be revealed currently only by case studies on best practices.
- Central issues for transitioning towards a green economy, such as the environmental awareness and behaviour of local citizens, are difficult to quantify.

Each of these shortcomings emphasizes the need for regional case study investigations. Local studies allow for a much more detailed analysis of the development of a green economy along with the qualitative analysis of the institutional dynamics that generate local and regional green growth initiatives.

Table 3 Indicators used for the analysis of green growth activity in Nordic regions

No.	Indicators	Year	Scale and Units	Source	Description
A	**Socio-economic Capital**				
1	Gross Domestic Product per capita (€)	2008 (2007 in Norway)	€ (PPP)	Eurostat. National Statistical Institutions's for Norway and Iceland	The market value of all final goods and services produced within a country in a given period
2	Unemployment Rate (%)	2010	%	Eurostat and OECD	Total unemployment rate within the Region
3	Active labour force (%)	2007	%	OECD, except Denmark where stats were flawed.	Total active labour force within the Region
11	Population Density	2007	(inhabitants/km²)	Eurostat	A measurement of population per unit area
B	**Innovation Capacity and Eco-Innovation Performance**				
12	Investment in Research and Development	2007	%	OECD	Investment in Research and Development as a percenatge of GDP
13	Total Patents per Capita	2007		OECD	Total patents in environmental technologies per million inhabitants
14	Green Patent Percentage	2007	%	OECD	Environmental technologies as a percentage of all patents issued
15	Education population - total population	2007	%	Nordregio calculations	Persons with a tertiary level education as a share of total population
16	Students in the region	2007		Nordregio calculations	Total number of students in the region in 2007
C	**Natural Assets - Energy**				
18	Nuclear power	2007	%	Nordregio's own calculations based on: Norway, Sweden: National Statistics institutions. Finland: Energiateollisuus and the International Energy Agency's national statistics for Denmark and Iceland.	Generation of electric energy per region by main sources
19	Hydro power				
20	Wind power				
21	Renewable energy - other				
22	Thermal power				
23	Renewable energy total				
24	Total Electricity Production per capita	2007	kWh/per capita	As Above	Electricity production within the region

Presentation of Indicators

In this section, the indicators will be introduced and analysed based on the maps below and the groupings in Table 3. As mentioned above, this will form the basis for contextualizing and describing the key elements of a green growth strategy for the Nordic countries. A brief justification for the inclusion of each indicator in the study is provided.

Theme 1—Socio-economic Capital

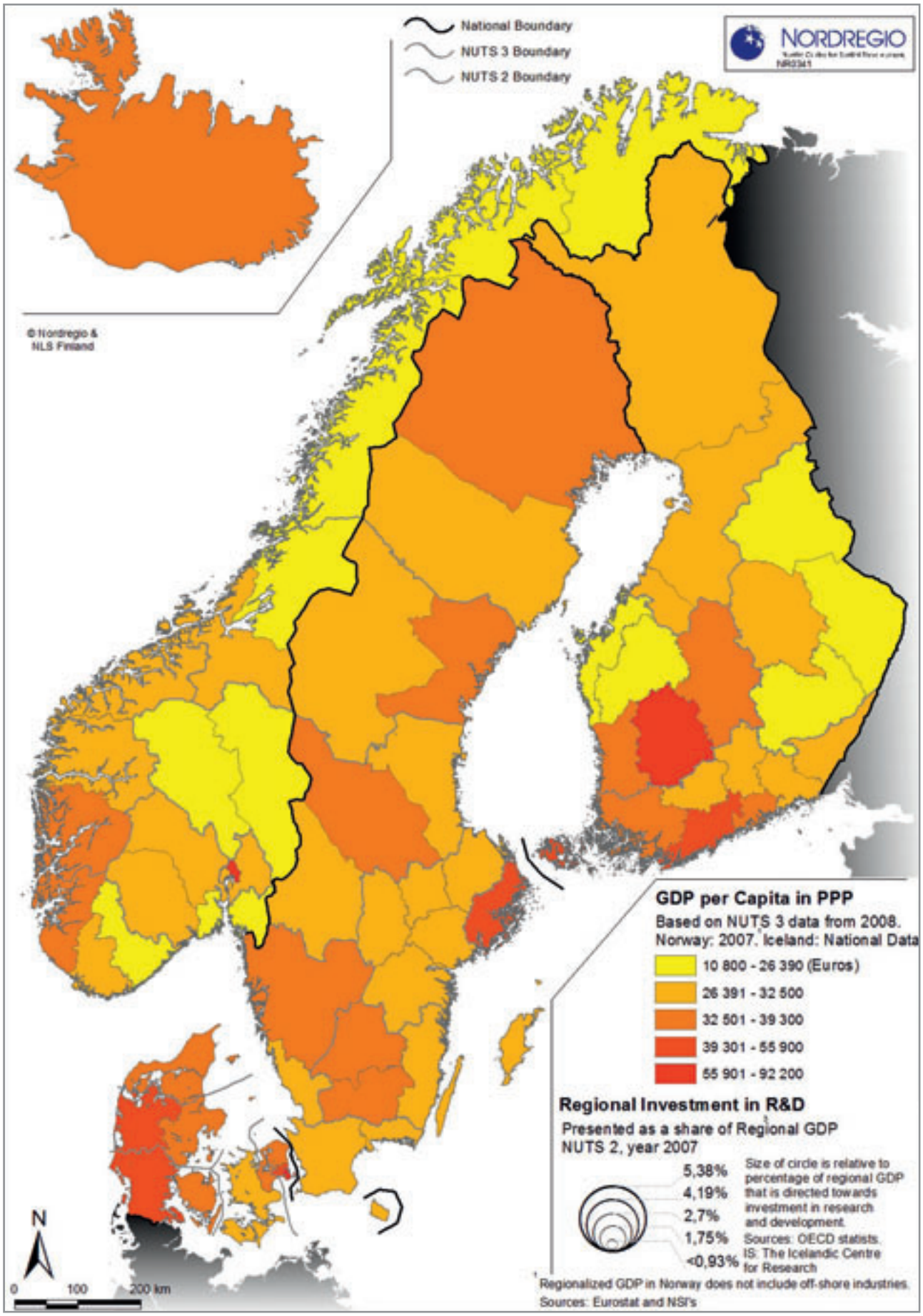
Map 1 presents the standard measure of GDP per capita. Although the Nordic countries as a whole is well above the European average in terms of value of production (which is taken as an indication of regional economic prosperity), significant internal variations exist. The range of values suggests that the wealthiest region is roughly nine times richer than the poorest. At the top of the spectrum lie the capital regions, along with Birkaland in Finland, the place of origin of Nokia, which still hosts many of the company's operations. The seemingly poor economic performance of a large part of Norway is the result of the dominant role of offshore oil-related activities that are attributed not to any one region's GDP but rather to the national aggregate only. Excluding this Norwegian statistical anomaly, Finland appears to be the only poorly performing country, with its south-eastern border and western coastal regions falling on the lower end of the spectrum.

The second map presents unemployment and labour force participation (LFP) rates. The former measures the percentage of people actively seeking jobs while the latter is an indirect measure of the percentage of the population of working age not participating in the labour force (and therefore economically dependent on those who do participate). First, note the superior performance of the Norwegian labour market, with the lowest unemployment rates and relatively high LFP rates. The highest unemployment figures can be found in the northern reaches of Sweden and Finland, in a cluster of regions in central and eastern Finland and in the county of Örebro in Sweden. LFP rates are reasonably high in Sweden and are comparable to those in Norway. Iceland exhibits the highest LFP rates, which translates to very low dependency rates. Denmark exhibits rates slightly lower than those of Norway and Sweden, while Finland appears to have the lowest rates, with a significant percentage of its working-age population not participating in the labour market. This is particularly pronounced in the eastern Finnish regions, which also exhibit low GDP per capita figures, painting a rather unfavourable socio-economic picture. As expected, the core–periphery dichotomy is apparent in all countries in the Nordic region, with the capital regions exhibiting much better functioning labour markets than do others. This will be a focus of further analysis below.

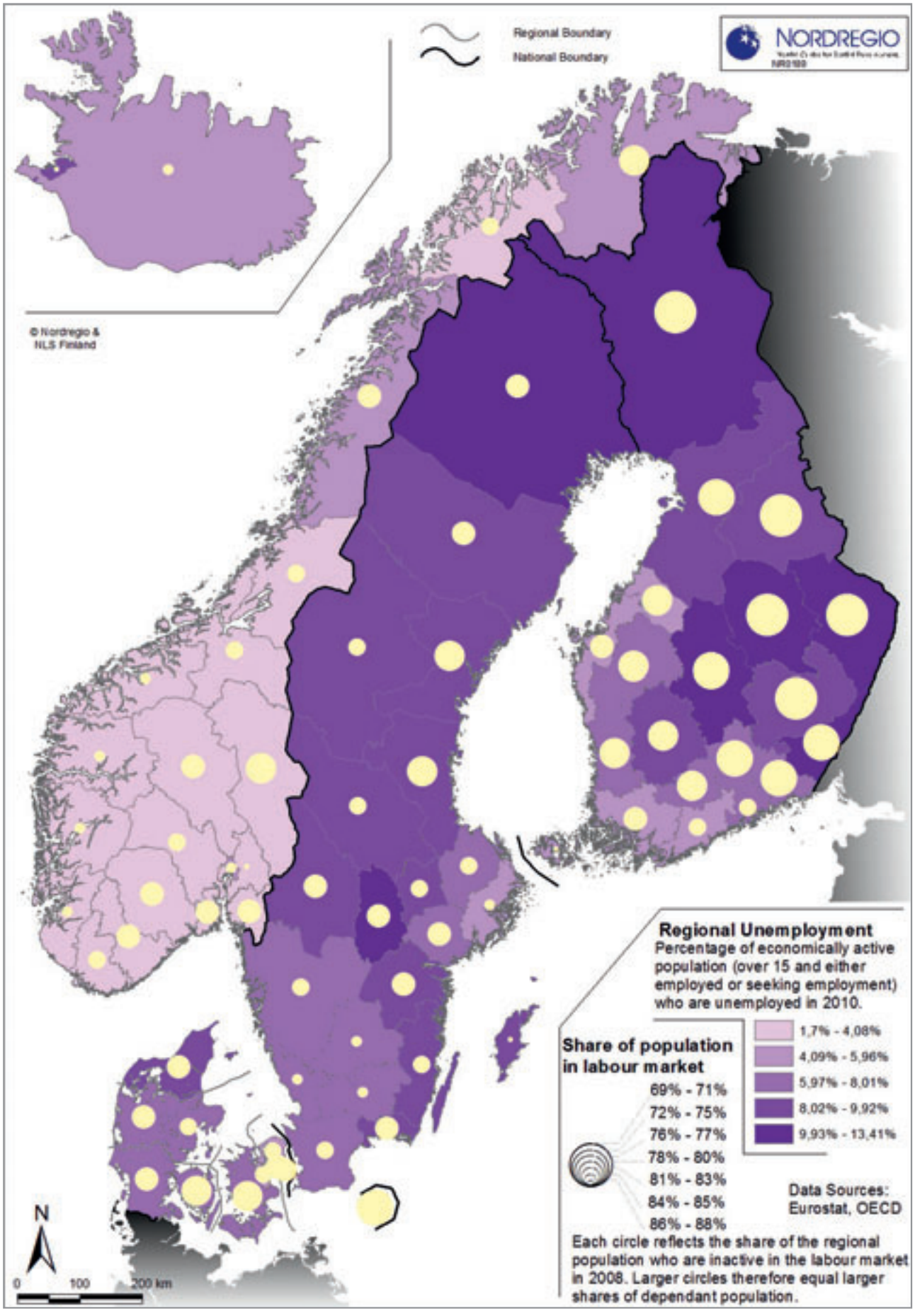
Map 3 shows the great range of regional population densities across the Nordic countries, from extremely sparsely to extremely densely populated regions. Denmark naturally has the highest values because of its small size, with Copenhagen in particular being the extreme outlier. There is a north–south divide characterizing the remaining countries, with higher densities in the south and extremely sparsely populated areas in the north.

From a green growth perspective, urban agglomerations are interesting for several reasons. First, these urban regions—and often those in close proximity to them—are the economic growth engines of the Nordic countries. For example, Indicator 1 (GDP) and Indicator 2 (Employment) highlight Nordic urban centres as regions of comparatively high GDP and low unemployment. These trends exist because Nordic urban centres provide a number of territorial assets that can attract and retain citizens: they are centres of investment in R&D (Map 5) and are the predominant sites of higher education institutions and pools of knowledge workers (Map 6) (e.g. Oslo, Copenhagen, Malmö, Gothenburg and Helsinki). This attracts knowledge-intensive industries, including cleantech, to these urban areas, in an effort to attract workers. Agglomerations are also self-sustaining and self-enhancing, leading to the creation of significant economies of scale that further promote their attractiveness and growth. In turn, service sectors such as building and construction, public services and finance are developed in parallel to the expanding agglomerations.

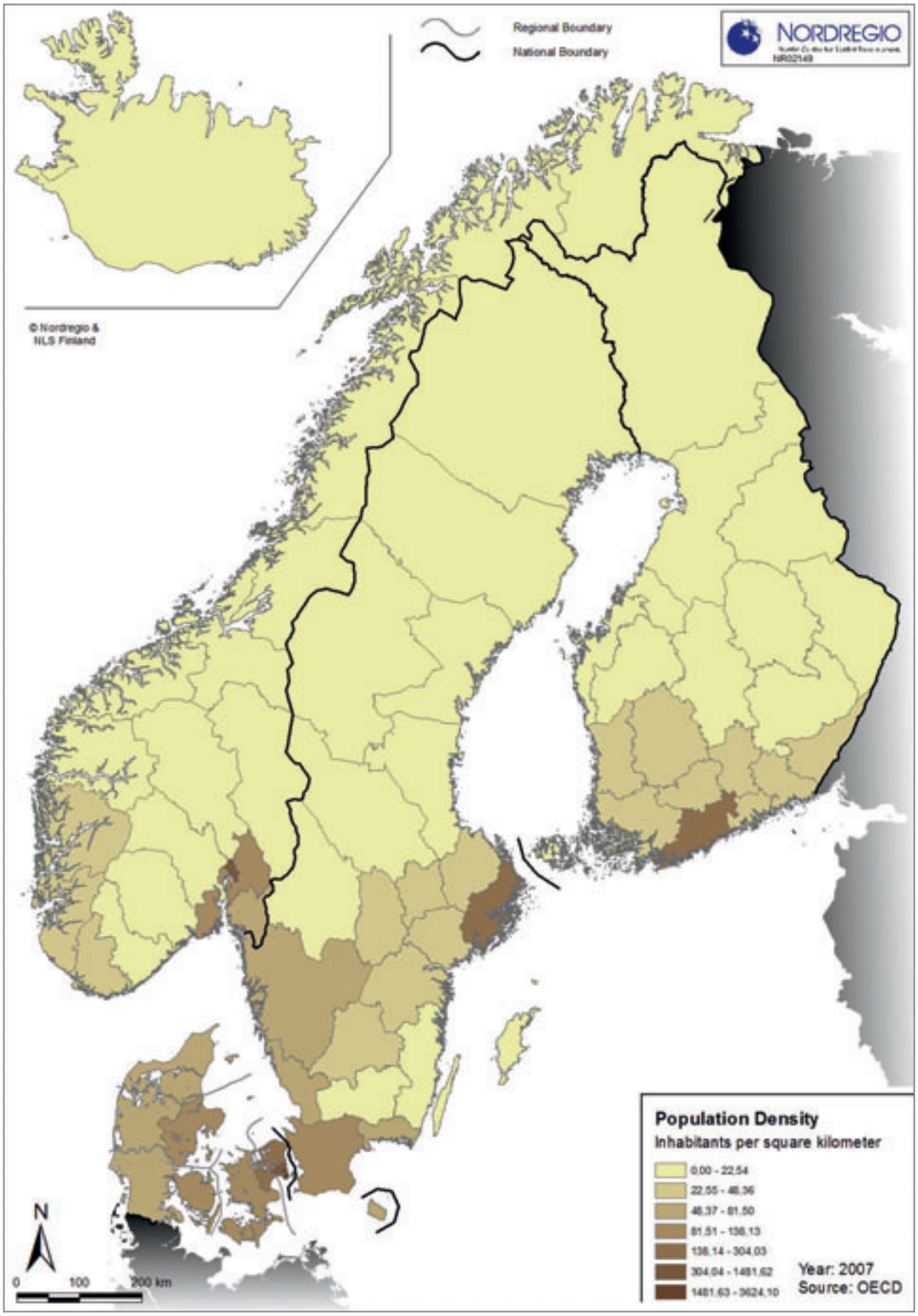
Map 1 GDP per capita (Indicator 1)



Map 2 Regional unemployment as a proportion of the economically active population (Indicator 2), showing regional variations in the proportion of inhabitants active in the labour market (Indicator 3)



Map 3 Regional population density (Indicator 11)

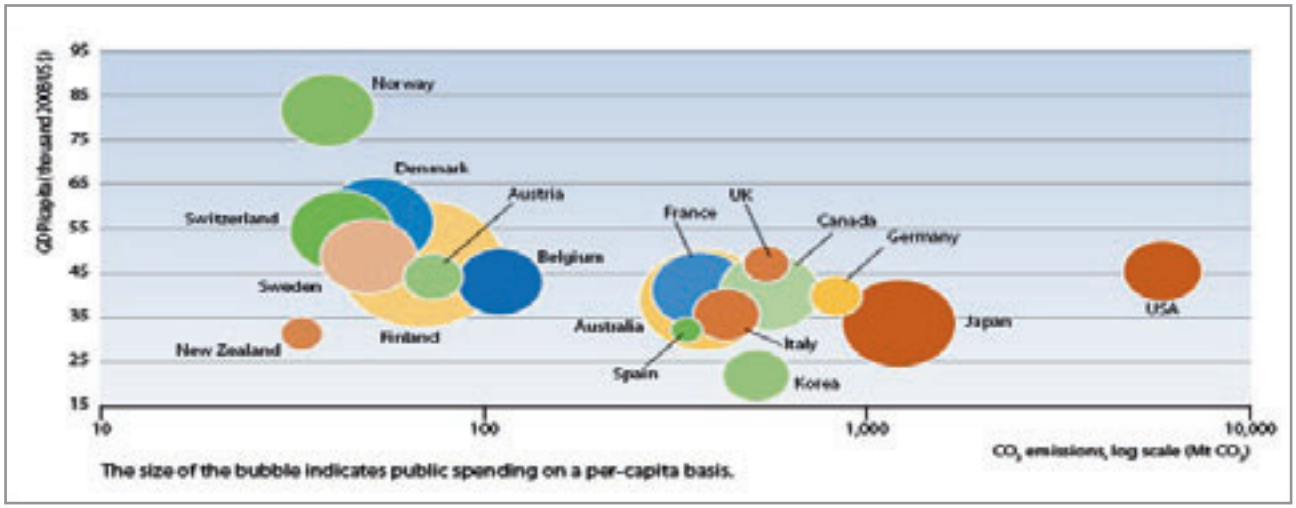


Theme 2 – Innovation Capacity and Eco-innovation Performance

Figure shows that Norway, Denmark and Sweden are among the highest investors (in terms of per capita public spending) on low-carbon R&D. It also shows that Finland provides the world's largest share of per-capita funding and is well ahead of Japan, which is in second place. This indicates that Nordic countries are already well positioned in this field.

Barker and Scrieciu (2009) approve of the position of the Nordic countries, suggesting that considerable cumulative benefits can accrue to countries that pioneer development in clean energy sectors. Their simulations illustrate how the overall competitiveness of a country or region improves when it commits early to innovation and the market penetration of clean energy technologies, particularly through policies that promote investment in green R&D. This is because green innovation requires support to overcome potential market failures, particularly in terms of R&D to reduce the private costs of innovation (UNEP, 2011a).

Figure 3 Public sector low-carbon R&D spending per capita as a function of GDP per capita and CO2 emissions (IEA, 2010b)



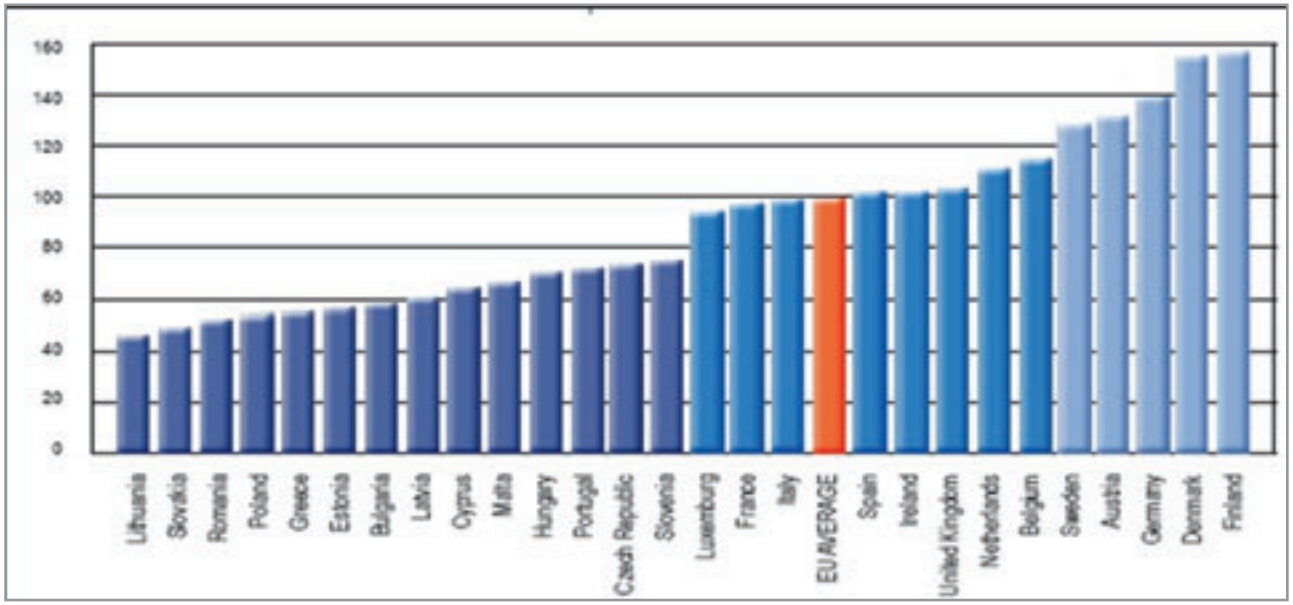
Eco-innovation

The results of the EIO's eco-innovation indicator analysis were made available in its 2010 annual report (2011). Figure shows the composite results of the 2010 Eco-IS, in which Finland, Denmark and Sweden appear as eco-innovation leaders (light blue), compared with eco-innovation followers (bright blue) and those countries catching up in eco-innovation (dark blue). Norway and Iceland are not part of the EU, so their performance is not included.

International Energy Agency (IEA) member countries and other major economies have announced their intention to double (or better) their R&D budgets in energy-related technologies as part of their approach to addressing climate change (IEA, 2010b). Accordingly, the public sector can support research institutions and fund research programmes targeted at specific low-carbon technologies and can supply grants for private sector R&D efforts. Energy research has been found to be most effective when targeted R&D programmes such as "technology push" projects are combined with "market pull" policies to support deployment (ibid.).

The EIO's 2010 annual report also shows a robust positive correlation between eco-innovation and GDP and between eco-innovation and competitiveness. This quite clearly suggests the strong impact that eco-innovation has on the competitive advantage of economies and firms engaged in these activities. Equally significantly in the Nordic context, it also alludes to the further potential for eco-innovation investment by institutions and firms in those countries with an established eco-innovation market (EIO, 2011).

Figure 4 Eco-IS for the EU-27 (EIO, 2011)



High scores in terms of innovation and R&D on a national level do not necessarily mean that this superior performance is evenly divided among subnational regions. In fact, given the socio-economic disparities discussed above, one would expect similar disparities in terms of innovation performance. However, limited availability of economic resources does not preclude the possibility of increased efficiency in their utilization. Maps 4 to 6 explore exactly this—the regional dimension of innovation. Innovation is currently recognized as being at the heart of economic growth and development, but neither exact methods of measurement nor equivalent datasets at the desired level of detail are widely available. Here we consider three proxies found to be closely correlated with innovation. These are: investment in R&D (the main input in the process of developing innovations), the number of students and level of education in the population (representing the regional stock of human capital that acts as the medium through which investments in R&D lead to innovations) and patent statistics (the most widely used proxy for innovation output).

Overall, Finland appears to be outperforming all other countries in terms of R&D investments. It can be divided into three distinct blocs: one covering the northern part of the country and scoring highest, one covering the southern part of the country and scoring next best, while the structurally weaker eastern regions invest less than the rest of the country, although they still outperform several other regions in the Nordic countries. The picture in Sweden is more mixed, with the regions including the main urban centres of Gothenburg, Malmö and Stockholm and the northern part of the country investing heavily in R&D, while the rest of the country performs only moderately well or poorly.

In a national context, however, the strong performance of Finland, and to a lesser extent Sweden, is constrained by the fact that high levels of eco-innovation input stand in contrast to lower output performance. In Finland, the relatively low output is indicative of poor investment turn-over. The Eco-IS also shows that Finland has Europe's highest negative correlation between eco-innovation input and positive environmental outcomes. This is because of very low material productivity, which in turn relates to the challenge of an economy that is highly dependent on the export of natural resources, coupled with very environmentally irresponsible domestic resource consumption habits. It therefore seems clear that Finland's firm-level eco-innovation support needs to be complemented by a policy to condition the domestic market for green products.

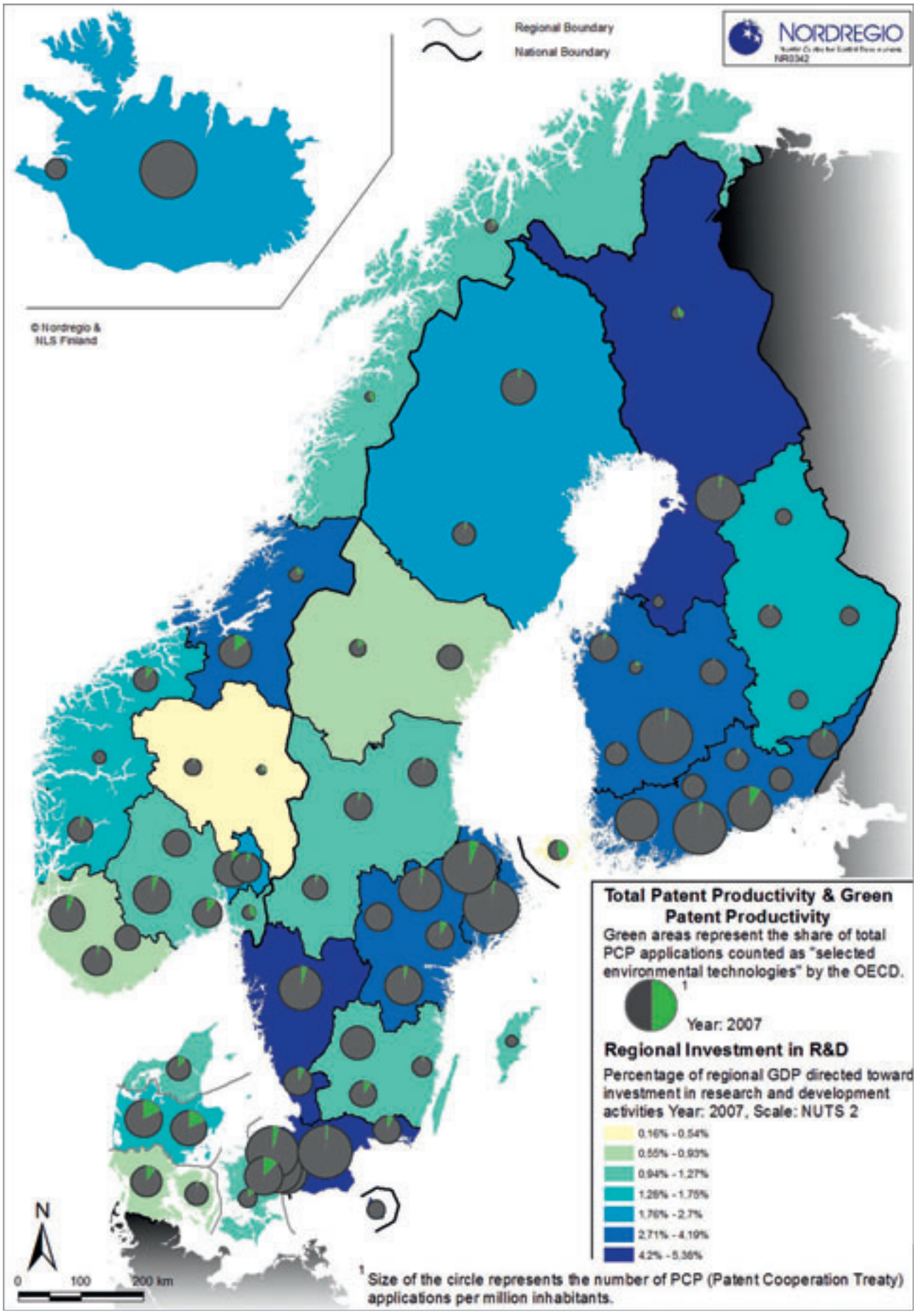
In Sweden, the level of eco-innovation is high, but the export-based market for the resultant technologies is not developing as expected. As mentioned in the eco-innovation country report for Sweden, there is a lack of large-scale public and private investment schemes in cleantech. This shortcoming resulted in the development of Sweden's environmental technology strategy.

Icelandic investments are close to the Nordic average, while Norway (with the exception of the capital and the Trøndelag region) and Denmark (again with the exception of the capital region) appear to invest the least in R&D. In terms of innovation output (as measured by patenting activity), southern Finland, central Sweden and Denmark appear to be performing best, with Danish regions also producing the highest percentage of green patents, most likely because of the patent intensity related to the high percentage of wind energy production. This reflects Denmark's status as a world leader in eco-innovation output, which is

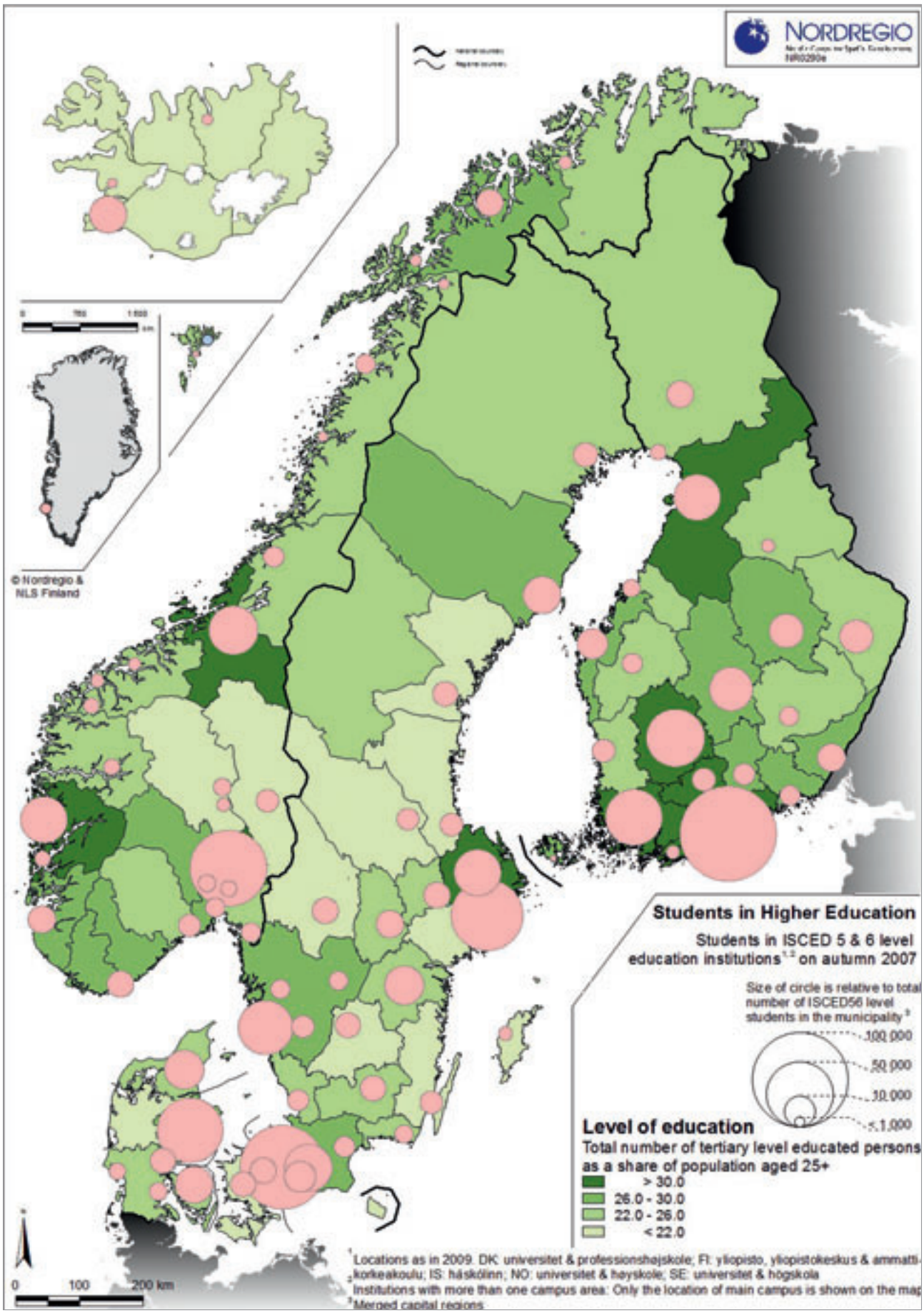
demonstrated by the fact that more than 700 firms are involved in eco-innovation, particularly for clean water and for energy systems such as wind turbines. Thus, relatively low investments in R&D actually reflect an industry that already stands on its own as a competitive performer.

When it comes to the educational attainment level of the local population, the picture is rather mixed. The number of students in higher education is obviously correlated almost perfectly with the size of local institutions of higher education. It is interesting to note the close correlation between the number of students in higher education and patenting activity, which attests to the importance of university research for effecting innovation.

Map 4 Distribution of investment in R&D activities (Indicator 12), the distribution of total patents (Indicator 13) and the proportion of total patents counted as 'environmental technologies' (Indicator 14)



Map 5 Tertiary educated residents as a proportion of the total population (Indicator 15), and the distribution of students enrolled in higher education institutions, which therefore reflects the size and distribution of these institutions (Indicator 16)



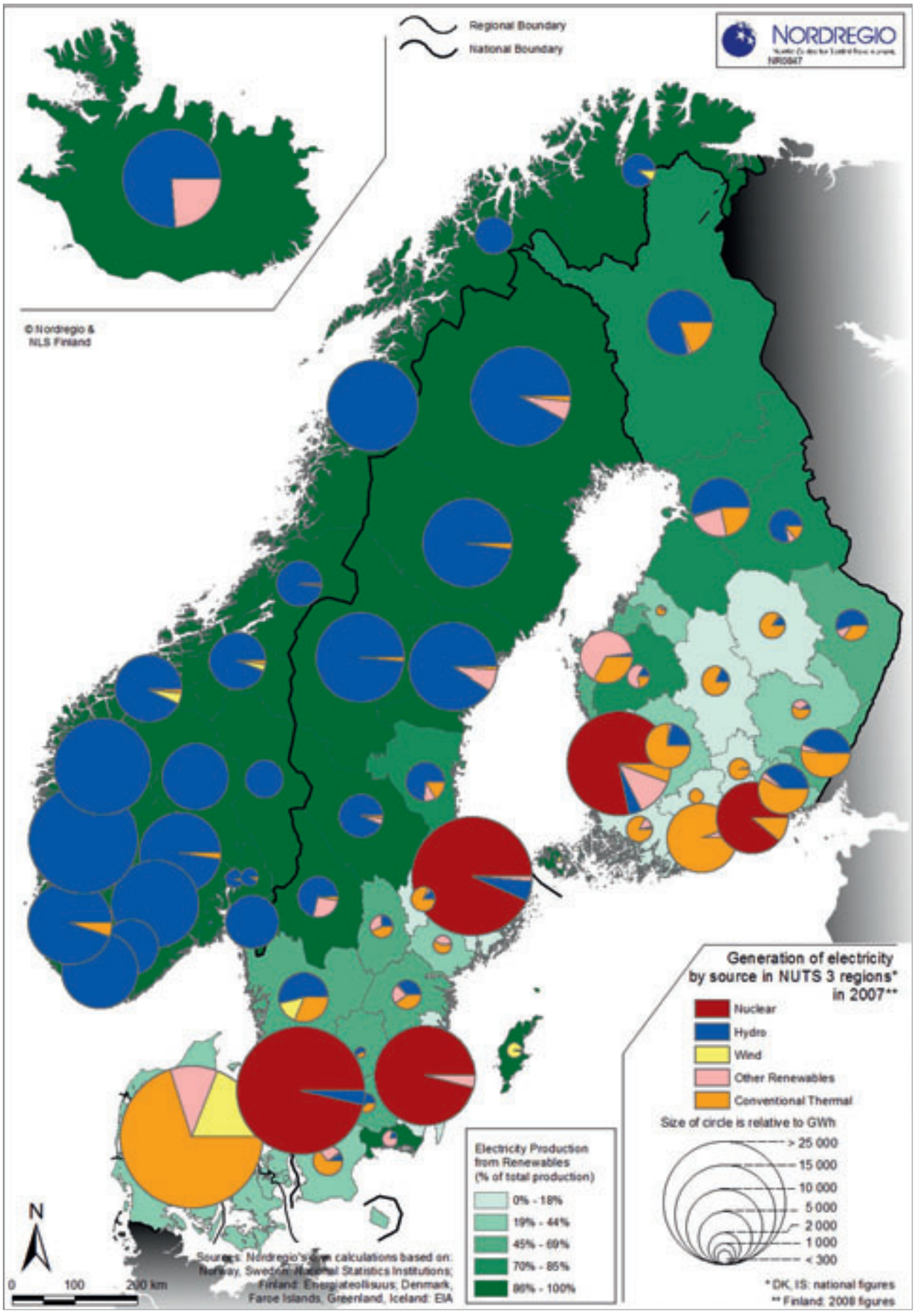
Theme 3—Natural Assets and Energy

The Nordic countries' overall strong economic performance is coupled with relatively low CO_2 emissions, and prosperity is becoming increasingly decoupled from CO_2 emissions. The region has the double advantage of especially good access to renewable energy resources and the innovative capacity to realize this potential using domestic technology. These conditions are further strengthened by efficient and proactive national energy policies.

- Map **6** shows regional electricity generation by source, volume and share of total electricity production. It reveals a number of territorial components that describe the Nordic countries as performing well overall but having significant regional differences:
- The most important energy sources for the Nordic countries are oil and renewable energy sources (mainly hydropower and geothermal and wind energy), nuclear power, coal and natural gas.
- National performance in renewable electricity production is mainly related to hydropower in Norway and Sweden; to hydropower and geothermal energy in Iceland; and to wind power in Denmark and southern Sweden. Nuclear power constitutes an important energy source in Sweden and Finland.
- In Norway, renewable energy sources generate nearly 100% of all electricity, mainly from hydropower. In Iceland, hydropower accounts for roughly 75% of the total electricity supply, while the rest is provided by geothermal power.
- Denmark shows very high performance in wind technologies and wind power. The high proportion of wind power production is also notable on the island of Gotland in Sweden, which indicates the viability of such energy sources as significant components of overall power production, which could provide a high measure of self-sufficiency in smaller and/or isolated regions.
- Innovative solutions are expanding in relation to bioenergy production, particularly in Demark and southern Sweden—and especially in Finland. There it has become an important component of the energy mix.
- The positive impacts of low-carbon electricity are clearly not consistent in terms of either time or space, and they pertain only to *electricity supply* and not to total *energy supply*. Here some additional points are relevant:
- Denmark is highly dependent on imported coal, which is processed as "conventional thermal" electricity.
- To varying degrees, each Nordic country maintains dependence on oil for space heating, particularly in the winter months, when hydropower production is constrained.
- Based on favourable national policies, selected regions in Sweden and Finland are notable for their production of nuclear energy. These regions are therefore exporters of electricity through the common Nordic electricity grid.
- As noted above (in the discussion of green regional governance and policy), there is a clear relationship whereby regions with electricity production from high-capacity, centralized hydro or nuclear infrastructure also generally have a poor record of developing other renewable energy sources. Conversely, those regions with hydro constraints—or with national policies restricting nuclear development—have responded with the development of more decentralized, complementary renewable sources. This suggests that energy complementarity through development of all regional renewable energy potentials will be a key component of green growth in the Nordic countries.

Current electricity production from renewables indicates the state of the art but says nothing about further potential. For instance, hydropower potential in the Nordic region is generally considered to be at or near maximum full economic and/or societal potential.

Map 6 Electricity Generation in selected Nordic regions by source, volume and proportion of total electricity production (Indicators 18–24)



Composite Indicator Analysis

Examination of the individual indicators shows that a concise and comprehensive analysis of green growth performance or potential—in any spatial context—is constrained by the breadth of the concept, which forces the analyst to exclude other important factors that ought to be considered, not least issues of economic diversity, the labour market and environmental governance. Discussions over the territorial dimensions of energy issues and innovation highlight the fact that green growth is not based on proactive strategies by individual sectors or activities; rather, it is a dynamic, multidimensional and relational pursuit that depends on complementarity between the characteristics of the society, economy, innovation, natural resources, governance and policy.

Clustering selected indicators are intended to provide further insight into the territorially specific drivers and constraints of green growth in the Nordic countries. Some key questions arise about a multidimensional issue such as this, for which several indicators need to be factored in. For example: 1) are all variables equally important; 2) which variables explain most of the variance between regions; 3) how do the different variables correlate; and 4) is it possible to combine the different scores into a single meaningful ranking of green growth performance/potential? An entire family of methods exists, generally grouped under the overarching title of 'Composite Indicator Analyses'. Most importantly, any result is conditioned by the assumptions made during the analysis about the structure of the underlying statistical processes. Here we present the results of such an exercise that was conducted to provide a synthesis of the thematic analysis above.

Cluster Analysis Results

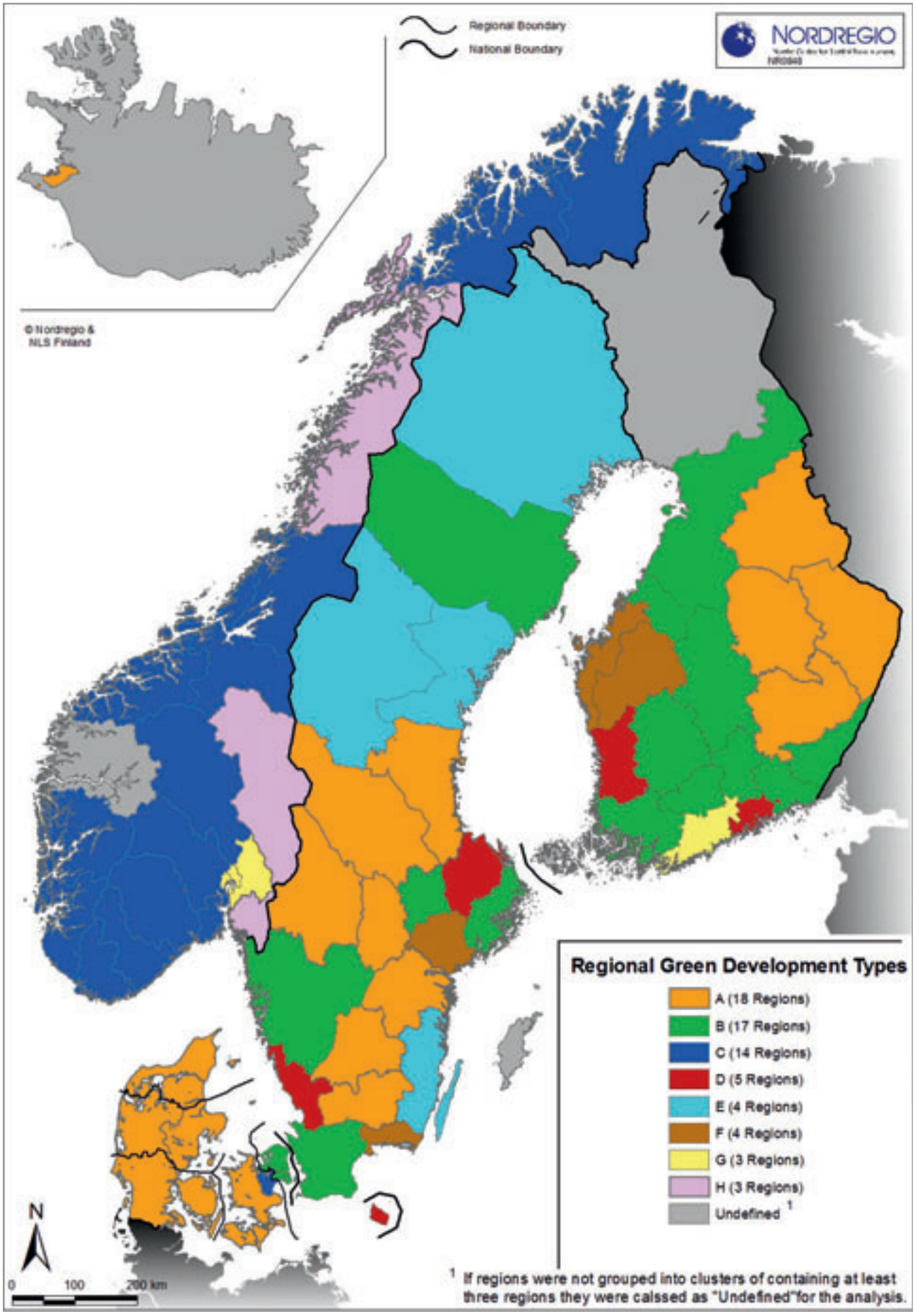
The composite indicator analysis consists of a basic cluster analysis supported by a principle component analysis (PCA) and a factor analysis (FA). The clustering procedure identifies regions that share commonalities based on a selection of indicators. Regions in a given cluster tend to be similar in terms of statistical patterns relating to individual indicators. PCA is then used to determine which indicators identify regional clusters, and the FA measures the correlation between the indicators. In summary, the cluster analysis provides a means to compile a territorial understanding based on the selected indicators[5].

Map 8 shows the results of the cluster analysis. Just seven indicators were chosen because the complexity of both the analysis and the interpretation of the results increases with the number of indicators considered. The chosen indicators are unemployment, energy production per capita, population educational attainment, green patents as a percentage of total patents and investments in R&D, wind power and "renewable energy—other". The resultant clustering analysis identifies eight clusters that group 68 of the 73 NUTS 3 regions in Sweden, Finland, Norway, Iceland and Denmark. A total of five regions exhibited sufficiently dissimilar statistical patterns to be deemed outliers[6]. Though not necessarily unique, the outlier regions are less similar to the clustered regions than the latter are to each other. Despite the limited number of indicators considered, some clear spatial patterns emerge from the results.

[5] See Annex 4 for a technical exposition of the methods of composite indicator analysis used in this project.

[6] It must be understood that the regions that are not members of any cluster are not what one might consider extreme outliers as such. In a sense, these regions fall outside the identified typologies because the interaction of their different indicators is not similar enough to those characterizing the clusters. This is driven by indicator scores at the lowest or highest ends of the spectra (but not necessarily exceptionally so), or by the indicators being correlated in quite distinct manners. One may examine why that is true for each individual case by examining the undefined regions' unique characteristics in Maps 1–7.

Map 7 Regional results of the cluster analysis showing eight distinct clusters and those regions remaining undefined



Cluster A: This is the largest cluster, with 18 member regions. It includes regions from south-eastern Finland and middle to southern Sweden, all Danish regions except the capital region and Østsjælland, as well as Reykjavik in Iceland. The statistical results show that these regions are mainly rural with potentially stagnant development characteristics and quite high average unemployment (8.9%). Electricity production is both low and predominantly based on fossil fuels. Average investment in R&D is considerably lower than in clusters B, D and F. These results indicate that rural regions are susceptible to challenges to green growth performance because of their socio-economic constraints, especially where there is a dependence on fossil fuels.

Cluster B: This is the second-largest cluster. It has a mix of urban and rural regions, but with more urban characteristics than cluster A. It consists of the Stockholm region and other major urban centres of Sweden (Gothenburg and Malmö), Västerbotten County in Sweden and a strip of regions running down central Finland. These regions tend to perform moderately well in terms of green growth, particularly in relation to a substantially higher average investment in R&D, a higher proportion of the population that is well educated and increased electricity production compared with Cluster A.

Clusters C and H: These two clusters consist almost entirely of regions located in Norway. The primary reason for this differentiation is Norway's uniquely low unemployment rate, high levels of electricity production from hydropower and artificially low regional GDP statistics, which do not reflect offshore oil production. The main difference between the two clusters is that while overall patenting levels are lower than the Nordic average in Cluster H, the percentage of green patents is four times higher than in Cluster C. It is very interesting to note that Østsjælland, which includes the city of Roskilde in Denmark, is also in Cluster C. This appears to be because of the comparatively low unemployment rate in Roskilde compared with the rest of the region of Zealand and the regions to the west of it in Denmark. This is likely because it is in the Copenhagen urban catchment and has very good transit connections for daily commuting.

Cluster D: While they are mainly rural, it is notable that the five regions in this cluster are located relatively close to large urban areas such as Gothenburg, Malmö, Stockholm and Helsinki. However, the defining characteristic of this cluster is its exceptionally high electricity production—which further investigation shows is because four of these regions have nuclear production facilities, with the exception being the island of Bornholm in Denmark. However, because the clustering is based on energy production as a whole and does not discriminate between hydropower and nuclear power, it is interesting to point out the differences between Clusters D and E.

Cluster E: Like Cluster D, these four regions have high average electricity production. Closer investigation of this 'Swedish' cluster shows that apart from Kalmar County, where a fifth nuclear production facility is located, electricity production is almost entirely from hydropower. From a green growth perspective, regions in this cluster should be regarded with caution because relatively little green economic production appears to be taking place, with the exception of low-carbon energy. Average unemployment is almost 10%—the highest of any cluster—and investment is R&D is below 1.5% of GDP. It is clear that these are very rural regions, devoid of major urban centres.

Cluster F: Although it only has four regions and the majority of its statistical averages do not deviate from Nordic or national averages, this is an interesting cluster from a green growth perspective. While the average GDP per capita is the second lowest of all the clusters, it appears that these regions have responded to energy and development constraints by pursuing less conventional forms of renewable energy. On average, 72% of these regions' total electricity production is from renewables, of which more than 85% comes from "other renewables" such as bioenergy. Further investigation of best practices in one of these regions could be an option for further research.

Cluster G: This group of three regions consists of the Helsinki and Oslo urban catchments. It has statistical characteristics that are similar to those of Cluster B but was separated based on its lower investment in R&D and higher proportion of tertiary educated people relative to the total population.

Some of the clusters seem somewhat surprising, and others quite natural. However, from the results of the PCA and FA we learn further that the main drivers of the clustering process (the variables that distinguish regions in one cluster from those in another) appear to be investment in R&D followed by renewable energy production as a share of total energy production and then unemployment. There are also distinct negative correlations between R&D investments and renewable energy production and between green patenting activity and wind energy production. It would appear that the regions enjoying the privilege of ample low-carbon energy invest least in further development of these competencies. This was also reflected in the analysis of eco-innovation for Denmark. Of course, part of

the story may well be that technologies need not be developed in the same region in which they are applied, but this finding certainly calls for further scrutiny.

These preliminary perspectives provide a number of observations related to the discussion of green growth opportunities and challenges in the Nordic countries. For example, regions facing few challenges in terms of development (i.e. those regions with more than ample supplies of energy resources, such as hydropower and oil) are perhaps less motivated to make strategic investments in innovation than are those regions that do need to respond to challenges. This suggests that a focus should be on strategic policy promoting complementarity of green economic activities in these regions.

A second example of low(er) performing regions outside urban centres is notable for these regions' good performance in terms of user–producer interaction, which produces innovative green solutions. This is because a large share of users who are set to benefit the most from the adoption of green technologies are situated in rural areas with low population and low(er) productivity. The stories of windmills, straw combustion ovens and small-scale biofuel conversion in rural and isolated areas in Denmark, Sweden, Norway and Finland are often cited as examples.

Analysis and Discussion

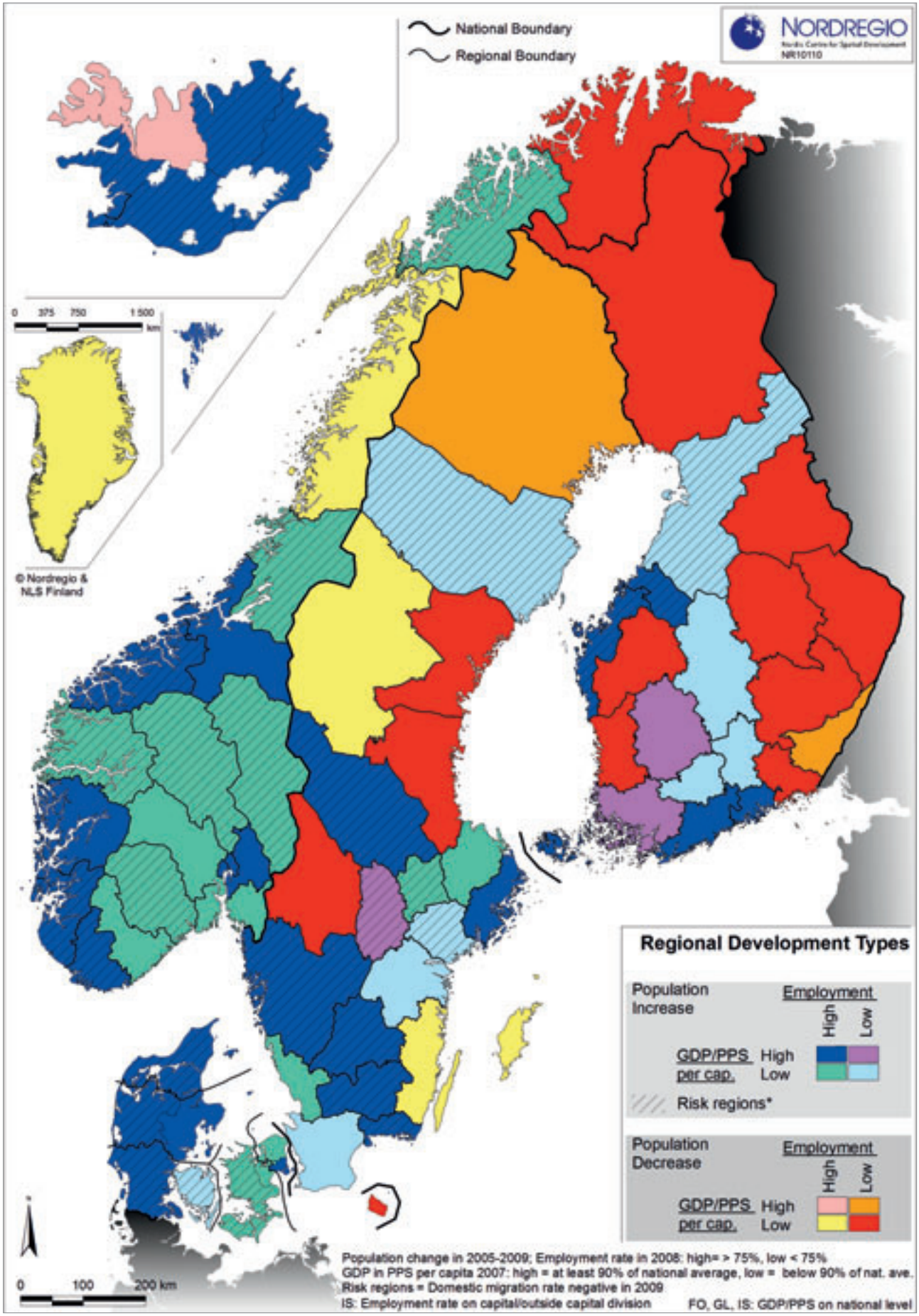
It should be generally concluded that the clustering activity did not reveal explicit territorial dimensions. Much of the analysis of the results is based on inferences and possible correlations. On one hand, a realistic clustering would be based on more robust indicators that reflect actual eco-innovation and the labour characteristics of green activities in various regions. It would also include an assessment of regional governance activity that supports the development of green growth from the bottom up. This, however, is virtually impossible to quantify in one region, let alone in a systematic way across regions in five countries.

At the same time, it is clear that the nature of the green growth concept does not lend itself to a robust regional typology that seeks to characterize a few key territorial dimensions. This is because it is such a broad concept, covering an array of socio-economic and environmental issues—everything from demographics, innovation and research to smart specialization and cluster development, all the way through to energy production and certainly not least consumption efficiency issues. More importantly, this array of issues often have parallel, overlapping, conflicting or contrasting territorial dimensions based on complex, interactive and often discrete local milieus more than anything else.

While unique local settings are crucial in providing a development basis, it is a significant challenge to refine these patterns and relationships into regional trends that provide insight at the Nordic level. This accentuates the role of bottom-up governance to complement national and international policy and funding schemes with a focus on endogenous assets and the mobilization of local actors, particularly those in the private sector. From a research perspective, this is an argument for the role of case studies in identifying how a network of local and regional actors and assets are mobilized for a regional approach to green growth.

Nevertheless, clustering results reaffirm the importance of at least one noteworthy territorial dimension discussed in the individual indicator analyses that can shed light on drivers and constraints of green growth in various regions. The results parallel the regional development types identified in Nordregio's 2010 report *Regional Development in the Nordic Countries* (Lindqvist (ed.), 2010). Shown in Map **8** below, this classified regions based on population change, employment and GDP in purchasing power standards (PPS) per capita. Both analyses clearly highlight the importance of the urban–rural dimension as a territorial context framing the conditions of development. For the Nordic regional development types, the challenge for balanced regional development is predominantly related to the issue of population change, especially in terms of the flow of people to urban regions at the expense of population loss and ageing in rural areas.

Map 8 Regional development types (in Lindqvist (ed.), 2010)



For the clustering exercise here, it was shown that R&D expenditure and unemployment levels were driving factors, and that these have explicit urban–rural distinctions. In this context, urban regions are noted for population growth, comparatively low unemployment and high GDP per capita. Because knowledge and innovation institutions, as well as economic production, are largely concentrated in these areas, they are also the recipients of the majority of R&D funding in the Nordic context.

Urban Regions – Innovators and Consumers

The performance of urban areas suggests the need for continued policy support to maintain their role as Nordic leaders of eco-innovation and cleantech that not only serve the local or domestic market but also are part of a global export base of green technologies. At the same time, the socio-economic and population development trends in urban regions relate to several issues of green growth throughout the Nordic region. First, it is notable that while urban centres have shown strengths in terms of innovation and the development of clean technologies, there are other, more rural regions that have proven to be formidable centres of clean technology innovation and development, i.e. Östersund and Jämtland (Sweden), and Kalundborg in the region of Zealand (Denmark).

In contrast to larger urban centres, where knowledge-intensive industries and the development of innovation are better understood within the scope of economies of agglomeration, the processes of bottom-up, locally bound growth in smaller urban centres in rural regions is much more difficult to decipher statistically. It is likely that the development of clean technologies in these areas is closely connected to processes of proactive local governance, technological adaptation from more traditional economic activities and the exploitation of unique and territorially specific assets—or most likely a combination of several of the above. Accordingly, the only way of analysing the drivers and enablers of these good performers is through local, case-based, qualitative analyses of the regions themselves.

In addition to how the knowledge-intensive economy relates to green growth through eco-innovation activities, the potential for green growth in denser population centres is undoubtedly related to the concentration of the majority of households' energy and goods consumption therein. Thus, the urban–rural distinction may be considered one of production versus consumption or supply versus demand. Not surprisingly, statistics show that urban regions are responsible for upwards of 80% of all energy consumption associated with urban activity, over half of which takes place in buildings. Moreover, buildings have the most potential in terms of low-cost emission reductions of any sector in Europe, and these reductions promote the greening of vast numbers of existing construction jobs. In fact, Jaeger et al. (2001) state that under the conditions of a new (greener) growth path for Europe, green building also has the greatest production potential of any sector. This is also advantageous because it means that people with a vast array of vocational skills can be transferred into the green growth economy with relatively little on-the-job training (Jaeger et al. 2011).

While the building sector is seen as having the highest energy savings and job growth potential, it also faces significant constraints. First and foremost, the rate of building turn-over is extremely slow, which means that the process of transforming the sector will be long and drawn out. Second, improvements to the energy performance of buildings involve high levels of upfront capital investment with extended pay-off horizons. This often makes it difficult for investors to justify the costs of building green, especially when they are not provided with all the necessary information to justify a greener investment.

To overcome these constraints a number of complementary policy perspectives are necessary, and each points to the need for increased effort by local and regional governments to promote green building. First, public administrations should lead by example. The extensive public sector in the Nordic region means that there is a significant opportunity for greening public buildings—both to reduce energy consumption and to promote green jobs. Hospitals, schools and public housing are ideal places to implement greener building practices because they will advertise the availability of green building opportunities to the public. Second, green building practices must focus on retrofitting existing structures in addition to constructing new buildings to accelerate the process of greening the sector. Third, local information and awareness campaigns need to target the investment and consumption behaviours of citizens. Fourth, public administration must simultaneously provide investors with the financial incentives to channel their investments into green building.

Each of these policy tools requires the development of a proactive local governance structure that is not only in control of land use and planning for buildings but also in touch with the local population. European and global networks such as the EU Covenant of Mayors are useful for promoting local green governance, but these alone are not enough. Therefore, proactive local governance to support green building should in turn be supported by a clear and unified Nordic message—one that sets expectations and provides the resources that are needed for local

authorities to lead by example and motivate private investment.

Rural Regions – Developing Renewable Energy from Agriculture, Forestry and Wind

In contrast to growing and prospering urban centres, the opposite conditions are faced by many rural areas, where labour forces are shrinking as young, educated people are drawn to the supply of knowledge jobs in urban centres, and where post-war baby boomers are reaching retirement age. As a result, there exists a double threat: rural populations are tending to shrink, and those who remain are becoming less active in the labour force. Consequently, the increasing dependency ratio of these rural areas challenges their potential for maintaining current productivity levels.

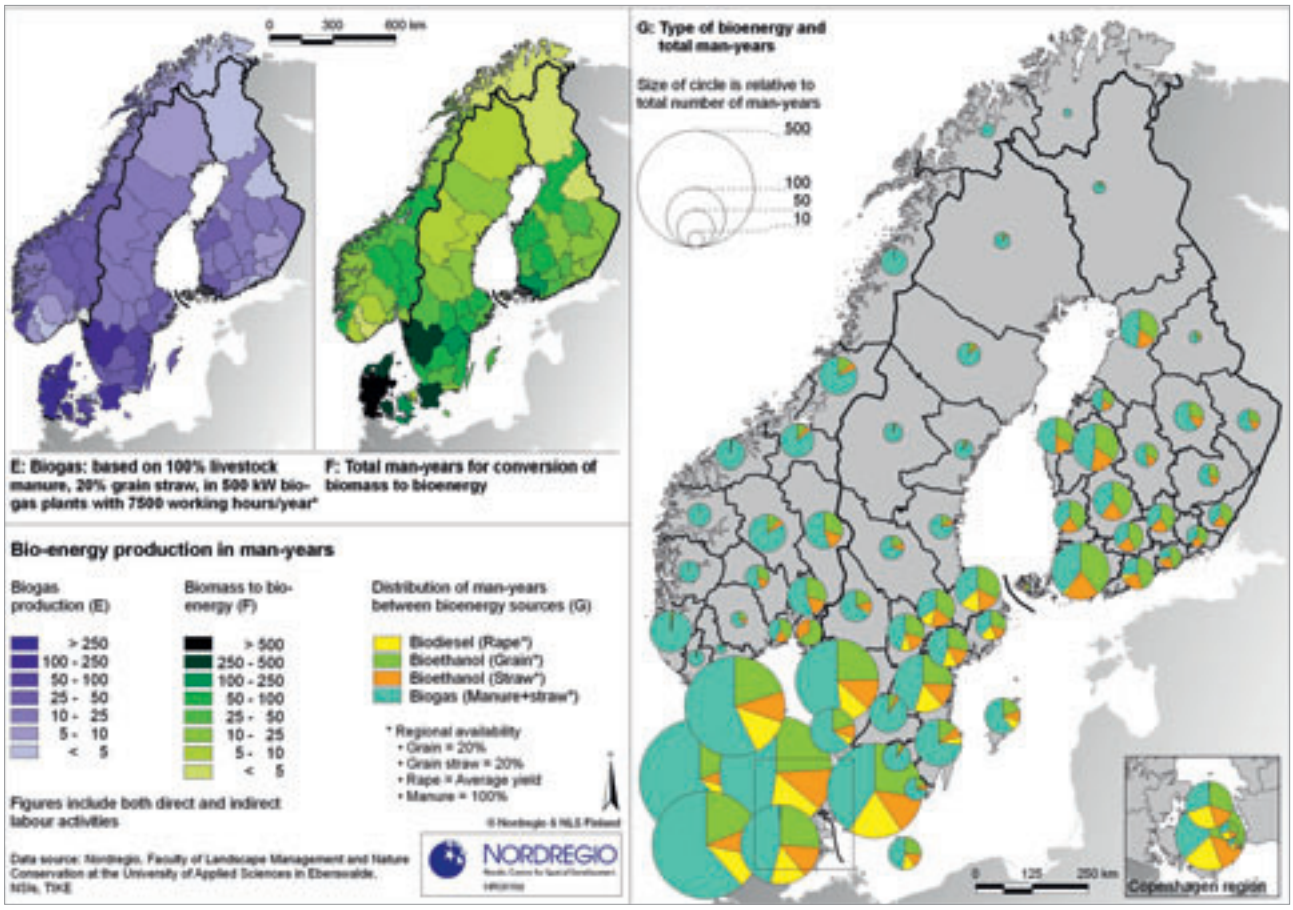
The drivers and enabling conditions of green growth can provide a means for rural and remote areas to mitigate their economic and demographic challenges. In particular, increasing renewable energy production relies on rural and remote areas in a number of ways. For example, renewable energy such as wind production inherently relies on the highly decentralized placement of infrastructure, just as bioenergy production is predominantly based on harvesting resources in rural Nordic areas. The development of these territorial assets directly translates into increased energy security, improved environmental performance and, not least, much-needed rural job opportunities. In addition, in the case of bioenergy and wind production, these opportunities are tied not only to traditional activities such as agriculture and forestry but also to non-traditional activities linked to the development and maintenance of infrastructure for renewable energy production. In fact, while Nordic urban areas are increasingly gathering the bulk of our society and economy, the demands of green growth imply a new territorial logic that will govern the roles of and relationships between urban and rural areas. For instance, urban areas will increasingly rely on the rural areas as green producers—a dependence that ought to dictate the manner in which rural areas are supported in a green growth policy.

Further development of bioenergy to increase the share of renewables in total energy production represents an important strategic opportunity for rural areas, by responding to the twin challenges of unemployment and population loss while contributing to the objectives of green growth. Contributing mainly to electricity production, heat generation and transport fuels, bioenergy production has increased significantly in the Nordic region over the past 25 years. In 2004, it accounted for 20%, 17%, 12% and 4% of total energy consumption in Finland, Sweden, Denmark and Norway, respectively. Thanks to the wide development of district heating, it is also the main renewable energy resource for heating in the Nordic region as a whole (Galera-Lindblom and Rasmussen, 2008).

Produced by Nordregio in 2008, the report *Bioenergy and Regional Development in the Nordic Countries* provides a quantitative assessment of the employment potential from the sustainable production of biomass and bioenergy in the agricultural sector. Map 9 shows the labour market effects of expanding the bioenergy sector through crop production and the transformation, conversion and distribution of bioenergy. A stretch from Denmark through southern Sweden and southern Finland has particularly notable potential. However, these statistics must be treated with caution because the labour intensity of producing bioenergy crops is roughly equal to that of producing food crops. The employment impact of bioenergy only relates to processing the crops into different forms of bioenergy and the management of energy production facilities.

In response to the zero-sum labour effect between agricultural and bioenergy production implied by the above — and furthermore, the need to sustain agricultural practices for the growth of domestic food resources—it is more valuable to focus only on bioenergy production that does not displace existing agricultural activities. In light of this, the potential labour effects of exploiting *fallow* agricultural land for bioenergy production are shown in Map 10. It indicates a wide margin of potential, with regions in Denmark and southern Sweden and Finland having the potential to create between five and more than 100 additional jobs each by growing energy crops.

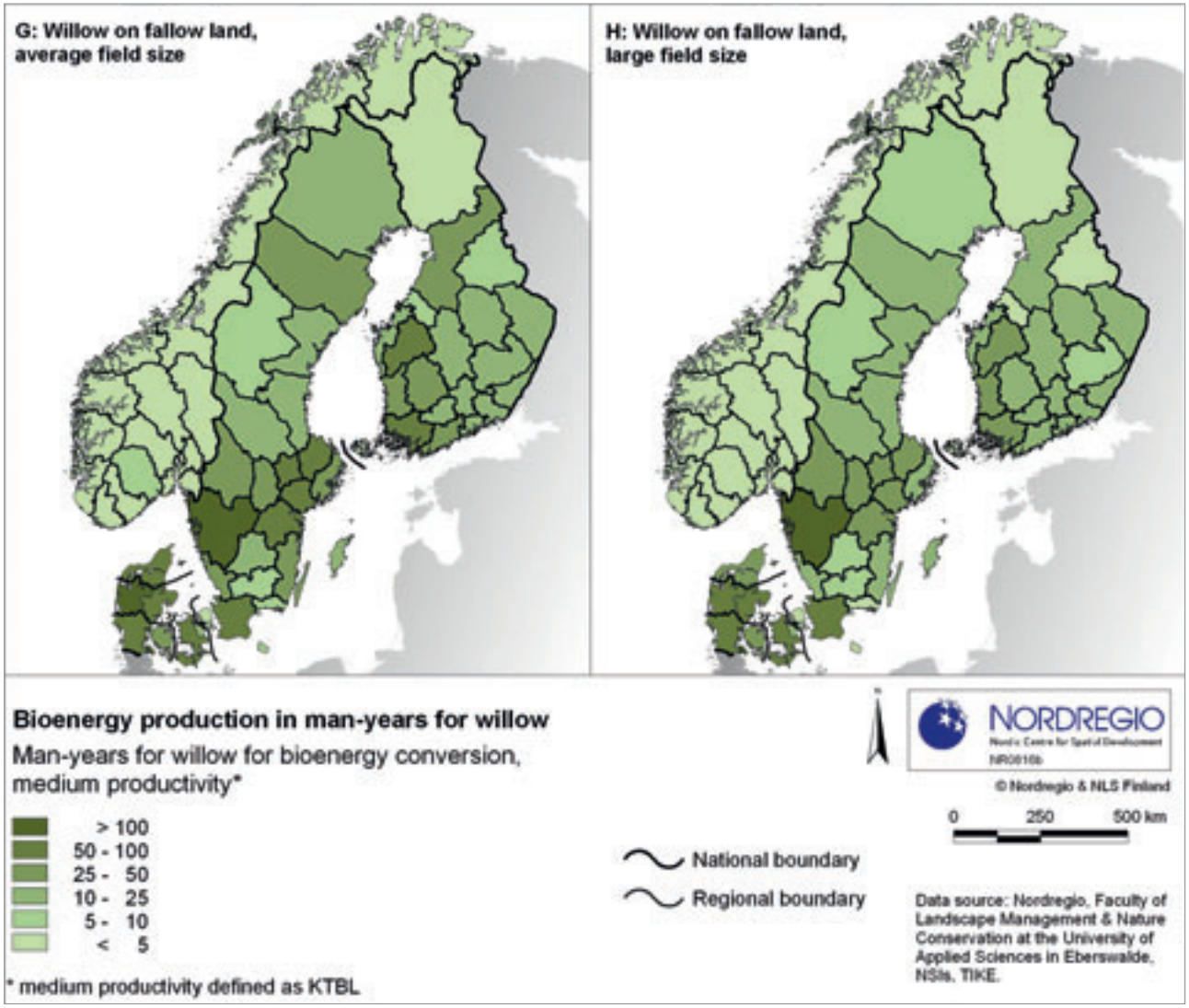
Map 9 Labour market effects of bioenergy (in Galera-Lindblom and Rasmussen, 2008)



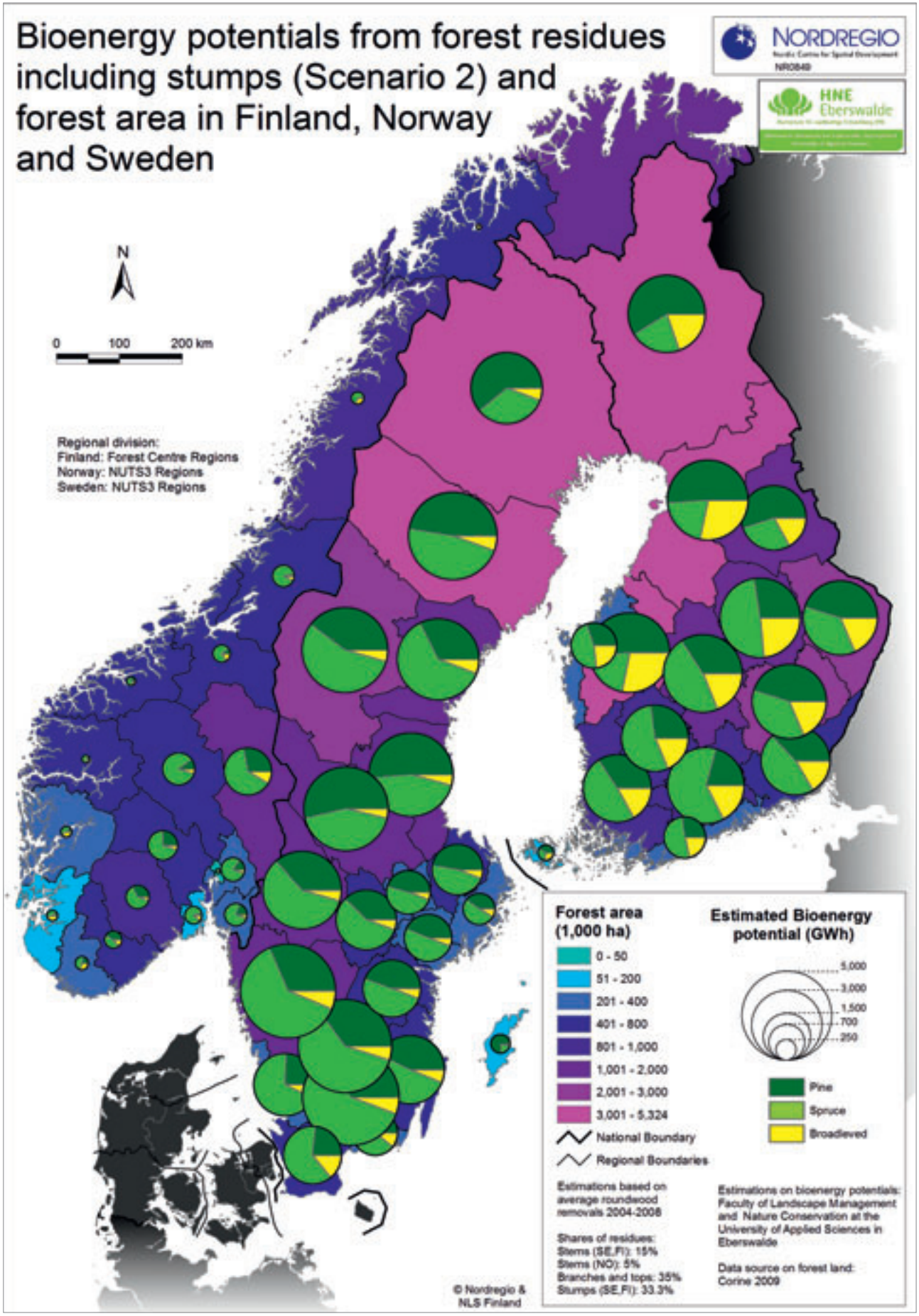
Exploitation of otherwise fallow land by growing perennial energy crops that, in contrast to food crops, can be cultivated under less favourable conditions can therefore provide jobs in marginalized agricultural areas where food production is handicapped by soil and climatic conditions. This enables farms located in marginal growing land to complement their food crops with perennial energy crops to ensure their business's sustainability (Galera-Lindblom and Rasmussen, 2008).

This represents notable support for the labour force because it allows for the maintenance of traditional economic activities in rural areas. In addition, jobs for the development and management of small- to medium-scale district heating and combined heat and power facilities will help make rural and remote areas more attractive in the labour market by providing more knowledge-intensive, non-traditional employment opportunities. In addition to the above agricultural opportunities, Map **11** shows that the use of residual materials from the forestry sector also has substantial potential for renewable energy production in the Nordic region. To date, this energy potential has not been translated into labour potential, so predicting the regional socio-economic implications of developing the supply of bioenergy from the forestry sector would be premature. It is nevertheless interesting to compare the spatial distribution of forestry-related energy potential with the labour potential from agricultural residuals. It is clear the two have offsetting potentials in various areas throughout the Nordic region. For instance, while Denmark clearly has the highest potential in terms of agricultural residues, its forestry potential is so negligible that it was not included in the analysis. In general, while bioenergy from agricultural activities acts as a regional development opportunity in Denmark and southern Sweden, bioenergy from forestry provides the most potential in the northern or eastern areas of Finland and Sweden. Furthermore, regions with high forestry potential in southern Sweden differ most greatly from those with high agricultural potential.

Map 10 Labour market effects of willow on fallow land (in Galera-Lindblom and Rasmussen, 2008)



Map 11 Estimated bioenergy potential from forest residues in Finland, Norway and Sweden



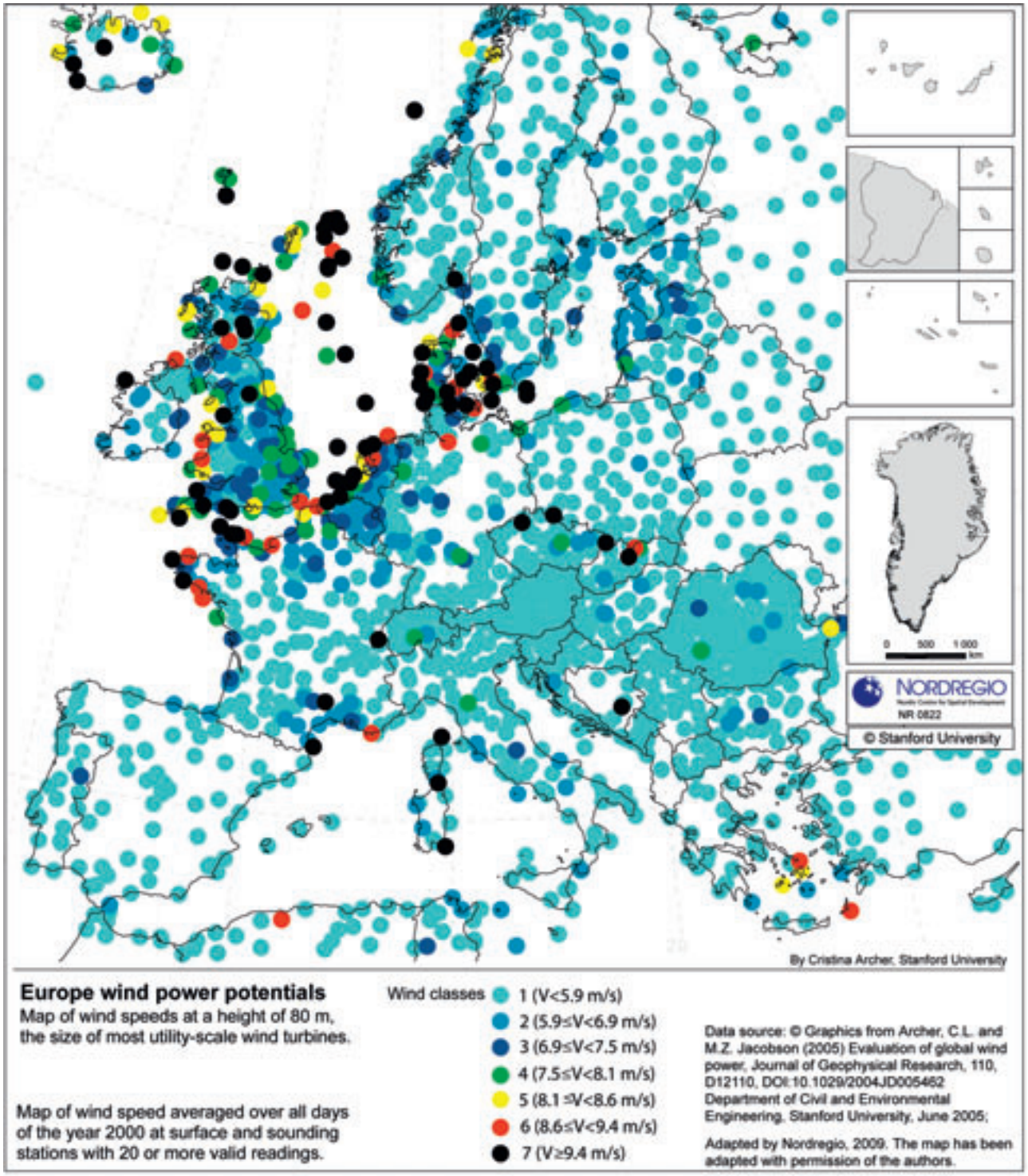
In addition to energy and development potential from bioenergy, wind energy has been emphasized in the Nordic region during the past three decades. However, wind power has only evolved in specific regions where high natural potential is combined with favourable national policy. As shown on Map 11, areas of high potential (viewed in terms of wind speed) are mainly centred in Denmark and southern Sweden, and to a lesser extent the coastal area of Norway. In Denmark, wind power has been embraced as a viable energy investment. In 2007, it accounted for 64% of the county's total renewable energy production (Lindqvist (ed.), 2010), but such widespread development means that most of the locations with the greatest natural potential are already being exploited. In contrast, while onshore and offshore wind energy has been a priority in selected Swedish regions,

Map 12 indicates more areas that could attract development in Sweden, Norway and Finland. In particular, offshore potential is highest and faces fewer socio-cultural constraints stemming from the impact on the landscape. Thus, offshore wind energy ought to be prioritized in policy and investment wherever possible.

The Institute for Energy Technology in Norway (IFE) advertises that there is excellent wind power potential in Norway. In contrast to the indication on

Map **12**, it estimates that typical sites along the Norwegian coast have annual mean wind ranges of 8–10 metres per second—higher than typical conditions in Denmark and northern Germany (Stenbro, 2012). However, offshore wind production has traditionally been constrained by factors such as ocean depth and climatic conditions. Challenging these constraints, recent research and innovation, particularly in Norway, have produced impressive advancements in the efficiency of turbines and development of floating installations. With these advancements, the potential for wind power in the Nordic countries has vastly expanded—but so has the need for policy and investment to realize this potential. Action on this front would support not only the green energy production in the Nordic countries but also its already well-established, export-driven environmental economy. It would also support a green growth economy extending from energy production in remote coastal areas to the research and innovation that often takes place in more urbanized localities.

Map 12 European wind power potentials (based on wind velocity)



Nordic Green Growth—Additional Considerations

A significant number of other possible angles of analysis of green growth are beyond the scope of this project, each having its own distinct territorial implications. As was the case for regional potentials for bioenergy, assessing their capacity to contribute to a greener economy would require entirely new projects. Examples of these could include analysing policies to facilitate the development of eco-tourism in rural Nordic areas or the territorial implications of greening manufacturing and industrial processes, especially in relation to policy drivers such as the EU Emissions Trading Scheme. Process innovations such as industrial symbiosis are proving extremely useful, not only for improving the environmental performance of industrial activities that have complementary inputs and outputs but also for their economic merit.

The Nordic prime ministers' Working Group

for Green Growth has established that Nordic co-operation as a unified territory is a high priority. This creates economies of scale to increase the viability of developing, testing and marketing local green innovations. It also presents the Nordic countries as a formidable political partnership that pioneers green growth in Europe across several spheres. This Nordic vision includes objectives of developing test centres for green solutions in Nordic regions, promoting the flexible consumption of electricity and working together on green technology norms and standards. The group is also committed to the joint Nordic electricity market (NordPool) as a means to increase energy flexibility and consumer choice at the Nordic level (NCM, 2011).

While NordPool and work on green certificates are good examples of ways to stimulate the Nordic market for green growth initiatives, such initiatives should now go beyond fiscal policy and energy flexibility from a consumer's perspective. In reality, a majority of the Nordic region's green growth objectives—including those mentioned above—are closely connected to an underlying need to reform the region's energy transmission infrastructure to meet the needs of a renewable energy future. It is widely understood (but rarely stated) that Europe will be unable to meet its long-term energy goals without a complete redesign of the ways in which energy is transmitted and consumed. A truly European energy market must be developed, and this will require the existing grid to be replaced by a smart grid to provide the flexibility needed for decentralized renewable energy production. Essentially, the grid must be transformed from a one-way flow to the consumer into a two-way system that treats all end points as either producers or consumers of energy (or both, at different times).

Even the ambitions for bioenergy potential and offshore wind energy development are contingent on smart-grid development for maximum efficiency. So are improvements in energy efficiency, which will not only require vastly improved consumer awareness but will also rely on new end-of-pipe smart meter technologies to allow individuals to take control of their energy consumption. Smart grids could provide all of this, but the scale of investment required is incredible. According to the report by Pike Research, *Smart Grids in Europe* (released in March 2011), the magnitude of investment in smart grid technology and infrastructure will exceed USD80 billion in Europe between 2010 and 2020 alone.

The Nordic region therefore has the opportunity to be a first mover and European leader in the most decisive way possible, by creating the policy structure and seed investment necessary to begin the transition to a smart grid. This will provide not only the infrastructure necessary for the realization of national and European energy policies but also new jobs throughout the entire Nordic region. Smart grid pilot projects have been established, including on the Swedish island of Gotland. As a first step, these projects could be extended to other regions and broadened in scope.

Conclusion

This paper analysed readily available green growth indicators, examined the inclusion of selected indicators in a regional clustering exercise and investigated general regional development in the Nordic countries. Unfortunately, the clustering activity did not identify clear territorial dimensions that could yield full understanding of sector-specific or region-specific potential for facilitating green growth in Nordic regions. The indicator analysis also reinforced the view that a myriad of territorial implications for green growth exist. This surely has to do with the breadth of the green growth concept, which includes socio-economic interventions across the full range of production and consumption sectors. The indicator analysis also showed that measuring green growth performance and potential places new demands on regional statistics—a demand that will take time and effort in improved co-ordination to solve. One clear example of this is the Eco-IS, which is measured at the national level. Making these types of statistics readily available at the regional level will do much to assist researchers and policymakers.

However, it is also clear that the breadth of the green growth concept, covering such a variety of socio-economic and environmental parameters, does not lend itself to a robust regional typology based on a few key territorial dimensions. This relates to the parallel, overlapping, conflicting or contrasting territorial dimensions that are contingent on development of local assets and complex local milieus. These bottom-up processes are extremely challenging to refine into regional patterns and relationships at the Nordic level.

Nevertheless, the work completed thus far underlines the existence of distinct regional types, with a distinct urban–rural dichotomy. It not only provides insight into the types of interventions necessary but also indicates their potential impact on regional development.

In rural and remote areas, the focus has been on

the potential for green growth alongside the predominant challenge of job and population loss. It was shown that policy and investment-driven interventions at the interface of the energy, agricultural and forestry sectors can provide a number of opportunities. However, with these opportunities comes the need for proactive regional governance, which is essential for understanding the local potentials of wind, bioenergy or any other renewable resource. The natural potential identified by indicators such as wind velocity or bioenergy are useful to a certain degree, but the indicators do not consider necessary local considerations that will have an impact on the potential in reality. Examples of these local perspectives may include socio-cultural or environmental considerations such as the impact on the landscape of renewable energy infrastructure or the impact of logging or stump harvesting on forest health or erosion. Therefore, increased regional responsibility for the comprehensive costing of future energy development is essential to promote green growth.

In contrast to rural areas, urban centres will continue to provide the bulk of the research and innovation capital that drives technological development of various domestic energy and environmental interventions. However, urban areas are also where the bulk of economic production and resource consumption takes place. As such, one of the main issues in reforming urban economies for green growth centres on identifying the potential to mitigate excessive material and resource consumption and developing knowledge-intensive, highly value-added innovation institutions.

Consumption-side interventions in building and transport (both within and between urban areas) and devising policy tools that improve awareness about energy consumption behaviour among end users are of special importance. Proactive policy guidance for local and regional planning institutions will be particularly important, given their authority over land use and transportation issues in urban areas. Government needs to lead by example through the greening of public procurement in a way that displays innovation and kick-starts the supply of green jobs (especially in the building sector) and thus makes green growth tangible in the built environments of cities. Through on-the-job training, such growth can provide an unparalleled number of green jobs in a relatively short period of time. It is stressed, however, that co-ordinated urban planning is critical if this is to win the support of local citizens and stakeholders, and one must note the importance of developing the environmental consciousness of a variety of consumers.

This broad green growth potential and its associated territorial dimensions make clear that policy instruction is needed at all administrative levels and across public and private institutions. This requires a bold and comprehensive policy package that takes into account underlying territorial dimensions, through improved awareness of endogenous regional assets that can be exploited with sensitivity to local strengths and challenges, in order to achieve green growth.

More importantly, a Nordic green growth policy must recognize what is at stake, from both environmental and multiple socio-economic perspectives. On one hand, natural conditions coupled with existing knowledge and innovation capabilities provide the necessary conditions for various forms of renewable energy development to grow substantially. On the other hand, this means that the Nordic region will continue to act as a first mover in the environmental economy, and a unified Nordic market for domestically produced clean technologies will spur the flow of our environmental goods, services and know-how into the global economy.

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Annex 1

Weak versus Strong Sustainability to Define the Transition to Green Growth

While it is understood that green growth is considered a subset of sustainable development, the comparison between *weak sustainability* and *strong sustainability* provides a good insight into the concept of green growth. On one hand, weak sustainability occurs as long as development is broadly viewed as non-diminishing from generation to generation (Brekke, 1997, in Ayres *et al.*, 2000). In this case, sustainability is viewed by neoclassical economists as the endeavour to preserve a nation's capital at a constant level (Ayres *et al.*, 2000). This includes *natural* capital, but the key distinction is that weak sustainability allows for virtually unlimited substitution between different forms of capital (*ibid.*). Therefore, weak sustainability is achieved in a brown economy because the environmental trade-offs of natural resource exploitation are not explicitly considered. Rather, development is deemed sustainable as long as the exploitation of fossil fuels and other forms of natural capital are balanced by gains in other forms of capital.

In contrast, green growth is aligned with strong sustainability, a perspective that acknowledges that different types of capital—such as economic, ecological or societal—must be interdependently maintained. In this context, the major motivation for green growth is that natural resources are essential inputs in economic production, consumption and welfare that cannot be substituted by physical or human capital (ibid.). Therefore, strong sustainability "...focuses on ecosystems and environmental assets that are critical in the sense of providing unique and essential services (such as life support) or unique and irreplaceable non-use values" (Ayres et al., 2000, p. 5). The green growth concept reflects an understanding that specific environmental resources fulfil irreplaceable functions that must be preserved in order to achieve genuine sustainability. In green growth, this aim is operationalized by policies that use sets of market- and non-market-based incentives to facilitate a reallocation of jobs, capital and technology to green activities (OECD, 2011a).

Annex 2

In addition to the Nordic prime ministers' Working Group for Green Growth, further examples of institutions and initiatives that expand green growth in a Nordic context are summarized here.

The Nordic Energy Municipality 2011projectprovides practical and concrete examples of how the Nordic vision of sustainable energy and green growth may be realized and shows the way forward (NCM, 2011). The project was initiated through co-operation between the Danish and Finnish chairs of the NCM, and was inspired by the Danish plan adopted by the Ministry of Climate and Energy in 2008 in relation to 'EcoCities'. The Danish Energy Agency was responsible for project co-ordination in 2010; and the Finnish Ministry for Employment and the Economy, in 2011.

The central focus of the project is on sustainable energy, green growth and climate change mitigation activities in relation to energy in the Nordic region. To inspire innovation, the project aimed at improving activities in the energy field at the municipal level. Nordic municipalities that make an extraordinary contribution to the implementation of innovative energy projects receive a high degree of recognition.

Forty-four Nordic municipalities submitted an application to participate in the Nordic Energy Municipality 2011 competition in the period from October 2010 to January 2011. Fourteen municipalities were shortlisted. The winner and the shortlisted municipalities were promoted internationally for the remainder of 2011, to increase awareness of innovative and sustainable Nordic energy projects.

Nordic Energy Research supports research innovation in new energy technologies with a strong focus on the impact of climate change on the energy sector and hence on renewable energy, energy efficiency and energy market integration. One example of their work is the Scandinavian Hydrogen Highway Partnership (SHHP) initiative, which is intended to promote the introduction of hydrogen fuel. The partnership is composed of regional clusters including large and small industries, research institutions and local and regional authorities.

The initiative has assisted individual entrepreneurs and enterprises in Norway (HyNor), Denmark (Hydrogen Link) and Sweden (Hydrogen Sweden) in taking advantage of this emerging green technology and making the Scandinavian region one of the first in Europe where hydrogen is available from a network of refuelling stations.

The Nordic Innovation Centre has implemented the Clean, Clever and Competitive Programme, whereby five Nordic triple helix projects were supported with the objective of enhancing innovation and the promotion of Nordic environmental technology. The centre also contributes to the Top Level Research Initiative through supporting the establishment of a Nordic User Driven Competence Centre for Carbon Capture and Storage (CCS). The objective of the centre is to increase innovation and joint action in the Nordic countries and to increase industry-driven innovation in CCS.

There is an increasing political emphasis on environmental policy intended to make an impact on markets and competition. The directors general of the Nordic competition authorities held their semi-annual meeting in the Faroe Islands in March 2010 to discuss challenges faced by their organizations as a result of the shift towards green growth.

An agreement was made to produce a joint Nordic report focusing on the links between environmental and competition policies, to establish common ground for the task of addressing future challenges in green growth. The key message of the report is that competition policy is imperative to the development and implementation of a green growth strategy and plays an important role in facilitating a successful shift to green growth. The report explains the relationship between competition policy and environmental policy by providing an overview of how environmental policies are reflected in the practices of market actors through various green schemes. Furthermore, the report speculates about future policies aimed at using effective competition to support environmental policy by conveying price signals that reflect environmental externalities. This competition may strengthen environmental policy by stimulating innovation efforts and efficiency improvements—important elements in a successful environmental policy.

Annex 3

Synthesis of the OECD's Proposed Indicators of Green Growth

The socio-economic context and characteristics of growth
Economic growth and structure
GDP gorwth and structure; net disposable income
Productivity and trade
Labour productivity; multi-factor productivity
Relative importance of trade (exports+imports)/GDP
Infaltion and comoodity prices
Labour Markets
Labour force participation and unemployment rates
Socio-demographic patterns
Population growth, structure and density
Life expectancy: years of healthy life at birth
Income inequality: GINI coefficient
Education Attainment: Level of access to education
Environmental and resource productivity
1. CO_2 productivity
Production-based CO_2 productivity GDP per unit of energy-related CO_2 emitted.
Demand-based CO_2 productivity. Real income per unit of energy-related CO_2 emitted.
2. Energy productivity
Energy productivity (GDP per unit of TPES)
Energy intensity by sector (manufacturing, transport, households, services)
Shape of renewable energy in TPES, in electricity production
3. Material productivity (non-energy)
Demand based material productivity (comprehensive measure; original units in physical terms) related to real disposable income.
Domestic material productivity (GDP/DMC) - Biotic materials (food, other biomass) - Abiotic
Waste generation intensities and recovery ratios. By sector, per unit of GDP or VA, per capita.
Nutrient flows and balances (N,P) - nutrient balances in agriculture (N,P) per agricultural land area and change in agricultural output
4. Water productivity
VA per unit of water consumed, by sector (for agriculture: irrigation water per hectare irrigated)
5. Multi-factor productivity reflecting environmental services
(comprehensive measure; original units in monetary terms)
Natural asset base
6. Freshwater resources
Available renewable resources (surface water, national, territorial) and related abstraction rates
7. Forest resources
Area and volume of forests; stock changes over time
8. Fish resources
Proportion of fish stocks within safe biological limits (global)
9. Mineral resources
Available (global) stocks or reserves of selected minerals (tbd): metallic minerals, industrial minerals, fossil fuels, critical raw materials; and related extraction rates
10. Land resources
Land cover types, conversion and cover changes
State and changes from natural state to artificial or man-made state

11. Soil resources
Degree of top soil losses on agricultural land, other land
Agricultural land area affected by water erosion by class of erosion
12. Wildlife resources (tbd)
Trends in farmland or forest bird populations or in breeding bird populations
Species threat status: mammals, birds, fish, vascular plants in % species associated or known
Trends in special abundance
Environmental quality of life
13. Environmentally induced health problems & related costs
(e.g.) years of healthy life lost from degraded environmental conditions)
Population exposure to air pollution
14. Exposure to natural or industrial risks and related economic losses
15. Access to sewage treatment and drinking water
Population connected to sewage treatment (at least secondary, in relation to optimal connection rate)
Population with sustainable access to safe drinking water
Economic opportunities and policy responces
16. R&D expenditure of importance to GG
Renewable energy (in % of energy related R&D)
Environmental technologies (in % of total R&D, by type)
All purpose business R&D (in % of total R&D)
17. Patents of importance to GG
% of country applications under the Patent Cooperation Treaty
Environmentally related and all-purpose patents
Structure of environmentally related patents
18. Environment-related innovation in all sectors
19. Production of environmental goods and services (EGS)
Gross value added in the EGS sector (in % of GDP)
Employment in the EGS sector (in % of total employment
20. International financial flows of importance to GG
(% of total flows; in % of GNI)
Official Development Assistance
Carbon market financing
Foreign Direct Investment (tbd)
21. Environmentally related taxation
Level of environmentally related tax revenues (in % of total tax revenues, in relation to labour related taxes)
Structure of environmentally related taxes (by type of tax base)
22. Energy pricing
share of taxes in end-use prices
23. Water pricing and cost recovery (tbd)
To be complemented with indicators on:
Environmentally related subsidies (tbd)
Environmental expenditure: level and structure (pollution abatement and control, biodiversity, natural resource use & management)
Regulations and management approaches
indicators to be developed
Training and skill deelopment
indicators to be developed

Reproduced from OECD, 2011c (Annex: Proposed List of Indicators)

Annex 4

Composite Indicators and Method of Statistical Analysis

Composite Indicators

Composite indicators (CIs) have grown in popularity, with new methods and approaches constantly under scrutiny. This led the OECD (2008) to develop a handbook on how to construct and interpret them properly. A CI is the result of a process of statistical aggregation during which trends and patterns described by a set of indicators are reduced to a set of fewer (preferably single) measures. Such methods make comparisons, rankings and groupings much easier and offer policy analysts a useful tool that simplifies the interpretation of sets of indicators. Some important limitations, however, need to be mentioned. During the process of reduction, information is unavoidably lost, and the risk of drawing overly simplistic conclusions arises. This is more severe when researchers have a less than perfect understanding of the method used to produce the CI and of the characteristics of the underlying data. In this context, extreme care must be taken to avoid blindly inferring that correlations in the data reflect causation.

At this point, it needs to be mentioned that constructing CIs is not simply a matter of choosing a method from the available arsenal and applying it to the underlying data. There is a series of steps to be followed. First, a theoretical framework needs to be developed that will dictate the selection of both the appropriate set of underlying indicators and the method of combining them into a CI. The underlying data need to be carefully collected, and more often than not, a certain degree of processing (normalization, weighting and aggregation) must be properly executed before constructing the CIs. Most importantly, once the composite indicator has been created, the results need to be properly presented, discussed and analysed. Given the amount of information usually contained in CIs, this is often the most challenging step.

At the moment no formal theoretical framework exists to guide the analysis in this report. This exercise is intended not to give a definitive answer on the spatial distribution of green growth potential or performance but rather to demonstrate how the multidimensional conditions presented in the previous section may be formally treated and combined in a meaningful way so that a spatial pattern may emerge. We apply three of the most commonly used multivariate analysis techniques. Specifically, a cluster analysis (CA) is applied to identify groupings of regions that exhibit structural similarities across the entire board of indicators considered. Factor analysis (FA) and principal components analysis (PCA) are used to determine which indicators appear to be the key determinants of regional similarities and disparities.

Method of Analysis

To perform the CA, three elements are important to note. First, we are able not only to identify regional variations but also to comment on the degree of similarity between the regions. Second, the use of PCA provides a method of data reduction to identify the indicators explaining as much of the variance in the data as possible. The first component accounts for as much of the variation in the data as possible, and each succeeding component accounts for as much of the remaining variation as possible. Third, the use of PCA to analyse regional clustering is further supported by FA, which differs from PCA in that it identifies underlying latent variables, thereby generating 'factors' that explain the interrelationships between the principal components. It is important to point out that FA is intended to identify the interrelationships between the variables, not to determine the importance of individual variables in driving the clustering process. Therefore, its benefit is its power to explain the complex interactions between the indicators that would otherwise be less visible.

In summary, the CA is the primary method to show the degree of similarity and variation between

groups of regions. PCA indicates the degree of similarity and variation between the regions according to each variable, and shows which variables drive the clustering process. Next, the FA essentially clusters the indicators themselves—as opposed to the regions—to show which indicators correlate. This in turn is used to infer which relationships define the territorial characteristics of green growth. For a more technical exposition of the methodology applied, we refer the interested reader to the relevant OECD publication (OECD, 2008).

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