SINTEF

TR A7472 Unrestricted

Report

Increasing the sustainable use of biomass in Norway. Assessment of the policy framework for more industrial use of seaweed

WP6 KS Bioeconomy

Authors
Jørgen K. Knudsen
Jens Jacob Kielland Haug

SINTEF Energy Research
Policy and Governance
2015-02-27

SINTEF Energi AS
SINTEF Energy Research
Address:

NO-
NORWAY
Telephone:+47 73597200
Telefax:+47

energy.research@sintef.no
www.sintef.no/energi
Enterprise /VAT No:
NO 939 350 675 MVA

Increasing the sustainable use of biomass in Norway. Assessment of the policy framework for more industrial use of seaweed

WP6 KS Bioeconomy

KEYWORDS:
Policy framework, governance, regions, bioeconomy, biomass, bioenergy, value-chains

Photo, front page: Shutterstock

VERSION
1

DATE
2015-02-27

AUTHOR(S)
Jørgen K. Knudsen
Jens Jacob Kielland Haug

CLIENT(S)
SINTEF Group

CLIENT'S REF.
102004697-6

PROJECT NO.

NUMBER OF PAGES/APPENDICES:
44

ABSTRACT
This report provides an assessment of the current policy framework for increased, sustainable use of biomass in Norway – with a specific view on the industrial usage of seaweed (macroalgae). The report takes the concept of 'bioeconomy' as a point of departure. In sum, there are no clear overall political priorities concerning seaweed, from the national level in Norway. This can be seen in line with an overall lack of clear objectives and incentives for increased use of biomass for energy and industrial purposes. However, new policy measures for research and innovation have recently been launched. The report recommends the formulation of a national bioeconomy strategy, with a related early evaluation of bioeconomy-related policy measures in order to ensure a stronger effectiveness vis-à-vis the industrial potential of macroalgae. A stronger focus on the regions' (counties) roles in such a strategy is also recommended. Finally, the report also builds on a review of existing social scientific research. The report recommends further knowledge-building, not least in relation to societal acceptance and improved communication between stakeholders – in order to ensure a more robust societal anchoring for the further development of the industrial potential of Norwegian macroalgae resources.

PREPARED BY
Jørgen K. Knudsen

SIGNATURE

CHECKED BY
Kari Dalen

SIGNATURE

APPROVED BY
Petter Røkke

SIGNATURE

REPORT NO.	ISBN	CLASSIFICATION	CLASSIFICATION THIS PAGE
TR A7472	978-82-594-3616-0	Unrestricted	Unrestricted

SINTEF

Table of contents

Glossary

Alginate: Alginic acid, also called algin or alginate, is an anionic polysaccharide distributed widely in the cell walls of brown algae (a macroalgae), where through binding with water it forms a viscous gum. In extracted form it absorbs water quickly.

Aquaculture: The farming of aquatic organisms, including fish, molluscs, crustaceans and aquatic plants. Farming implies some form of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc. Farming also implies individual or corporate ownership of the stock being cultivated. For statistical purposes, aquatic organisms which are harvested by an individual or corporate body which has owned them throughout their rearing period contribute to aquaculture, while aquatic organisms which are exploitable by the public as a common property resources, with or without appropriate licences, are the harvest of fisheries.

Bioactive compounds: A compound that has an effect on a living organism, tissue or cell.

Bioeconomy: Sustainable production and/or transformation of biomass for industrial and energy products.

Biorefinery: A facility that integrates biomass conversion processes and equipment to produce fuels, power, heat, and value-added chemicals from biomass. The biorefinery concept is analogous to today's petroleum refinery, which produce multiple fuels and products from petroleum

Biomass: Originally used in the field of ecology simply referring to amount of animal and plant. After the oil shocks, the meaning of the word was widened beyond the ecological field and came to include the meaning 'biological resources' as 'energy resources'.

Biotechnology: Biotechnology can be defined in a number of ways: It can be defined as the use of biotechnical methods to modify the genetic material of living cells so they will produce new substances or perform new functions. It also refers to genetic engineering and genetic modification, or more generally to moving or transferring genetic material between sources. The broadest definition of biotechnology is the use of living organisms to make a product or run a process. This definition includes using bacteria to make nutrition, as well as the use of plant or animal cross-breeding techniques to produce stock with enhanced qualities

Bioprospecting: The Convention on Biological Diversity (CBD) Secretariat defines bioprospecting as ‘the exploration of biodiversity for commercially valuable genetic and biochemical resources'.

Carbon footprint: Historically defined as 'the total sets of greenhouse gas emissions caused by an organization, event, product or person'.

Governance: The sum of actors and networks relating to governmental organizations which produce collective, authoritative decisions which must be complied with by all members of a given society. Policy proposals are often prepared by public authorities, but public authorities are just one collective actor among many. Like other groups, public policy makers have limited power and resources to influence innovation dynamics. This acknowledgement has caused a general shift in policy studies from a focus on government to governance which also encompass non-public actors, such as industrial companies and interest organizations.

Landbased biomass: The part of 'biomass' (c.f. definition above) which is grown on the land, all of which is not part of the marine sector. It can hence both be related to the forest and fields.

Macro-algae (seaweeds): Belong to the lower plants, meaning that they do not have roots, stems and leaves. They are subdivided in three groups, the red, green and brown macroalgae.

Marine biomass: The sum of 'biomass' (c.f. overall defintion above) being part of the marine environment, encompassing the range from small, cellular organisms to all vegetation – such as macroalgae, fish stocks and up to the largest sea mammals.

Policy framework: The sum of public and compulsory laws, regulations, proscriptions – as well as public incentives in the form of economic instruments (taxes, investment subsidies, feed-in tariffs). In addition, there are also policy instruments related to information and education which can be seen in relation to the policy framework within a given field – such as for macroalgae.

Trophic level: The *trophic level* of an organism is the position it occupies in a food chain.

Value chain: A value chain is a chain of activities that a firm operating in a specific industry performs in order to deliver a valuable product or service for the market. The concept comes from business management and was first described and popularized by Michael Porter in his 1985 best-seller, *Competitive Advantage: Creating and Sustaining Superior Performance*.[1]

1. Summary

This report is written as part of the KS Bioeconomy project, a strategic research project initiated by the SINTEF group (2013-16) (SINTEF 2013). This report is a delivery from the project's work package 6, Governance. The report offers a specific view on marine biomass and, more specifically, macroalgae (seaweed).

Marine bioresources are often referred to as the new 'petroleum resource' for Norway because of the abundant availability of marine biomass along the Norwegian coast. A major question is then how to utilize this resource within an industrial context. The potential for industrial exploitation in Norway is considerable, but there are clear challenges with the current policy framework. Therefore, this report addresses the governance and policy challenges for marine biomass in Norway.

The current policy framework with relevance for the industrial usage of seaweed is presented and assessed. The report takes the concept of 'bioeconomy' as a point of departure, and assesses to what extent there is a strategic guidance from the national political level in Norway. Bioeconomy has been a strategic goal from the EU during recent years, but is mainly employed within a scientific and industrial context, and to a lesser degree 'translated' into concrete policy measures. Hence, there is no international, policy-related guidance as to how to realize greater potentials of biomass in a sustainable manner. However, given the EU's focus on strategic objectives for climate-change mitigation, increased sustainable use of biofuels for transport is a priority – as reflected in Norwegian regulations.

In sum, there are no clear overall political priorities concerning seaweed, from the national level in Norway. This can be seen in line with an overall lack of clear objectives and incentives for increased use of biomass for energy and industrial purposes. There are few economic incentives concerning the phase-in of biofuels, whereas the overall picture for biomass for stationary energy purposes is more mixed with support schemes and a strategic focus on the recycling of waste. Concerning the development of industrial activities and innovation related to biomass, new support schemes are recently launched by the national agency Innovation Norway. The Research Council of Norway has signaled an overall priority of bioeconomy-relevant activities, but concrete projects will fall into different programs. There is no specific support mechanism in place for the stimulation of cultivation, harvesting and industrial usage of macroalgae. Furthermore, the process of licensing new cultivation and related facilities is considered to be cumbersome.

The report also builds on a review of social scientific research conducted on related subjects, in order to identify recommended policy measures and societal strategies. In sum, the research literature has highlighted the importance of political commitment and suitable framework conditions, as well as societal acceptance. However, we have not identified studies providing concrete recommendations for how to achieve this in practice within a context comparable to Norway, and no specific recommendations for seaweed and macroalgae have been provided thus far. Secondly, no social scientific study has thus far looked more in depth into how policies and governance arrangements affect the development of the seaweed sector in Norway.

Finally, the report provides recommendations for further policy development, as well as related knowledge needs. The formulation of a national bioeconomy strategy is recommended, together with an early evaluation of the newly launched bioeconomy-related innovation measures. This is considered to be important in order to ensure a stronger effectiveness vis-à-vis the industrial potential. A stronger focus on the regions' (counties) roles in such a strategy is also recommended. Concerning further knowledge-building, there is a need of more research combining foci on policy measures and societal acceptance – in order to ensure a more robust societal anchoring for the future's biomass policy and the industrial usage of macroalgae.

2. Introduction

This report is part of the SINTEF group project Bioeconomy (2013-16) (SINTEF 2013). A major focus in this project is improved knowledge on how to induce and enable innovative business development in relation to biomass in Norway. The present report discusses the policy framework for biomass in Norway with a specific view on macroalgae.

Norway is characterized by a small and fragmented biomass sector, with certain limitations in knowledge, innovation and market development (c.f. Forbord et al. 2012). However, there are large potentials in a country with huge wood-based and marine biomass resources (SINTEF 2013). This report focuses on marine biomass resources, and more specifically macroalgae. The assessment centers on major features of the policy framework relevant for these resources, and to what extent and how this framework represents drivers and/or barriers for the further innovation and industrial development of macroalgae in Norway.

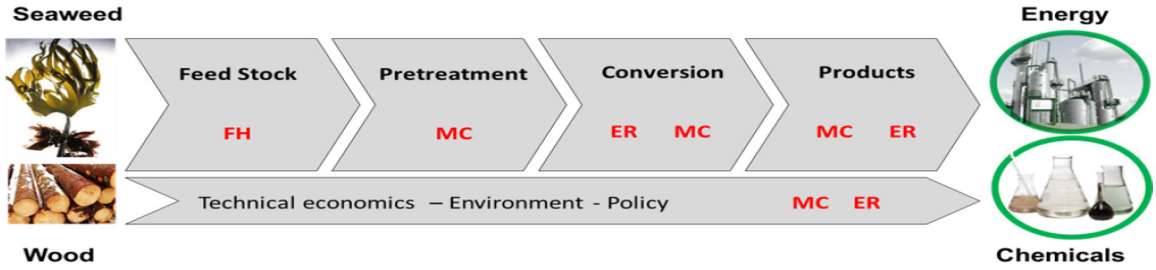

Figure 1: *An illustration of a value-chain approach to bioeconomy, including a biorefinery concept. This perspective stipulates an integrated value-chain for energy and industrial products (SINTEF 2013).*

A key finding in former research is that although there are a significant number of technical, economic and practical challenges associated with the development of a marine industrial development, major challenges are governance-related (c.f. Roberts and Upham 2012: 1051).

The transition to a biobased economy has gained increased attention in research during recent years. From 2005 onwards, the number of scientific articles has markedly increased (Staffas 2013: 2755). A majority of the bioeconomy studies have been conducted within the fields of biotechnology and genetic engineering (Kleinschmit et al. 2014). Social science studies, and more specifically, social science studies concerning policy development, including seaweed as a feedstock, have to a lesser extent been conducted.

The main research question of the report is:
What are the main drivers and barriers for increasing the industrial usage of seaweed in Norway – given the current policy framework?

We have in this report a specific focus on macroalgae. However, since there is no specific macroalgae policy in place, we will take into consideration a framework which in many ways also is relevant for land-based biomass. The more established and major part of this segment is the forestry and wood industry sector, which for the last years have been confronted with substantial structural and economic challenges, due to reduced current and expected future demand for conventional pulp and paper products.

Marine bioresources are often referred to as the new 'petroleum resource' for Norway because of the abundant availability of marine biomass along the Norwegian coast (Partnerskapet BioVerdi 2014). A major question is then how to utilize this resource within an industrial context. Biomass is often referred to as a major source for the future's renewable, non-fossil energy system. However, bioenergy is not the most

profitable product of a refinement process of biomass (SINTEF 2013). The industrial products, not least related to chemistry and pharmaceuticals, are generally considered to be more than twice as profitable than bioenergy. A biorefinery-centered value chain will, however, also include bioenergy production: Hence, there is a need to get an economic profit from both bioenergy and the industrial products. Given the complexity of this innovative approach to a more integrated biorefinery concept, it is necessary to address the relevant policy framework and consider to what extent it can enable such an innovation.
Biomass amounted to only 8.5 per cent of total energy usage in Norway in 2012 (18.1 TWh), mainly as firewood used in households and biomass used in manufacturing industries, and the current growth rate is only at approximately 1 TWh a year (NVE 2014). The resources for this usage are mainly land-based biomass, the usage of macroalgae for energy purposes is still not the case in Norway. There are particular challenges related to the transport sector, not least given Norway's commitment from the EU Directive on the promotion of renewable energy sources (RES) [1] of 10% renewable fuel by 2020. However, with Norway's abundant forest-based resources[2], there is a unique opportunity to position the country for a future growth of the bioenergy market in Europe.

Norway has decided a national bioenergy objective of 14 new TWh stationary bioenergy by 2020[3], as well as the target under the EU RES Directive – mentioned above. Improved knowledge and value creation related to both marine and land-based biomass will therefore also be relevant for the fulfilment of Norway's commitments for climate-change mitigation.

In an international perspective, increased usage of bioenergy will contribute to the mitigation of greenhouse gas emissions, but can at the same time affect the availability of natural resources – as well as providing new industrial and economic opportunities. This can be related to the fulfilment of objectives for sustainable development (social, economic and environmental dimensions)[4]. Biomass is considered a critical resource pertaining to land use, food production and other environmental and societal sid-effects – like reduced biodiversity and consequences for recreation, which must be accommodated by a coherent policy framework. These issues are addressed through the on-going process of developing sustainability criteria for biomass in relation to the EU RES Directive. Major foci are the trade-offs between: (i) food, feed and fuels and their impact on global agricultural markets; and (ii) the environmental impact of crop-based biofuels production, including the land use change.

There is a clear need for improved and more applied knowledge on how to utilise Norwegian biomass resources in a sustainable value chain perspective, not least in order to maintain and develop a Norwegian wood-based industry. Hence, there is a clear need for more knowledge contributing to more industrial usage of Norwegian biomass resources, which at the same time clearly take sustainability requirements into account.

This report will focus on non-technical aspects, based on a political scientific research approach. The main focus is the policy framework in Norway and how this is governed by responsible public agencies, including relevant policy objectives and mandates for further development and/or follow-up. In this vein, we will also highlight the interaction between different levels of public decision-making. In relation to decision-making at these various levels, other societal actors can also be involved, such as for example different industrial interests.

[1] EU, 2009, Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC.
[2] Estimated to be ~16-33 TWh untapped energy potential in forest resources including residues: http://www.regjeringen.no/pages/2196816/PDFS/STM200820090039000DDDPDFS.pdf
[3] National Bioenergy Strategy (Ministry of Petroleum and Energy, 2008).
[4] World commission on Environment and Development (1987): Our Common Future, Oxford: Oxford University Press.

Outline of the report

The report opens with chapter 3 outlining the analytical framework employed, in order to study the potential of industrial usage of macroalgae within a Norwegian context. In addition, references to relevant, existing knowledge on how to increase biomass use given non-technical conditions are provided. Chapter 4 provides a background analysis, and overview of the actual marine biomass resources and related industrial structures in Norway. Chapter 5 presents and discusses the current political framework. This includes the follow-up of international obligations, such as relevant EU directives. The political anchoring of this policy, as well as the public agencies which are to administer this policy – both nationally and at the regional and local levels of governance, are highlighted. The chapter finally provides a scrutiny of relevant policy instruments which regulate and eventually serve as incentives for increased use of marine biomass in Norway. Chapter 6 constitutes the report's concluding chapter, including recommendations for further policy development and research priorities.

3. Analytical approach

This chapter will outline some key analytical dimensions which are assumed to be important for the further research on increased industrial use of macroalagae, including references to existing research on non-technical factors. The analytical framework outlined here has an exploratory character in terms of seeking to combine different theoretical approaches, not least given the innovative character of the new, biomass-based value-chains. By doing this, the report aims at contributing to the development of a social scientific framework by which we can explore, understand and assess the various initiatives taken by relevant industries on the one side, and the ones of the political and public authorities' side on the other. Science and research appear to be fundamental for both the industrial and political approaches. A major question is therefore how scientific actors could be mobilized more strongly in order to induce more activity, as well as to contribute to bridge the industrial and political visions and activities.

The concept of 'bioeconomy' has its roots in sciences and biotechology-based industries, and has been prominent in recent EU strategy documents (European Commission 2012a). 'Bioeconomy' can be understood as sustainable production and/or transformation of biomass for industrial and energy products (ibid.).
The transition to a biobased economy has gained increased attention in research during recent years (Staffas 2013: 2755). Furthermore, there has been considerable attention for sustainability issues in the scientific bioeconomy debate (for an overview, see Pfau et al. 2014) and this is still seen as a key opportunity, as well as a key challenges, for the development of a bioeconomy. Given the challenges associated with the sustainable production and use of biomass resources, as well as the cross-sectoral character of a bioeconomy, an analytical framework building on governance for and policies for sustainable development, as well as innovation processes across different levels of governance, is here taken as a major point of departure.

More specifically, policy research on seaweed in Norwegian is scarce. A study by Meland and Rebours (2012) provides a brief overview of the regulatory and management systems in Norway. Another study that has briefly touched upon policy relevant issues with regard to the Norwegian seaweed industry is a study by Skjermo et al. (2014). This study looked at opportunities and research needs related to the development of a Norwegian bioeconomy based on the cultivation and processing of macroalgae.

3.1. Analytical framework: Focusing on transitions towards more sustainable innovations

With a focus on how a new value chain can emerge, given the existing policy framework and prevalent economic structures, we need an analytical framework capturing which factors induce and/or hinder a gradual change of the same framework. There will also be different degrees of change. A focus on 'governance' builds on the acknowledgement that the directionality and coordination of complex societies imply different approaches than traditional policy paradigms such as a classic top-down steering model. A strengthened focus on governance is therefore in accordance with the growing interaction between multiple societal groups. A related point of reference is 'multi-level governance', a quite wide-ranging concept, but one which captures dynamics between different levels of decision-making. The concept encompasses both public and non-public strategies and actors (Hooghe & Marks 2003; Pierre & Peters 2005). Policy coherence can be considered as a complimentary theoretical approach to multi-level governance, by which one analyzes the stringency of policy objectives and targets set at different decision-making levels, and within different policy sectors – as well as how they are followed up during the phases of policy implementation and execution (Nilsson et al. 2012).

Hence, such analytical tools help us to assess and de-compose the crosscutting nature of the framework for bioeconomy activities, as a basis for exploring more coordinated or integrated policy measures. This is also important in order to avoid challenges related to unsustainable practices.

Several contributions have pointed to the importance of combining the concepts of 'governance' and 'sustainable development', at the same time as these are considered as equally difficult to decompose in an unequivocal manner (Jordan 2008). Referring to the numerous ways that the notions of 'governance' and 'sustainable development' have been combined, Jordan calls for a clearer linkage between sustainable development studies and the mainstream governance studies (ibid.). This call has still a substantial value, also given the fact that both the political and scientific focus on sustainable development has decreased during recent years.

The transition towards a bioeconomy can be seen as developments in different socio-technical systems, such as the energy system, the agricultural and fisheries segments, as well as the industrial sector (c.f. Geels 2002). This is the focus of the theoretical contributions associated with 'transition management'. Transition management theorists have pointed to the potential associated with the emergence of technological niches which can engage in articulation processes vis-à-vis other industrial actors, policy makers and consumers (Ruud et al. 2007). Furthermore, different technological niches could be combined and gradually become more established and thereby impacting upon the 'socio-technical regime' in question (ibid.). In the present context this will be associated with relevant policy frameworks. In addition, the niche-regime dynamic is influenced by developments in general scientific, technological, societal and political trends, nationally and internationally ('landscape') (ibid.).

The various influences of different socio-technical systems may create barriers to innovation through various 'lock-in mechanisms' (ibid.). This means that various factors such as existing infrastructure, large technical investments, actor networks, organizations, resource use (leading to resource competition) and institutional practices imply on, for example, current and future decisions and decision-related behavior (ibid.). Furthermore, these socio-technical systems can be assumed to vary according to the specific regional context. Therefore, interconnected systems also influence the sustainability of different options, and the opportunities and risks the innovations may face. Opportunities, viability and likelihood for the adoption of new concepts are limited or enabled by existing structures (infrastructure, technology, land use planning, institutions) and related socio-technical systems (electricity, transport, agriculture) locally, nationally and internationally. Given a regulatory perspective, these different trends must be considered together, and

coordinated both across sectors and levels of governance in order to induce optimal solutions within an overall, societal perspective.

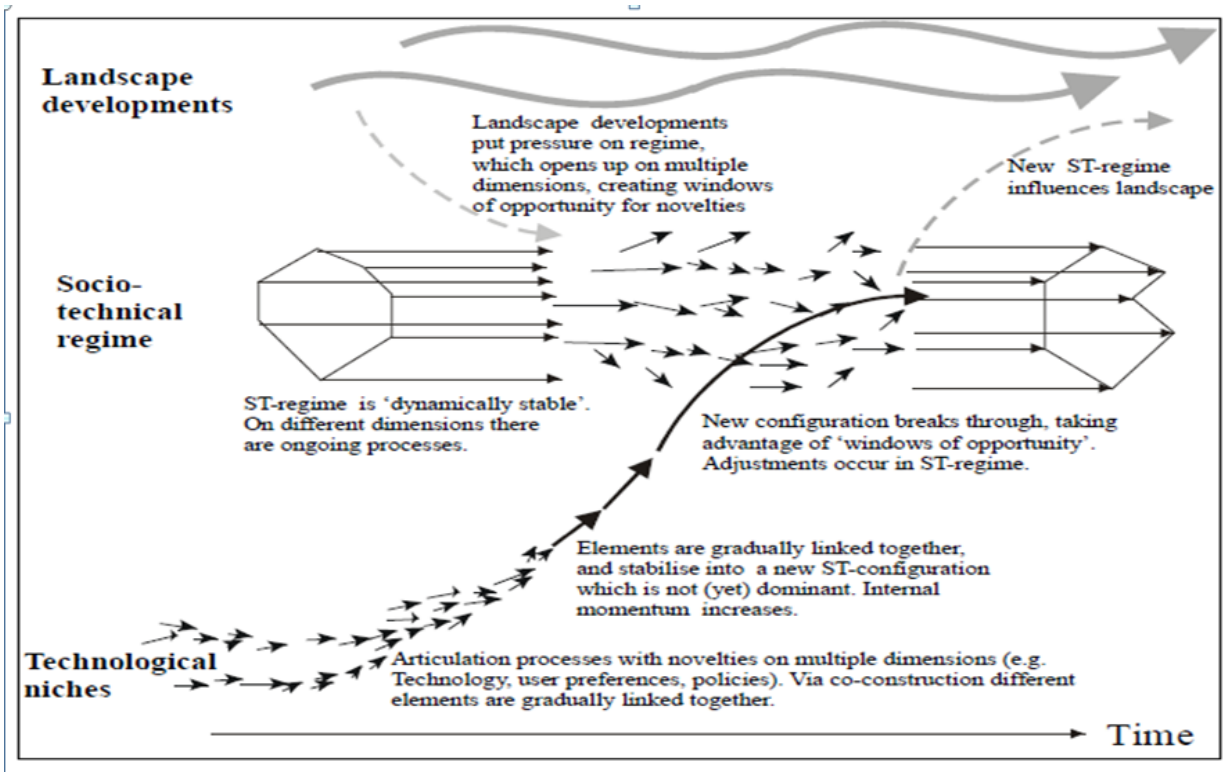

Figure 2: *An illustration of the analytical framework called 'transition management' which can also be understood as a political and societal model for the phase-in of new technologies and innovative industrial practice. Technological niches are being initiated and develop in a dynamic with overall societal trends ('landscape developments'), and the framework provided by the policy framework and related institutions and actors ('socio-technical regime'). Source: Geels (2002).*

It is therefore important to stress that the future development of a bioeconomy will imply a co-evolution of technological and socio-political changes. There will be substantial challenges both at the actor-technology level in specific industrial enterprises ('niche'), the level of the concerned industrial value-chain with framework conditions ('regime'), as well as the relevant national and international strategic and economic driving-forces. Traditional solutions and specific directions are often proposed by public authorities, but public authorities are just one collective actor among many with the capacity to influence innovation towards more sustainable solutions. In line with the reasoning of Garud and Karnøe (2003), stimulating the interaction among different, relevant actors holds several benefits. The first potential benefit is an improvement in the quality of government strategies per se. Like other groups, public policy makers have limited power and resources to influence innovation dynamics. Therefore, analytically we need to capture the two-way dynamic between the industrial and political actors.

The potential transition towards a bio-based economy is linked to developments in other socio-technical systems, such as the transport system, the paper production system, and the food production system. The influence of other socio-technical systems may create barriers to innovation through various lock-in mechanisms, such as existing infrastructure, large technical investments, actor networks, organisations, resource use (leading to resource competition) or fixed beliefs (see Geels 2010; Geels and Schot 2007).

Therefore, interconnected systems also influence the sustainability of different bioenergy options, and the opportunities and risks the innovations may face. Opportunities, viability and likelihood for the adoption of new biomass products, production technologies, novel decentralized concepts and advanced integrated concepts are limited or enabled by existing structures (infrastructure, technology, land use planning, institutions) and related socio-technical systems (electricity, transport, agriculture) locally, nationally and internationally (ibid.).

Given a perspective on landscapes, regimes and niches one can discern the possible process of emerging niches, like the ones associated with bioeconomy (c.f. Kern et al. 2014). In this regard, emerging niches can be stimulated and enabled by an established regime. This can also require the need for an enabling institution or arena within the regime (ibid.). Given this perspective, it is important to provide insights on how such nascent niches can be stimulated as well as providing inputs for regulatory changes, within the relevant policy framework.

In line with the perspectives outlined in this section, the report will further assess and explore to what extent the current policy regime in Norway, here called 'policy framework', is oriented towards and prepared for accommodating – eventually inducing the emergence of a 'bioeconomy niche'.

4. Background: Resources and structures

As far as the potential for industrial usage of biomass is concerned, Norway has large amounts of marine biomass and an important marine-based industrial sector. Anchoring this value chain at a regional level can make the exploitation of biomass more sustainable, not least given a closer connection between harvesting and refining, with for example less footprint related to transport. In a European perspective, bio-resources stand out as specifically de-central – not least compared to other energy-related resources. Hence, European regions are supposed to play a major role in the transition to a sustainable bio-economy (ESAIA 2014). At the same time a biorefinery concept would have to deal with a more complex industrial context, building on and exchanging with several different industrial segments. Hence a more composite value chain will have to handle a more complex regulatory context than the established, 'sector-based' industries. This, in turn, also challenges the policy framework and the public industrial regime as to how to induce a nascent industrial, cross-cutting segment – as well as planning for the regulation of a more mature bioeconomic sector in the future.

In section 4.3 we will discuss the regional perspective further. We will, however, first – in sections 4.1 and 4.2 provide assessments of the Norwegian resource potential for land-based, and marine biomass – specifically focusing macroalgae (seaweed), respectively.

4.1. Land-based biomass

The forestry sector is thus far considered to be the most important source for bioenergy in Norway and the limited production thus far is mainly stemming from this sector. However, the Norwegian forestry and wood sector is considered to be small and fragmented, with certain limitations in knowledge, innovation and market development (Pöyry 2011). At the same time, the sector is confronted with substantial structural and economic challenges, due to reduced current and expected future demand for conventional pulp and paper products. Such a critical situation could also lead to an improved focus on innovation for the usage of Norwegian biomass resources in a sustainable value chain perspective. A positive example on innovation and industrial development in the sector is the wood-based biorefinery under development by the traditional Norwegian industrial group, Borregaard. Based on the production of wood the company produces

biochemicals, nutritional products, fish feed stock and biofuels. The company has established one of the world's most advanced biorefineries and is the world's largest producer of 2nd generation bioethanol. Another promising case is the Norwegian Aviation Authority, Avinor, which has laid ambitious plans for the production and usage of aviation biofuels (Avinor 2014). As part of a broad and ambitious research program, Avinor foresees to introduce biofuels from algaea by approximately 2035 (ibid.).

As far as the *bioenergy sector* is concerned, land-based biomass amounted to only 6-7 per cent of energy usage in Norway in 2011, mainly as firewood used in households and biomass used in manufacturing industries (Bøeng & Holstad 2013), and the current growth rate is only at approximately 1 TWh a year. There are particular challenges related to the transport sector, not least given Norway's commitment from the EU Directive on the promotion of renewable energy sources (RES) of 10% renewable fuel by 2020 (EU 2009). However, with Norway's abundant forest-based resources, one has politically considered this to be a unique opportunity to position the country for a future growth of the bioenergy market in Europe (c.f. Landbruks- og matdepartementet 2009).

4.2. Norwegian seaweed potential, and actual harvesting

Large potentials are also associated with marine biomass such as macroalgaes, along the Norwegian coastline. There can also be combinations of the established aquaculture industry, and the nascent marine biomass-based industry, such as the aquaculture industry developed alongside and on the grounds of the traditional fisheries industry. Modern aquaculture industry also illustrates challenges for a relatively fresh industry in a global context; in terms of technology – and not least the environmental concerns addressed by nutrition and veterinary medical aspects – with consequences for biodiversity (Liabø et al. 2007).

The Norwegian aquaculture sector is considered to be an important, regionally based industry. The sector is part of a wider industrial field often called the 'seafood sector' (c.f. Fiskeri- og kystdepartementet 2012). This includes fisheries, aquaculture, fish processing, and wholesale. This wider sector, together with its affiliations with related activities, employed in 2010 approx. 44.000 people, and provided approx. 3.5. bn. euros to the Norwegian GNP (ibid.). SINTEF Fisheries and Aquaculture publishes annual assessments of the Norwegian production of marine-based nutritional products (Henriksen et al. 2012). This assessment includes the aquaculture, fisheries and various support and supply products and services, as part of a wider marine-based industrial sector. Main areas within the Norwegian marine bio-mass related sector are; traditional fisheries, salmon catching, new species including shellfish and marine algae; biochemical products; and energy products; feeding products; in addition to technical equipment, foreign based aquaculture, and scientific and industrial competence (c.f. Det Kongelige Norske Videnskabers Selskab 2012: 15).

In 2013, the total seaweed harvest of macroalgae in Norway amounted to 154.150 tons. The total value was approximately 30 million NOK (The Norwegian Directorate of Fisheries 2014)[5] . The potential for the production of macroalgae, however, has been estimated to 4 million tons by 2020 and 20 million tons by 2050 (DKNVS 2012, p. 69). Currently, alginate is the only compound that is isolated from macroalgae in Norway. Norway has a strong, industry-driven R&D on production and applications of alginate, both for traditional and novel markets, including pharmaceuticals (Skjermo et al. 2014). FMC Biopolymer is by far the biggest producer of alginate and alginate-like products in Norway (DKNVS 2012).

Cultivated macroalgae may constitute a future feedstock for the alginate industry, but is also a new and important raw material for the provision of valuable components for use in several products (for an overview

[5] http://www.fiskeridir.no/english

the various applications, see Skjermo et al. 2014; DKNVS 2012). Two products are of particular importance for this study; fuels and chemicals. For chemicals and bioactive compounds, the opportunity to develop products and new value chains based on seaweed have been pointed out, as Norway possesses high levels of expertise in the fields of biotechnology and bioprospecting (DKNVS 2012). Cultivation to be able to provide reliable quality and supply stability and a high price for the products is seen as prerequisites for profitability (ibid, p. 73).

For biofuels produced on macroalgae, there is no existing commercial value chain. Industry and research organisations are working to resolve issues related to biology, cultivation facilities and processing (DKNVS 2012). The key to profitability – which is estimated to occur by 2020, is seen to be mechanised and automated harvesting systems, cultivation that exploits the genetic potential inherent in seaweeds, and full exploitation of all harvested biomass (ibid: 74).

Skjermo et al. (2014) point out that cultivation of macroalgae at the lowest trophic level, using only sunlight and nutrients from the sea while taking up CO_2, will have a neutral carbon footprint and the biomass will contribute significantly to meet the demand for food, feed, materials, chemicals, fuels and pharmaceuticals in the near future. Through a new bioeconomy based on cultivated macroalgae Norway will establish a future feedstock bypassing the competition with landbased agricultural resources and at the same time contibrute to the replacement of fossil resources. Skjermo et al. (2914) recommend three priority areas in order to boost a new bioeconomy based on cultivated macroalgae:

- Biomass production technology
- Biorefinery processes
- Market and product development (ibid.).

For the marine industrial segment the search for substitutions as to feeding and other input factors within the value chain, is crucial in order to obtain and further preserve a high level as to sustainability (c.f. Det Kongelige Norske Videnskabers Selskab 2012). One example is that resources which are currently exploited as feeding for marine species in aquacultural production, later can be considered as important human nutritional resources, not least given the challenges with over-population in the future (ibid: 28).

Another relevant, more recent, industrial activity is the biotechnology industry based on marine biomass. One important part of this is the marine biobased ingredient industry which has increased its importance substantially during the last decade (Det Kongelige Norske Videnskabers Selskab 2012). In 2010 around 50 enterprises had a turnover of approx. 0.6 bn. euros – including the processing of foreign marine biomass (ibid.). This industry seems to have a further growth potential, not least related to further research and development (c.f. Fiskeri- og kystdepartementet 2012). The industry is also related to biomass prospecting activities in order to discover new biological components for industrial refinement and new products, as well as new qualities in discovered organic elements. Furthermore, the industry is expected to draw on remaining raw material from the aquaculture industry, in addition to the culture of macroalgae. In this more integrated approach to biomass-based industry both more established industrial processes and more recent, technology intensive biomass prospecting activities are crucial parts of an innovative value chain. The marine biomass in Arctic waters is considered to be of a particular importance in a Norwegian context, because there is assumed to be important numbers of organisms and molecules not yet discovered, as well as specifically interesting qualities due to the extreme living conditions in these waters (Det Kongelige Norske Videnskabers Selskab 2012).

It has been pointed out that a further reinforcement of this sector is depending on a more comprehensive industrial strategy (Det Kongelige Norske Videnskabers Selskab 2012; Partnerskapet BioVerdi 2014). Important measures which should be covered by such a strategy could encompass industrial property rights (IPR), investments in human capital, strategic alliances nationally and internationally, attractiveness for

industrial and long term capital, policy instruments supporting exports of marine products, services and competences (ibid.).

In international research, the potential of seaweed for biofuels has been treated in studies with a focus on technical development, economic status and environmental impact (Kraan 2013, Wei et al. 2013, Dave et al. 2013). The existing policy literature is, however, scarce. An exception is Benson et al. (2014) who have studied the EU governance arrangements ensuring environmental protection for large-scale algae production (both micro- and macroalgae). The analysis revealed evidence of significant policy mismatches and gaps and showed that there is an obvious divergence between the Renewable Energy Directive (RED) to increase biofuels production and its sustainability objectives with regard to algal technologies (Benson et al. 2014).

Moreover, a study by Roberts and Upham (2012) highlight some important governance challenges for the cultivation of seaweed in the UK and Ireland. The authors have reviewed stakeholders' perceptions of main issues, including, governance challenges, for the cultivating and harvesting of seaweed for biofuels and bioenergy. A key finding was that although there are a significant number of technical, economic and practical challenges associated with the development of a marine biofuels industry, the major challenges were seen as governance-related (ibid: 1051). The most important governance challenge to cultivation and harvest of seaweed near the coast was perceived to be the Marine Special Areas of Conservation initiated by the European Habitats Directive, making permission for new activities difficult to obtain (ibid). It was noted that the vast majority of the governance challenges mainly were related to the coastal management, and that policymakers were perceived to be sceptical because seaweed culture is perceived to be too intrusive visually (ibid.). This was the case from the point of view of the fishing, navigation and tourism sectors as well (ibid.). Communication with policymakers and cultivating seaweed further offshore was suggested to potentially alleviate these challenges. Moreover, integration of permissions for cultivation trials with existing aquaculture development was seen as a possible way of improving the permitting process (ibid.).

4.3. Regions as arenas for sustainable usage of biomass resources

By considering the situation within specific regions with different resources and industrial structures one can also discern more explicitly the foundations for emerging *niches* composed of marine bioeconomy-related actors. A value-chain approach stands out as an important part of a transition towards bioeconomy. An important prerequisite for the further development and success of an innovative value chain would also be the possibility to interact with the relevant, but different industrial structures and markets. How and to what extent the specific regional context is disposed towards taking positions within a bioeconomy perspective, will be influenced by a number of factors related both to the resources, industrial structures and the political factors governing innovation and industrial development within the given region.

An innovative value chain, cross-cutting more well-established industrial sectors, also challenges societal structures, and sector-based policy frameworks. Hence, an important question to address is to what extent the current policy framework is prepared for the planning, realization and management of such value-chains – including the challenges of sustainable development. What policy measures stand out as the most crucial ones given the societal context in question? What kind of cooperative efforts are needed, and to what extent are relevant decision-makers and authorities willing to provide incentives?

When analysing the potentials for an innovative Norwegian marine biomass-based sector, it is important to consider the structures of related, more established industrial sectors. Three important sources for lessons to be learned in this regard are the aquaculture, marine biomass ingredient industry and bioenergy sectors.

The Norwegian aquaculture industry is an important sector in the Norwegian economy, being a cornerstone in many regions. A recurrent challenge for this industry during many years is the nutrition of fishes, and the need for marine-based nutrition for aqua culture facilities. The production of feeding stock for aquaculture is a growing industry, and the interaction between aquaculture and the feeding stock production can also constitute an important part of an innovative cluster for marine biomass. Aspects related to sustainable development and a more environmentally friendly aquaculture are also of important in this regard, not least in a societal and political perspective. If this production could be combined in a joint value chain for energy and industrial purposes – one could gain important societal benefits with effect for industrial development, climate-change mitigation, better resource management and more environmentally benign management of natural resources.

Given the innovation potential related to macroalgae, as compared to other more established economic structures and actors, it is important to discuss to what extent and how relevant resources and initiatives eventually are managed by one or more specific actor constellations, eventually with the capacity to challenge and induce changes in the relevant public governance and policy framework.

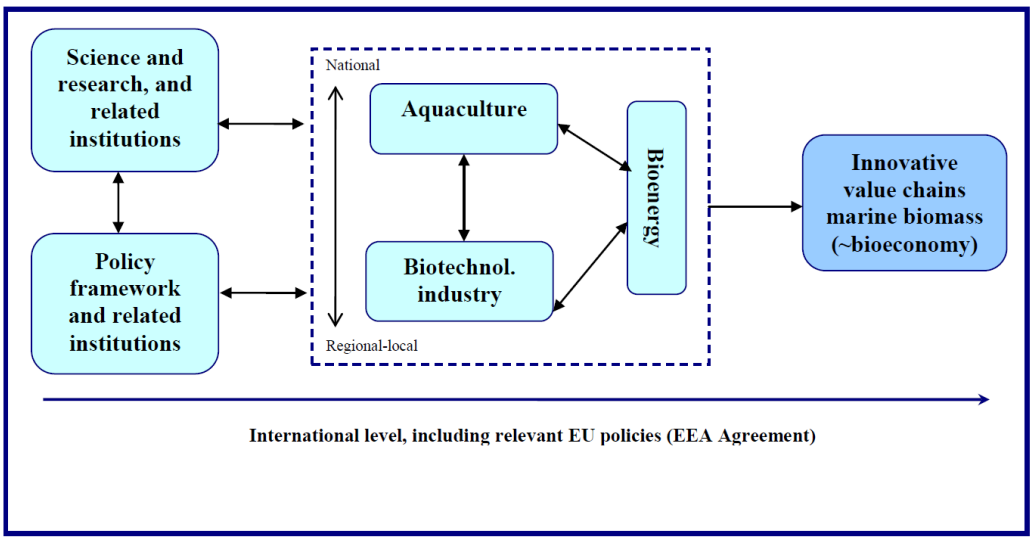

Figure 3: *General illustration of innovative value chains as products of the interaction between three more or less established industrial sectors, as well as between national and regional levels with policy frameworks.*

An emerging, innovative value chain based on marine biomass – with a bioerefinery as a central focus, could emerge from a combination of already established industries, and new technological concepts and industrial processes. Given a Norwegian industrial context, the combination of the existing fish farming and aquaculture industry, with the more recent biotechnology industry, could be a possible path ahead (Partnerskapet BioVerdi 2014). In addition, in order to succeed in producing both industrial products (e.g. pharmaceuticals, chemical products), and energy for stationary and/or mobile sources, this innovative value chain must be developed in interaction with the energy system and energy markets. This is illustrated by the above figure which seeks to highlight the need for a more coordinated industrial focus.

Such innovative value chains imply the need for integrating currently quite separate industrial structures and markets, which would also challenge established policy frameworks, and the institutions governing this framework. A more integrated industrial development could therefore evolve in dialogue with the frameworks provided by national and regional-local authorities, as well as the need for public acceptance at several levels (c.f. European Commission 2012a). Finally, the lessons to be learned from comparable phases

of industrial development and establishment from other countries and former historical periods could serve as supportive guidance. The compilation of relevant experiences, former success stories etc. could also be provided as a supporting mechanism by for example national and regional innovation agencies.

5. Norway's current policy framework in an international perspective

This chapter will present and discuss the policy framework within which industrial exploitation of biomass in Norway is to be realized and further developed. This includes the follow-up of international obligations, such as the implementation of relevant EU directives. We have in this report a specific focus on macroalgae. However, since there is no specific macroalgae policy in place, we will take into consideration a framework which in many ways also is relevant for land-based biomass. We will also highlight the political anchoring of this policy, as well as the public agencies which are to administer this policy – both nationally, and at the regional and local levels of governance.

5.1. Relevant international strategies and processes

Two sets of international strategies and obligations can be said to influence on relevant national objectives and strategies. First, internationally there has been an increasing interest for the concept of 'bioeconomy' during the last years (OECD 2009). Secondly, the harvesting and industrial processing of biomass will be influenced by regulations on biodiversity, sustainability and climate-change mitigation.

Within a European context, the European Union (EU) has been at the international forefront in terms of formulating policy strategies and objectives pertaining to the industrial use and development of biomass, not least in the perspective of sustainable development. This chapter will therefore start with a closer scrutiny of relevant EU processes and its outcomes, and thereby Norway's commitments for follow-up.

International treaties concerning climate-change mitigation and the preservation of biodiversity will also play into the policy framework for biomass development and usage at the national level. When it comes to biodiversity, the international convention and related follow-up treaties do not concretely regulate or constitute a framework for biomass exploitation as such, but will often constitute the basis for what kind of biological resources one could exploit in this regard, and from what kind of eco-systems. Furthermore, the regulations related to Land Use, Land Use Change and Forestry (LULUCF) have for more than a decade been an important part of international climate-change mitigation negotiations – not least in order to decide to what extent national forests can be accounted for as carbon sinks, and thereby be counted towards the fulfilment of national commitments for reductions in greenhouse gas emissions. The LULUCF regulations are only related to land-based biomass in the form of forests and woods. Hence, thus far, there are no climate-relevant regulations from the international level which count for marine biomass.

The onset of publications of national bioeconomy strategies and policies can be, at least partly, attributed to the publication of the Organisation for Economic Cooperation and Development (OECD) document 'The Bioeconomy to 2030: Designing a Policy Agenda' (OECD 2009; c.f. Staffas et al. 2013: 2752). From a global perspective, the OECD argues that government policy will play a decisive role in shaping the bioeconomy by stimulating or blocking development (ibid.). A major challenge facing policy-makers is to design policy schemes that promote innovation and development without locking into particular systems or technologies, or locking out future opportunities (ibid.). The report provides scenarios for a bioeconomy in 2030 and 2050 (ibid.).

The OECD has issued a report on status and prospects for marine biotechnology, including contributions to a bioeconomy (OECD 2013). The report points to the importance of two recurrent themes: (1) The need for communication between stakeholders, and (2) internationally coordinated action (ibid: 7). The former aspect implies scientific actors' understanding of what can be understood as sustainable solutions in a societal context (ibid: 88). In addition, the report points to the importance of industrial cooperation and transfer of knowledge between different indstrial and societal sectors (ibid.).

5.1.1. The European Union and the Bioeconomy

In 2012, the European Commission adopted a strategy for «Innovating for Sustainable Growth: A Bioeconomy for Europe» (European Commission 2012a). This strategy proposes a comprehensive approach to address ecological, environmental, energy, food supply and natural resource challenges (ibid.). It also contains an action plan with policy measures and recommendations for further action by the Member States (ibid.).

An important background for the strategy is the global situation with increasing competition for limited and finite natural resources, a growing population, the risk of too scarce food supply, not least given the potential impacts of climate change (ibid.). The Commission emphasizes that a transition is needed towards an optimal use of renewable biological resources, and sustainable primary production and processing systems that can produce more food and other bio-based products with fewer inputs, less environmental impacts and reduced greenhouse gas emissions (ibid.). Importantly in the present context, is the Commission's emphasis of integrated and diversified biorefieneries, including small-scale local plants (c.f. action point 10). It is important to emphasize that the EU strategy is still quite recent, and it is a still bit too early to evaluate eventual impacts. At an overall level, however, the follow-up - as stipulated by the action plan part of the strategy – seems to have its most substantial focus on research-related activities. An important part of this is also several networks in the Member States that coordinate research efforts.

One follow-up measure has been the establishment of a European Bioeconomy Panel, aiming to support interactions among different policy areas, sectors and stakeholders in the bioeconomy (European Commission 2012b). There is also European Bioeconomy Observatory that is to provide regular analysis and data that will help policy makers and stakeholders to monitor the development of the Bioeconomy (ibid.). The information and data from the Observatory will also focus on reinforced policy interaction and stakeholder engagement, as well as enhancement of markets and competitiveness in Bioeconomy (‘markets pillar’) (ibid.).

The Bioeconomy strategy/plan is part of the EU's strategic approach to a resource-efficient economy, a flagship initiative under the Europe 2020 Strategy (European Commission 2011a). Norway, as an EEA country[6], is taking part in the EU's research activities. The Norwegian Research Council has actively communicated the EU's priority of bioeconomy in research (Forskning/Forskningsrådet 2012). Furthermore, Norway is committed by the EU's internal market and environmental legislation that could eventually constitute a driving-force for the establishment of a European bioeconomy.

McCormick and Kautto (2013) have provided a relevant overview of bioeconomy in Europe, examined from both policy framework and conceptual perspectives. The authors particularly underline the importance of two important themes as a response to both the benefits and challenges of developing an advanced bioeconomy in Europe: First, the authors point to the likelihood of policy-makers remaining hesitant to introduce or maintain a strong supportive policy for bioeconomy related activities if there is a lack of social acceptance. Therefore, participatory governance that engages the general public and key stakeholders in an

[6] The Norwegian participation in the EU internal market, as well as involvement in related EU policy areas, has since 1994 been regulated by the Agreement on the European Economic Area (the EEA Agreement). Through the EEA Norway, Iceland and Liechtenstein are participating in the Internal Market, while not assuming the full responsibilities of EU membership.

open and informed dialogue about the many issues, trade-offs and decisions to be made on the design and development of the bioeconomy is seen as vital for stimulating the bioeconomy in Europe. Secondly, commitment by government and industry to innovation that drives concerted efforts on sustainable development of the bioeconomy is seen as essential.

However, there exist very few studies on the potential role of seaweed cultivation in the bioeconomy at large**.** A study of the opportunities and challenges in the biobased economy from a Dutch perspective (van Hal et al. 2014) concludes that there are many techno-economic challenges for a seaweed based cascading biorefinery. It also briefly mentions that there are many policy and societal aspects that need to be addressed: That is, legal and spatial planning aspects of large-scale farming of seaweeds in the North Sea, legal and environmental aspects of processing seaweed on vessels, and the impact of this new industry on the coastal economy. Moreover, the possibility of integrating seaweed farming with other uses of the sea – e.g. large-scale wind farms, was highlighted as an area that needs to be further researched.

5.1.2. EU energy policy

The current bio-resources supply chain in Europe can be considered as very complex and there is still a way to go to obtain a good economic use of these resources in the EU society (c.f. ESAIA 2014). One particular aspect of a biobased economy is its link to a sustainable energy system. The European Union has framed its future energy policies in a number of documents covering a wide range of issues, including *Europe 2020* (c.f. European Commission 2014), describing Europe's ambition for a smart, sustainable and inclusive economy from an overarching socio-economic perspective. The EU's *Energy Road Map 2050* (European Commisson 2011b) described the EU's energy strategy towards the year 2050 and called for even more ambitious goals for reduction of greenhouse gas emissions (between 80-95 % by 2050). The Road Map can be seen as a fundament for the most recent update and reinforcement of the EU climate and energy targets set for 2030; that is, 30 % reduction of GHG emissions; and 27 % more renewable energy production and energy efficiency, respectively (ENDS Europe Daily 2014a).

The EU energy strategy documents as well as the renewable target more specifically all call for a mix of renewable energy technologies and energy efficiency measures in order to achieve the ultimate goal of a zero-emission society. The EU approach is technology-neutral in the sense that there are no specific targets set for e.g. bioenergy. However, other international institutions have provided assessments of the future role of bioenergy, such as the International Energy Agency (IEA 2012b). The IEA estimates that by 2050 bioenergy will contribute 160 EJ per year of primary energy to the global energy mix, covering roughly a quarter of the total primary energy supply, which represents a doubling of its current share (ibid.). At the same time, the prospect of important increases in the world's population implies an increased need for food supply and potentially reinforced conflicts of interest related to particularly land-based biomass for energy purposes – in eventual competition with food production (ESAIA 2014: 7).

Currently the EU is in the process of developing the energy technology policies needed to respond to the energy and innovation challenges Europe is facing in the global competition. The Strategic Energy Technology Plan (SET Plan) is considered to be the technology pillar of the EU's energy and climate policy (European Commission 2007). More specifically, the European Commission also addresses bioenergy development through one of the seven SET Plan Road Maps on Low Carbon Energy Technologies (ibid.). Nevertheless, the Renewable Energy Directive (RED; Directive 2009/28/EC) constitutes the most forceful policy instrument at a European level as to the promotion of biomass for energy purposes. There is still no new directive, or amendment of the 2009 version, as a follow-up of the recent decisions concerning the new 2030 targets. The initial objective set for renewable fuels in the 2009 Directive, was 10 % in each Member State by 2020. The Directive did originally not distinguish between first- and second-generation biofuels.

However, in September 2013, the European Parliament voted for a change, in order to ensure that first-generation biofuels should not exceed 6% of the final energy consumption in transport by 2020, as opposed to the 10% target in the original version of the EU RED Directive (ENDS Europe Daily 2014b). The EU Commission has for their part proposed that the amount of first-generation biofuels should be lowered to 5%, in order to limit the negative side-effects on indirect land use change (ILUC) and feed stocks (ibid.). According to this proposal, an eventual increase from 5 to 10% will have to come from non-food feed stocks; that is, second-generation biofuels. The EU biofuels industry has been critical towards this lowered ambition, but the algae producers applaud the change, because it can stimulate the development of second-generation biofuels (ibid.). In June 2014, a compromise between the EU Member States governments was reached in the European Council, when a limit of 7 % food-crop biofuels was agreed upon (ibid.). The European Parliament will discuss and vote on these proposals during the winter 2015, and a final decisions based on an eventual agreement between the EU institutions can be expected during 2015 (ibid.).

In studies on barriers for bioenergy in Europe it has been argued that non-technical barriers represent a greater challenge than the technical ones (see i.e. McCormick and Kåberger (2007). Current studies on policy instruments typically focus on economic incentives, comparing across countries the effectiveness of different economic instruments (fixed pricing, taxation, subsidies and green certificates) (see e.g. Thornley and Cooper 2008; Trømborg et al. 2008). However, it has been pointed out that there is also a need to focus on societal and political responses and eventual support – both nationally and locally (see Forbord et al. (2012). Increasingly, therefore, researchers addressing bioenergy supply chains emphasise the need to take society-based differences into account, from the national to the local level, as well as highlighting the challenge of social acceptance (see Gold 2010). Given the existing knowledge and research on the bioenergy sector from a social and political science perspective there is still a need for multilevel analysis with a focus on sustainability and governance issues.

5.1.3. Examples of national strategies in European countries

Among other countries, Finland, Germany, the Flemish region of Belgium, Denmark and the United Kingdom have formulated national strategies for bio-economy.

The Finnish Bioeconomy Strategy of 2014 highlights the importance of providing cooperation platforms across sectoral boundaries (Finnish government 2014), including representatives of the government, industry and research community.

Building on the national strategy for bioeconomy (Federal Government, undated), t*he Federal Governement of Germany* put forward a Biorefineries Roadmap in 2012 (Federal government 2012). This builds on the German policy objectives for a bio-based economy and a national Research Strategy for a Bio-economy (ibid.). The Road map presents and assesses different current and future concepts for biorefineries. None of the presented concepts do, however, encompass marine biomass or macroalge.

In *Denmark*, there is a national Bioeconomy Panel commissioned by the Government in order to promote Denmark's advanced position in a future bio-economy (Ministry of Food, Agriculture and Fisheries 2014). The panel's members encompass representatives from different industries, research and academic institutions, and governmental agencies at both the national and regional level (ibid.). Furthermore, the region of Central Jutland (Midtjylland) has supported a demo project on macroalgae for biogas, during 2010-13 (Region Midtjylland 2013). This project identified lack of knowledge in the industry as a main barrier for further development and large-scale production, and will therefore now develop a permanent scientific center in order to overcome such barriers (ibid.).

There are few policy analysis regarding actual strategies and policies for developing a bioeconomy. An exception is Staffas et al. (2013) who have compared strategies and policies in the EU, USA, Canada, Sweden, Finland, Germany and Australia. They found strategies and policies to be largely based on the prerequisites of the country in focus and the need for increased research, development and demonstration in the area were particularly highlighted. Moreover, it was found that the main emphasis was often to enhance the economy of a nation and provide new employment and business possibilities (Staffas et al. 2013). On the hand, aspects of sustainability and resource availability were addressed only to a limited extent in many of the documents (ibid.).

Furthermore, Thornley and Cooper (2008) have made a review of policy instruments for bioenergy in Germany, Italy, Great Britain and Sweden, and assessed how effective they have been. Their study indicates mixed experiences with different types of policy instruments. Fixed prices have not been as successful in growing biomass as for wind, PV and other renewables in Europe (ibid.) Taxation can be an effective means of growing the biorefinery industry, but investment subsidies do not appear to have been a particularly effective, whereas green certificates on its own has been insufficient (ibid.).

5.2. Norwegian policy strategies

A major challenge for a successful implementation of innovative marine biomass-based value chains would be to coordinate and adapt established policy measures across different policy segments: Not least the ones pertaining to research, innovation and environmental regulations, stand out as important. This is also due to the cross-cutting character of an innovative marine biomass industry. In addition, energy, and the management of the marine environment and resources, are of relevance.

The Research Council of Norway (NRC) provides funding to relevant research activities related to biomass development and bioeconomy through the research program BIONEAR. NRC is now aiming at a closer coordination of its activities with other agencies responsible for innovation and phase-in of renewable energy technology, such as Innovation Norway and Enova (c.f. Innovation Norway 2014a) (see also section 7.3).

Except for the research policy field with the above-mentioned programs supporting bioeconomy-related activities, no specific policy target for bioeconomy in Norway has yet been formulated. Furthermore, there are no specific targets or regulatory instruments in place pertaining to marine biomass development and innovation as such. On the other hand, the marine biomass sector is a priority within specific public research and innovation programs (c.f. Kunnskapsdepartementet 2011; Fiskeri- og kystdepartementet 2012).

However, a majority within the Parliament's Standing Committee for Industry called for the formulation of a national Bioeconomy strategy when they discussed the Government's state budget for 2015 (Stortinget 2014). This led to a motion approved by the Parliament's majority, according to which such a strategy should be formulated as a cooperation between the industry, organizations and the government (ibid.). This strategy should lead to overall, but concrete measures (ibid.). The Parliament demanded simultaneously that the funding of this strategy process is ensured through the state budget for 2016 (ibid.).

Moreover, in 2011 the Norwegian government adopted a National strategy for biotechnology, which stands out as the most concrete political initiative to be associated with bioeconomy thus far – at least at this level (Kunnskapsdepartementet 2011). The Strategy was formulated in cooperation with the Ministries of Health and Care Services, Agriculture and Food, Trade and Industry, Environment, and Fisheries and Coastal Affairs (ibid).

As far as the bioenergy sector is concerned, a former Norwegian government adopted a Bioenergy strategy in 2008 (Olje- og energidepartementet 2008), but this strategy has not been substantially followed up or

evaluated. As mentioned above, the bioenergy sector in Norway is mainly composed of wood-based providers for stationary purposes, including the district heating sector. Bioenergy for stationary purposes is eligible to the common Norwegian-Swedish green certificate market (Olje- og energidepartementet 2013).

In 2012, an expert commission nominated by the Government in order to assess and provide policy recommendations for the further development of the energy system in Norway delivered its report (NOU 2012: 9). This report also offers some assessment of the potential of biomass for energy purposes in Norway (chapter 11.8). However, the report did not stipulate or recommend any specific or reinforced role for bioenergy in Norway. The report will probably also represent an important reference for a coming White Paper on energy policy, which the Government has signaled it intends to put forward in 2016. This forthcoming White Paper can have importance vis-à-vis the future policy framework for bioenergy within the Norwegian energy system.

Regarding biofuels there is no specific incentive in place, except a requirement of blending conventional fuels with bioenergy. A former tax relief was suspended in 2011. Moreover, the public policy framework for biofuels has considered not to promote more advanced alternatives, like 2nd and 3rd generation products – with little connection between measures for research funding and actual market deployment (Greaker 2011). The current Government has, however, signaled that they aim at revising the taxes for transport fuels, in order to favor more environmentally benign alternatives (Sundvollen 2013). In the current government's first state budget, the Government signals that a more coherent assessment of taxes related to road transport will be conducted in relation to the revised state budget, to be presented in May 2015. When the State Budget for 2015 was debated in the Parliament, an agreement between the Government and the parliamentary majority resulted in a decision on exempting biodiesel from the road usage fee, in addition to an increase in the requirement for all fuel distributors to include a certain percentage biofuels (from 3.5 to 5.5. percent) (Høyre 2014). The interest organization promoting the usage of bioenergy, NOBIO, has also called for stronger policy incentives in order to increase the use of bioenergy (NOBIO 2014). In particular, they require full tax exemption for biofuels for transport, and 2nd generation biodiesel – if the EU sustainability criteria are fulfilled, in addition to increased CO_2 tax for fossil fuels (ibid.). Furthermore, they point to the importance of long-term predictability in such a policy and that this framework is provided by 2025 (ibid.).

As part of the same state budget the Government presented a biogas strategy (c.f. the Government's political platform document, 2013/Sundvollen 2013). The strategy is also a follow- up of the climate policy agreement in the Parliament (Stortinget 2012). The Government's Biogas strategy builds upon a report and assessment conducted by the Norwegian Environment Agency (Miljødirektoratet 2013; Klima- og miljødepartementet 2014). The Government intends to reinforce the development of innovative biogas facilities (Klima- og miljødepartementet 2014). Support for a specific pilot biogas plant is foreseen as a follow-up of the strategy, in order to stimulate research on cost-efficient solutions and lower prices for biogas deliveries (ibid.). More financial resources and funding for biogas-relevant research are also promised in the Strategy (ibid.). Biogas projects should also be eligible under the recently established Climate and Energy Fund, managed by Enova. The Ministry of Climate and Environment also intends to assess various cost-effective measures in order to promote a more environmentally benign treatment of wet, organic waste from households and industry (ibid.). A national contact group for the promotion of biogas is to be established under the auspices of the Norwegian Environment Agency (ibid.).

The promotion of biogas is hence still to be the responsibility of Enova, and funneled through the program Biogas production. The program is running for 6 years in total, until 2015 (Enova 2014a). The program is focusing on projects and measures which can result in cost reductions for the production of biogas (ibid.). During the period 2009-14 21 projects have been granted investment support from Enova, although 7 projects have been cancelled. A total of 344.7 mill. NOK have been granted from ENOVA towards these projects (ibid.). The projects encompass different sources and types of biomass and waste resources. In

addition, Enova's program for New Technology can provide economic support for innovative projects related to biogas.

The use of biogas in transport has been particularly prominent in relation to urban public transport, and buses in some cities (ibid.). The cities of Oslo, Sarpsborg and Fredrikstad have all introduced biogas-driven buses, whereas the cities of Trondheim and Bergen have awaited the phase-in of biogas-driven buses due to a shortage of available deliveries (Miljødirektoratet 2013).

In sum, the resources for biogas production and the actual demand are proportionally dispersed: That is, the resources and production are primarily located at South-West coast of Norway, whereas the demand is centered around the more populated areas in South-Eastern Norway, and the urban conglomerates with their public transport systems (ibid.).

Moreover, the government established an expert panel in 2013 in order to provide recommendations for an improved resource management and increased industrial activity related to Norwegian forest resources (Landbruks- og matdepartementet 2013). This strategic activity called Skog22 (Forest22) was further divided into more specialized expert panels; for example one on bioenergy and one of the industrial usage of forest resources. The specialized reports were put forward in late autumn 2014, with related policy recommendations (Skog 22 2014a, 2014b). For bioenergy the expert group recommends, among other measures, more differentiated taxes in order to stimulate increased use of wood-based biofuels – both for road transport and aviation (Skog 22 a). The group also recommends a more dynamic follow-up of existing incentive arrangements, and the use of public contracts stimulating the establishment of full-scale wood-based biofuel production sites (ibid.). The main report is to be presented by end of January 2015.

In addition to policy objectives and strategies aiming directly at an increased use of biomass for industrial and energy purposes, there can also be policy processes which more indirectly induce the use of biomass. One such process can be the policies related to recycling and waste disposal. The policy framework regulating waste and recycling for energy and industrial purposes affects the usage of biomass, because the infrastructure and framework for energy recovery and recycling can be a platform for the supplement of other biomass, like residues from wood and forest industries, as well as marine biomass. In this way, the framework for a recycling perspective on the economy could induce an expanded use towards new forms of biomass, and thereby also technological development towards bio-refinery centered value-chains. The framework conditions for energy recovery are also connected to the production of district heating in Norway. The former government published a waste policy strategy in 2013 (Miljøverndepartementet 2013). There is no explicit mentioning of marine biomass or macroalgae, but main objectives are to increase the share of waste being recycled (ibid.).

Concerning the environmental policy field, there is currently no integrated approach pertaining to the usage of marine areas or coastal zones in order to assess different usages and industrial activities. (See also section 5.4.1 on regulation of licenses for macroalgae cultivation).

In general terms, and given the overall status of bioeconomy perspectives and the role of bioenergy in Norway, a main political focus thus far has been the stimulation and facilitation of research and innovation activities, and to a lesser extent actual economic and other incentives providing a more direct stimulation of the industrial usage of biomass, including for energy. This represents a rather ‘soft policy approach’ where no initiative on explicit regulation is yet on the table. This situation appears to reflect the still immature character of a recent policy strategy, aiming at providing a step-wise development towards a bioeconomy. As indicated above, important lessons can be learnt from the experiences from the fisheries and aquaculture industries, not least the combination of traditional structures and innovative approaches. Former assessments of the aquaculture industry in Norway have emphasized the specific character of the Norwegian governance

of this sector, given a comparative perspective with other strong, national aquaculture sectors such as the UK/Scotland, and Chile (Liabø et al. 2007). The Norwegian aquaculture policy priorities have focused on re-distribution, with a strong regional dimension (ibid.). However, the specific Norwegian market regime and regional policy priorities is considered to have led to a relatively complex aquaculture policy field which in the next round could lead to less predictable future policies (ibid.). On this background, a relevant question is to what extent the aquaculture policy framework can be a model and/or transferable to a new sector building on marine biomass.

5.3. Regional and local policy framework

There are 19 counties in Norway, encompassing a broad variety as to demography, natural resources and industrial structures. There are also substantial variations as to the focus on innovation and industrial development. Since 2009, the county administrations have been provided with the responsibility for industrial development, innovation and employment within their jurisdictions (Kommunal- og regionaldepartementet 2009). From 2012, they also have the responsibility for formulating strategic guidelines for innovation in the counties (Kommunal- og regionaldepartementet 2013). The Norwegian innovation agency, Innovation Norway, has regional offices cooperating with the counties in innovation affairs. Innovation Norway provides support for innovation, industrial development and the establishment of new enterprises through specific regional incentives (ibid.).

In parallel with comparable trends in many European countries, also in Norway there has been an increasing interest for the regional level as a crucial framework for economic and industrial innovation. The 'triple-helix' approach is actively pursued in a majority of Norway's counties (c.f. Triple Helix Association 2014). This approach is manifest within the organization of regional, innovative clusters – the Norwegian centers of expertise (NCE) based on the cooperation between the county, the regional office of Innovation Norway, and regionally based industries, as well as regionally based research institutions (NCE 2014).

This cluster thinking is also manifest in a second Innovation Norway-based funding arrangement called the Arena centres. Arena and NCE represent important structures for regional cluster thinking and already established actor constellations in a number of Norwegian regions. The NCE program provides some more financial support and is more explicitly oriented towards the establishment of a cluster by supporting secretariat and facilitating services (ibid.).

At the local level, Norwegian municipalities are generally provided with a high degree of discretion to act on land use. The Planning and building Act provides regulations on issues to be covered by the municipal planning, including the land use of the municipalities. Energy installations such as renewable energy production, electricity grids and infrastructure for district heating should all be covered by the overall planning. Based on the overall municipal planning, the municipalities must regulate more specific activities according to specific zoning plans (Lovdata 2015a). However, the municipality does not need to issue zoning plans for energy installations and infrastructure, for which the licensing process conducted by the energy regulating authorities are considered to be sufficient (ibid.).

More specifically, the Planning and Building Act also provides the municipalities with the authority of requiring constructors and property developers to connect to existing district heating systems (ibid.). This obligation is, however, only related to areas where a licenced district heating system with infrastructure exists. The municipalities have, however, also the opportunity to exempt from mandatory connection to the district heating system if other energy solutions are more environmentally friendly (ibid.).

Furthermore, in 2009 the then Ministry of the Environment issued a planning instruction for municipalities which requires the municipalities to formulate specific energy and climate plans, based on the Planning and Building Act (Miljøverndepartementet 2009). The objective of this instruction is to ensure that the municipalities take the lead in local communities' efforts in mitigating GHG emissions, as well as in inducing more effective energy usage and local energy conversion (ibid.). All other local plans based on the Planning and Building act should, according to this instruction, highlight climate and energy measures. In sum, this instruction provides the municipal authorities with a mandate for strategic decisions which can also be conducive for a more sustainable, industrial perspective – by which a biomass-based value chain locally and regionally can be stimulated. Most municipalities have by 2014 formulated energy and climate plans, but a major observation is that the municipalities do not possess sufficient capacity to fulfil all the intentions of the instruction, not least related to the technical aspects (c.f. Pedersen & Bruvoll 2014).

In addition to these formal requirements provided by the legislation, it is also worth mentioning that there are a number of development schemes and incentives for alternative municipal planning and development in Norway. An important initiative has been the program called 'Cities of the Future' ('Framtidens Byer'), established in 2008 and governed by the former Ministry of the Environment, now under the auspices of the Ministry of Local Government and Modernisation (Ministry of Local Government and Modernisation 2014). The program has been a co-operation between the Ministry and the municipal authorities of the 13 largest towns in Norway (ibid.). The program has provided research, documentation and some economic support for municipalities with pilot projects on area development, also including alternative energy provision and infrastructure. The program Cities of the Future was terminated in October 2014, but the focus on energy benign city development and climate-friendly municipal planning seems to have become more manifest during the recent years, also as a product of this program.

Such development programs, as well as the local planning arrangements in general, can also provide opportunities for alternative societal and industrial planning – including pilot projects for increased use of biomass. However, as far as we know, no directly biomass-relevant projects have thus far been initiated as part of the Cities of the Future program.

Text box 1: An example of strategic cluster thinking

A cluster with a significant number of Norwegian research and industrial actors, having a main basis in the Oslo region, recently published a report with perspectives on how to promote and manage more competitive industrial clusters for biomass-based innovation in Norway (Partnerskapet BioVerdi 2014). The report focuses on the 'four big biomass sectors'; that is, health and medicine; the marine and aquaculture sector; the industrial sector (including wood processing, and pulp and paper); and the agricultural sector (ibid.). The report formulates two main objectives with this work: (1) to propose concrete policy measures in order to increase the growth potential for Norwegian biomass-based industries; and (2) establish a common understanding between the project partners (industry and research) on status, further developmental potentials and further cooperation (ibid.). The report builds on and searches to compliment the National Strategy on Biotechnology (Kunnskapsdepartementet 2011).

The report points to the fact that biomass-based industries constitute a surprisingly limited part of the overall Norwegian industrial output and investments. If one considers the turnover figures at the Oslo Stock Exchange (status as of 10 Oct. 2013), aquaculture and the production of nutritional products based on marine resources are increasing in value and importance, whereas the share of biotechnology is very limited (ibid: 5). When considering the established industrial companies, the Norwegian biomass-based industries are generally positioned below the OECD average as far as R&D investments are concerned (ibid.).

An explanation proposed is that there is a limited cooperation with R&D institutions, and some barriers in establishing industry-based R&D activities (ibid.). Moreover, there are a limited number of industry-focused R&D projects from the public R&D institutions (ibid.). A major proposal of the BioVerdi report is, therefore, to strengthen the access to R&D resources – not least the ones that can be provided from the universities (ibid.). Hence, the report argues for a much closer and stronger cooperation between industry and research in this area in particular, and for Norwegian industrial development and innovation in general (ibid.).

At the same time, experiences indicate the importance of cooperation between the industrial companies and the regionally based colleges and research institutions as a way of inducing innovation activities. Developing a national innovation and competence system for the biomass-based industries within which regional clusters can play a more prominent role.

Text box 2: Counties as an arena for industrial development:

Given the crosscutting, innovative character of a biorefinery-centered value chain, one could assume that a joint strategic perspective shared by policy-makers, public authorities, researchers and industrial actors is important. This could come from all of the three sectors, but it is here assumed that the county administration and politicians could play a more prominent role given the county's mandate to induce new industrial activity.
We can briefly illustrate the role of the county level in Norway with some example from three coastal counties; Møre og Romsdal, Sør-Trøndelag and Troms.

Sør-Trøndelag county hosts Norway's technological university (NTNU) and important research institutions with relevance for the further develpment of a marine biomass value chain. In addition, the county with its governor and political majority has engaged itself in formulating a marine industrial strategy – together with its neighbouring county, Nord-Trøndelag (Sør-Trøndelag og Nord-Trøndelag fylkeskommuner 2013). The main vision of this strategy is to host the 'world's leading and most sustainable aquaculture, and becoming Norway's most important region in marine-based industrial sectors (ibid.).

Møre og Romsdal county has traditionally had an important fisheries and seafood producing sector. The county also hosts Norway's first macroalgae cultivation site (Algae Industries Norway 2014). The county is also the county hosting the highest number of bioingredient industrial enterprises (Fiskeri- og kystdepartementet 2012). However, the county is not specfically strongly profiled in terms of research activity as to biomass refinement, and there is no university in the county. Furthermore, the county politicians have not yet formulated any marine-specific industrial strategy, in contrast to Sør-Trøndelag. In particular, within this county one also finds the cluster Legasea, working with marine biomass – and funded as an Arena network by Innovation Norway (Skjermoen et al. 2013). According to Skjermoen et al. (2013) this county represents a core region well positioned for a competitive global market, focusing on bioingredients. The region disposes of resources and facilities related to the whole value chain in addition to proximity to international industrial actors, and potential access to global markets and thereby commercialization of products (ibid.; Partnerskapet BioVerdi 2014).

The county of Troms is a traditional stronghold in the fisheries sector and related industries. There is also an important aquaculture sector, but a relatively smaller one than in the two other counties (Statistics Norway 2014). In addition, the county hosts the University of Tromsø and other marine-oriented research institutions. The center for research-driven innovation (MabCent) is specifically oriented towards marine biomass. Tromsø also hosts *BioTech North* which is an emerging biotechnology cluster of enterprises and R&D organizations, cooperating closely with regional funding and development actors (triple helix) (BioTech North 2014). As part of this biotech cluster one also finds enterprises and institutions working with biological prospecting – not least exploring new biological components for medical and nutritional purposes. However, the county has not yet formulated any specific policy strategy.

5.4. National regulations and incentives

5.4.1. Ministry of Trade, Industry and Fisheries: Authorization of seaweed cultivation sites

It is the Ministry of Trade, Industry and Fisheries (NFD) that is the authority for seaweed cultivation, and has the responsibility to process applications and grant licenses. After receiving an application, NFD submits the application to the relevant municipality. The municipality registers and publishes the application for feedback from the local public and stakeholders. The municipality also assesses whether the location relevant for cultivation is compatible with the municipality's area plan. Thereafter, the municipality is authorized to decide. Relevant directorates that also will have to decide on the application according to their respective sectoral responsibilities is the Directorate of Fisheries, the Norwegian Agricultural Authority, the Norwegian Coastal Administration, the County Governor and the Norwegian Water Resources and Energy Directorate.

It is the NFD that finally grants or rejects the application, whereas it is the County municipality that issues the permit document. The previous government proposed to transfer the responsibility for the handling of permits to the County Municipality, as this authority also handles applications for aquaculture (other than seaweed aquaculture). However, this transfer process was never finalized under the previous government, and the current government has thus far not addressed a follow-up of this. NFD has to date received 22 applications for seaweed aquaculture. Thus far – as of January 2015, ten licenses have been granted, whereas the rest are currently under consideration.

Skjermo et al. (2014) point to the fact that cultivation of macroalgaes is different from other aquacultural activities since no nutrition or feed is added. Hence, they recommend that the legislation for the cultivation of macroalgaes must be distinguished from the regulation and licensing of fish farming. Since macroalgae are to be cultivated in the upper layers of the sea – since much sunlight is required, large areas are also necessary in order to provide sufficient cultivation sites (ibid.). Skjermo et al. (2014) therefore recommend a system with time-limited licenses for test sites, in order to identify and assess suitable sea areas, as well as analyzing environmental impacts.

A major environmental consequence is related to the possible reduction of nutrients and plankton biomass as a consequence of seaweed cultivation (ibid: 15). Large-scale cultivation will therefore have the potential of reducing other marine productivity, in contrast to e.g. fish farming which tends to release nutrients to the environment (ibid.). Environmental legislation stemming from the EU level, like the Water Framework Directive and the Maritime Framework Directive are both oriented towards limiting such environmental impacts. Hence, licensing and related environmental impact assessments of future cultivation sites will have to deal with potentially stricter regulations of release of nutrients. This again, can imply a stronger potential for weighing in positive effects as to the reduction of additional nutrients in water (ibid.).

5.4.2. The Research Council of Norway

The Research Council of Norway (NRC) is the agency responsible for awarding grants for research as well as promoting research and science. There is no specifically dedicated research program for bioeconomy and this will likely continue until the Government decides to develop a strategy for the development of Norwegian bioeconomy. However, as indicated in section 5.2 there are several existing programs that underpin the idea of a bioeconomy. For seaweeds in particular, grants for research regarding seaweed cultivation can be applied for under the Aquaculture program. Use of seaweed for chemicals and fuels falls into other programs. In general, the Research Council has not received many applications regarding seaweed cultivation.

In 2014 the Research Council granted funding for the establishment of new research-based innovation called 'Foods of Norway', coordinated by the Norwegian University of Life Sciences. The center's main objective is to provide new knowledge on feedstock and for a more sustainable production of meat and dairy products from the agricultural sector (NMBU 2014). In this way the center is to conduct research for more innovative practices along the whole value chain for food production, and relates itself to the concept of bioeconomy (ibid.). This will probably also include seaweed as components in development of new feedstocks and nutrition for the agricultural and food-producing sector.

According to NIFU survey (2013) R&D activities related to biotechnology amounted to a value of 3.8 bill. NOK in 2011 (Børing & Wendt 2013). R&D and industry accounted for one third each of this number, whereas health and medicine represented 50 % of these resources (ibid.). Compared to other countries, Norway has a leading position in the marine part of the bioeconomy given the role of the country's aquaculture industry and related biotechnological supply industry (Partnerskapet BioVerdi 2014).
One example of research-industry cooperation is the NRC-funded scheme for research centres for Environment-friendly Energy Research (FME), which since 2009 has provided a framework for industry-research cooperation related to a range of different renewable energy technologies, energy efficiency and usage in buildings, and societal and environmental aspects of the renewable energy system.

5.4.3. Innovation Norway and innovation policy measures

Innovation Norway (IN) is the public agency responsible for innovation and development of Norwegian enterprises and industry, both internationally and regionally in Norway. Recently, IN launched a long-term bioeconomy commitment, with emphasis on new processing technology (Innovation Norway 2014c). The purpose of the commitment is to contribute to increased value from a wide range of raw materials from forestry, agriculture, fisheries and aquaculture. In 2013, IN also established a Bioeconomy Program to support industrial biorefinery projects in order to induce Norwegian industrial competitiveness in new bioeconomy sectors (Innovation Norway 2014c).

An important measure within this program structure, and resulting from the commitment, is the Biorefinery program (Bioraffineriprogrammet), where small- and medium sized enterprises working with processing of biomass in the early pilot phase can receive support (Innovation Norway 2014d). Another new measure is an innovation network and other measures are also considered. As a follow-up of the overall commitment, the new program will be supplemented with Innovation Norway existing schemes.

Specifically for seaweed, the most relevant schemes are the Biorefinery program and the Environmental technology scheme (Miljøteknologiordningen). The few seaweed-relevant applications Innovation Norway has received have been granted support through these schemes (Innovation Norway 2014d). Innovation Norway works actively to bring bioeconomy relevant stakeholders together and strengthen collaboration. In conjunction with the new innovation network, Innovation Norway also wants to create a subgroup for development of seaweed which could ultimately result in more projects eligible for support.

Given the Bioeconomy program's recent establishment it has been too early to evaluate its actual impact. However, one could say the program demonstrates public authorities' willingness to foster new bioeconomy-related activities in Norway, and thereby indicates the potential of more cross-cutting policy incentives.

Innovation Norway has supported a demonstration project where conversion of biomass to hydrogen and electricity for transport purposes included carbon capture as a part of the process.[7]

[7] http://www.zegpower.no/homepage/prosjekter/avsluttede-prosjekter/

A more established program for biomass related industrial development is Innovation Norway's Bioenergy program. A main objective with the program has been to promote small-scale producers of biomass-based heating based on agriculture. During the period 2003-10, 94 facilities were granted economic support. These facilities produce a total of 71 GWh heating, mainly to municipalities [8]. From 2005 onwards small farm-based facilities were approved as eligible for the delivery of heating to farms and residential buildings.

In addition, a recent grant from the Norwegian Parliament illustrates the possibilities for new industrial development in the axis between marine activities and land based activities, as well as indicating the potential for combining framework conditions for different technological developments; here carbon capture and storage (CCS) and fish feeding stock: In June 2014 the Parliament granted NOK 6 million to a pilot plant for the production of algae using CO2 on Technology Centre Mongstad. The shortage of omega-3 fatty acids used in fish feed is a growing problem for the growing aquaculture industry and the aquaculture industry looks for alternative and sustainable sources of omega-3 that can be used in feed and ensure the continued growth of the Norwegian aquaculture industry.[9]

5.4.4. ENOVA and energy-related incentives

Enova is a public enterprise owned by Ministry of Petroleum and Energy, established in order to promote more efficient energy consumption and increased production of renewable energy. There are also funding schemes by which bioeconomy-related activities, including seaweed cultivation, can be funded. In particular, Enova has a Biogas program (Program biogassproduksjon) that financially supports enterprises who wants to develop industrial production of biogas. The program provides investment support for construction of facilities for biogas production, as well as distribution in conjunction with production. Plants that produce biogas from biological waste, energy crops or forest material and that supply the gas to external customers can be granted support (ENOVA 2014a). Moreover, one can apply for funding for pilot projects within the New Technology scheme (Ny teknologi). The funding is here directed towards demonstration of energy technology under real operating conditions (ENOVA 2014b).

Transnova was established in 2009 and has the mandate to facilitate and support R&D projects in the transport sector which are to reduce GHG emissions from the transport sector in Norway. Transnova has funded demonstration and pilot projects with a potential of competence building, learning and knowledge sharing, as well as providing concrete solutions for a transition towards a GHG-emission free transport sector (ibid.). This includes projects on biogas for transport. Transnova is led by the Ministry of Transport and shares secretariat with the Norwegian Public Roads Administration. From 2015, Transnova has become a part of Enova, and the programs for transport funding, are to be integrated into the Enova program structure (Transnova 2014).

5.4.5. Regulations and incentives for biomass for stationary energy

As indicated in section 5.2 the policy framework regulating waste and recycling for energy and industrial purposes affects the usage of biomass, because the infrastructure and framework for energy recovery and recycling can be a platform for the supplement of other biomass. The framework conditions for energy recovery are also connected to the production of district-heating in Norway.

[8] https://www.regjeringen.no/contentassets/adb6bd7b2dd84c299aa9bd540569e836/NO/PDFS/STM201120120009000DDDPDFS.pdf

[9] http://www.tcmda.com/no/Presserom1/Nyheter1/2014/Algepilot-til-TCM/

The use of bioenergy, including waste, as a source of heating (and cooling) is increasing in Norway, both due to municipalities' requirements on connection to district heating infrastructure, and public financial support to district heating projects (Olje- og energidepartementet 2013). In 2010, the usage of district heating amounted to 4.3 TWh in Norway (ibid: 30). There was an increase in the use of district heating at 30.6 percent between 2009 and 2010 (ibid.). Since 2000 the use of district heating in Norway has almost tripled, and currently constitutes 3 per cent of stationary energy usage (ibid.).

One prominent example is the municipality of Oslo where one has developed an extensive network of district heating, based on an extensive collection and processing of household and industrial waste. Oslo's waste combustion facility is one of Europe's largest and most advanced (Oslo Energigjenvinningsetat 2014). This production is highly dependent on the development of the 'waste market'. This market development could again impact upon the competitiveness of alternative biomass like seaweed.

The use of waste as a source for energy/energy recovery in Norway is mainly regulated through the regulations pertaining to the ban of waste deposits (2009), withdrawal of combustion fee (2010), in addition to investment support for district heating facilities and waste-based electricity production (Thema/Avfall Norge 2014). However, Norwegian waste – in line with waste from other countries is becoming a tradable good that can be profitable in a Nordic and European market (ibid: 7). In light of this, the Norwegian combustion facilities have been confronted with challenges as to profitability. The Norwegian policy framework is developed in accordance with the EU Waste Framework Directive (Dir. 2008/98/EC). This Directive sets requirements related to waste deposit, combustion, recovery and trade with waste as a resource for recovery – by different subordinate Directives and regulations. The two main alternatives for the recycling of waste are energy recovery or material recycling. In Norway there is no target as to the eventual priority between these two alternative paths (c.f. Miljøverndepartementet 2013).

A direct, relevant policy measure for the development of district heating infrastructure has been the public program for investment support provided by Enova. In addition, it is important to emphasize that the establishment and management of waste recycling and energy recovery facilities are the product of political decisions in the municipalities. This will again both be related to economy and the societal acceptance for the very localization of these facilities and infrastructures (c.f. Thema/Avfall Norge 2014: 34).

Related to the waste deposit and recycling, regulations are also the issue of phasing in biogas as an alternative energy production option, both for transport and stationary energy purposes. As far as the stationary energy part is concerned, the challenge is to provide a viable market for this option given Norway's electricity- and hydropower-based energy system. The status for biogas facilities in Norway indicates that this has been an option mainly exploited by some actors in agriculture and industry (Miljødirektoratet 2013). In 2013 approx. 0.5 TWh biogas for energy purposes were produced in Norway (ibid.).

The main resource utilized for biogas production today is drain mud, but the potential for this resource is already more or less fully exploited (ibid.). The economic most viable alternative option seems to be manure from the agricultural sector, and wet organic waste. Given the expected increase in the volume of waste, wet organic components seem to be more competitive than manure – given recent economic calculations (ibid.). The main economic incentive today is the investment support provided from Enova in order to contribute to the establishment of biogas production facilities. If the full potential for biogas production is to be realized, new economic incentives are needed (ibid.).

5.4.6. Regulation of biofuels and chemicals

In Norway, the regulation of biofuels – which is also part of the country's fulfilment of its obligations under the EU Renewable Energy Directive, is based on the Product regulation (chapter 3) – as well as related guideline documents (Lovdata 2015b). This regulation covers most of the life cycle; from biomass harvesting, processing/production, to waste disposal and emissions (ibid.). The regulation pertains to both liquid and gasified biofuels, as well as biomass for stationary purposes (including biogas). The regulation includes the overall requirement that min. 3.5 % of all auto fuels annual sales in Norway must be composed of biofuels. As mentioned under section 5.2, this requirement will be increased to 5.5 percent, according to the Parliament's decision on the State Budget for 2015 (Høyre 2014). The Norwegian regulation reflects the EU legislation and guidelines concerning sustainability criteria, and particularly the avoidance of conflicts with food-production (ibid.).

Regarding specific incentives for biofuels, none such is in place – as mentioned in section 5.2, except a requirement of blending conventional fuels with bioenergy.

Furthermore, biomass can provide us with substitutes to a whole range of assumed environmentally damaging chemical substances (SINTEF 2013). In this way, the support of innovative production of platform chemicals based on seaweed may contribute to the fulfilment of requirements under the EU REACH regulation, the main regulatory framework for chemicals in Europe – providing commitments Norway has to fulfill in line with other EU Member States.

5.5. Summary

There are a number of relevant incentives and regulations related to the overall provision and management of biomass in Norway. However, there are not any measures specifically aiming at seaweed and macroalgae – except the regulatory regime for the licensing of algae-cultivation sites.

A major challenge for a successful implementation of innovative marine biomass-based value chains would be to adapt the established, sectorally divided policy measures – not least the ones pertaining to research, innovation and environmental regulations. When turning to the current policy framework in Norway, and given the crosscutting character of an innovative marine biomass industry, it is relevant to consider the policy fields of research and innovation, in addition to energy, and the management of the marine environment and resources. Except for the research and innovation policy fields, where there are public programs supporting bioeconomy-related activities, no specific policy target for bioeconomy has yet been formulated. Furthermore, there are no specific targets or regulatory instruments in place pertaining to marine biomass development and innovation. On the other hand, the marine biomass sector is a priority within specific public research and innovation programs.

As far as relevant research is concerned, there has not been published any policy studies regarding the development of a Norwegian bioeconomy. For bioenergy, Scarlat et al. (2011) claim that the main barriers for bioenergy development in Norway rely on the lack of a real market for bioenergy, as well as the lack of a proper infrastructure for biomass-based heating and electricity. The availability of cheap electricity in Norway, mainly from hydropower, is also one of the main issues preventing the development of the bioenergy sector (Scarlat 2011). However, framework conditions have also proven vital for the bioenergy sector in Norway.

Although profitability is generally a major challenge for the bioenergy sector, Forbord et al. (2012) found an increase in new bioenergy firms in Norway in recent years. The results from analyzing five cases of local and regional forest based (wood chips) supply of heat in three regions in Norway showed that national and local

framework conditions were vital. Various types of public funding (e.g ENOVA, Innovation Norway, support for logging of wood aimed for wood chips) played an important role. Another key factor was local political support in developing conditions for the establishment and operation of the supply chains for bioenergy. This occurred through motivation and drawing attention to bioenergy as a solution to local needs. Local authorities were also crucial also in two other respects: through investments and adaptations in infrastructure and as a customer (Forbord et al. 2012). Moreover, Damman (2014) found that the political framework conditions are not consistently adapted to the overall policy goals for developing bioenergy in Norway. Stakeholders in the bioenergy sector in Mid-Norway requested a new strategy with a greater focus on increasing the demand for bioenergy (ibid.).

6. Conclusion and further perspectives

Bioeconomy visions within the European context have mainly been formulated in scientific terms at a strategic level, and have thus far mainly addressed a scientifically informed audience. The complexity inherent in an industrial transformation of biomass value chains – not least related to sustainable development, could trigger reinforced political interest as the concept grows stronger and the current R&D focus shifts towards more concrete industrial development. Bioeconomy visions and strategies need, therefore, to be more strongly anchored within concrete industrial sectors.

At the same time, given the crosscutting nature of bioeconomy-oriented value chains, there is a need for more cross-cutting strategies - both from industrial and political actors. Considering concrete industrial foundations for transitions towards bioeconomy stands out as an important and fruitful research strategy, as well as considering specific geographic locations. However, given the challenges related to the sustainability of a bioeconomy, innovative industrial strategies should be echoed by crosscutting policy strategies – clearly anchored at the appropriate level – substantially reflecting objectives and concerns of sustainable development.

As far as a more innovative development of a sea-based bioeconomy there are no clear overall political signals from the national level in Norway. This can be seen in line with an overall lack of clear objectives and incentives for increased use of biomass for energy and industrial purposes. However, an emerging political interest can be discerned as exemplified by the Parliament's recent call for a national bioeconomy strategy. It is, furthermore, also possible to employ alternative perspectives on further policy development, focusing on the impact of industrial initiatives. In particular, the activity related to industrial clusters at the regional level can induce a stronger political focus and clearer political priorities from the national level. Hence, it is possible to combine 'top-down' (national to regional level) and 'bottom-up' (regional to national level) perspectives for further policy development.

Given the focus on marine industrial development and related technologies at the county level, the counties could be in a position of governing such transitions more substantially and concretely – than would have been the case from the national level. However, there seems to be more room for a political-strategic thinking and practice at the regional level than what is currently the case in Norway.

Moreover, an important aspect to consider in a comparative perspective with other European countries is the importance of established economic and industrial structures. Norway is rich on natural resources, renewable energy is already highly developed, and has a generally strong economic situation: Thereby the country could be said to represent a 'hard case' for a bioeconomy transition. Norway's situation on energy supply with abundant hydropower is, for example, an important explanatory factor behind the relatively less ambitious strategy for increased shares of bioenergy (Knudsen et al. 2008).

Based on the research literature review, there are few recommendations in place for how policy should be tailored to facilitate the development of a biobased economy, including seaweed, as the point of departure. However, it stands out as important to provide a better multi-disciplinary understanding of the factors that can lead to a bioeconomy transition. Another important aspect is how concerns of sustainable development are managed and accounted for. Such trade-offs can also be managed within updated and more coherent regulatory framework where environmental aspects can be considered in line with economic and social aspects, and different concerns thereby can be weighed according to policy objectives , values and different interests (c.f. Bryden et al. 2013). In sum, relevant research literature has highlighted how to secure political commitment and suitable framework conditions, as well as securing societal acceptance. However, studies providing concrete recommendations for how to achieve this is in practice are lacking. More particularly, no specific recommendations concerning the policy framework and societal acceptance for seaweed and macroalgae have been provided thus far. Furthermore, no social scientific study has thus far thoroughly analyzed how policies and governance arrangements affect the development of the seaweed sector given a Norwegian context. Based on this knowledge status, it appears as important to increase the social scientific research on these matters. We specifically recommend projects and studies combining foci on policy framework and societal acceptance. It would also be very fruitful to take into account various experiences internationally – and thereby provide a research agenda where comparative assessment of societal and political factors stand out as crucial elements.

In this respect, it is important to include an industrial focus, albeit at the same time focusing on the political foundations and the public institutional framework that can induce and manage such a transition, in line with the research on governance for sustainable development (c.f. Meadowcroft 2011). This focus could be accompanied by more research on the regional context and thereby provide a more concrete understanding of conditioning factors and their relative weight.

Based on the findings by Staffas et al. (2013) it may be especially important to establish and substantiate how the seaweed industry can enhance the Norwegian economy and provide new employment opportunities. Moreover, as pointed out by McCormick and Kautto (2013), lack of social acceptance will likely greatly diminish the policy-makers' support of bioeconomy related activities. Hence, participatory governance that engages the general public and key stakeholders in an open and informed dialogue is pointed out as crucial for future development (ibid). However, thus far, no documentation on how this participatory governance should be enacted in practice, has been published. Moreover, for seaweed cultivation, very little has been written about social acceptance related challenges associated with expanding the seaweed industry (Roberts and Upham 2012). However, conflicts with other interests on the use of sea areas have been pointed out as a potential important a challenge due to the large space necessary for seaweed cultivation (see van Hal et al. 2014, Skjermo et al. 2014) and possible opposition from local communities and marine users have been highlighted as a potential conflict (Roberts and Upham 2012).

Hence, more research could be conducted studying perceptions of both seaweed cultivation and processing and how local communities and stakeholders view these developments, as well as if and how integration of seaweed cultivation with existing aquaculture development (e.g salmon farming) and energy production facilities (wind farms) could alleviate sea use conflicts. Moreover, how local communities and stakeholders best can be engaged and involved in resolving potential conflicts should be studied in order to ensure communication. Here, the approaches and methodologies used in the extensive literature[10] on stakeholder/public engagement could serve as a fruitful starting point.

[10] For an overview of the various types of public engagement mechanisms, see Rowe and Frewer 2005

6.1. Recommendations

Based on the report's assessment we will point to the following policy areas and measures which can be relevant in order to more strongly induce: (1) the industrial usage of biomass and establishment of related value-chains in Norway; (2) stronger development of the industrial potentials for macroalgae; and (3) more knowledge and competence-building regionally in order to ensure a continuing focus on sustainable development and innovation as part of the value-chain development.

- Formulation of national Strategy for the Bioeconomy:
  - Following up the Parliament's decision and building on the examples of, among other countries, Denmark, Finland, Germany and the UK, Norway should develop a strategic thinking of how to approach a bioeconomy – anchored at the national, political level. Both the formulation and follow-up should take place in dialogue with relevant research and industrial actors, as well as other concerned parties.
  - Coordinate the national strategy with strategic plans in other countries and in relation to relevant international cooperation (c.f. OECD 2009).

- Early evaluation of Bioeconomy-relevant support schemes, as provided by the Research Council of Norway, Innovation Norway and Enova:
  - Given the recently established Bioeconomy program, managed by Innovation Norway, in addition to the relevant programs for research and energy support, it is relevant to see these measures taken together. An early evaluation of how these programs are followed up and eventually interact would be relevant. This would also support these three agencies' ambition of working more closely together in order to realize a Norwegian bioeconomy.
  - This would also be the basis for considering more effective policy measures for the phase-in of the sustainable usage of biomass for industrial and energy purposes.

- More coordinated licensing processes for macroalgae cultivation sites.
  - Today's system where the Ministry of Industry and Fisheries coordinates a number of inputs from sectoral agencies and regional and local authorities – at several stages, should be simplified.
  - Establish a strategic framework within which different settings for seaweed cultivation in different regions can be assessed in a coherent way in order to identify the most optimal and environmentally benign locations.

- The formulation of regional biomass industrial strategies.
  - Industrial, research and political actors at the county level could cooperate more closely in order to prepare and establish competitive industrial clusters for biomass-based value chains. Coastal regions are specifically encouraged to develop strategies whereby existing maritime industries, including aquacultures, can be integrated with a more innovative and sustainable usage of marine bio resources. Vice versa, existing industries – not least the ones related to biotechnologies and bio-ingredients, should be encouraged to cooperate more closely with regionally based biomass producers. Such clusters can also be established within the current support schemes of Innovation Norway (Arena, NCE).
  - Such regional industrial networks or clusters could also form the platform for the formulation of inputs for policy-makers, both regionally and nationally. By including regional policy-makers in the cluster one can also induce policy learning between the different actors in the cluster.

- Strengthen the focus on societal acceptance and public engagement, and the communication between stakeholders (c.f. OECD, Roberts & Upham (2012).

- Given different experiences with industrial establishment, the construction of energy infrastructure and other physical installations in the local environment where people live, the regional clusters recommended above should also engage in the development of measures which can duly inform and involve affected local inhabitants. This can prevent conflicts of interest to escalate, thereby shortening the time consumption for the realization of biomass-based industrial projects. It will also contribute to a more robust political support. Much can be learned from energy companies which have been increasingly experienced in conducting various information and involvement activities locally.

References

Algea industries, Norway (2014): Presentation available via http://www.algea.com/ [Accessed on 13 April 2014]

Avinor (2014): 'Biodrivstoff til sivil luftfart – fra idé til realisering', Conference presentation by Aanonsen IR. Conference on aviation, Oslo 11 March 2014.

Bellona (2013): 'Tradisjonelt og integrert havbruk. Dagens miljøutfordringer og morgendagens løsninger', *Bellona rapport,* Oslo: Bellona.

Benson, D. et al. (2014): 'Algal biofuels: impact significance and implications for EU multi-level governance', in *Journal of Cleaner Production* 72: 4-13.

BioTech North, Tromsø (2014) Available via http://biotechnorth.no/ [Accessed on 13 April 2014]

Bryden, J., S.S. Gezelius, K. Refsgaard (2013): 'Governing Innovation for Sustainable Development: Designing creative institutions', *Working Paper* 2013-5, Oslo: Norwegian Agricultural Economics Research Institute (NILF).

Bøeng AC, Holstad M (eds) (2013): *Fakta om energi. Utviklingen i energibruk i Norge*. Statistics Norway, Oslo

Børing, P. & K. Wendt (2013): 'Bioteknologisk FoU 2011. Ressursinnsats i universitets- og høgskolesektoren og instituttsektoren', *Rapport* 18/2013, Oslo: NIFU – Nordisk Institutt for studier av innovasjon, forskning og utdanning.

Damman S. (2014). 'Ikke sultne nok? En studie av vilkår for vekst og innovasjon i bioenerginæringa i Midt-Norge', *SINTEF Report* A25940, Trondheim: SINTEF Teknologi og Samfunn.

Dave, A., Huang, Y., Rezvani, S., McIlveen-Wright, D., Novaes, M., Hewitt, N. (2013): 'Techno-economic assessment of biofuel development by anaerobic digestion of European marine cold-water seaweeds', in *Bioresource Technology* 135: 120-127.

Det Kongelige Norske Videnskabers Selskab (DKNVS), Norges Tekniske Videnskabsakademi (NTVA) (2012): *Verdiskaping basert på produktive hav i 2050*, Oslo: DKNVS, NTVA.

ENDS Europe Daily (2014a): 'EU leaders set 2030 climate, energy targets', ENDS online, 24 Oct. 2014. Available at: http://www.endseuropedaily.com/articles [Accessed on 31 October 2014].

ENDS Europe Daily (2014b): 'Last ditch protest against 'weak' biofuel reform', ENDS online, 9 Dec. 2014. Available at: http://www.endseuropedaily.com/articles [Accessed on 10 December 2014].

Enova (2014a): 'Støtte til biogassproduksjon', accessible via http://www.enova.no/finansiering/naring/fornybar-varme/stotte-til-biogassproduksjon/stotte-til-biogassproduksjon/122/144/, accessed on 19 Jan. 2015.

Enova (2014b) 'Ny teknologi' accessible via http://www.enova.no/finansiering/naring/ny-teknologi/80/0/, accessed on 27.1.2015

ESAIA (European Sustainable Energy Innovation Alliance) (2014): *Innovation Challenge towards Rational Use of Bio-Resources in Europe. A discourse book,* European Sustainable Energy Innovation Alliance, Working Group 1, May 2014, Brussels: ESAIA Secretariat.

European Commission (2007): COM(2007) 723 final, Communication on 'A European Strategic Energy Technology Plan (SET-PLAN) – towards a Low Carbon Future', Brussels: The European Commission.

European Commission (2011a): COM(2011) 21 final, Communication on 'A resource-efficient Europe – Flagship initiative under the Europe 2020 Strategy', Brussels: The European Commission, 26.01.11.

European Commission (2011b): COM(2011) 885/2 final, Communication on 'Energy Roadmap 2050', Brussels: The European Commission.

European Commission (2012a): COM(2012) 60 final Innovating for Sustainable Growth: A Bioeconomy for Europe. European Commission, Brussels

European Commission (2012b) Innovating for Sustainable Growth. A Bioeconomy for Europe. European Commission, Brussels

European Commission (2014): COM(2014) 130 final/2, Communication on'Taking stock of the Europe 2020 Strategy for smart, sustainable and inclusive growth', Brussels: The European Commission, 19.03.14.

European Union (2009) Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC.

Federal Government of Germany: 'National Policy Strategy on Bioeconomy', Berlin: Federal Ministry of Food and Agriculture.

Federal Government of Germany (2012): 'Biorefineries Roadmap', Berlin: Federal Government.

Finnish government (2014): 'The Finnish Bioeconomy Strategy'.

Fiskeri- og kystdepartementet (2012): ' Meld.St. 22 (2012-13) Verdens fremste sjømatnasjon', Oslo: Fiskeri- og kystdepartementet

Forbord, M., et al. (2012): 'Development of local and regional forest based bioenergy in Norway – Supply networks, financial support and political commitment', in *Biomass and Bioenergy* 47(0): 164-176.

Forskning (2012) Bioøknomien er en stor mulighet for Norge. Forskning 1/12 available via http://www.forskningsradet.no/bladetforskning/Nyheter/Biookonomien_er_en_stor_mulighet_for__Norge/1253973306394 Accessed on 13 April 2014

Garud R. & P. Karnøe (2003): 'Bricolage vs. breakthrough: distributed and embedded agency in technology entrepreneurship', in *Research Policy* 32: 277-300

Geels, F.W. (2002): *Understanding the Dynamics of Technological Transitions*, Doctoral dissertation, University of Twente

Geels, F.W. (2010): 'Ontologies, socio-technical transitions (to sustainability), and the multi-level perspective, in *Research Policy* 39: 495-51

Geels, F.W. & J. Schot (2007): ' Typology of sociotechnical transition pathways', in *Research Policy* 36: 399-417

Gold, S. (2010): 'Bio-energy supply chains and stakeholders', in *Global Change* 16: 439-462

Greaker M (2011): 'Innretning av støtte til biodrivstoff', *Økonomiske analyser* 5/2011: 17-20

Henriksen, K., M.G. Sandberg, T. Olafsen, H. Bull-Berg, U. Johansen, A. Stokka (2012): ' Verdiskaping og sysselsetting i norsk sjømatnæring 2010', *SINTEF Rapport* A23089, Trondheim: SINTEF Fiskeri og Havbruk AS og SINTEF Teknologi og samfunn.

Hooghe L. & G. Marks (2003): 'Unraveling the Central State, but How? Types of Multilevel Governance', in *American Political Science Review* 97: 233-243

Høyre (2014): 'Enighet om Statsbudsjettet 2015. Avtale mellom Høyre, Fremskrittspartiet, Venstre og Kristelig Folkeparti av 21.11.14', Oslo: Høyre.

Iida, T. (1998): 'Competition and communal regulations in the kombu kelp (Laminaria angustata) harvest', in *Human Ecology* 26(3): 405-423.

IEA (2012a): 'IEA Bioenergy Task 42 Biorefinery, Bio-based Chemicals: Value Added Products from Biorefineries', *Report*, Paris: International Energy Agency

IEA (2012b): *Energy Technology Perspectives 2012. Pathway to a clean energy system*, Paris: International Energy Agency.

Innovation Norway (2014a): 'Bioøkonomi gir muligheter til norske bedrifter', available via http://www.innovasjonnorge.no/no/Nyheter/biookonomi/ Accessed on 19 Jan 2015.

Innovation Norway (2014b) http://www.innovasjonnorge.no/no/energi-og-miljo/Nyheter/Posisjonerer-norsk-industri-for-fremtidens-biookonomi/Fakta-om-biookonomi/ Accessed on 13 April 2014

Innovation Norway (2014c): On the bioeconomy program, available via http://www.innovasjonnorge.no/no/energi-og-miljo/biookonomi/, accessed on 19 Jan. 2015.

Innovation Norway (2014d): On the biorefinery program, available via http://www.innovasjonnorge.no/no/finansiering/bioraffineringsprogrammet/ accessed on 19 Jan. 2015.

Jordan, A. (2008): 'The governance of sustainable development: taking stock and looking forwards', in *Environment and Planning C: Government and Policy* 26: 17-33

Jordan, A.J. & A. Lenschow (eds) (2008): *Innovation in Environmental Policy? Integrating the Environment for Sustainability*, Cheltenham UK: Edward Elgar

JRC (EU Joint Research Centre) (2013): 'Carbon accounting of forest energy', *Technical report.*

Kemp, R. S. Paro & R.B. Gibson (2005): 'Governance for sustainable development: moving from theory to practice', in *International Journal for Sustainable Development* 8: 12-30

Kern, F. et al. (2014): 'From laggard to leader: Explaining offshore wind developments in the UK', in *Energy Policy*. Available at http://dx.doi.org/10.1016/j.enpol.2014.02.031. [Accessed on 31 March 2014].

Kleinschmit, D. et al. (2014): 'Shades of green: a social scientific view on bioeconomy in the forest sector', in *Scandinavian Journal of Forest Research* 29(4): 402-410.

Klima- og miljødepartementet (2014): 'Nasjonal tverrsektoriell biogasstrategi. Foreløpig utgave', Oslo: Klima- og miljødepartementet, 08.10.14.

Knudsen J., Larsen O.M. & Ruud A. (2008): 'Norway: Trying to maintain maximum RES-E in a petroleum driven economy', in W.M. Lafferty and A. Ruud (eds), Promoting Sustainable Electricity in Europe: Challenging the Path Dependency of Dominant Energy Systems, Cheltenham UK: Edward Elgar, pp. 250-278.

Kraan, S. (2013). "Mass-cultivation of carbohydrate rich macroalgae, a possible solution for sustainable biofuel production." Mitigation and Adaptation Strategies for Global Change 18(1): 27-46.

Kunnskapsdepartementet (2011): *Nasjonal Strategi for bioteknolog,* Oslo: Kunnskapsdepartementet

Lafferty,W.M. & E. Hovden (2003): 'Environmental Policy Integration: Towards and Analytical Framework', in *Environmental Politics* 12: 1-22

Lafferty,W.M. (ed.) (2004): *Governance for Sustainable Development,* Cheltenham UK: Edward Elgar

Landbruks- og matdepartementet (2009): 'St.meld. nr. 30 (2008-09) Klimautfordringene – landbruket en del av løsningen', Oslo: Landbruks- og matdepartementet

Landbruks- og matdepartementet (2013): Press release on the establishment of the expert commission on improved industrial utilization of forest resources (Skog 22).

Liabø, L. et al. (2007): 'Rammebetingelser og konkurranseevne for akvakultur. En sammenlikning mellom Chile, Skottland og Norge', *NILF-rapport* 2007-3. Norsk Institutt for landbruksøkonomisk forskning (NILF), Oslo

Lovdata (2015a): Plan- og bygningsloven, available via https://lovdata.no/dokument/NL/lov/2008-06-27-71?q=plan-+og+bygningsloven, [accessed on 19 Jan. 2015]

Lovdata (2015b): Produktforskriften, available via https://lovdata.no/dokument/SF/forskrift/2004-06-01-922?q=produktforskriften , [accessed on 19 Jan. 2015]

McCormick, K. & T. Kåberger (2007): 'Key barriers for bioenergy in Europe', *Biomass and Bioenergy* 31: 443-452

Meadowcroft, J. (2011): 'Engaging with the politics of sustainability transitions', in *Environmental Innovation and Societal Transitions* 1: 70-75

Meland, M. & C. Rebours (2012): 'The Norwegian Seaweed Industry', work package 1&2 of the NETALGAE project, Bioforsk – Norwegian Institute for Agricultural and Environmental Research.

Miljødirektoratet (2013): 'Underlagsmateriale til tverrsektoriell biogasstrategi', Oslo/Trondheim: Miljødirektoratet.

Miljøverndepartementet (2009): 'Statlig planretningslinje for klima- og energiplanlegging i kommunene', Oslo: Ministry of the Environment.

Miljøverndepartementet (2013): 'Fra avfall til ressurs. Nasjonal avfallsstrategi', Oslo: Miljøverndepartementet.

Ministry of Local Government and Modernisation (2014): Website on the Cities of the Future, available at: http://www.regjeringen.no/en/sub/framtidensbyer/cities-of-the-future-2.html?id=551422

Ministeriet for Fødevarer, Landbrug og Fiskeri (2014): 'Det nationale Bioøkonomi-panel', Copenhagen: the Minstry of Food, Agriculture and Fisheries.

NCE (2014): Overview of the Norwegian centers of expertise. Available via http://www.nce.no/ [Accessed on 13 April 2014]

NMBU (Norwegian University of Life Sciences) (2014): 'Foods of Norway – et nytt senter ved NMBU', news article on the NMBU website, 26 November 2014. Available via http://www.nmbu.no/forskning/tema/mat/nyheter/node/18866 [Accessed on 26 January 2015]

Nilsson, M. et al. (2012): 'Understanding Policy Coherence: Analytical Framework and Examples of Sector-Environment Policy Interactions in the EU', in *Environmental Policy and Governance* 22: 395-423

NOBIO (2014): Press release commenting the State Budget, Oslo: Norsk Bioenergiforening (NOBIO).

NOU 2012:9: *Energiutredningen – verdiskaping, forsyningssikkerhet og miljø*, Oslo: Norges offentlige utredninger.

NVE (Norges vassdrags- og energidirektorat) (2014): 'Bioenergi i Norge', *Rapport* 41/2014, Oslo: NVE.

Nærings- og fiskeridepartementet (2014): 'Sjømatnæringens bidrag til verdiskaping øker', *Press release,* 22 July 2014, available at: http://www.regjeringen.no/nb/dep/nfd/pressesenter/pressemeldinger/2014/Sjomatnaringens-bidrag-til-verdiskaping-oker.html?id=765387 [Accessed on 13 April 2014]

OECD (Organisation for Economic Cooperation and Development) (2009): *The Bioeconomy to 2030. Designing a Policy Agenda. Main Findings and Policy Conclusions,* Paris: OECD.

OECD (2013): *Marine Biotechnology. Enabling Solutions for Ocean Productivity and Sustainability,* Paris: OECD.

Olje- og energidepartementet (2008): *Strategi for økt utbygging av bioenergi*, Oslo: Olje- og energidepartementet

Olje- og energidepartementet (2013): *Fakta 2013. Energi- og vannressurser i Norge*, Oslo: Olje- og energidepartementet

Oslo Energigjennvinningsetat (2014): On the energy recovery of waste; available via http://www.energigjenvinningsetaten.oslo.kommune.no/optisk_utsorteringsanlegg/, [accessed on 19 Jan. 2015]

Partnerskapet BioVerdi: *BioVerdi. Slik kan bioøkonomien bli den nye oljen,* Oslo: Partnerskapet BioVerdi.

Pedersen, S. og A. Bruvoll (2014): 'Erfaringer og utfordringer med klima- og energiplanlegging i kommuner og fylkeskommuner', Rapport 2014/23, Oslo: Vista Analyse.

Pfau, S. F. et al. (2014): 'Visions of Sustainability in Bioeconomy Research', in *Sustainability* 6(3): 1222-1249.

Pierre, J. & B.G. Peters BG (2005): *Governing Complex Societies. Trajectories and Scenarios,* Basingstoke: Palgrave Macmillan,

Pöyry (2011): ' Evaluering av trebasert innovasjonsprogram. Utarbeidet for Innovasjon Norge', R-2011-016. Oslo: Pöyri

Region Midtjylland (2013): 'Alger til Biogas i Region Midtjylland 2010-2013', Report.

Reve, T. (2012): *Et kunnskapsbasert Norge*, Oslo: Universitetsforlaget

Roberts, T. and P. Upham (2012): 'Prospects for the use of macro-algae for fuel in Ireland and the UK: An overview of marine management issues', in *Marine Policy* 36(5): 1047-1053.

Rowe, G. & L.J. Frewer (2005): 'A Typology of Public Engagement Mechanisms', *Science, Technology & Human Values,* 30: 251-290.

Ruud A, W.M. Lafferty, R. Marstrander & O.M. Larsen (2007): 'Exploring the conditions for adapting existing techno-industrial processes to ecological premises: A summary of the CondEcol project', *ProSus Report* no 1/07, Oslo: Program for Research and Documentation for a Sustainable Society (ProSus), University of Oslo

Sandberg, M.G., K. Henriksen, S. Aspaas, H. Bull-Berg, U. Johansen (2014): ' Verdiskaping og sysselsetting i norsk sjømatnæring – en ringvirkningsanalyse med fokus på 2012', *SINTEF Rapport* A26088, Trondheim: SINTEF Fiskeri og Havbruk AS og SINTEF Teknologi og samfunn.

Scarlat, N. et al. (2011): 'An overview of the biomass resource potential of Norway for bioenergy use', in *Renewable & Sustainable Energy Reviews* 15(7): 3388-3398.

SINTEF (2013): 'Biobased products from sustainable resources', *Project description and plan*, Trondheim: SINTEF

Skjermo, J., I.M. Aasen, J. Arff, O.J. Broch, A. Carvajal, H. Christie, S. Forbord, Y. Olsen, K.I. Reitan, T. Rustad, J. Sandquist, R. Solbakken, K.B. Steinhovden, B. Wittgens, R. Wolff, A. Handå (2014): 'A new Norwegian bioeconomy based on cultivation and processing of seaweeds: Opportunities and R&D needs', *SINTEF Report* A25981, Trondheim: SINTEF Fisheries and Aquaculture.

Skjølsvold, T.M. (2012): *Towards a new sociology of innovation. The case of bioenergy in Norway and Sweden*', Trondheim: Norges teknisk-naturvitenskapelige universitet

Skog 22 (2014a): Rapport Energi. Arbeidsgruppe Energi – Bioenergi. Høringsutkast.

Skog 22 (2014b): Rapport fra arbeidsgruppe skog. Høringsutkast.

Staffas, L. et al. (2013): 'Strategies and Policies for the Bioeconomy and Bio-Based Economy: An Analysis of Official National Approaches', in *Sustainability* 5(6): 2751-2769.

Statistics Norway (2014) Statistics on aquaculture in Norway. Available via https://www.ssb.no/statistikkbanken/SelectVarVal/Define.asp?MainTable=FiskeTimeverk&KortNavnWeb=fiskeoppdrett&PLanguage=0&checked=true [Accessed on 13 April 2014]

Stephens, J.C., E.J. Wilson, T.R. Peterson & J. Meadowcroft (2013): 'Getting Smart? Climate Change and the Electric Grid', in *Challenges* 4**:** 201-216

Stortinget (2012): 'Innst. 390 S. (2011-12). Innstilling fra energi- og miljøkomiteen til Stortinget om Meld. St. 21 (2011-12) om klimapolitikk' (Klimaforliket), Oslo: Stortinget.

Stortinget (2014): 'Innst. 8 S. (2014-15). Innstilling fra næringskomiteen til Stortinget om om bevilgninger på statsbudsjettet for 2015, kapitler under Nærings- og fiskeridepartementet og Landbruks- og matdepartementet (rammeområdene 9, 10 og 11), Oslo: Stortinget.

Sundvollen (2013): 'Politisk plattform for en regjering utgått av Høyre og Fremskrittspartiet'.

Sør-Trøndelag og Nord-Trøndelag fylkeskommuner (2011): 'Marin strategiplan for Trøndelag 2011-14', Trondheim: Sør-Trøndelag fylkeskommune

Thema/Avfall Norge (2014): 'Avfall Norge: Status for energiutnyttelse av avfall i Norge', *Rapport* 3/2014.

Thornley, P. and D. Cooper (2008): 'The effectiveness of policy instruments in promoting bioenergy', in *Biomass and Bioenergy* 32(10): 903-913.

Transnova (2014): 'Transnovas overgang til Enova', Press Release 10 Dec. 2014, Oslo: Transnova.

Triple Helix Association (2014): Introduction to the Triple Helix concept. Available via http://www.triplehelixassociation.org/ [Accessed on 13 April 2014]

Trømborg et al. (2008): 'Biomass market and trade in Norway: Status and future prospects', in *Biomass and Bioenergy* 32: 660-671

van Hal, J. W. et al. (2014): 'Opportunities and challenges for seaweed in the biobased economy', in *Trends in Biotechnology* 32(5): 231-233.

Wei, N.,Quarterman, J, Jin, Y. S. (2013). "Marine macroalgae: an untapped resource for producing fuels and chemicals." Trends in Biotechnology 31(2): 70-77.

Upham, P., J. Tomei & L. Dendler (2011): 'Governance and legitimacy aspects of the UK biofuel carbon and sustainability reporting system', *Energy Policy* 39: 2669-2678.

Technology for a better society

www.sintef.no