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Nordic industrial green transition

A literature review and Nordic benchmark

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Summary

This literature review provides an overview of some key aspects of the green transition, as well as providing examples of a number of green initiatives seen across Nordic regions. Besides policy and decision makers at a governmental level, private enterprises also play a critical role in greening the economy in Nordic and Arctic regions. Sustainable competitiveness requires the preservation of biodiversity and a natural regeneration capacity. The green economy is likely to consist of a mixture of new objectives and new ways of doing things, all of which could require a mix of specifically green skills and more traditional skills. Working in symbiosis or with a systems-thinking approach will be key to build and sustain resilient Nordic and Arctic regions.

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1. Introduction

This report is part of the Green Transition in the Arctic (GROM) project 2019-2021, financed by the regional research fund (RFF) Nord and with NORCE institute as the Lead Partner.

The aim of the project is to strengthen NORCE's collaborative approach and dialogue with the private sector on regional sustainable innovation for value creation, and industrial transition towards a more climate-friendly business sector. GROM will strengthen the knowledge base for a sustainable transition by providing applied and relevant knowledge for decision-making in the private sector, management, and politics. The project aim is three-fold:

1) Strengthen the collaborative capacity between research institutions, commercial and industrial actors in the Northern Norway to enable the industrial green transition. Collaboration surrounding environmental innovation processes will also contribute towards increasing the capacity to use research as a tool to support company-driven innovation processes in the Northern Norway.

2) Building the knowledge capacity of private and semi-private companies' actions regarding choices of technology, production methods and energy sources as alternative to fossil fuels and traditional production methods, while clarifying the connections between profit, innovation and the green transition in product and service provision

3) Increasing knowledge around the ability of businesses and industries to act for sustainable development: identifying their room to manoeuvre – barriers and innovation processes.

The project's main research question is: 'What are the driving forces behind the green transition, and what is "the green transition" in relation to innovation in businesses working in sectors such as maritime industries, waste treatment and logistics in an Arctic context?'

This literature review, prepared by Nordregio for NORCE in 2019-2020, provides input into a specific research question of GROM: In what way could Nordic experiences of green transition provide increased knowledge for sustainable innovation and business development in an Arctic and Northern Norway context? The literature review includes an in-depth analysis of the key industrial sectors of GROM: waste management, logistics and the maritime sector.

The report is structured as follows. In Chapter 1, the path towards green transition is described. In Chapter 2, the literature review focuses on green transition themes and issues most relevant to the Arctic /Northern Norway context of the GROM project. In Chapter 3, the major findings are presented.

2. The path towards the green transition

2.1. What is the green transition?

Our actions and interactions are increasingly complex and intertwined. The consequences of our decisions exceed the boundaries of their intent. Understanding our decision-making from a systems perspective is thus necessary to respond to this complexity. The Paris Agreement is one reaction and attempt to combat the most pronounced consequence of human actions, namely climate change. The Paris Agreement states that the signatories to the agreement are to limit the increase in the global average temperature to 2°C above pre-industrial levels, as well as committing to efforts that will limit it to 1.5°C (UNFCCC 2015). To do so, measures need to be in place to cap emissions drastically.

One strand of these measures is the process and transition to a more sustainable economy by moving away from the petro-economy towards a greener economy, based on circular practices and a sustainable use of resources. This demands a green transition, and it requires a 'whole-of-society' approach to come to fruition, taking people, politics and businesses on board.

According to UNEP (2011), the green economy is socially inclusive, resource efficient and low carbon. It results in '*improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities'* (UNEP, 2011, p. 1). Echoed in Altenburg and Roderik (2017), the necessity to understand human development and value creation as dependent upon the well-being of the planet is overdue. This is supported by McCormick *et al*., who state that conventional economics does not adequately reflect the value of essential factors (such as clean air, clean water, biological diversity, social and generational equity), arguing for the adoption of ecological economics to promote a more transdisciplinary approach (McCormick, Richter, & Pantzar, 2015).

The concept of 'green' is by definition dynamic, according to Tanner *et al*., (2019). The concept of 'green' is a moving target, since what was once considered green may not be considered 'green' in the future (Tanner *et al.,* 2019). According to Altenburg and Rodrik (2017), 'radically new techno-institutional systems are needed to decouple economic development and human well-being from resource depletion and waste production' (Altenburg & Rodrik, 2017). Understanding the green transition merely in terms of the current economic system will therefore prove limiting. The frame of reference for what is considered green may thus also change, as institutional structures alter and develop alongside new green practices. In this way, agility and a systems perspective are both needed in order to understand the wider implications of the green transition, now and in the future.

Preceding the notion of a green transition is the concept of **green growth**. The OECD defines green growth in terms of innovation and its capacity to foster sustainable growth. Innovation may, in this regard, be understood as the introduction of any new or significantly improved goods or services, processes, organisational changes or marketing solutions (Annala & Teräs, 2017). According to Ambec (2017), green growth may contribute positively towards economic competitiveness based on three preconditions: the flexibility of environmental policy instruments targeting green innovation, the ease of technology and patent transfers in industrial policy, and the level of technological absorption capacities in the industries in question (Ambec, 2017, p. 47).

Environmental technology, green technology and **clean technology** are identified as important drivers of green growth in the Nordic Region (Annala & Teräs, 2017). Greentech refers to all technologies that mitigate negative effects on the environment. But it may also include technologies connected to sustainable management of natural resources, monitoring and development, greener production processes and products (Annala & Teräs, 2017). In looking towards the application of greentech, it is necessary to unpack the idea of a circular economy. The circular economy involves

shifting the conceptualisation of economics from a linear to a 'circular systems' way of thinking. In straightforward terms, this means circular or closed-loop systems that promote resource-saving and greater resource optimisation throughout all stages of the production, distribution and consumption process.

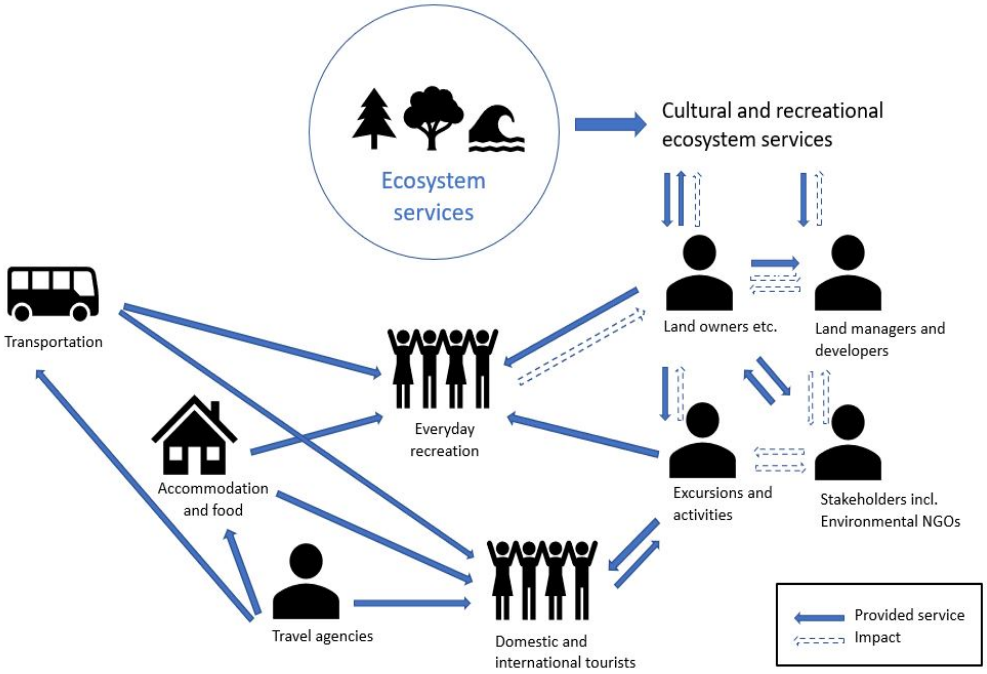


Figure 1. Ecosystem services. Author's adaption of Rönnlund *et al.* (2014).

The **bioeconomy** is another term frequently seen in discourse around the green economy. The bioeconomy focuses on the optimisation and smarter use of biomass, extracting value from across the natural resource supply chain. This extends from energy (power, heat and fuels), to chemicals and materials, to food and feed, and finally to pharmaceuticals and fine chemicals. In the bioeconomy, the bio-resources should be maximised to their full potential and should provide a basis for value cascading, where in a series of biomass products, the high-value products are recovered before they are damaged by pre-treatment, and then subsequently recovered and processed for use in lower value products (e.g. nutraceuticals-pharmaceuticals) (Lange, Björnsdottír, Brandt, & Hildén, 2015, p. 16). The bioeconomy is central to the circular economy, and the pathway to the bioeconomy requires both technical and institutional innovation (Refsgaard, et al., 2020). Underlying both the circular economy and the bioeconomy, and their integration, is the need for giving appropriate consideration to ecosystem services.

Ecosystem services (Figure 1) are defined as 'the direct and indirect contributions of ecosystems to human well-being' which directly or indirectly support 'our survival and quality of life' (Biodiversity Information Systems for Europe, n.d.). According to Biodiversity Information Systems for Europe, ecosystem services have four classifications: providing services (e.g. food, water, genetic resources, fibre, wood, etc.); regulating services (e.g. regulations pertaining to the climate, hazardous substances, pollutants, etc.); habitat services (e.g. migratory species, healthy gene-pools, biodiversity), and finally, cultural services (recreation, spiritual values, aesthetics) (Biodiversity Information Systems for Europe, n.d.). There is great potential for capitalising on ecosystem services in the Nordic Region, due to its abundance of recreational areas and the sustainable management of forests and landscapes. According to Rönnlund *et al*. (2014), innovations in SMEs working in the

area of ecosystem services are often linked to pioneering services which complement the work of existing service providers (Rönnlund *et al*., 2014).

Ecosystem services as recreational services. Photo: Simon Smith, Unsplash.

Ecosystem services are a complex concept, capturing how we understand our relation to, and use of, nature. One example of its complexity lies in the fact that the value of ecosystem services is hard to measure, and is not measured on a regular basis in the Nordic Region, in fact (Björk, et al., 2016, p. 114). This is mainly due to the methodological issues involved in attributing value to, for instance, recreation, and standardising these. Ecosystems may indirectly impact on local employment and public health, for example. These can prove difficult to measure in monetary terms.

According to Lockie (2013), two assumptions are made when thinking of ecosystem services. One concerns processes and the distribution of services, and the other is about the rights and duties involved in utilising these. Most environmental policies take heed of this balance, and this balance becomes increasingly important when it comes to the future of the bioeconomy and green growth. The discourse on property rights is not only prominent in that part of the bioeconomy and of the green transition which concerns physical bioresources. It also includes existing healthcare pathways, for example, since 'technology and therapies are restructuring the entire industrial [healthcare] sector' (Mittra, 2015), and this sector is increasingly relying on patient groups and the public sphere. The involvement of these groups raises questions around consent and the use of data for third parties (Mittra, 2015). This is naturally also tied to Intellectual Property (IP) rights issues – following the way in which the bioeconomy intertwines with life sciences and surrounding emerging technologies, and in terms of the diverse group of beneficiaries in bioeconomy value chains (Rönnlund *et al*, 2014). Both IP rights and property rights bring to mind the US ruling on the case of Henrietta Lacks' and the discovery of the first immortal human cancer cell line in 1951, leading to the adoption of the Common Rule *(Policy for the Protection of Human Research Subjects)* (Smith, et al., 2017)

Considering the use of data: coupling the green transition to digitalisation for extracting or optimising value chains, and regulations and laws surrounding definitions of, for example, waste as seen in the EU Waste Directive, will play an increasingly important role. Determining what strains of resources are eligible for what purpose (provided it does not infringe on other usage) will be key to the smooth operationalisation of biomass resources. The EUs Waste Framework Directive was amended in 2018 to reflect the EU's efforts towards sustainable material management, "with a view to"

'[P]rotecting, preserving and improving the quality of the environment, protecting human health, ensuring prudent, efficient and rational utilisation of natural resources, promoting the principles of the circular economy, enhancing the use of renewable energy, increasing energy efficiency, reducing the dependence of the Union on imported resources, providing new economic opportunities and contributing to long-term competitiveness.' (European Union, 2018, p. 1)

This is in contrast to Directive 2008/98/EC, which sought to define waste and by-products and recycling and recovering (European Union, 2008). The amendments seen in current Directive 2018/851 are solidifying efforts in the European countries with regard to the circular economy and green growth.

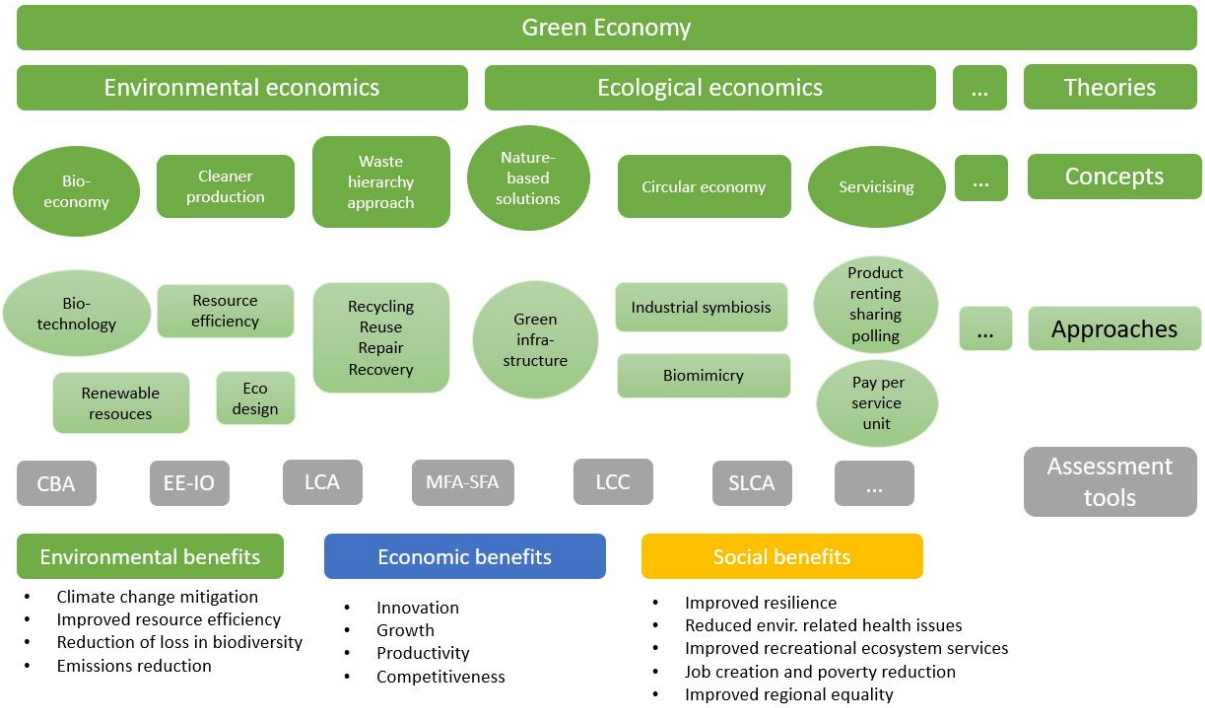


Table 1. Conceptual framework for implementing a green economy in practice (current concepts are marked with boxes, while emerging concepts are in circles). Simplified version, based on Loiseau *et al.* (2015).

Table 1 helps to illustrate some of the connections and context for the concepts presented above. It also provides a rough overview of environmental, economic and social benefits connected to the green economy.

2.2. Measuring the green transition and its interconnections

The production of goods and services is realised within all economic sectors, ranging from agriculture to manufacturing and trading, through to transport services, financial activities, etc. It is often difficult to follow the complicated interactions between economy, society and nature. This interaction is frequently opaque and may impede a timely recognition of what steps need to be taken. A number of good approaches provide a brief overview of these interconnections, however, including compound statistical models/frameworks, and these will be discussed briefly below.

2.2.1. Approaches to measuring environmental and economic linkages

The 'Drivers, pressures, state, impact, response' (DPSIR) approach is a framework which offers a model of intervention and understanding for the causal links between society, economics and the environment. The components can be described in the following way (FAO, 2004):

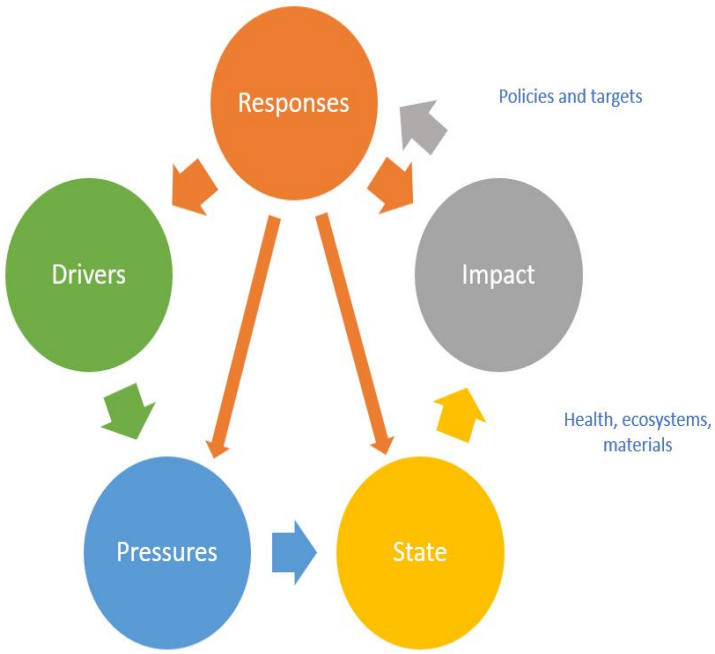


Figure 2. The DPSIR Framework. Based on Kristensen (2004).

- **Drivers:** Economic sectors and human activities
- **Pressures:** Stressors, such as pollutants and emissions
- **State:** The condition of the environment (physical, chemical, biological)
- **Impacts:** effects on ecosystems, human health, etc.
- (**Political) Response:** Prioritisation, target setting, indicators to mitigate effects and impacts.

The DPSIR model was created in order to capture information which shows how different activities in society affect the state of the environment and what is done to prevent further degradation. The connections are complex and difficult to describe, and they are often referred to in a sub-task sense (e.g. pressure – state) (Kristensen, 2004). Figure 2 explains the interaction between these forces.

Although the DPSIR framework provides a useful lens for understanding the complexity of all this, the main critique standing against the universal application of this framework is that the framework itself cannot generate neutral knowledge, because it 'reproduces the discursive positions the applicant brings into it' (Svarstad, Petersen, Rothman, Siepel, & Wätzold, 2008, p. 116). Furthermore, DPSIR has been critiqued for not being able to address or capture informal responses which might occur in reaction to environmental challenges (Carr *et al*., 2007). Carr *et al.* (2007) furthermore states that *'an issue that emerges within the structure of DPSIR itself through the unexamined, unacknowledged hierarchy of actors that this framework implicitly creates with its typology'* (Carr, et al., 2007, p. 544). It is therefore necessary to be mindful of all these considerations when applying the DPSIR method to understanding environmental, social and economic linkages.

Another internationally acknowledged comprehensive framework which considers links between the environment and socio-economic activity is the System of Environmental-Economic Accounts (SEEA). The SEEA looks at these linkages from a statistical point of view. The FAO (2014) states that SEEA is:

'a multipurpose conceptual framework that describes the interactions between the economy and the environment, and the stocks and changes in stocks of environmental assets,' and furthermore that the SEEA is based on a *'systems approach to the organisation of environmental and economic information [covering] the stocks and flows that are relevant to the analysis of environmental and economic issues'* (FAO, 2014, p. 1).

By using SEEA accounts, a number of relevant policy questions can be addressed. These include the questions concerning the use of natural resources, as well as responses made by governments to minimise environmental pressures (UN, 2014). This framework brings the relationship between the environment and well-being into direct focus. This relationship is not revealed through traditional measures of economic activity, such as GDP and national income.

2.2.2. Pressures and responses on the environment in the Nordic Region

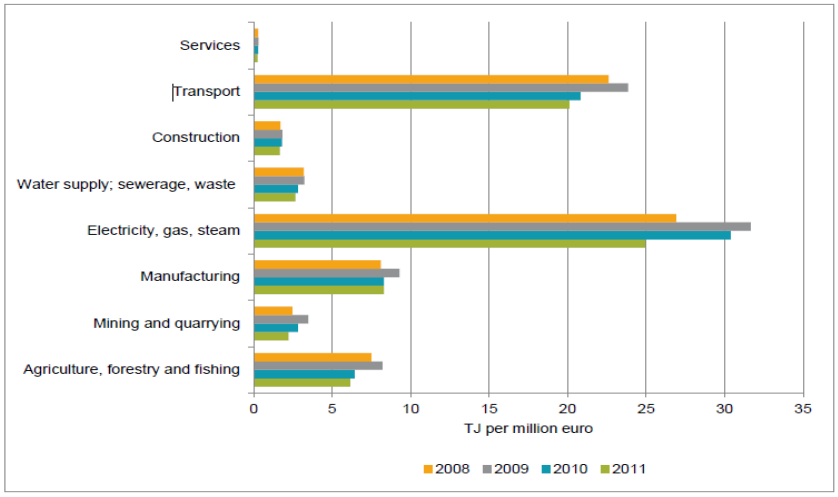


Figure 3 Energy fossil fuel use intensity, TJ per million Euro value added, by industry, NACE 2008–2011, Nordic countries total, excluding Iceland (Björk, et al., 2016)

In the Nordic Region, the largest consumers of fossil fuels are the transport and energy industries accumulated across all Nordic countries (Björk, et al., 2016) . That said, most industries are becoming more efficient in their use of fossil fuels, and the largest reduction of energy-use intensity has come from the very same supply industries: electricity, gas, steam and air conditioning (Björk, et al., 2016). The Nordic countries have all invested in renewable energy, and have established carbon taxes as an incentive to steer economic development towards a greener energy system. Environmental taxes are also increasing (Björk, et al., 2016). Björk *et al*. also point towards the difficulties of agreeing on a harmonised carbon tax system internationally. They say that it would imply that the cost for emitting would need to be the same, regardless of the country or origin. Regarding collaborative efforts, some projects already involve sustainable energy production. One example is the Swedish-Norwegian support measure *'Elsertifikat'.* This measure has been put in place specifically to encourage the production of energy from sustainable energy sources (Energifakta Norge, 2019).

The share of renewable energy as part of total energy supply across the Nordic Region is around 41 %, and 57 % of total energy supply is carbon neutral (Weber & Søyland, 2020). Looking at Figure 4 this is much higher than the EU average. These statistics still leave room for improvement in terms of mitigating adverse effects on the environment, but steps are being taken towards achieving carbon neutrality. In response to the UN Paris Agreement of 2016, Nordic Prime Ministers announced an acceleration of their climate policy, culminating in the common Declaration on Carbon Neutrality. This Declaration is a commitment by all countries to increase their efforts towards combating climate change as of 2020 (Weber & Søyland, 2020).

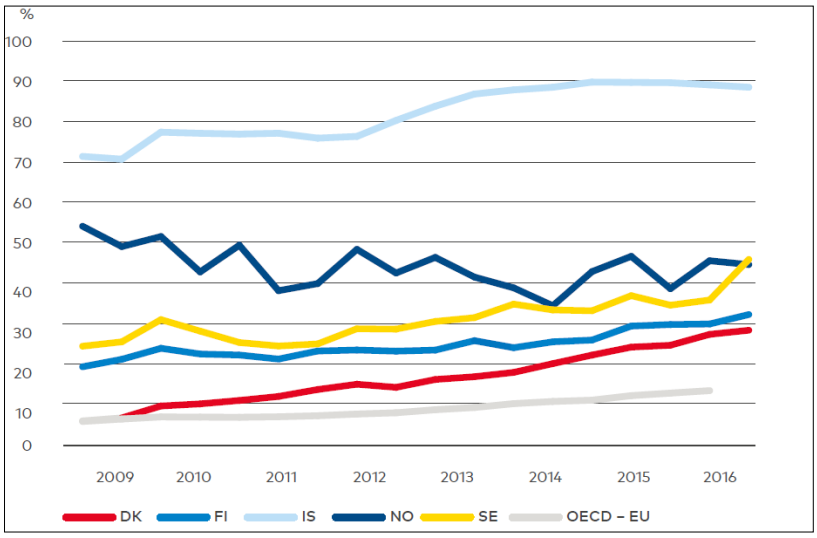


Figure 4. Renewable energy as a share of total primary energy supply (Nordregio, 2018).

Wind turbines. Photo: Jan Kopriva, Unsplash.

2.2.3. Green transition and the private sector

Multiple factors are driving the green transition. Looking back to the environmental pressure component of the DPSIR model, the driving forces which determine the scale of environmental pressure can also be recognised, concomitantly, as driving forces towards a green transition. The complexity, scale and the relevance of the former will ultimately correlate with the latter. In other words, the transition of the socio-economic system will need to happen in precisely those areas where environmental pressures and their driving forces lie. What stimulates pressure on the environment is the size of production and consumption activities in a given region. A negative impact on human prosperity is linked to degraded ecosystems and the stress on natural resources brought about by these socio-economic human activities. As seen in the DPSIR model, ensuring a green transition and the green practices that follow from it will therefore be interlinked with sustaining human prosperity. Aspiring to

achieve a green transition will also help to prepare communities to cope with a future that comes with many uncertainties and challenges.

The private sector plays a critical role in greening the economy. The drivers for corporate initiatives to support a green transition can be divided into two broad categories. These are 1) drivers related to changes in, or the limits of, natural resources and the ecosystem; and 2) drivers related to requirements and expectations from influential stakeholder groups. Seen in this way, preserving the environment could be a corporate opportunity involving economic gain. Considering the potential economic opportunities environmental preservation offers, waste should be seen as an inefficiency in the economic process. The appreciation of this has extended to the whole lifecycle of a product, incorporating circular economy practices, or sustainability management practices. This viewpoint indicates another paradigm shift: namely, the move towards lifecycle thinking (McCormick *et al.*, 2015). From a consumer perspective, information and knowledge is key to determining the relative sustainability profile of a company and the products they provide, in order to be able to make more sustainable choices. While companies need to change towards more environmental practices, they will also need to adapt to ensure competitiveness and growth. In order to achieve the desired transition, corporate practices and decisions must be aligned with broader social and environmental needs and priorities.

This brings us to Corporate Social Responsibility (CSR). CSR is not new and, as Carroll writes in 1983 and again in 1999: 'CSR involves the conduct of a business so that it is economically profitable, law abiding, ethical and socially supportive' (Carroll, 1999, p. 286). Coupling CSR to sustainable development, following on from the Brundtland Commission's report on *Our Common Future* (1987) has encouraged a concurrent focus on people, planet and profit (PPP) (Kolk & van Tulder, 2010). Corporate managements across the world have been asked to consider the impact of their activities on people and planet. But the actual level of impact, and the degree of mere 'window dressing' involved, is also discussed widely – especially in the discourse around international development (see e.g. Meyer, 2004; Frynas, 2008). Turning 'social problems' into economic opportunities is nothing new (Carroll, 1999), and the compatibility between the two comes down to their ability to understand the potential that the situation provides. Turning green transition into a profitable opportunity for the private sector – from SMEs to big businesses and multinational companies – could arguably help bring about a greener economy at a faster rate. But as this literature review has indicated, the question is in fact a 'chicken and egg' one: the speed of systemic change is seemingly both enabled and impeded by the complexity of existing interactions between the private and public sectors. In light of the DPSIR- model and social constructivist analysis, for example, the ability to agree or create a framework for action, and accompanying policy measures, is not inherently neutral. The journey towards green transition therefore becomes increasingly cumbersome, and cannot be straightforward. In relation to the more recent turn towards a stronger focus on climate change, Corporate Climate Responsibility (CCR) has more recently emerged. The Nordic Region is well-situated to make climate change and sustainability an even greater part of its business environment. See Box 1 for more information about the specifically Nordic characteristics and qualities for CCR.

Nordic qualities in CCR/CSR:

- Social responsibility
  Trust, norms and laws
  Culture of collaboration
  Long-term focus
  Public awareness of the role of nature and sciences
- Ambitious climate goals
- Technology competence
- Value-driven companies
  Environmental focus among core values
- Rich in natural resources
  Sustainable management of natural resources

Key factors for reducing GHG emissions in companies:

- Policy instruments and political framework
- Strengthened international cooperation
- Clear targets from management and owners
- Awareness of the climate issue
- Customer demand
- Committed employees
- Societal/political focus on circular/bioeconomy
- Purchasing power of the public sector
- Tax shift (tax on emissions rather than labour)
- Long-term frameworks
- Sustainable investment and green finance
- Increased focus on food security
- Access to cost-efficient renewable energy
- Digitisation
- Electrification and energy efficiency

Source: (Ekelund & Westling, 2018)

The main challenges for developing a green economy are often related to a general challenge faced by small and medium-sized enterprises (SMEs). This is a lack of funding that is linked to the fact that such investments have a long life-cycle and are capital intensive, and that emerging sectors are not familiar either to investors or to potential customers. Lack of cross-sectoral industry networks is also regarded as a significant obstacle to the development of green growth (Lindberg, Johnsen, Kristensen, Teräs, & Hodgson, 2016).

Rearranging the business model in favour of the environment altogether can provide an opportunity to combine environmental improvements with increased business value. This type of business model is likely to become more common in the future. One example is leasing a product, rather than selling it. Considering the management of environmental and societal impacts within the supply chain, imagining a company's different tiers within that chain would be helpful. The first tier represents those companies which provide the business with parts, materials and services directly into manufacturing. Second tier suppliers are those companies who provide to the first-tier suppliers. Third tier suppliers provide the second tier, and so on. However, real supply chains rarely resemble a neat chain, but are complex and intertwined webs. Upstream collaboration with service providers and suppliers is important in greening the economy, but it is not complete without making serious efforts in-house to increase the efficiency in the use of resources and to reduce waste.

While reviewing physical streams is important, going digital also offers companies interesting opportunities to save energy and resources – and thus cut costs. As McCormick has stated, 'moving bits in the digital world requires a fraction of the energy it takes to move atoms in the physical world' (McCormick *et al*., 2015). As Randall and Berlina also detected, in their report on the role of digitalisation for sustainable regional development, the human element plays an important part (Randall & Berlina, 2019). By the human element, Randall and Berlina refer to the mindset change needed to bring about change. Digitalisation may also produce smarter, but also potentially disruptive, business models, as they enable companies to move closer to their customers. This may also lead to increased transparency in the supply chain (Randall, L., Vestergård, L. O, & Wøien Meijer, M., 2020).

Sustainable competitiveness requires the preservation of biodiversity and natural regeneration capacity, through:

- Closed cycles, high quality, cleanliness, eco-design and sustainability criteria
- New ownership structures and business models, networking and clustering, shared value marketing processes and paths, shared competences
- Identification, support and evaluation of transformation processes, training of new bioeconomy experts.

Source: (Natural Resource Institute of Finland, 2018)

2.3. Innovation processes and the green transition

Innovation is defined as something novel in terms of knowledge and ideas, which are then applied in commercial markets or in society more widely. To understand innovation – whether it is a product, technology, services, societal or operational innovation – it is important to understand the difference between linear and systemic innovation models. Louiseau *et al.*, at the European Environmental Research Partnership (2015), suggested that transforming the economy requires innovation in terms of:

- Available technology
- Organisational support
- Market conditions
- Broader societal conditions
- Overarching governance framework
- Political will (needed most of all)

Altenburg and Pegels (2012) propose that innovation pathways in sustainability-oriented industries are country specific, due both to the important role of public policies and public finance, and to technological factors such as dependence on national infrastructure. The capacity for innovation is often considered in terms of path dependence and 'lock-in', and Schumpeter's concept of creative destruction. Schumpeter describes the 'gale of creative destruction' as the 'process of industrial mutation that incessantly revolutionises the economic structure from within, incessantly destroying the old one, incessantly creating a new one' (Scumpeter, 1994 [1942]). Path dependency is usually described as the way in which innovation is recreated within the same framework from which it came, locked into a system from which it cannot break free. History is rich in examples of both intentional path dependency, path creation, and path disruptions (Lema, Nordensvärd, Urban, & Lütkenhorst, 2014).

A linear innovation model estimates the development of products, technologies, and services from the traditional linear perspective: research leads to more applied research and development (R&D) activities. These in turn lead to piloting, demonstration, and finally commercialisation of the innovations that have been developed, and their wider diffusion in society. The traditional linear innovation model usually has one main driving force: either technology (technological push), or market (market pull).

Systemic innovation targets a system-wide view. It provides completely new value chains, new markets, and radically more effective ways of operating. It can link together innovations developed elsewhere and take these into new markets. In these terms, cooperation in open innovation among different actors is needed in both value chains and markets to enable the development and introduction of the various innovations. The advantages of systemic innovation include the possibility of creating significant value in a shorter time frame, with a reasonable development effort and the added possibility of utilising synergies between different competences, actors and value chains. The potential disadvantage of this approach is that it can be challenging to adapt in practice, particularly in terms of management and contractual relationships between various partners (Rönnlund *et al*., 2014).

2.3.1. Green Patents

Tracking and evaluating innovation processes is quite difficult. However, some tools do enable us to get closer to specifying the state of innovation in a given region. One of these involves following the generation and number of green patents. The definition of 'green technologies', and consequently of green patents, is widely debated. Patent offices define patents as green by using both objective and subjective measurements. Due to a lack of reference points, the patenting process is conducted on a case-by- case basis (Björk, et al., 2016) (SITRA, 2016). There is a promising pattern in the Nordic Region, involving a significant connection between the distribution of patents among different technological areas and the climate potential of these technological solutions. Whether it is conscious or not, it points towards a tendency that suggests that the most innovation-affected areas are the ones which contribute most to achieving carbon neutrality.

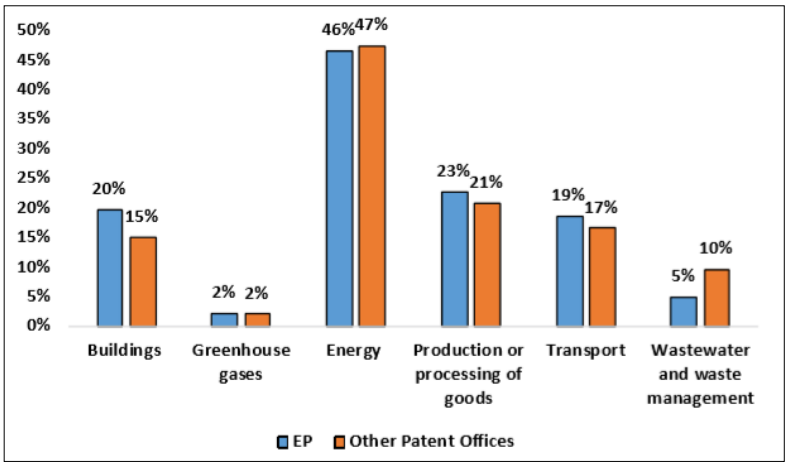


Figure 5. Distribution of patents among the six technological areas for EPO and other Patent offices – Nordic countries (Tanner *et al*., 2019).

Looking at Figures 7 and 8, patents are primarily distributed amongst the energy sector, construction, transportation, and the production or processing of goods.

In Finland, 75 % of the 1,700 green patents are distributed across three Climate Change Mitigation (CCM) technologies – production or processing of goods, energy, and construction (buildings). The patent activity is quite concentrated geographically. Helsinki-Uusimaa and Länsi-Suomi contribute to 75 % of all CCM technology patent families (Tanner, et al., 2019). Sweden's strength in the automotive industry is reflected in its position with regard to CCM technologies related to transport, with more than 900 patent families present.

2.3.2. Sustainable and Green Finance

Green finance is increasingly popular, and the financial news outlet Bloomberg wrote in the summer of 2019 that, 'Money is gushing into any kind of asset labelled green or sustainable. The frenzy now has investors and firms alike grappling with what counts as "green finance"—and with funds that are no longer seen as green enough' (Bloomberg, 2019), despite the indecision of some politicians.

Green finance includes a variety of green and sustainable bonds. Green bonds are *'issued in order to raise finance for climate change solutions. They can be issued by governments, banks, municipalities or corporations. The green bond label can be applied to any bond format, including private placement, securitisation, covered bond, sukuk* [Islamic financial bond/certificate, ed. note] *and others. The key is for the proceeds to be applied to "green" asset'* (Climate Bonds Initiative, 2018, p. 2).

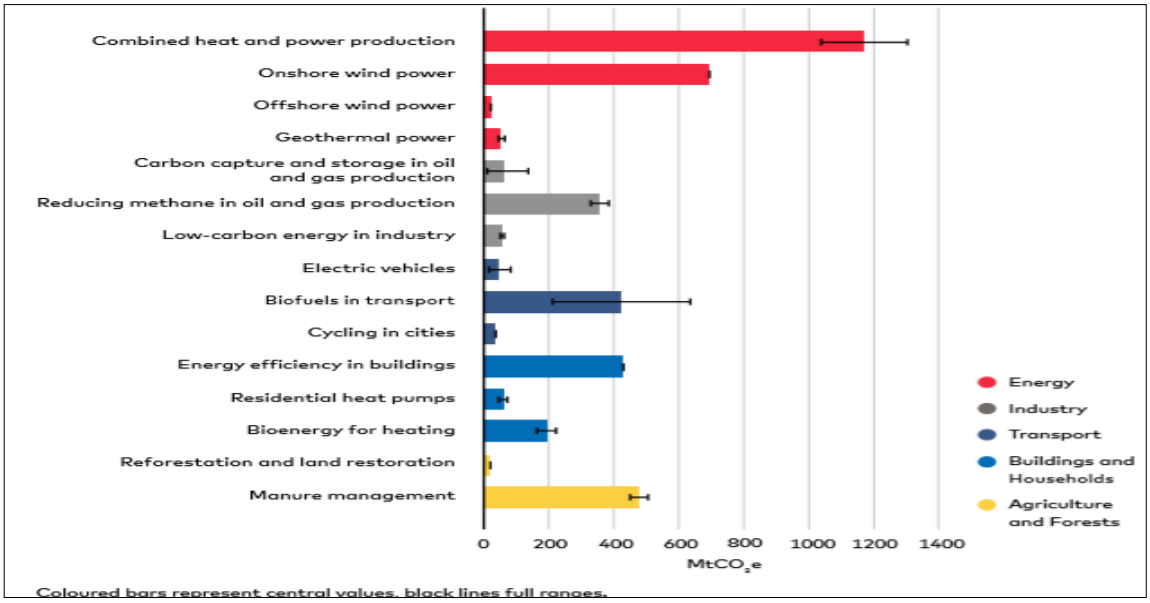


Figure 6. Total climate potential of solutions in 2030 (Nordregio, 2018).

Nordic countries embraced the green bond market when it was still in its infancy. Doing this may help track a region's intention to innovate in green technologies. The Nordic Investment Bank (NIB)[1] started issuing green bonds in 2010, with the first city bond being issued in Sweden in 2013. NIB is the biggest issuer of green bonds in the Nordic Region, according to the Climate Bonds Initiative (2018). In 2019, the aggregate amount was EUR 131.8 million by 30th November. That year, NIB allocated EUR 500 million to be invested in green bonds issued by companies or municipalities in the bank's member countries (Nordic Investment Bank, 2019). According to the Climate Bonds Initiative (CBI), the Nordic Region accounts for 6.7 % of global issuance and 18.5 % of European issuance, and in 2017 government-related issuers accounted for two-thirds of Nordic issuance (Climate Bonds Initiative, 2018). According to this report, Norway, Finland and Denmark are in the top 20 green bond issuers in the world, and Sweden is number six. Iceland was not mentioned in the report.

Sectors where the Climate Bond Initiative sees potential for green bond issuance include property (low carbon buildings and energy efficiency), forestry and the paper industry, rail transportation, waste management, and water and wastewater treatment – as well as certain renewable energy sectors, such as hydropower, biomass/biogas and electricity grids. In terms of the issuance of green bonds in relation to the low carbon buildings and energy efficiency sectors, Sweden secures third place after France and the USA, for example (Climate Bonds Initiative, 2018).

2.3.3. Examples of Nordic green innovation

In Finland, the key national coordinator for circular economy and industrial symbiosis is Sitra – an independent Finnish fund which reports directly to the Finnish Parliament. Sitra has started a national collaboration with interested companies in order to utilise the global market opportunities and to develop domestic and international strategies for targeted markets. To gain an

[1] NIB is a multilateral bank owned by Denmark, Estonia, Finland, Iceland, Latvia, Lithuania, Norway and Sweden (Climate Bonds Initiative, 2018).

understanding of the volume and scope of industrial symbiosis activities in Finland, the Finnish Industrial Symbiosis System prepared a map showing the location and distribution of such activities across the country. According to the strategic ten-year goals outlined in the government programme, Finland is aiming to become the world leader in bioeconomy, circular economy, and cleantech.

In Sweden, although no national industrial symbiosis programme or strategy exists, relevant work has been underway in relation to business projects, demonstration areas, research projects, etc. For example, Linköping University has a research unit focusing on industrial and urban symbiosis, and it has been highly involved in a project in the Biogas Research Centre (Linköping Universitet, 2021). The research group at Linköping University also developed the Swedish Platform for Industrial and Urban Symbiosis, which was established in 2015 (Johnsen, et al., 2015). The aim of this platform is to mobilise and improve the capacity of Swedish municipalities and regions to support the development of industrial symbiosis; to support regional facilitation nodes; to increase visibility and connect initiatives, to have a stronger position in meeting with the national authorities, and much more. Part of this network is, *inter alia*, the industrial and social symbiosis network in Sotenäs 'Symbioscentrum', and industrial and urban symbiosis networks in Örnsköldsvik, Stenungsund and Karlstad (Svensk Plattform för Industriell och Urban Symbios, n.d.).

Circular economy was selected as one of the key projects in the Strategic Programme of the Finnish Government from 2016 onwards. Finland has demonstrated high performance levels in terms of eco-innovation (40 % higher than the EU average). Approximately 17 % of all Finnish firms implement innovation activities aimed at improving energy intensity. About 17 % of companies also seek to reduce overall material input through innovation. These shares are 60 % and 73 % higher than the EU average, respectively. The main high-level driver of eco-innovation stems from the fact that Finland still ranks among the world's best in R&D intensity, in addition to performing well in terms of scientific and technological excellence. Finland has several hot-spot clusters in technological areas such as materials, energy and agriculture. Impressively, most wood waste in Finland ends up being used as an energy source. The country has a new generation of young people and students who have, in recent years, helped to create a broad ecosystem of start-ups and venture capital investors, many of them focusing on fields related to the circular economy and to eco-innovation (Lastunen, 2016). Sweden can also demonstrate efforts in achieving a circular economy. In 2017, the Swedish Government appointed task forces to be an advisory body to government on circular and bio-based economic issues (Regeringskansliet, 2017).

Many different types of innovation are required in order to take advantage of opportunities in bioeconomy. These include product, technology and service innovations, as well as societal, systemic and operational innovations. The systemic innovation model is particularly interesting for bioeconomy, because bioeconomy is, in essence, a systemic transformation within business and society (Rönnlund *et al*., 2014). Correspondingly, it is interesting to consider the major opportunities and needs of the Nordic biorefining industry. Biorefining is the process of refining various biomass feedstock for the production of bioenergy and other bio products. It has been identified as Europe's most promising route to a bio-based industry. The types of biomass available are quite variable within the region. The report, involving 37 Nordic biorefinery stakeholders, derives from 2016. From what it says it is clear that stakeholders from Finland and Sweden focused mostly on wood-derived biomass, the utilisation of which can be supported by established value chains, technologies and equipment from the existing forestry, pulp/paper and chemical industries. Iceland, the Faroe Islands

and Greenland focus mostly on the utilisation of sustainable natural biomasses, waste from fish and shellfish processing industries, and household waste (Björk, et al., 2016).

Looking at things from a Nordic perspective, the wind power industry has great potential for eco-innovation. The wind power industry operates on two different levels: the core technology level (the wind turbine), and the deployment level (the installation of turbines). However, there is no strict distinction between the two. For example, turbine manufacturers partake in deployment in various ways. So different paths may emerge at both levels. While there are rival turbine designs in core technology, there are also a variety of deployment models. The key determinants of innovation paths within the wind power industry are government policies, firms' strategies, stakeholder networks, and demand conditions. Specific innovation paths are presented in terms of turbine size, turbine quality/reliability, turbine design, onshore/offshore installation, project size, and deployment services. Key determining factors are:

- Government policies
- Policy measures (demand-side, supply-side)
- Demand and supply conditions
- Business context (corporate strategies, vertical or horizontal integration, internalisation, domestic versus export market focus)
- Firm networks and clusters
- Geographic factors.

Current wind power industry ownership structures and financing models are shifting in favour of big business. The same applies to the innovation process itself, i.e. to the formerly community-based and collaborative innovation model in core technology. This has changed from being a predominately informal process to a more organised one in which formal R&D plays a more important role. The increasing maturity of the technology involved means that experience-based learning has been replaced by more formal learning methods (German Development Institute 2014).

Denmark's path in the wind energy sector is outstanding. Denmark has been the world leader in turbine technology for more than thirty years (Lema, Nordensvärd, Urban, & Lütkenhorst, 2014). This status has been achieved with strong support from government policy. Today, wind energy constitutes more than 30 % of electricity consumption in Denmark. A 2012 agreement reached by all major parties in the Danish parliament stipulates that, by 2020, 50 % of the electricity consumption in Denmark shall be supplied by wind power. As the German Development Institute concluded in their overarching study of wind power, national policies and institutions are pivotal to the creation of this pathway. There is a complex interplay of specific determinants in each country that may determine processes and outcomes. According to the German Development Institute, natural potential in their 1.3 metres of coastline per capita played a major role in kick-starting the Danish wind energy sector. The Danish Government has not provided R&D support to specific technological developments, but it has provided R&D support to research conducted across a broader technological field. Therefore, decisions regarding the further development and commercialisation of the wind energy sector seems to have been made primarily at the level of companies. For this reason, corporate strategies appear to be important for driving change and development, which prompts a question about the extent to which innovation paths are also company-specific (German Development Institute, 2014). Although the geographical scope is outside the arctic aspect, wind energy is relevant from the arctic perspective. It is important to note that the operation of *wind turbines* in a cold climate involves additional challenges not present in warmer locations. This may give rise to further innovation potential. Challenges to developing a green economy are often related to a general challenge for small and medium-sized enterprises.

These challenges are particularly related to a lack of funding, investment, and an absence of cross-sectoral networks.

Industrial symbiosis is an approach to realising green economies, e.g. the circular economy or the bioeconomy. The fundamental principle of industrial symbiosis is an exchange of resources between firms. It is possible to distinguish between three main types of exchange: by-product re-use (substituting for commercial products or raw materials); utility/infrastructure sharing (the management of commonly used resources, such as energy, water, electricity, heat, and joint treatment of emissions); and joint provision of services (such as transportation or food provision) (Martin, 2013). Through these symbiotic activities it is possible to minimise the input of raw materials, while simultaneously eliminating waste and interlinking traditionally separate industries – such as the physical exchange of materials, energy, water and by-products – in order to create mutual benefit (Boons *et al*., 2011). Industrial symbiosis usually occurs between geographically proximate firms, e.g. firms co-located in clusters or industrial parks, as well as at a regional level (Paquin 2009).

In sum, green innovation may be characterised by many different factors. For green innovation to transform the economy it will require innovation in many different areas – such as technology, organisational structure, markets, governance, and politics. Innovation pathways in sustainability-oriented industries are particularly country specific, and systemic innovation is preferable to the regular linear model. Tracking and evaluating innovation processes is not easy, but it is somewhat simplified by the ability to track movements through green bonds and green patents. Industrial symbiosis is a good approach to consider for the purposes of realising a green economy. There are several success stories concerning this within the circular or bioeconomy. Many different types of innovation are required in order to take advantage of opportunities in the bioeconomy. These include product, technology and service innovations, as well as societal, systemic, and operational ones. The business ecosystem in bioeconomy-related recreational services is relevant for all Nordic countries

Regarding Nordic innovation potential, obstacles include lack of finance, difficulties in achieving commercialisation, the Nordic market being relatively small and lacking a track record, unclear beneficiaries, and insufficient experience in open innovation among multiple parties. The branding of the bioeconomy (in an effort to bringing companies, researchers, investors and venture capital and politicians together), may facilitate further conversation, and therefore improve cooperation, funding options and regulation for promoting advanced, value-added bioeconomy sectors, according to Rönnlund *et al.* (2014).

3. The Green Transition in the Nordic Region

3.1. Green growth in Nordic regions

Nordic regions, being relatively well-endowed with natural resources, carry great potential for both future regional and local development (Refsgaard, et al., 2020). Although successful regional and local development hinges on finding or optimising existing organisational and institutional structures, getting there would contribute towards a reduction in greenhouse gas emissions, while enhancing skills development, new jobs and general economic growth in rural areas (Refsgaard, et al., 2020).

In 2015-2016, Nordregio published a working paper on interventions for ensuring the green economy (Lindberg, Johnsen, Kristensen, Teräs, & Hodgson, 2016). Their survey found that the following topics were the most relevant ones for green transition in these regions[2] (2016, p. 36):

1. Renewable energy and solutions
2. Waste handling and recycling: industrial symbiosis between companies
3. Promotion of green or circular business models for entrepreneurs and existing companies
4. Sustainable transport solutions
5. Primary production (e.g. the bioeconomy: agriculture, forestry, fisheries etc.)

The barriers to putting these actions and measures in motion were also listed. These can be summed up as policy and legislation; finance and funding, and stakeholder communication (Lindberg, Johnsen, Kristensen, Teräs, & Hodgson, 2016). The study found that, at the national level, the sustainability part of the green economy often gave way to a focus on technological solutions, rather than addressing the *systemic aspects* of enabling a greener economy. Other challenges mentioned by key experts interviewed for the study included a weak focus on the integration of local perspectives in national policy making, uncertain future demand for upscaling production, and ineffective public procurement efforts (Lindberg, Johnsen, Kristensen, Teräs, & Hodgson, 2016, p. 43).

Ensuring a future labour force with competence in green growth industries was also on the list of challenges, along with focusing on developing strong educational programmes and courses (*ibid*.). The International Labour Organisation (ILO) also points to this, because the green transition and aspirations connected to innovation around the circular economy and green growth necessarily demands investment in skills and competence development (ILO, 2019). The main driver of skills for green jobs is the 'changing environment, policy and regulation, green technology and innovation, and green markets' (ILO, 2019, p. 55).

Generally, governments in the Nordic Region have given high priority to clean technologies and green growth, and in that sense follow developments seen throughout the EU. As a part of this priority, the Nordic Prime Ministers set up a green growth initiative in 2016, looking to further development of the green economy within the region. Incorporating the industrial perspective into these processes can be a key element in making the initiative a success (Lange, Björnsdottír, Brandt, & Hildén, 2015). When looking at the case of Nordic bioeconomy, Lange *et al*. wrote, in 2015, that the bioeconomy was developing more rapidly than expected, particularly in R&D and businesses – but that a number bottlenecks prevented further growth. These bottlenecks, as seen in the Nordic Region, were primarily a lack of political ambition towards elevating underexploited bioresources,

[2] The report states that the low number of respondents may distort the ranking of the topics. Therefore it cannot be used as an exhaustive list of high-ranking topics, though it remains indicative (Lindberg *et al*., 2016, p.36).

and the slow development of a favourable frameworks for stimulating new bio-based industries (Lange *et al.*, 2015, p. 20).

The *Finnish Bioeconomy Strategy* is multi-fold, combining a competitive environment for businesses where there is room for new ones to grow, a strong focus on the sustainability of biomass resources, and building skills and competence to move the bioeconomy forward (Ministry of Agriculture and Forestry of Finland, 2014). This strategy is anchored across governmental agencies, ministries and institutes, and the implementation and monitoring of the strategy's progress is supported by a bioeconomy panel. Lange *et al*. (2016) point towards the importance of open access test facilities having been important for the research and development of biofuels in Finland. The Finnish focus on R&D&I for supporting the development of the bioeconomy is also evident in the number of universities and funding opportunities available (Lange, Björnsdottír, Brandt, & Hildén, 2015). Scanning the Nordic Region, Finland, Norway and Iceland all have pronounced bioeconomy strategies to point towards. Similar strategies are underway in Sweden and Denmark, with a bioeconomy panel supporting its development in each case (See: Swedish Parliament, 2019; Ministry of Agriculture and Food in Denmark, 2019). Table 1 shows some examples of different national strategies towards enabling greener economies across the Nordic Region.

Looking at the Swedish case in Lange *et al*.'s overview (2015), the focus on the bioeconomy is vested in the EU's definition. In recent years there has been an upsurge in funding opportunities connected to the development of the bioeconomy. Sweden is endowed with great natural resources which are capable of being utilised and optimised in the years to come – both within the usual suspects (such as the forestry industry and agriculture), but also in underused resources such as marine applications. Thus far, there has been no concerted bioeconomy strategy written on behalf of the Swedish government. But a group was appointed in 2019 to develop such a strategy. In 2018, explorations into possible collaborations were launched between the Research Institute of Sweden (RISE) and the Technical Research Centre of Finland (VTT). The agreement signed by VTT and RISE in Espoo, Finland, in May 2019 will help strengthen efforts to collaborate on test and demo infrastructures for the bio-based and circular economy (VTT, 2019).

As Rönnlund *et al*. (2014) point out, there is a mix of policy level strategies and strategies for R&D&I, and the latter can be found in all Nordic countries (See Figure 2). Rönnlund *et al*. further stress that, although the development of R&D&I is a vital part of the development of a green economy, a policy framework is also important in ensuring a common vision. This is particularly important with regard to existing infrastructure and the operational environment, because the room to manoevure for R&D&I is dependent upon favourable policy frameworks and regulation.

The study conducted on behalf of Nordic Innovation also found several bottlenecks connected to the realisation of the Nordic bioeconomy and green growth. These bottlenecks were in the lack of capital, lack of funding and lack of knowledge and familiarity with the bioeconomy amongst investors, customers and a larger number of actors in the field, for example. This is particularly evident when comparing the situation to other markets, such as that of the USA. Access to larger markets outside national territorial boundaries is a key enabler in driving the bioeconomy, as the home markets tend to be too small to provide the necessary momentum (Rönnlund *et al*., 2014).

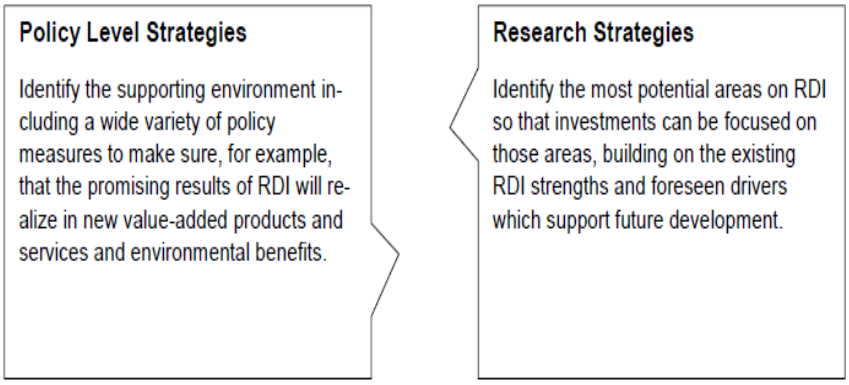


Figure 7. Type of strategies (Rönnlund *et al*., 2014, p.24).

The study conducted by Rönnlund *et al*. also points to those areas with the greatest innovation and growth potential for bioeconomy across the Nordic Region in 2014. The value-added seemed to be situated in crosscutting areas such as bio-based chemicals, biomaterials, biofuels and bioenergy, biorefineries, resource-efficiency and industrial symbiosis, and services based on ecosystem services (2014, p. 29). Furthermore, supporting these areas through design may play an important role for creating intangible value. The report lists a number of support measures to enable green growth through the bioeconomy. These include: making access to financing easier for small and medium-sized enterprises (SMEs); including venture capitalists in networks to help create a knowledge base for the value added by the bioeconomy and similar concepts; enhancing the support to find commercially viable applications and connect these with markets and customers (bridging the 'valley of death'); and finally, strategically using public procurement as a way to create demand (Rönnlund *et al*., 2014, p. 9). The latter is a strategy which has been adopted in one way or another, in terms of sustainability measures, at the national level across the Nordic Region.

The Nordic Region is cooperating in many areas, and collaboration between ministerial levels dates back to the 1970s. Promoting sustainable development has been on the agenda for a long time. The Nordic countries share values regarding the importance of a healthy environment, sustainable economic growth, and wellbeing for all citizens. Although the industrial development and economic structures of the Nordic countries differ from one another, the Nordic Region was the first macro-region in the world to adopt a Strategy for Sustainable Development in 2001. The most recent strategy, entitled *A good life in a sustainable region,* was adopted by the Nordic Council of Ministers in 2013. This strategy explains that all work conducted by the Nordic Council of Ministers will incorporate a sustainability perspective. The strategy's outlook is towards 2025, and the focus areas are, for example: the Nordic welfare model, viable ecosystems, changing climate, sustainable use of the earth's resources, and education, research and innovation. *Vision 2030* was adopted by the Nordic Prime Ministers and the Ministers for Nordic Co-operation in August 2019. It sets out an ambitious framework for future collaboration. This vision is based upon the idea that the region will become the most sustainable and integrated one in the world. To achieve *Vision 2030*, the following areas will be targeted:

From *Vision 2030* (Nordic Co-operation, 2019):

- **A green Nordic Region** – together, we will promote a green transition for our societies, and work towards carbon neutrality and a sustainable circular and bio-based economy.
- **A competitive Nordic Region** – together, we will promote green growth in the Nordic Region, based on knowledge, innovation, mobility and digital integration.
- **A socially sustainable Nordic Region** – together, we will promote an inclusive, equal and interconnected region, with shared values and strengthened cultural exchange and welfare.

3.2. Arctic green transition and business innovation

This section will focus on the three main areas under scrutiny for knowledge development in the GROM-project: waste management, logistics, and the maritime sector. In addition to these, the authors have included aspects on transportation under the logistics umbrella, and a shorter paragraph on the potential of the marine sector in the green transition. The latter provides insights into examples which show how entrepreneurship and cluster-efforts can help elevate new ideas. As the GROM-project is primarily focusing on Northern Norway and the Arctic, examples are taken from outside this context, providing a menu for potential Nordic benchmarking.

Resources in the Norwegian Arctic contribute significantly to overall Norwegian value creation, and the Arctic's marine resources play a particular role in the further development of the region (Regjeringen, 2017)). Coupled with marine resources, the renewable energy potential is significant. Following the Norwegian Government's Arctic Strategy (2017), and the EU's ambition of mitigating emissions by 20 % in 2030, the project aim is three-fold. It revolves around the aforementioned objectives: 1) Strengthening the collaborative capacity between commercial and industrial actors in the Northern Norway moving towards an industrial green transition; 2) Building knowledge capacity about private and semi-private companies' actions regarding choice of technology, production methods and energy sources as alternatives to fossil fuels and traditional production methods, while also clarifying the connections between profit, innovation and the green transition in product and service provision; 3) Increasing knowledge around the ability of businesses and industries' to act for sustainable development: this includes their room to manoeuvre, barriers and innovation processes. To answer these objectives, this report on the green transition aims to address the following research questions:

1) What are the driving forces behind the green transition?
2) What characterises innovation processes in businesses working with the green transition?
3) What does the 'green transition' mean in relation to businesses, and what does 'transitioning to environmental sustainability' mean in the maritime and marine sector and in waste management and logistics?
4) Which barriers surface, and what are the conditions needed for sustainable transitions?
5) In what way could experiences from Finnish and Swedish industries and businesses provide increased knowledge capacity for the necessary framework conditions for sustainable and environmental innovation in an Arctic/Northern Norway context?

3.2.1. Waste management

The Waste Framework Directive 2008/98/EC sets out measures to protect the environment and human health by preventing the generation of waste, adverse impacts of the management of waste, and the overall impact of resource use – seeking to improve the efficiency of such use. The Waste Framework Directive was updated in 2018 to reflect the European Union's increasing focus on sustainable management of resources (European Union, 2018). As mentioned in section 1.1, the amendments seen in Directive 2018/851 seek to solidify efforts regarding the circular economy and green growth. In 2019, the Joint Research Centre within the European Commission published a policy report on the state of play in waste management. This report defined the waste management hierarchy, among other things, outlining that landfilling is the least preferable option and should be limited to the necessary minimum (Blengini, Mathieux, Mancini, Nyberg, & Viegas, 2019).

Nordic countries have prioritised their waste prevention programmes, as well as areas identified as having the highest environmental impact (NCM, 2015). These sectors are:

- Food / Packaging
- Textiles /Furniture
- Electric and electronic equipment
- Building, construction and demolition

Critical Raw Materials are important to the European economy, and particularly to the Arctic region. This provides considerable room for change when greening the economy. Improving the circular use of CRM is an objective of various policy documents. It is a key tool for improving supply security, and it is pointed out that the industry needs to be reimagined to reduce risks of supply disruption anyway. The availability of data and information on secondary materials, as well as a harmonised legislative framework, appears to be crucial for the large-scale implementation of recovery practices. Non-energy raw materials link to all industries across all supply chain stages. They are therefore fundamental – and currently irreplaceable – in driving change, for instance through digital technologies, low-carbon energy technologies (e.g., solar panels, wind turbines, energy-efficient lighting) and sustainable mobility (e.g., electric vehicles). Furthermore, very little knowledge is currently available about the potential of secondary raw materials (SRM) in mining waste, municipal solid waste, and industrial waste. Although Eurostat collects and reports relevant data, for example on volumes of extractive wastes and on statistics about the flows of municipal solid waste disposed in landfills, there is no systematic and consistent collection of data relevant to raw materials contained in these wastes flows (Mathieux et al., 2017). The Smart Ground H2020 project (2015-2018) was funded under Horizon2020. It targeted the main waste streams, including extractive, industrial and municipal solid waste. The project involves 14 partners from five countries, with Finland taking part from the Nordic Region. Knowledge of the quality and quantity of such wastes is fundamental in evaluating potential SRMs exploitable from different waste streams. In order to collect relevant information on waste characteristics and volumes, a total of 10 sites were investigated as pilots (Blengini, Mathieux, Mancini, Nyberg, & Viegas, 2019).

Besides energy-efficiency, material efficiency of natural resource utilisation is pivotal. Ideally, materials are to be implemented in a closed-circuit system which not only reduces GHG emissions, but also reduces the amount of waste generated, without endangering natural ecosystem services.

The EU directives regarding waste management impact on the legal framework for competition in waste management across the Nordic Region. The municipalities still enjoy extensive rights in managing waste, and as waste management is conceived within EU directives, this allows the member states and the EEA to go about fulfilling the requisite targets as they see fit. This may be one of the reasons behind the different setups of waste management across the Nordic countries, as the report from the Nordic Competition Authorities (Nordic Competition Authorities, 2016) states. In their report *on Competition in the Waste Management Sector – Preparing for the Circular Economy*, the Nordic Competition Authorities recognise the profoundly transformative challenges that the circular economy may bring to the waste management sector. In addition to venturing further into R&D&I, and the need for improved policies and legislation, the authorities point to the need for a mindset change: the move from 'waste management' to 'waste *market* management', since 'Waste management of a circular economy implies a market and competition-based industry' (Nordic Competition Authorities, 2016, p. 161). The competition that ensures this will demand availability of waste resources, and systemic adjustments must follow.

3.2.2. Logistics and transportation

The role of logistics is increasingly important, as the supply chain has become increasingly globalised (Zacharia & Mentzer, 2007). A greater degree of customisation of products and services also constitutes a reason for the newfound focus on making logistics part of regular business strategies (Isakson, 2012). Isakson points out that the general 'greenification' of the logistics sector is partly due to the pressure experienced among companies to meet and adapt to the future; but it is also partly triggered by wanting to stay ahead of the curve in terms of global competition (Isakson, 2012). The degree to which green aspects are incorporated within the logistics practices of a company depends upon both customers and senior management. Demanding green logistical services to transport goods is also seen in global companies, such as the Dutch beer-brewing company Heineken. In 2019, Heineken launched a pilot project to transport cargo on electrically powered inland barges. The company will also be using electric trucks for last-mile distribution (Supply Chain Movement, 2019). In the Nordic Region, a group of experts from the Nordic Council proposed that the Nordic Swan ecolabel could be used to certify logistics companies, and that transport and taxation policies across the Nordics could be developed with a view to favouring low-emission/zero-emission transport (Nordic Council, 2016).

Digitalisation and transportation meet in the 'sharing economy'. The Aurora project, centred around the Main Road 21 Kolari – Kilpisjärvi in Finland, promoted smart transport automation in an Arctic context, and developed the *Mobility as a Service* concept. The goal was to create an internationally unique smart transport testing ecosystem for extreme Arctic conditions in the Lapland region. The Aurora project tested various digital transport infrastructures and smart-car initiatives which allow transport-related message delivery between the road users, the service providers and the authorities, for example (Finnish Transport Infrastructure Agency, 2018). The project was completed in 2018.

Furthermore, a proposal by a group of experts from the Finnish Innovation Fund suggested enhancing the role of employers in the promotion of carbon-neutral and health-promoting commuting. This was to happen by increasing the mobility service based on shared use of vehicles. To achieve this suggestion, there would need to be financial steering methods and incentives supporting the goal. This could be achieved by (for example) offering mobility packages as side benefits, reforming the deduction of commuting expenses, and providing benefits for mobility planning to employers. The 'green deal' was launched in 2019, aiming to engage as large a number of employers as possible in achieving common carbon-neutral mobility goals. This was to include major growth in the volume of people using public transport, shared-use cars, commuting by bicycle, and car sharing (SITRA, 2019).

Returning to the demand on logistics companies to 'go green', greenification happens across the supply chain – also down to the warranties from engine manufacturers in terms of fuels. In 2015, vehicle manufacturers such as Volvo, Scania and Daimler greenlighted the use of hydrogenated vegetable oil (HVO) in their vehicles: namely, the ones operating on a Euro VI engine range (Neste, 2016). HVO is a drop-in fuel based on vegetable or animal fats, and it meets the fuel standard EN 590. It is not to be confused with first generation biodiesel (FAME), which has a different chemical composition, and which has generally been frowned upon by engine manufacturers because it damages engines. However, being able to use HVO in engines opens up the possibility of a greener (heavy) transportation fleet.

3.2.3. Maritime sector

Nordic shipping companies own approximately 20 % of the world's shipping fleets. Consequently, the Nordic countries have a special responsibility for leading the way when it comes to developing more energy-efficient maritime transport (Nordic Council, 2016). New pilot and demonstration projects have recently focused on developing fresh product service systems for ballast water systems, the development of electrical ferries (or retrofitting existing ferries with green technologies), the development of scrubbers for reducing SOx and NOx emissions, and the use of bio-LNG as fuel in long-distance cargo and roro shipping (Andersen, et al., 2019)

The maritime sector's efforts to reduce carbon emissions are mainly focused on shipping, port operations and shipyards. The global shipping industry is one of the most direct sources of GHG emissions to the world's oceans (Islands Formannskabprogram, 2014). The SECA and ECA zones in Europe are also placing stringent requirements on SO_x and NO_x emissions. Solutions to find ways to limit these further are being developed.

Cruise and cargo. Photo: Vidar Nordli Mathisen, Unsplash.

An increasing proportion of ferries and short-sea shipping vessels are demonstrating both hybrid and full-electric solutions. This requires extensive infrastructural development, not only to find adequate charging stations, but also to face challenges in the development of the grid *contra* the existing electricity usage onboard e.g. cruise ships (see e.g. Teknisk Ukeblad, 2017). The electrification of ports could further contribute to the reduction of emissions. Current harbour emissions involve docked ships, since they burn fossil fuels to produce electricity. Running ships on shore power has great potential for minimising local pollution (Islands Formannskabprogram, 2014)

The maritime industry in North Jutland evolved from the existing shipbuilding industry in the region. This has a high concentration of knowledge organisations and educational institutions engaged in the development of new competencies and skills for the maritime industry. After a case study examining the region in terms of hindering and enabling forces in greening the maritime sector, the main barriers appeared to be as follows. First, the slow regulatory developments. The regulatory landscape at the international, EU and national level for greening the maritime sector has been lagging behind, and it is somewhat fragmented between the different authorities. Another significant challenge is related to the significant amounts of time involved in getting a new regulation passed at International Maritime Organisations (IMO) level. This is because the global organisation requires consensus between different member countries when passing new regulations. However, regulatory initiatives at the international level have still provided a blueprint for driving the greening of the maritime sector. Considering the Danish example, a lack of incentives is also among the barriers to greening maritime operations. Stakeholders such as ship owners and equipment manufacturers often face significant barriers to investing in green technologies, since

they lack relevant incentives. Finally, the maritime industry has faced challenges in greening due to low levels of co-operation between the different stakeholders (Andersen, et al., 2019).

3.2.4. Marine sector

The marine sector also plays an increasingly important role in the development of the bioeconomy and green transition in the Nordic Region (Refsgaard, et al., 2020). With strong actors in both Norway and Iceland, these countries are at the forefront of R&D&I in the marine sector. The new bioeconomy brings about new opportunities both outside and within the traditional sector.

One example is the Iceland Ocean Cluster, which creates value from by-products of the extensive Icelandic fishery sector. The Iceland Ocean cluster brings together actors within the 'new' seafood industry. It opens up a plethora of product possibilities through research and data analysis. What is also interesting about the Iceland Ocean cluster is that is does not focus solely on the development of ocean biotechnology in companies developing therapeutics, cosmetics, and exotic fish-based leather. It also emphasises the importance of the new knowledge spill-over effects that occur when the 'old' and 'new' seafood industries meet (Iceland Ocean Cluster, 2020). The Iceland Ocean Cluster is a cluster enabling entrepreneurs and smaller businesses to reach their potential through their networks, and through incubator and consulting services. What remains to be seen is whether the willingness and ability of the 'old' seafood industry to adopt or absorb new knowledge can be sustained, and whether this will have an effect on the overall status of (and mechanisms within) the traditional part of the industry.

4. Enabling the green transition

4.1. Enabling and impeding factors for sustainable transitions

The main challenges to developing the green economy are often related to a general challenge for SMEs, namely a lack of funding linked to the fact that such investment has a long lifecycle and is capital intensive; and the accompanying fact that emerging sectors are not familiar to investors or potential customers. Lack of cross-sectoral industry networks is also regarded as a significant obstacle to green growth development.

Regulations and economic instruments are among the enablers of sustainable transition. Enterprises rely on public authorities (through the implementation of policies) to control demand, and thereby to guide the environmental technology market. Legislation, including environmental taxes and quotas, is important for the sale of existing environmental technologies and the development of new ones. Without such regulation, there is little chance of a demand for such technology. Studies confirm that strict environmental policy is crucial for corporate investment in environmental measures. This includes financial penalties for polluting. Such penalties are also crucial for green technology to become viable in the long term (Nordregio, 2016). Making sustainable development a key part of the assessment of applications for public funding is already part of many strategies. However, the scale of this, and unification of policies, could be heightened and improved, as the Finnish Innovation Fund points out (SITRA, 2019).

The overall proposals of the Nordic energy group for potential Nordic policy cooperation on green energy provide an insight into the necessary conditions for a particular element of the transition (Nordic Council, 2016):

- They propose constant exchange of experience at the Nordic level (the Nordic action plan on energy co-operation for 2014–2017 states that, where appropriate, it may be necessary to develop joint Nordic positions ahead of EU decisions).
- It is also suggested that there should be a joint energy research, a joint endeavour on energy efficiency, and a stronger joint electricity market (ensuring a growing supply of electricity from wind and solar sources, strengthening power grid links between the Nordic countries, and establishing a joint Nordic end-user market for energy – which will also ensure a reliable supply of energy).

There is very limited information regarding how progress can be made in terms of the green transition. Standards and measures are uncertain, and are based on traditional measures of economic activity (e.g. GDP). While many initiatives can be found at the national/local level, there is a particular inconsistency and lack of agreement on what indicators to use for analyses within specific areas. These include indicators for the re-structuring of labour markets, organisational and production processes, the adjustment of education and training systems, and promoting general low-carbon activities. The necessity of measurable indicators has been mentioned in OECD's Green Growth Strategy, which looks at Greater Copenhagen, and which targets four areas of analysis (OECD, 2012):

1. Changes in productivity in the use of environmental assets and natural resources
2. Natural asset base
3. Environmental dimensions of quality of life
4. Policy responses and economic opportunities.

The links between ecosystem services and the green economy are evident. These connections can emerge within forestry, mining, water supply, the food sector (agriculture, game, fisheries), cosmetics and pharmaceuticals, the textile industry, and the generation of tourism. On the way towards a green economy, the integration of the value of ecosystem services into national policies and decision-making processes is fundamental. It can be done by identifying and developing a common set of indicators to monitor the status, trends and socio-economic value of ecosystem services, and to assess nature's long-term ability to provide services. There are still significant gaps in the information available on biophysical status. Available data is mainly based on specific case studies, and is therefore inconsistent (Jäppinen & Heliölä, 2015).

The green economy is likely to consist of a mixture of new objectives and new ways of doing things. These in turn could require a mix of specific green skills and more traditional ones. Considering the section on the green transition above, and Østergaard *et al*.'s study of the geographic distribution of skills and environmental firms, the majority of definitions pertaining to green skills are not particularly relevant to eco-innovation. The exception here is the share of employees with a green education, and the size of the respective firm, both of which positively relate to eco-innovation. Interestingly, the proportion of highly educated employees is negatively related (Østergaard, et al., 2019).

There are a few concrete examples of barriers to, and conditions needed for, the development of specific areas. Let's take a look at the bioeconomy, for instance. The Nordic countries have a strong foundation for the successful implementation of new value chains within the bioeconomy. These include knowledge-based primary production in agriculture, forestry, and fisheries and aquaculture; very efficient agro-industrial, feed, food and non-food industries; a globally leading industrial biotechnology sector; a globally leading pharmaceutical industry built on biological production; a well-regulated waste handling sector; and a legal framework which allows introduction of products from new value chains based on biomass, waste and side stream conversion. There are still reasons for enabling open access to bioeconomy-relevant test facilities for more efficient use across all regions and sectors. Coordination of bioeconomy efforts across sector ministries in the Nordic countries is recommended to be implemented on a higher level than happens at present. Governmental co-investment in the commercialisation of innovative biorefineries is also underrepresented. The expert group at the Nordic Council of Ministers recommends setting up a strong Nordic biorefining innovation centre (Lange, Björnsdottír, Brandt, & Hildén, 2015).

4.2. Knowledge increase for sustainable and environmental innovation

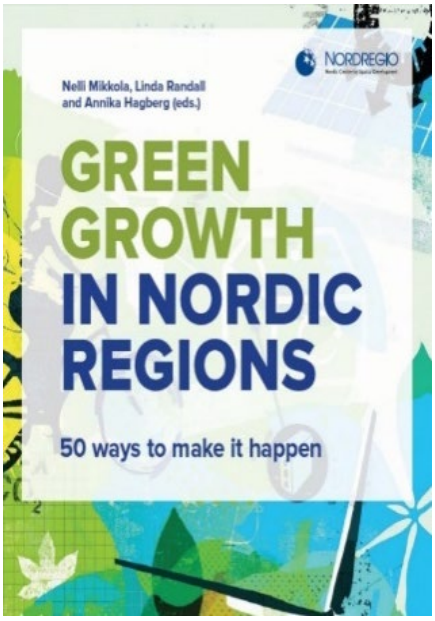
To increase the knowledge capacity for developing relevant and timely framework conditions for sustainable and environmental innovation across the Arctic and Northern Norway, it is pertinent to look at experiences from Finnish and Swedish industries and businesses. A joint study of the Nordic Council of Ministers and the Finnish Innovation Fund collected information about how the largest successes already achieved within the green economy in Sweden and Finland could be scaled up (Korsbakken & Aamaas, 2016). This could be done through:

- Finland's combined heat and power production
- Sweden's electricity share (8 %) in onshore wind energy
- Finland and Sweden having successes in pulp and paper industry in terms of carbon intensity
- Finland and Sweden covering around 10 % of their transport needs with biofuels
- Sweden having cut energy use in buildings faster than most other countries
- Sweden providing and increasing the share (25 %) of its heat with heat pumps
- Finland providing a large share (28 %) of heat for buildings with bioenergy

Another study looked at, 'Green Growth in the Nordic Region', by Mikkola, Randall and Hagberg (eds.), spans a range of examples of green growth practices. The report is a collection of 50 regional green growth examples from the Nordic Region, and is available in a study by Nordregio (see the cover and map). This compilation of cases provides insights into policy instruments and good practice across the Nordic regions, and it aims to highlight the different solutions and accomplishments which are making greener regions a reality.

The following main areas are covered in the study:

- Circular economy (water circulation system, industrial symbiosis / cluster, textile recycling)
- Bioeconomy (paper production, public-private commitments, regional developments)
- Blue growth (marine clusters, ocean rainforest, algae factory, circulation concept for aquaculture)
- Cleantech and renewable energy (gasification powerplant, green highway, biodiesel from fish waste, electric ferry)
- Green cities and municipalities (creating jobs by eliminating carbon, ride-sharing).



4.2.1. Circular and bioeconomy approaches in the Arctic Region

In this report we emphasise only the cases which are relevant in the Arctic context. Both are from Finland – the ecosystem of Arctic industries in Kemi–Tornio (signalled with an 8 on the map) and the carbon neutrality case from the northern Finnish municipality of Ii (47), as part of the HINKU Network. Additionally, from a bioeconomy perspective, we would like to highlight two success stories: one from central Sweden, and one from central Finland.

The circular economy within the bioeconomy builds upon five areas: a sustainable food system; forest-based loops; technical loops; transport and logistics; and common action. One of the technical loops focus area's key projects is the Arctic industries ecosystem and the Kemi-Tornio circular economy innovation platform in Finland. This is associated with industrial and construction materials streams. Digipolis-Kemi Technology Park has been co-operating with industry in Sea Lapland and Lapland for 20 years in order to develop industry services across sectoral boundaries systematically. Four years ago, industry and other stakeholders requested better promotion of the utilisation of industrial and community side streams in the Kemi-Tornio region. The work began immediately, employing an open operating model in which information was relatively transparent. The work also involved experts from industry, educational institutes, sector research institutes and the authorities co-operating across industrial and sectoral boundaries. This endeavour resulted in the creation of a systematic model for the process and tools needed to promote the use of production and community side streams, industrial symbiosis and the circular economy in a company-oriented manner, through a wide-ranging co-operative network. The next phase will involve piloting and further development of the concept and tools, on a broader basis, in Northern Finland, Sweden and Norway. Since this work entails the forestry, metal, mining and energy industries all being involved, it also has clear interfaces with the forest-based loops and transport focus areas (SITRA, 2016).

Ii is a municipality of approximately 10,000 inhabitants just north of Oulu, in Northern Ostrobothnia. The municipality is a member of the HINKU Forum (see the map below), and it is on a journey to becoming a carbon neutral municipality. Ii's mission is to increase the use of renewable energy and to improve energy efficiency in its municipal operations, businesses and households.

HINKU forms a network of municipalities which creates and implements solutions for reducing GHG emissions. It has been doing this since 2008. The members of the HINKU network are committed to reducing their emissions by 80 % from the 2007 level by 2030. The remaining 20 % will be sequestered in carbon sinks and compensated for. At the moment, there are 60 HINKU municipalities in Finland, with a total of over 1.3 million residents. This is over 20 % of all Finns (Carbon Neutral Finland, 2019). The HINKU network started with small municipalities, but even large cities are now joining, such as Tampere, Kouvola, and Lahti (Carbon Neutral Finland, 2019).

A further example of projects implementing the green economy in practice across Finland is the Start-up and Co-creation Communities as Ecosystems for Eco-innovations (SCINNO). This was formed in 2014-2016 as a collaborative project financed by Tekes, SKYE and Aalto University (SYKE, 2014). The project is based on the idea that, although eco-innovations play a crucial role in achieving green growth, less attention has been devoted to the actors in innovation networks. The main focus of the project is to support the transition to a green economy by examining the creation and diffusion of eco-innovations in business ecosystems, with special focus on growth entrepreneurship and emerging ecosystems. The objective is to identify success factors for constructing and managing eco-innovation ecosystems in different circumstances, and to identify processes and tools that encourage co-creation.

Bioeconomy in Central Finland

For over a century, Central Finland has been a forest industry region. The green economy (revolving around bioenergy and forestry) has been emphasised in regional strategies from at least the mid 2000's onwards. With the new bioproduct mill investment from the Metsä Group, a new bio- and circular economy concentration has started to develop in the northern part of Central Finland. The mill produces not only high-quality softwood and hardwood pulp, but also a range of other bioproducts (tall oil, turpentine, bioelectricity, product gas, and sulphuric acid). Additionally, the actors in local development are actively involved in constructing a second ecosystem ring. They are working to mobilise companies from different industries, such as manufacturers related to bioeconomy, knowledge intensive services, logistics, maintenance services, and so forth. They also aim to encourage scientific research practitioners to become members of the ecosystem. In sum, the bioproduct mill is seen as a platform for other organisations to experiment with, and from which to produce their own products. Market demand for forest bioeconomy products and ample wood resources are clearly the largest drivers. There are noticeable examples of effective national, regional and local policy initiatives enabling the forest bioeconomy to develop in Central Finland. A potential hindering factor could be raw material supply for industrial needs (since two-thirds of all forests are privately owned, and multiple wood suppliers may fragment these markets, despite the supplier co-operatives). Increasing difficulties in recruiting students and professionals to forestry-related occupations and logistical tasks is resulting in a potential shortage of labour. Also, the lack of funding for pilot and demonstration projects and for the commercialisation of inventions, plus unpredictable and fluctuating political decision-making, could result in further bottlenecks (Nordic Institute for Studies in Innovation, Research and Education, 2019).

Bioeconomy in Örnsköldvik, Sweden

Forestry industries have been important for the Örnsköldsvik area since the late 19th century. The bioeconomy concentration in the region has a long tradition, originating from pulp mill activities in the early 20th century. The main products have been paper and pulp, with energy production from less refined parts of the raw material coming as a side product. The production of chemicals, chlorine and ethanol entered the scene in the 1930s, when the region's leading pulp and paper company established what can be seen as an early version of a biorefinery (Coenen 2013). The industry in this region was one of the first to combine pulp production with production of ethanol, and a large number of other chemicals. The idea for building a cluster and technology park based on the novel biorefinery initiative, together with the increasing popularity and awareness of clustering initiatives, paved the way for a regional biorefinery cluster formation in the Örnsköldsvik region. The Örnsköldsvik Biorefinery of the Future Cluster has 20 member companies, most of which are in some way connected to the forest industry, the chemical industry, or the energy industry. They base many new ideas on existing capital investment in the mills of the pulp and paper industry. It is a challenge to link such a knowledge-intensive cluster with wider aspects of rural and regional development. There is also a temporal dimension to the question of regional development. In the long run, the region may need new firms to build economic activity, enhance attractiveness and expand labour markets, because of the narrow type of growth taking place today. An integrated vision for the region would seem to be a good tool for enabling long term, Nordic success. (Nordregio, 2014)

The development of a sustainable bioeconomy in the Arctic requires (Natural Resource Institute of Finland, 2018):

- Courageous and open-minded ideas and new solutions
- New forms of cooperation within the Barents region, and between northern and southern actors in the Nordic Region
- International Arctic cooperation and business partnerships
- Specialisation in the production of sustainable and high value-added services and products, based on Arctic resources, and their export to international markets.

Research funding Programmes relevant for eco-innovation and the circular economy include, for instance, the Arctic Academy Programme, ARKTIKO (2014– 2018) and Arctic Seas, which aims to turn Finland into an internationally attractive concentration of Arctic know-how.

In addition to these examples from Finland and Sweden, it is important to reiterate the relevance of the work undertaken at the Iceland Ocean Cluster as a method for supporting entrepreneurs and for encouraging the development of green skills for the future. As this literature review has already demonstrated, relying upon good communication with local businesses and research institutes is key, as there is significant potential for the traditional bioeconomy sectors to become part of a modern economy. This is particularly evident when looking at the potential use of data. Another interesting organisation in the Nordic Region is the Faroese Ocean Rainforest company. The Ocean Rainforest is a relatively new blue growth company, offering products based on seaweeds for cosmetic and food producers (Ocean Rainforest, n.d.). Looking to materials that were formerly understood as waste or by-products, both the Iceland Ocean Cluster and Ocean Rainforest are paving the way for new applications of bio-based resources, thereby replacing fossil-based chemicals.

4.2.2. Arctic characteristics

Land use is becoming a critical international issue. It involves a wide range of problems and associated phenomena, such as the externalisation of food production by consumers through urbanisation. The ability of the soil to act as a carbon sink may deteriorate. In the north, especially, there are plenty of organic soils and marshlands which form a sink from large amounts of carbon. The Arctic population is aging faster than average; but while the need for services increases, services are also departing the region.

The natural and climatic conditions of the Arctic are due to the Gulf Stream. They may offer the possibility of developing a diverse bioeconomy north of the Arctic Circle (66.5° N), in the boreal coniferous forest zone. The Gross Domestic Product (GDP) of the area is largely based on products from the forest. The area has good international traffic and communications links, and the agility to operate in the climatic conditions of the Arctic. The social structure is highly organised, flexible and well-functioning. Natural resource-based industries like agriculture, forestry, reindeer husbandry, fisheries, tourism, mining and civil engineering already exist. Further potential in the area can include northern wild fish and berries, which can be exported for the health food industry.

The shortage of fresh water in southern Europe will probably force global bioenergy production processes to move north. In Lapland alone, the annual growth of the forests is projected to be 3-4 m^3 per hectare in 2050. If growth is in line with the forecast, the yield potential of northern forest biomass at the end of the century will almost be the same as that of the southern Finnish forests in the 1980s.

4.2.3. Strategies in Swedish and Finnish Arctic regions

In 2016, the Finnish National Commission on Sustainable Development published a strategic framework entitled ‘The Finland We Want by 2050 - Society's Commitment to Sustainable Development’. This identifies eight objectives, among others of which is a carbon-neutral society and a resource-wise economy. Progress will be monitored, and the indicators for the strategy will complement the global SDG indicators. Nearly half the RDP budget is used to support farming in areas affected by natural constraints. Other RDP measures are targeted in sparsely populated rural areas. The natural constraints of climate and soils in the far north of Europe shape the rural economy of Finland, in which forestry plays a major part. Cooperation is a long-standing tradition in rural

areas, and there are opportunities for new links between different types of rural business within a given locality, even across borders. Fragmented farm holdings and land ownership patterns could pose difficulties and challenges, although different types of rural businesses and services might interact positively in a thriving rural area (European Network For Rural Development, 2016).

The Finnish Arctic Strategy (2013, updated 2016 and 2017), and the related action plan, define Finland's key measures in Arctic cooperation. Under the Finnish Presidency of the Arctic Council, in 2017-2019, the implementation of the Paris Climate Agreement and the UN's Sustainable Development Goals were emphasised in Arctic cooperation.

Minerals

The mining of raw materials is particularly significant to the Arctic region, and it provides considerable room for change when attempting to make the economy greener. In Finland's Minerals Strategy (2010), the key objectives are to promote domestic growth and wellbeing, to offer solutions for global challenges faced by the minerals chain, and to mitigate damage to the environment. The mining industry employs 30.000 people in Finland, and has significant export potential. One of the key objectives is to ensure that material and energy efficiency in the exploitation of natural resources happens in a closed-circle. This will reduce GHG emissions and the amount of waste generated, without endangering natural ecosystem services. It requires a suitable operating environment, with appropriate legislation, the proper planning of land use, the evaluation of environmental effects, and permit procedures and administrative practices that support this objective.

Ten working groups have been engaged to look at the measures required to make Finland's extractive industry economically, socially and environmentally sustainable, and to elevate Finland to being a global leader for the industry. The measures proposed were to be implemented by 2019. The Material Efficiency Programme is currently under preparation. Extractive mining activities are primarily practiced by companies, and their communication plays a key role in the development of environmental friendliness and proactive risk management. This ultimately increases public trust in the company's operations (Ministry of Employment and Economy, 2013). Following the Swedish Mineral Strategy, an overall geological investigation of both primary and secondary raw materials is being undertaken across all the important mining districts in Sweden. Based on the information collected and evaluated, it has become quite clear that there is significant potential for secondary CRM resources in Sweden (Blengini, Mathieux, Mancini, Nyberg, & Viegas, 2019).

Arctic buildings

Finland has been increasing its construction of large-scale buildings made from wood since the 1990s (Louiseu et al., 2015). Wood has special hydrothermal properties that work well for indoor climate control. During dark periods of the year, the quality of the indoor environment has a great impact on human wellbeing, while moisture increases health risks. With moisture buffering, wood can decrease humidity changes in indoor air. Massive wooden buildings have typically low embodied energy and emissions. Energy efficiency is also affected positively, since massive wooden structures lower heating and cooling demands. Wood is renewable and stores bioenergy that can be used for substituting fossil fuels. Wood materials themselves can be recycled into new components or new elements several times over. After demolition, the wood can enter the biorefinery process. According to the Wood Building Programme of the Finnish Government, wood construction will be promoted in line with the actions set out in the National Energy and Climate Strategy (Le Roux, 2018):

- **Goals:** promote the growth of internationally competitive industrial wood construction know-how and production in Finland; promote long-term carbon storage in timber structures, and support the responsible use of forest resources.

- **Quantitative targets**: a 10 % annual increase in the production of wooden apartment buildings, annually increasing the industrial use of timber in construction.

Value of water

Both marine and freshwater habitats provide a wide range of ecosystem services which affect overall human well-being. Provisioning services include water for direct use (e.g. irrigation and drinking water), power generation (e.g. hydropower), fish and shellfish stocks (food), and other plant and animal-based materials. The recreational value of clean lakes and rivers in Northern Europe is very high, both for domestic and foreign tourism. In the summer tourist season, clean water and attractive landscapes have not yet been fully utilised. Water landscape tourism should be developed as a modern option for summer cottage culture, or for unique wilderness hotels (Natural Resource Institute of Finland, 2018). The state of water ecosystems affects the provision of many ecosystem services and, in turn, the benefits people obtain from them. Although the value of some ecosystem services is inferred from market behaviour and prices, their value cannot be seen in markets or prices alone. Water restoration and management, water quality in general, the effects of oil spills, and preserving endangered species – all these are studied regularly. However, there are only a few studies that deal with the value of ecosystem services provided by groundwater (Jäppinen & Heliölä, 2015).

4.3. Policy integration for Arctic Europe

In the final section, we will present the Arctic concept developed by Stępień and Koivurova, from the Arctic Centre of the University of Lapland. Their study was published by the Prime Minister's Office in Finland in 2017. As their statements and suggestions are relevant to the GROM project, the presentation of their findings will be kept almost intact.

The northernmost regions of Finland, Sweden and Norway can be described as *Arctic Europe*, an integral part of the socio-economic landscape of the European Economic Area (EEA). The use of the term *Arctic Europe* also implies policy and social development, cross-border cooperation, and investment that could further strengthen the connections of the region to common markets, value chains and technological changes in Europe. When adopted, strategic Arctic Europe priorities should gradually be incorporated into regional, national and EU policies and programmes. For example, they could interact productively with the Nordic cooperation frameworks. The Nordic Council of Ministers has been working on a new Arctic Cooperation Programme for 2018-2021, aiming at supporting a broader spectrum of economic opportunities in the Arctic, and especially emphasising opportunities beyond large-scale resource extraction. Bioeconomy, circular economy, climate technologies and digitalisation are among such areas.

Stępień and Koivurova (2017) mention that the Arctic regions could serve as testbeds or incubators for new technologies. Successful Nordic solutions can then be disseminated across Europe and the broader Arctic region. Elements of the smart specialisation concept appear particularly suitable for developmental circumstances in remote, sparsely populated areas. Smart specialisation requires EU member states and regions to focus their efforts and resources on a limited number of ambitious yet realistic priorities (such as energy, agri-food and industry modernisation). In this way they would be able to build excellence, as well as compete within the global economy in sustainable manner. In using this concept, the facilitation of trans-border businesses and research clusters seems to be particularly pivotal.

Remoteness and sparse populations are seen as key permanent developmental disadvantages within Arctic Europe. They affect transport costs (for people and goods) and accessibility to markets (especially within the EU's single market). They also entail difficulties in generating the critical mass needed for successful business ventures or innovations. Sparsity is coupled with demographic

challenges: population loss in some regions across Arctic Europe, an aging society, as well as the out-migration of women and young people. EU and Nordic support are needed to develop feasible, low-carbon options for areas characterised by the above-mentioned features. Arctic Europe remains dependent upon the extraction of hydrocarbons and fisheries in Norway, and raw materials and forestry in Sweden and Finland. Structural changes in many of these industries are among the reasons for the demographic challenges mentioned earlier. All regional development strategies aim at tackling this dependence by investing in the diversification of local economies, as well as bringing the refining of resources extracted in Arctic Europe into the region.

The Arctic regions can be places for innovative bioeconomy developments, including biofuels, the blue economy, and specifically Arctic bio-based organic products – for instance Arctic foods and cosmetics. There is still a considerable renewable energy potential, with wind power particularly on the rise. In the last few years, the region has seen an increase in investment in data centres, testing facilities and tourism. There is also a hope that economic development in the Circumpolar Arctic could create markets for Nordic cold climate technologies and e-services, for instance e-healthcare.

Traditional livelihoods may generate less monetary output than resource extraction or modern industry, but they are endowed with other types of value in terms of culture, wellbeing, nature, and identity. If the Nordic Sámi Convention is ratified by the three Nordic countries and enters into force, it would enhance pan-Sámi entrepreneurship, business networking and climate change adaptation.

There is a need for regions to take advantage of opportunities arising elsewhere. Companies and workers from northern Finnish and Swedish regions could utilise the developments taking place in Northern Norway, and the other way around. For many decades, workers moved to Northern Norway from neighbouring regions. They did so in order to work in the fisheries industry or in hydrocarbon development. Stępień and Koivurova point out that it is time to expand these interlinkages.

Currently, the vibrant development of a blue bioeconomy in Troms county could create opportunities for companies across Arctic Europe. Ways to utilise booming tourism in Finnish Lapland for neighbouring regions are already in place (Visit Arctic Europe, 2021). The Visit Arctic Europe programme has been developed under Interreg Nord. It involves 122 tourism companies operating across the Arctic. It seeks to develop all-year-round, sustainable, and high-quality destinations.

Furthermore, Lapland could also seek ways to take advantage of the data centre boom or space industry development in neighbouring Norrbotten. Cross-border clusters are one way of achieving such synergies. In order to facilitate business and employment linkages and clustering, intra-regional transport connections are needed. However, the limited popularity of these routes can put into question the viability of solutions relying on long-term public subsidies (see 'Arctic Airlink' between Oulu, Luleå and Tromsø). Also, the 'Visit Arctic Europe' project has identified a lack of viable intra-regional connections as one of the key challenges in creating a viable Arctic Europe-wide tourism offer. The role of TEN-T ports (Kemi, Oulu, Luleå, Narvik and Hammerfest) is mentioned as important for opening up access to the region. The transport of goods on the East-West axis across the region is not smooth enough for the needs of the private sector at present. Improving logistics across Arctic Europe has been one of the key challenges, and it remains a continuing priority for regional cooperation.

Events organised by the EU – primarily Arctic stakeholder conferences planned from 2018 onwards – can be used for promoting and revisiting a common strategic framework. These events can also be utilised as a space for the cross-presentation of regional strategies, extending cooperation beyond EU programmes. In drafting a common Arctic Europe strategy, cooperation with other northern forums and mechanisms – including four Northern Dimension partnerships, the European Investment Bank, NCM, the Nordic Investment Bank, Barents Euro-Arctic Region, and even the Arctic Council – should be encouraged. Such cooperation should not entail forceful coordination of

funding, but rather an exchange of fruitful ideas and experiences. Stępień and Koivurova concluded that facilitating multi-fund projects clusters could be considered.

Developing technologies, products and services can be utilised in other parts of Europe to improve wellbeing. Recent developments within these industries in Finland provide good examples of this potential. For instance, researchers from the Lappeenranta University of Technology see the potential for Finland to export smart grid electricity technologies, with the Arctic dimension of the Finnish economy allowing for the development and testing of these solutions in peripheral, sparsely populated regions. At the same time, some of Finland's wind power technologies are clear examples of export success. There is also much potential in Finnish space technologies. The Finnish Funding Agency for Innovation (Tekes) has identified 80 new companies working on space-related products, some of which are relevant for Arctic conditions (e.g. Iceye solutions that could be used in maritime shipping, natural resource extraction, forestry, or handling environmental disasters).

To address these needs, the Task Force of the Arctic Council considered several potential mechanisms, including a new Arctic Council subsidiary body to enhance coordination and integration on marine matters, and also an Arctic marine Expert Group. In addition, there is a need for regional cooperation in implementing an ecosystem-based approach for the Arctic as a whole, including in areas which exist beyond national jurisdictions, based on the best available scientific information and a balance between conservation and sustainable use of marine resources (Arctic Council, 2017).

Future projections for the Arctic climate change, and expectations for the exacerbation of its impact, have encouraged regional actors to consider how best to adapt to the change (Stępień A. & Koivurova T, 2017). The people of the Arctic are at the forefront of global climate change, yet they are not its primary cause. The fate of the Arctic will be decided by actions taken largely outside the Arctic itself. However, efforts are underway in the Arctic to help build resilience. These efforts can be magnified by sharing ideas, replicating and adapting promising efforts, by scaling up, and by coordinating. Carson and Peterson (2016) additionally add the following aspects to enhancing arctic resilience: 1) Integrating social and ecological monitoring using a systems perspective; 2) strengthening knowledge integration, and 3) increasing the capacity of Arctic people to engage with, respond to, and shape change.

5. Findings

This literature review has provided an overview of some key aspects of the green transition, as well as providing examples of a number of green initiatives seen across Nordic regions. Below are a few of the main findings from the overview which may be particularly useful when embarking on a green transition.

The development of environmental technology, bio- and circular economy to promote green transition requires a cross-sectoral approach with a broad range of system-level changes and innovations. Such transformations require innovation in many different forms: technological, organisational, market-based, societal, governmental, and (not least) political.

Multiple factors are driving the green transition. The transition in the socio-economic system for sustaining the environment that we rely on ultimately needs to happen in areas where the environmental pressures and their driving forces lie. Concretely, this is in different areas and at various levels of production and consumption. Besides policy makers at a governmental level, private enterprises also play a critical role in greening the economy. Drivers for corporate initiatives to support the transition to a green economy can be divided into two broad categories – drivers related to changes or limits in our natural systems, and drivers related to requirements and expectations from influential stakeholder groups.

Innovation pathways in sustainability-oriented industries are particularly country specific, and systemic innovation is preferable to the regular, linear model. Tracking and evaluating innovation processes is not easy, but the evolution of green bonds and green patents can at least provide a starting point. Industrial symbiosis is a good approach to consider for realising a green economy, and there are several success stories to be recounted within a circular or bioeconomy**.** Many different types of innovation are required in order to take advantage of the opportunities provided by the bioeconomy. These include product, technology and service innovations, as well as societal, systemic, and operational ones. The bioeconomy-related recreational services business ecosystem is relevant for all Nordic countries. Wind energy is also relevant from the Arctic perspective, but the operation of wind turbines in a cold climate involves additional challenges not seen in warmer locations. However, this dilemma may contribute to new niches for innovation. Challenges to developing a green economy are often related to a general challenge for Small and Medium-Sized Enterprises (SMEs), most particularly the lack of funding and the lack of adequate cross-sectoral networks. Regarding Nordic innovation potential, obstacles are often related to difficulties in commercialisation.

Rearranging the business model in favour of the total environment can provide an opportunity to combine environmental improvements with increased business value. Sustainable competitiveness requires the preservation of biodiversity and a natural regeneration capacity. Upstream collaboration with service providers and suppliers is important in the greening of the economy, but this is not complete without making serious in-house efforts to increase efficiency in the use of resources, and to reduce waste. Critical Raw Materials (CRMs) are seriously important to the Arctic region. This therefore provides considerable room for change when greening the economy. Gaining more knowledge about the potential of secondary raw materials in mining waste is recommended. In terms of the transportation sector, it would be useful if a standard was adopted for manufacturers and charging-stations installers, in order to enable a quicker rate of conversion. It is also suggested that it would be helpful to enhance the role of employers in the promotion of carbon-neutral and health-promoting commuting. The maritime sector's efforts to reduce carbon emissions are mainly focusing on shipping, port operations and shipyards. An increasing proportion

of new vessels are diesel electric. Several Nordic ship projects are pioneering hybrid or pure electric solutions.

The green economy is likely to consist of a mixture of new objectives and new ways of doing things, all of which could require a mix of specifically green skills and more traditional skills. We took a brief look at the barriers and enablers for sustainable transition, and we concluded that the main challenges to developing a green economy are often related to a more general challenge for SMEs, especially through a lack of funding linked to the fact that such investment has a long life-cycle and is capital intensive. Also, emerging sectors are not familiar to investors or to potential customers. Lack of cross-sectoral industry networks is also regarded as a significant obstacle to the development of green growth. Regulations and economic instruments are among the enablers of sustainable transition. A constant exchange of experiences, joint research endeavours and stronger joint energy markets are also recommended. In order to address how progress can be made at all in green transition (and if addressed, measuring how it is going) requires the identification of a proper set of necessary indicators.

There are already many efforts towards building resilience underway in the Arctic. Their impact can be magnified by sharing ideas, replicating and adapting promising efforts, by scaling up, and by coordinating. The use of the term "Arctic Europe" also postulates fresh policy developments, cross-border cooperation through smart specialisation (for example), and investment that could further strengthen the connections of the region to other parts of Europe and the world. The smart specialisation concept appears particularly suitable for the circumstances prevalent in remote, sparsely populated areas. Arctic regions could serve as testbeds or incubators for new technologies in this regard. Remoteness and sparse populations are seen as key and permanent developmental disadvantages across Arctic Europe. They affect transport costs and accessibility to markets. In order to facilitate business and employment linkages and clustering, intra-regional transport connections are needed (also on the East-West axis). Regions need to take advantage of opportunities arising elsewhere, too. The Arctic regions can be places of innovative bioeconomy development, including biofuels and a blue economy, as well as Arctic-produced bio-based organic products. There is great renewable energy potential, especially with wind and wave power on the rise. The region has seen an increase in investment in data centres, testing facilities and tourism. There is also a hope that economic development in the Circumpolar Arctic could create markets for Nordic cold climate technologies and e-services. Facilitating multi-funded project clusters should be considered.

6. Conclusion

This literature review has provided an overview of some key aspects of the green transition, as well as providing examples of a number of green initiatives seen across Nordic regions. Besides policy and decision makers at a governmental level, private enterprises also play a critical role in greening the economy in Nordic and Arctic regions. Innovation plays a key role, and the development of appropriate technologies to promote and support green transition requires a cross-sectoral approach with a broad range of system-level changes. However, sustainable competitiveness requires the preservation of biodiversity and a natural regeneration capacity.

Arctic regions can be places for green and innovative leaps in sectors such as the bioeconomy, renewables, and recreational tourism. There are also indications that economic development in the Circumpolar Arctic could come from businesses needing colder climates, for example e-services and data centres, making use of Nordic cold climate technologies. What is clear is that the green economy is likely to consist of a mixture of new objectives and new ways of doing things, all of which could require a mix of specifically green skills and more traditional skills. Working in symbiosis or with a systems-thinking approach will be key to build and sustain resilient Nordic and Arctic regions.

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8. Annex 1

8.1. Brief summaries of key documents used in the report

Below is an overview of the documents consulted for this report. It comprises grey literature, reports, and policy documents covering the period 2014-2019.

Document	Author/Organisation, Year	Brief description
1.5- degree lifestyles: Targets and options for reducing lifestyle carbon footprints	Institute for Global Environmental Strategies, 2019	Analyses carbon emission scenarios and policy strategies, with Finland among the case study countries.
A united Nordic Region on green energy policy	Nordic Council of Ministers 2016	Summarises the findings of the Energy Group of the NCM, on potential for Nordic cooperation on green energy policy.
Arctic Europe: Bringing together the EU Arctic Policy and Nordic cooperation	Adam Stępień and Timo Koivurova, 2017. Prime Minister´s Office, Finland	The study considers how the European Union's Integrated Policy for the Arctic can productively interact with Nordic cooperation frameworks in order to support developments in Arctic Europe.
Arctic resilience report	Stockholm Environment Institute, 2016	The report is the culmination of a five-year effort to better understand the nature of Arctic change, including critical tipping points, as well as the factors that support resilience, and the kinds of choices that strengthen adaptive capacity.
Arctic strategy of Finland in bioeconomy, wood building and circular economy	Simon le Roux, Ministry of the Environment, 24.5.2018 Kemi, Arctic Wood Building and Circular Economy Forum	Presentation at the Arctic Wood Building and Circular Economy Forum in Kemi in 2018
Bioeconomy in the Nordic Region: Regional case studies	Nordregio, 2014	A case study that introduces and analyses the bioeconomy in the Forssa sub-region of south-west Finland, and another case study focusing on the bioeconomy in the Örnsköldsvik region in north-east Sweden.
Case study: Finland Programming for the Green Economy	European Network for Rural Development, 2016.	Brief overlook of Finnish green growth strategies.
Copenhagen: Green economy leader report	London School of Economics, 2014	Study exploring the underlying drivers of Copenhagen's leading position in the green growth transition.

Creating value from bioresources. Innovation in Nordic Bioeconomy.	Nordic Council of Ministers, 2014	Studying business ecosystems within the bioeconomy, chosen by given criteria, as they are exemplified with forerunner company case studies (Biorefinery concepts, Bioeconomy related services etc) Supportive measures and activities, and how they tackle the obstacles – by country.
Developing a greener economy in Nordic regions: interventions to overcome the challenges	Nordregio, 2016	Existing challenges and the corresponding interventions to ramp up improvements in the green economy.
Development of the Nordic Bioeconomy: Test centres for green energy solutions – Biorefineries and business needs	Nordic Council of Ministers, 2016	Scoping the new bioeconomy, developing a Nordic bioeconomy – showing the business needs and opportunities. Scoping each country's infrastructure in terms of the bioeconomy.
Eco-innovation in Finland	European Commission, 2016	Country profile by the Eco-Innovation Observatory, detailing new trends, barriers and drivers of eco-innovation and the circular economy.
Financing the transition: Sustainable Infrastructure in Cities	WWF, 2015	Addresses investment in sustainable urban infrastructure and provides an overview of the financial instruments commonly used to finance infrastructure development. Sweden is among the areas studied (specifically, Gothenburg).
Finnish road map to a circular economy 2016-2025	Finnish Innovation Fund, 2016	Describes the concrete actions that can accelerate the transfer to a competitive circular economy in Finland. The road map highlights best practices and pilots that can be easily replicated and provide added value on a national scale.
Green growth in Nordic regions: Eight case studies	Nordic Institute for Studies in Innovation, Research and Education, 2019	Findings of eight case studies: Northern Jutland and Southern Denmark for Denmark, Tampere and Central Finland for Finland, Hordaland and Trøndelag for Norway, and Scania and Värmland for Sweden. Discusses barriers and drivers for regional growth and analyses the main actors and networks, as well as the main processes of green growth in the respective regions.
Greening the economy: Lessons from Scandinavia	McCormick *et al*. International Institute for Industrial and environmental Economics at Lund University, 2015	This study includes possible green economy initiatives, following on from a closer look at the models implemented in Scandinavia since the 1970s, at different levels.

Implementing the green economy in a European context	Partnership for European Environmental Research, 2015	Lessons and case studies from various European countries, including Finland. It studies both governance and policy aspects, and practical experiences on the ground.
Innovation paths in wind power: Lessons from Denmark and Germany	German Development Institute, 2014	Examines the key features and similarities of (and differences between) Denmark's and Germany's technological and organisational innovation paths in wind energy, shedding light on their main determinants.
Making Finland a leader in sustainable extractive industry – Action plan	Ministry of Employment and the Economy, Finland, 2013	Political action plan on advancing the national position with regard to sustainable resource extraction.
Making the environment count – Nordic accounts and indicators for analysing and integrating environment and economy	Nordic Council of Ministers, 2016	Describes how statistics on the environment and the economy (through the System of Environmental-Economic Accounts) can be used to enable cross-sectorial analysis. Proposes indicators which can be compiled annually in a Nordic context, employing existing statistics.
Measuring the potential of local green growth: An analysis of Greater Copenhagen	OECD, 2012	First trial of the OECD-developed 'green growth indicator' approach.
Nordic businesses on climate transition, competitiveness and growth – An interview study among leading businesses in the Nordics	Nordic Council of Ministers, 2018	Overview report on findings from research interviews conducted with Nordic CEOs, all relating to the green economy and green growth.
Nordic green to scale	Nordic Council of Ministers, Finnish Innovation Fund, 2016	This project looks at 15 existing climate solutions which have been proved to work successfully in the Nordic Region, and the scaling-up potentials of these.
Policy brief – The potential of the Finnish arctic bioeconomy depends on entrepreneurial spirit and cooperation	Natural Resources Institute Finland, 2018	Takes a look at arctic natural and human resources, regional strengths, and the challenges of the arctic bioeconomy.
Recovery of critical and other raw materials from mining waste and landfills	European Commission, 2019	Gathers together six examples (including SE and FI) of existing practices for the recovery of critical raw materials from extractive waste and landfills, highlighting technological innovation and contributions to a comprehensive knowledge-base on raw materials.

Regional distribution of green growth patents in four Nordic Countries: Denmark, Finland, Norway and Sweden	Tanner *et al*., 2019, Technical University of Denmark	Maps green patenting activity across regions in the Nordic countries: Denmark, Finland, Norway and Sweden. This is a descriptive exercise, with the aim of providing an overview of regional patterns of green technological specialisation across the Nordic countries.
Report to Ministers of the Task Force on Arctic Marine cooperation	Arctic council, 2017	The Task Force was established by the Arctic Council of Ministers in 2015, to assess the future needs of a regional seas programme or other mechanism, aimed at increased cooperation in Arctic marine areas, and making recommendations on any such mechanisms.
Share: Moving towards a circular economy – Successful Nordic business models	Nordic Council of Ministers, 2015	Summarises the findings of a project initiated by the Nordic Waste Prevention Group, under the aegis of the Nordic Council of Ministers.
The geographic distribution of skills and environmentally innovative firms in Denmark, Norway, Sweden and Finland.	Ostergaard *et al*., 2019, Aalborg University	Tracks the regional distribution of green skills across the Nordic countries, analysing whether these are important for firms' introduction of eco-innovations. The report draws on a combination of firm-level survey data on eco-innovations, linked with employer-employee census data from Denmark, Sweden, Finland, and Norway.
The green bond market in the Nordics	Climate Bonds Initiative, 2018	Provides an overview of the region's green bond market and sets out an analysis by issuer type, finance sectors, and countries.
The potential of industrial symbiosis as a key driver of green growth in Nordic regions	Nordregio, 2015	Circular economy, industrial symbiosis, country specifications.
These circular economy actions are also needed in Finland	Finnish Innovation Fund, 2019	A brief overview of focus areas needed for green transition in Finland.
Towards a sustainable and genuinely green economy. The value and social significance of ecosystem services in Finland	Ministry of the Environment, 2015	Analysis of value creation through ecosystem services in Finland, integrating ecosystem aspects into decision-making at all levels.
Transition governance for energy efficiency – insights from a systematic review of Swedish policy evaluation practices	Sandin *et al*., 2019, in *Energy, Sustainability and Society*	Review of 33 policy evaluations for energy efficiency in buildings in Sweden, commissioned by the Swedish governmental authorities over a decade.

Wind energy and green economy in Europe: Measuring policy-induced innovation using patent data	Lindman & Söderholm in Applied Science, 2016	This paper examines the various impacts of public R&D support and feed-in tariff schemes on innovation in the wind energy sector. The analysis was conducted using patent application data for four western European countries over the period 1977–2009. Denmark is among the countries observed, in particular.
Towards green growth in Denmark: Improving energy and climate change policies	OECD, 2012	Working Paper exploring Denmark's green growth strategy.
Environmental reviews and case studies. From a brown to a green Economy: How should green industries be promoted?	Svendsen, 2013, Environmental Practice	An illustrative example of green growth incentives in the case of Danish wind energy production.
Green growth: from religion to reality, seven case studies on ambitious strategies to shape green growth	Green growth Leaders, Berkley Roundtable on the International Economy, 2011	Examines case studies from various countries and regions, including Denmark, and their strategies to shape green growth, as well as the obstacles encountered.
Place leadership and the challenge of transformation: policy platforms and innovation ecosystems in promotion of green growth	Sotarauta & Suvinen 2019, in *European Planning Studies*	Explores how place leadership aims at producing transformational changes in the context of green growth. Uses two case studies of cleantech-related path development in the Tampere city-region, plus bioeconomy-related path development in Central Finland.
Arvoa ainekierroista: Teollisten symbioosien globaali markkinakatsaus	SITRA, 2013	Overview report by SITRA on developing incentive structures for the circular economy and for green growth.
Green growth – A synthesis of scientific findings	Capasso *et al*., 2019 in *Technological Forecasting and Social Change*	Synthesises insights from 113 recent scientific articles, dealing with both environmental issues and economic growth, as well as with innovation. The articles have been reviewed with a focus on six themes, derived from current discussions in economic geography and transition studies: skills, technology, physical resources, markets, institutions, and policies.
Policy instruments to support green growth in agriculture	OECD, 2013	Synthesises the experience of OECD countries in developing and implementing policies, programmes and initiatives related to green growth in the agricultural sector.
Skills for green jobs: A global view	International Labour Organisation, 2011	Examines the experiences of countries in adjusting their training provision to meet the new demands of a greener economy.
Green growth in Nordic regions – 50 ways to make it happen	Nordregio, 2016	Overview of green growth initiatives across the Nordic Region.

Future opportunities for bioeconomy in the west Nordic countries	Nordic Council of Ministers, 2014	Provides an overview of bioresources in the West Nordic Region, focusing on Iceland, the Faroe Islands and Greenland. Looks at their utilisation and future opportunities based on green growth.
Synthesis report on Nordic green growth	Nordregio, in collaboration with Gaia consulting, 2017	Summarises the work and results of the Nordic Working Group for Green Growth. Innovation and entrepreneurship from 2013 to 2016.
Eco-innovations in the Swedish Context – Master's Thesis	Nyqvist, Lund University, 2017.	Presents a descriptive analysis of national and regional patterns of eco-innovation in Sweden, using new long-run data over the period of 1970-2013, derived from the SWINNO database.
Green growth in Cities	OECD, 2013	Synthesises findings from six case studies of urban green growth policies, including those in Stockholm.
Green growth in Stockholm, Sweden	OECD, 2013	Studies green growth trends, challenges and opportunities in Stockholm.
Möjligheter och hinder för en grön energiomställning: erfarenheter från andra regioner med lärdomar för Norrbotten	Luleå Tekniska Universitet. 2017	(Title: *Opportunities and hindrances for green transition: Experiences from other regions with lessons for Norrbotten*.) Explores the potential regional benefits of green energy transition, along with the obstacles. Identifies and discusses various strategies, policy instruments and business models relevant to Norrbotten, Sweden.
Circular economy in the Nordic construction sector: Identification and assessment of potential policy instruments that can accelerate a transition toward a circular economy	Nordic Council of Ministers, 2018	A report on potential policy instruments that can accelerate a transition towards a circular economy in the Nordic construction sector. Most of the policy instruments identified focus on rules and regulations.
Omställning till hållbarhet och konkurrenskraft – Sveriges väg mot ett fossilfritt och resurse ektivt välfärdssamhälle	Regeringskansliet, 2016	[Title: *Transition to sustainability and competitiveness: Sweden's way towards a fossil-free and resource effective welfare society.*] Government report and policy recommendations on green transition in Sweden.
An integrated and effective Nordic ecosystem for innovation and green growth: A closer look at access to risk capital in the Nordic countries	Nordic Council of Ministers, 2018	Explores the potential for increased Nordic collaboration in relation to financing early-phase companies and companies in the growth phase.

Policy outlook: A cellulose-based Society	Innventia (part of RISE), 2016	Investigates the conditions for a transition to a more bio-based economy, including conditions in Sweden.
San Giorgio group case study: Jädraås Onshore Windfarm	San Giorgio Group, 2013, Climate Policy Initiative	Case study on the background factors enabling the development of the Jädraås wind farm.
Statens roll vid grön omställning genom aktiv industripolitik	Tillväxtanalys, 2016	[Title: *The role of the state in green transition via active industrial policy*.] A discussion about the role of the state in industrial transition and green economy, with a case study example of a Swedish battery factory.