THE BIOBASED ECONOMY AND THE BIOECONOMY IN THE NETHERLANDS

BIOMASS RESEARCH REPORT 1601

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FINAL REPORT

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PREFACE

Biomass can serve as a valuable feedstock for energy purposes including electricity, heat, biofuels, and a range of materials including wood, pulp and paper, chemicals and polymers. The Netherlands has been developing policies for the implementation of a biobased economy as an instrument to replace fossil inputs, reduce greenhouse gas emissions and develop an innovative and competitive economy.

The present study evaluates developments in the Netherlands vis-à-vis similar developments in other countries in Europe. The main focus will be on comparing policy, research and market developments in six countries in the North-west of the continent (the Netherlands, Germany, Belgium, France, the United Kingdom and Denmark).

The current report has been prepared as the request of RVO. Valuable guidance has been provided by Kees Kwant and Wouter Siemers. I want to express my gratitude for their valuable comments. Research for the report has been done by Koen Meesters (Food & Biobased Research) and Mirjam Breure (Biomass Research) who also provided many figures and tables.

Koen Meesters prepared wood balances and figures on biofuel production, wood import and use, and biofuel production; he also provided essential parts of the text (including, but not limiting himself to, wood production and consumption, biofuels production and use of biomass for chemicals and biopolymers).

Bert Annevelink has provided useful background information and valuable feedback. I want to thank all for their efforts to making this report comprehensive, accurate and accessible. Responsibility for any errors, however, remains with me.

Wageningen,

J.W.A. Langeveld

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SUMMARY

The Netherlands

Policy

The Netherlands are one of a number of countries that have implemented a bioeconomy strategy originally in 2007, with a follow-up in 2012. A national agency (RVO) is implementing its bioeconomy policies. Key objective is sustainable biomass valorization ("value pyramid") or production of biobased materials and use residues for biofuels, electricity and heat ("co-production"). Realisation of the valorisation potential is done focussing mostly on biorefineries as key technologies.

Research and Development

The Netherlands is providing many types of support to Research and Development (R&D) of the biobased economy and bioeconomy. Several programmes have been implemented for research on biomass production and conversion into fuels, energy, chemicals and biomaterials. Investment support instruments provided up to €120 million in 2013. Bioenergy (biogas/anaerobic digestion, combustion and gasification) is profiting mostly from this support, while bioplastics and other biomaterials are emerging application fields.

Total regional investments amount to some €1.5 bilion, two thirds of which is allocated to bioenergy. Regional initiatives mostly focus on the final stage of the innovation cycle, relating to specific market formation, but showing considerable regional differentiation.

The Netherlands are known for its top quality education and training. Enrolment rates are comparable to OECD average. There is a growing need for students that are aware of the principles and practices of biobased production chains. A demand for 10,000 biobased experts is expected in the next ten years. Many universities and schools of applied sciences are responding by developing dedicated courses, BSc and MSc programmes.

Market development

Well-developed agricultural, transport and chemical sectors provide a solid basis for the implementation of a biobased economy. The most significant market development can be expected in the production of electricity, biofuels, biobased chemicals and biopolymers. Innovation and chain development are stimulated by the introduction of so-called 'Green deals', oriented towards the development of the biobased economy, bioenergy and to biobased materials. The focus is on improving innovative business and development, developing business cases and remove obstacles of non-technical origin. Many activities will depend on biomass imports as domestic production is mostly limited with exception of crops like grass and sugar beets.

Over the last decade the use of biobased resources for energy production in the Netherlands has increased with 77%. Biomass wastes (including residual wood, chicken manure and paper sludge) were responsible for half the input of bioenergy; solid biofuels,

municipal waste and biogas the other half. The situation in other small countries (Belgium, Denmark) is mostly similar to that in the Netherlands.

The Netherlands have a small forestry and wood sector and large transit of paper pulp. Most wood products are imported. Dutch import of wood pellets in 2011 vary from 0.425 to 1.28 million tonnes. Total use of wood for bioenergy was estimated at 0.56 to 3 million tonnes (2011). Biofuel production in the Netherlands took off only recently, with major bioethanol production based on starch and biodiesel from vegetable oils. As is the case with fossil fuels, the Netherlands are a strong exported to the rest of the continent.

Renewables provide 10% of electricity in 2013, with a modest role for biomass in power and heat production so far. Co-firing of biomass is second largest contributor after wind energy on land. Biogas and other biomass is playing a minor role (total less than 2%). Production of biobased chemicals and biopolymers still is very modest. They are mainly based on processes involving oils, sugars and starch. AVEBE annually produces 254 ktonne of modified potato starch while 145 ktonne of vegetable oils are used in technical applications. Production further includes lactic acid and lactides based on sugars and starch. Other promising biobased developments have not yet reached the production level.

The turnover of the biobased economy in the Netherlands has been estimated at €20 billion for 2013 (Piotrowski and Carus, 2015). The added value was earlier estimated at €2.6 tot €3.0 billion (figures for 2011). This includes materials, chemicals and energy sectors. Together, the biobased element of these sectors generates 0.5 to 0.6% of the Dutch economy. The biobased economy is dominated by the materials sector (€2 to €2.4 billion added value), followed by the chemical sector (€ 442 million), biofuel production (€100 million), and the energy sector (€70 mln). Employment estimates amount to some 45,000 including inclusion of indirect employment. Estimates for 2013 vary between 12,600-14,000 and 80,000.

Peer countries

Policy

Many countries have implemented national strategies for the bioeconomy and biobased economy, be it that some countries are further in implementation. The main focus is on research and development and market development, with bioenergy still playing a dominant role in most countries. Early bioeconomy policy strategies have been published by a number of countries including Denmark (2009, 2012), Germany (2010, 2014), France (2012), the USA (2012), Sweden (2012) and South Africa (2013). In most cases, economic drivers are dominant reason for the development of a bioeconomy policy; strategic (food security, energy independency) and environmental (climate change, waste reduction) drivers are given a lower priority.

Research and development

Large variations in national R&D efforts that have been reported are mirrored by the patterns of national market development. Funding for biobased R&D so farm mostly seems to depend on public sources although private investments have been reported (Germany, France, the UK and the Netherlands). An extensive overview of biobased education in

Europe could not be provided. A first inventory showed biobased economy is included in the curriculum in countries like Germany, Belgium, and the UK. It may be expected to be included in other European countries as well.

Market development

Biobased production in Europe is mostly focussing on bioenergy, wood-based products, and liquid biofuels; production of biochemicals and biopolymers being much smaller. Over the last 10 years, the use of biobased resources for production of bioenergyhas shown the highest growth. The largest increase was realised in Belgium (194%); the smallest in France (35%). The United Kingdom are lagging behind in terms of bioenergy production per million inhabitants; Denmark is far ahead. Belgium and Denmark have mainly expanded the use of biomass waste and solid biofuels over the years. Bioenergy use in France has grown much slower than other countries.

Wood material flow analysis suggest individual countries use different definitions or have different statistical gaps and statistics on energy use of biomass are incomplete. Densely populated countries with little forestry have a low potential to feed the biobased economy from their own forest. As would be expected, these countries also have a far smaller wood industry.

Large-scale liquid biofuel production in the Netherlands took off rather recently, producing bioethanol from starch (wheat, tapioca), and biodiesel from vegetable oils (mainly palm oil). As is the case with fossil fuels, the Netherlands provide fuels that are further exported to the rest of the continent. This is also the case in Belgium (also a country with a large harbour) which has a relatively very large production of biogasoline. Production of biofuels in the United Kingdom is very low. Biofuel production per inhabitant is very high in the Netherlands and Belgium due to processing of imported raw materials. Germany and France remain relatively large producers. Ethanol in the EU is mostly made from wheat (approximately 50% of the supply), corn (30%) and barley (20%). Rapeseed oil (85%) is the dominant feedstock for biodiesel production, followed by soybean and sunflower oil. In comparison, biofuels in the Netherlands seem to be produced from a larger variety of feed-stocks.

Production of heat and power from bioenergy varies by region. Wood still is an important source of heat in many countries of the central and eastern part of the continent whereas coal, natural gas and oil are dominant fuels elsewhere. Electricity production is dominated by nuclear power in France and Belgium and renewable sources in Norway. Other countries generally depend on fossil fuels (coal, lignite and natural gas).

Subsidies and mandatory blends have created a market for biobased fuels and bioenergy. Without support, these markets would not have grown to the present scale. Production of biochemicals still is small compared to production of biofuels and bioenergy but in some niches, the chemical and polymer biobased products may develop without support. Large scale substitution of fossil based polymers such as PE and PP in low added value products (garbage bags) will however require policy measures (especially at low current oil prices).

Added value of the bioeconomy in the EU28 is estimated at some €2.1 trillion in 2013. Most of this (69%) is associated with agriculture and food production (including beverages). Paper, pulp and other forestry production contribute some 18%. The remainder is related to textiles, biofuels and other bioenergy plus pharmaceuticals. Turnover in Europe (excluding food, beverages and tobacco) amounts to €1 trillion. Biofuels and other bioenergy make up 8%; biobased chemicals and biopolymers 5%. Germany, Italy and France together are realising half of the turnover. The UK, Spain, Sweden, Finland, Poland, Austria, and the Netherlands, all smaller players, together generate nearly one third of the total. Turnover in the Netherlands is calculated at some €20 billion, similar to that of Poland and Austria but significantly lower than Sweden, Spain or the UK.

Total EU employment in biobased economy is calculated at 3.2 million (figure for 2013). Again, forest-based production, paper and textiles dominate.

Comparison

Policy

Biobased policy development in the Netherlands has started relatively early compared to peer countries and is mostly driven by economic objectives, as strategic and environmental legislation mostly was already in place at the time. A more or less full implementation is pursued, including installation of a national policy, an implementation agency, R&D programme and regional and local implementation.

Research and development

Dutch public research programmes are broadly oriented in terms of activities, instruments, and participants. Funding is strongly focused on agricultural production and development and implementation of dedicated conversion technologies. The Netherlands also have a relatively high success rate in European research framework programmes while they are also strong in eduction and training (top-5 among OECD countries in terms of performance; average in enrolment rates). The development of academic biobased programmes seems to be ahead of similar programmes in other countries.

Market development

The increase in bioenergy production in the Netherlands over the last decade has been below average growth in the peer countries. Together with the United Kingdom, the Netherlands are lagging behind in terms of bioenergy produced per million inhabitants. Renewable energy from municipal waste is quite high in the Netherlands, where imported municipal waste from other countries is incinerated. As is the case in other densely populated countries with little forestry, the Netherlands have a lower potential to develop a solid wood industry or linking this industry to feed the biobased economy.

SAMENVATTING

Nederland

Beleid

Nederland is één van een aantal landen die een bioeconomie strategie heeft geïmplementeerd. Het nationaal agentschap RVO is verantwoordelijk voor het implementeren van het bioeconomie beleid. Het kerndoel is duurzame biomassa valorisatie (waardepiramide) door de productie van biobased materialen en het gebruik van residuen voor biobrandstoffen, elektriciteit en warmte ("co-productie"). Bij het realiseren van het potentieel ligt sterk de focus op bioraffinaderijen als kerntechnologie.

Onderzoek en ontwikkeling

Steun voor onderzoek naar en ontwikkeling van de biobased economy en de bioeconomie kent vele vormen. Verschillende programma's zijn ontwikkeld voor onderzoek naar de productie van biomassa en omzetting naar brandstoffen, energie, biobased chemicaliën en biobased materialen. De nadruk ligt op innovatie en ontwikkeling, het ontwikkelen van business cases en het verwijderen van obstakels van niet-technische oorsprong. Subsidieregelingen voor investeringen bedroegen €120 miljoen in 2013. Bio-energie (vergisting, verbranding en vergassing) profiteert het meest, bioplastics en andere biomaterialen zijn opkomende toepassingsvelden.

Totale regionale investeringen bedragen €1.5 miljard, waarvan twee derde wordt toebedeeld aan bio-energie. Regionale initiatieven richten zich meestal op het laatste stadium van de innovatiecyclus, die gerelateerd is aan specifieke marktformatie. Echter, grote regionale verschillen worden gevonden.

Nederland staat bekend om de hoge kwaliteit van onderwijs en training. Qua omvang – relatief aantal inschrijvingen van leerlingen en studenten – ligt het op het OECD gemiddelde. Er is een groeiende vraag naar studenten bekend met de principes en praktijk van biobased productieketens. Voor de komende 10 jaar wordt een vraag van 10.000 deskundigen verwacht. Veel universiteiten en hogescholen spelen hierop in door het ontwikkelen van biobased cursussen en studies.

Marktontwikkeling

De goed ontwikkelde landbouw, transport en chemische sector legt een solide basis voor het implementeren van een biobased economie. Marktontwikkeling wordt vooral verwacht in de productie van elektriciteit, biobrandstoffen en biobased chemicaliën, inclusief polymeren. Innovatie en marktontwikkeling worden gestimuleerd door het instellen van zogenaamde 'Green deals', die zich richten op de ontwikkeling van de biobased economie, bioenergie en biobased materialen. Nadruk ligt op het verbetren van innvatieve ketens en het verwijderen van niet-technische obstakels. Veel activiteiten zullen afhankelijk zijn van de import van biomassa daar Nederland met uitzondering van gewassen als gras en suikerbieten geen grote hoeveelheden biomassa produceert.

Gedurende de afgelopen 10 jaar is de toepassing van hernieuwbare grondstoffen voor productie van bio-energie toegenomen met 77%. Bioafval (onder andere hout, kippenmest en afval uit de papierindustrie) zijn een belangrijke bron. Tezamen produceren zij de helft van de bioenergie; vaste biobrandstoffen, huishoudelijk afval en biogas genereren de andere helft.

De omzet van de biobased economy in Nederland is geschat op €20 miljard in 2013 (Piotrowski and Carus, 2015). De **toegevoegde waarde** is eerder geschat tussen €2.6 en €3.0 miljard (cijfers voor 2011), inclusief de materiaal-, chemie- en energiesector. Samengenomen, genereert de biobased component van deze sectoren 0.5 tot 0.6% van de Nederlandse economie. De biobased economie wordt gedomineerd door de materiaalsector (€2 tot €2.4 miljard toegevoegde waarde), gevolgd door de chemiesector (€442 miljoen), biobrandstoffen productie (€100 miljoen) en de energiesector (€70 miljoen).

Schattingen van werkgelegenheid bedragen 45,000, inclusief indirecte werkgelegenheid. Schattingen voor 2013 variëren tussen 12,600-14,000 en 80,000.

Vergelijkbare landen

Beleid

Veel landen in de EU hebben nationale strategiën geïmplementeerd voor de bioeconomie enf biobased economie, zij het dat sommige landen verder zijn in implementatie dan anderen. De nadruk ligt bij onderzoek en ontwikkeling, waarbij bioenergie nog steeds domineert in de meeste landen. Vroege bioeconomie beleidsstrategiën zijn gepubliceerd door een aantal landen, waaronder Nederland (2007, 2012), Denemarken (2009, 2012), Duitsland (2010, 2014), Frankrijk (2012), de Verenigde Staten (2012), Zweden (2012) en Zuid-Afrika (2013). In de meeste gevallen heeft de ontwikkeling van bioeconomiebeleid economische drijfveren; strategische- (voedselzekerheid, energieonafhankelijkheid) en milieudrijfveren (klimaatverandering, afvalvermindering) hebben een lagere prioriteit.

Onderzoek en ontwikkeling

Er zijn grote verschillen gevonden in termen van nationale onderzoeksinpsanningen, die in principe een afspiegeling zijn van patronen van bioeconomie en biobased marktontwikkelingen. Fondsen voor biobased onderzoek lijken vooralsnog vooral van publieke bronnen afkomstig te zijn hoewel ook private investeringen worden gerapporteerd (Duitsland, Frankrijk, het Verenigd Koninkrijk en Nederland). Een uitgebreid overzicht van biobased onderwijs in Europa kon niet worden gegeven. Een eerste inventarisatie laat zien dat biobased economie deel uitmaakt van het curriculum in landen als Duitsland, België en het Verenigd Koninkrijk. Het is te verwachten dat het ook in andere Europese landen deel uit maakt of gaat maken van het curriculum.

Marktontwikkeling

Biobased productie in Europa is voornamelijk gericht op bioenergie, producten op basis van hout en vloeibare biobrandstoffen; de productie van biochemicaliën en biopolymeren is veel lager. Tijdens de afgelopen 10 jaar, heeft de toepassing van hernieuwbare grondstoffen voor productie van bio-energie de grootste groei doorgemaakt. De grootste toename werd gevonden in België (194%), de kleinste in Frankrijk (35%).

Het Verenigd Koninkrijk ligt achter in termen van bio-energieproductie per miljoen inwoners. Denemarken ligt ver voor. België en Denemarken hebben met name het gebruik van biomassa-afval en vaste biobrandstoffen uitgebreid door de jaren heen. Het gebruik van bio-energie in Frankrijk is veel trager gegroeid dan in andere landen.

De analyse van de stromen van houtmateriaal suggereert dat individuele landen verschillende definities gebruiken en dat statistieken incompleet zijn. Dichtbevolkte landen met weinig bosbouw (zoals Nederland) hebben weinig ruimte de biobased economie te voeden met hun eigen bos. Zoals te verwachten is, hebben deze landen ook een veel kleinere houtindustrie.

Grootschalige productie van vloeibare biobrandstoffen in Nederland kwam pas recentelijk van de grond. Bioethanol wordt geproduceerd van zetmeel (tarwe en tapioca) en biodiesel van plantaardige oliën (voornamelijk palmolie). Zoals het geval is met fossiele brandstoffen, voorziet Nederland in brandstoffen die worden geëxporteerd naar de rest van het continent. Dit is ook het geval voor België (ook een land met een grote haven), wat een relatief grote productie van bio-benzine heeft. De productie van biobrandstoffen in het Verenigd Koninkrijk is erg laag. De biobrandstofproductie per inwoner is erg hoog in Nederland en België, wat te danken is aan het verwerken van geïmporteerde ruwmaterialen. Duitsland en Frankrijk blijven relatief grote producenten. Ethanol in de EU wordt voornamelijk gemaakt van tarwe (ongeveer 50% van het aanbod), maïs (30%) en gerst (20%). Koolzaadolie (85%) is de dominante grondstof voor biodiesel productie, gevolgd door soja- en zonnebloemolie. Ter vergelijking: biobrandstoffen in Nederland lijken te worden vervaardigd uit een grotere variëteit aan grondstoffen.

De productie van warmte en elektriciteit van bio-energie varieert per regio. Hout is nog steeds een belangrijke bron van warmte in veel landen in het centrale en oostelijke deel van het continent. Kolen, aardgas en olie zijn de dominante brandstoffen in andere delen. Elektriciteitsproductie wordt gedomineerd door kernenergie in Frankrijk en België en door hernieuwbare bronnen in Noorwegen. Andere landen zijn over het algemeen afhankelijk van fossiele brandstoffen (steenkool, bruine kool en aardgas).

Subsidies en verplichte bijmenging hebben een markt gecreëerd voor biobased brandstoffen en bioenergie. Zonder ondersteuning zouden deze markten niet gegroeid zijn tot de huidige schaal. De productie van biochemicaliën is nog steeds laag vergeleken met de productie van biobrandstoffen en bio-energie, maar in sommige niches kunnen de chemische en polymeer biobased producten ontwikkelen zonder ondersteuning. Echter, grootschalige substitutie van polymeren op fossiele basis, zoals PE en PP in producten met een lage toegevoegde waarde (vuilniszakken), vraagt om beleidsmaatregelen (met name met de lage, huidige olieprijzen).

De toegevoegde waarde van de bioeconomie in de EU28 wordt geschat op zo'n €2.1 biljoen in 2013. Het grootste gedeelte van dit bedrag (69%) wordt geassocieerd met landbouw en voedselproductie (inclusief dranken). Papier, pulp en andere bosbouwproductie draagt ongeveer 18% bij. Het resterende bedrag is gerelateerd aan textiel, biobrandstoffen en andere bio-energie, plus farmaceutica. De omzet (exclusief voedsel, dranken en tabak)

bedraagt €1 biljoen. Biobrandstoffen en andere bio-energie beslaat 8%; biobased chemicaliën en biopolymeren 5%. Duitsland, Italië en Frankrijk realiseren samen de helft van de omzet. Het Verenigd Koninkrijk, Spanje, Zweden, Finland, Polen, Oostenrijk en Nederland, allemaal kleinere spelers, genereren samen bijna een derde van het totaal. De omzet in Nederland is berekend op €20 miljard, vergelijkbaar met Polen en Oostenrijk, maar significant lager dan Zweden, Spanje of het Verenigd Koninkrijk.

De totale biobased economie werkgelegenheid in de EU is berekend op 3.2 miljoen (cijfers van 2013). Nogmaals, bosbouwproducten, papier en textielen domineren.

Vergelijking

Beleid

Biobased beleidsontwikkeling is relatief vroeg gestart in Nederland in vergelijking met andere landen en wordt vooral gedreven door economische doelstellingen. Strategische en milieuwetgeving waren al in werking rond die tijd. Er wordt gestreefd naar een volledige implementatie, inclusief het installeren van nationaal beleid, een agentschap verantwoordelijk voor de implementatie, een R&D programma en regionale en lokale implementatie.

Onderzoek en ontwikkeling

Het Nederlandse publike onderzoeksprogramma is breed georiënteerd in termen van activiteiten, instrumenten en deelnemers. Financiering is sterk gericht op agrarische productie en ontwikkeling en inzet van speciale conversietechnologieën. Nederland heeft een relatief hoog succespercentage in Europese onderzoeksprogramma's en hoort bij de top-5 van OECD landen voor kwaliteit van onderwijs en training. De omvang– het aantal inschrijvingen - is vergelijkbaar met het OECD gemiddelde. De ontwikkeling van academische biobased programma's lijkt voorop te lopen op vergelijkbare programma's in het buitenland.

Marktontwikkeling

De groei van de productie van bioenergie in Nederland in het afgelopen decennium was minder dan die van andere landen in de omgeving. Samen met het Verenigd Koninkrijk ligt Nederland achter in termen van de toepassing van bio-energie per miljoen inwoners. De productie van energie uit huishoudelijk afval is behoorlijk hoog, mede door import van afval uit andere landen. Zoals het geval is in andere dichtbevolkte landen met weinig bosbouw, heeft Nederland een kleiner potentieel om een gedegen houtindustrie te ontwikkelen of om deze industrie de biobased economie te laten voeden.

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ABBREVIATIONS

1,3PDO	1,3-propanediol
BBE	Biobased Economy
CCS	Carbon Capture and Storage
EIA	Energie Investeringsaftrek
GHG	Greenhouse gas
ICT	Information and Communication Technology
MIA	Milieu Investeringsaftrek
MTBE	Methyl-tert-butylether
OECD	Organisation for Economic Cooperation and Development
PBAT	poly(butylene adipate-co-terephtalate)
PEF	Polyethylene furanoate
PLA	Polylactic acid
R&D	Research and Development
TRL	Technology Readiness Level
UK	United Kingdom
WF	Wood Fuel
WBP	Wood Based Panels
WBSO	Wet Bevordering Speur- en Ontwikkelingswerk
WP	Wood Pellets
WR&P	Wood Residues and Particles

1. INTRODUCTION

The European Union is committed to significantly reducing greenhouse gas (GHG) emissions while at the same time ensuring security of supply and competitiveness. A focus on the development of low-carbon energy technologies is crucial and should focus on low-carbon heat, power, and fuel as well as biobased products (ERKC, 2014). The bioeconomy has been proposed as a key element of a smart and green development path which allows the stimulation of rural development and provision of new markets for the agricultural and forestry sectors while facilitating greening of chemical, logistical and materials production. Advancements in bioeconomy research and innovation can facilitate the opening and development of diverse food and bio-based markets.

Bioeconomy has been defined in the European Commission's COM(2012)60 as:

> ''The bioeconomy is encompassing the production of renewable biological resources and their conversion into food, feed, bio-based products and bioenergy. It includes agriculture, forestry, fisheries, food and pulp and paper production, as well as parts of chemical, biotechnological and energy industries. Its sectors have a strong innovation potential due to their use of a wide range of sciences (life sciences, agronomy, ecology, food science and social sciences), enabling and industrial technologies (biotechnology, nanotechnology, information and communication technologies (ICT), and engineering), and local and tacit knowledge''[1]

Biomass is well suited to replace fossil feedstocks in liquid fuels, materials and chemicals. Biomass has unique properties which make it a suitable feedstock for materials such as plastics, chemicals and cosmetics. A biobased economy (BBE) is defined as business based on biomass feedstocks with the exception of classical sectors like food, fisheries and feed (e.g. Langeveld et al., 2010; OECD, 2014; Meesters et al., 2014; Bos and Besseling, 2015) (Figure 1.1).

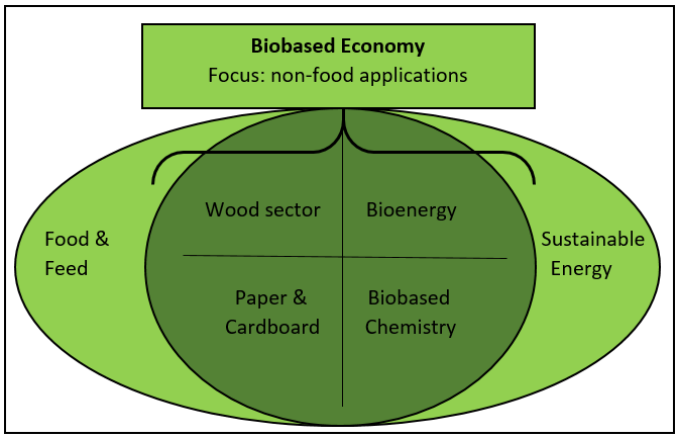

Figure 1.1. The biobased economy (BBE) and its position in the bioeconomy

Source: RVO (2015)

[1] Commission Staff Working Document of COM(2012) 60 final. Innovation for Sustainable Growth. A Bioeconomy for Europe.

Confusion as to the precise content of different biobased economy related terms has led to different interpretations often leading to conflicting views of the situation in the field. Major sources describing policy and market developments have been published by OECD (OECD, 2014; 2015; Bos and Besseling, 2015), Nova-Institut (2014, 2015; Piotrowski and Carus, 2015), IEA Bioenergy (Beermann et al., 2015) as well as E4Tech (2015), CE Delft (Blom et al., 2015) and Food and Biobased Research (Meesters et al., 2013).

Several countries implement bioeconomy strategies; among them Canada, Denmark Finland, Germany, Ireland, the Netherlands, Norway, Sweden, the United States, and South Africa. Many foresee a gradual replacement of fossil-derived materials with bio-based alternatives (OECD, 2014). The European Commission has implemented policies to facilitate the development of a bioeconomy and within that the development of biobased economy practices. Activities designed for the biobased economy include biofuels policies, intensive research programmes and a public private partnership on Bio-Based Industries Joint Undertaking investing €2.8 billion up to 2020.

The Netherlands has a knowledge-based economy, which benefits from the EU Common market and its consumers, supported by full access to world markets, trusted and well-functioning institutions, and generally sound policies (OECD, 2015). While the Netherlands has an excellent starting position for the development and implementation of a bioeconomy and biobased economy, so far the speed at which the classical, fossil-based, economy is transforming is limited. This report evaluates the development of the biobased economy in the Netherlands, comparing it to developments in other countries nearby. Main focus will be on research and development activities, regional and private initiatives and market developments.

Aim of the study

The current study aims to gain insight in the development of bioeconomy in the Netherlands as compared to other European countries, with special reference to the Biobased Economy (BBE); and to make available the main conclusions to the Netherlands monitoring rapport series as well as the Bioeconomy website of the Bioeconomy Observatory. Work for this report has been done by staff of Food and Biobased Research (part of Wageningen University and Research Centre) and Biomass Research.

This report is organized as follows: data on the biobased economy in the Netherlands are presented in Chapter 2. A comparison to a number of neighbouring and other European countries is presented in Chapter 3. This is followed by a brief discussion and conclusion (Chapter 4).

2. THE BIOBASED ECONOMY IN THE NETHERLANDS

2.1 Introduction

The Netherlands has an innovative and export oriented agricultural sector, which realizes a high added value along the food chain and significant export shares. The country is the second largest exporter of agricultural products in the world, with a value of export in 2013 of €79 billion (Bos and Besseling, 2015). Continuous innovation has permitted to reach high levels of productivity and sustained productivity growth, in particular at the farm-level. The challenge is whether marginal improvements in existing technologies and know-how will be enough to pursue sustainable productivity growth, and whether new ideas can be generated are needed to face future challenges, including those linked to climate change (OECD, 2015).

The Netherlands also has a large, strong and innovative chemical sector, with a turnover of €60 billion. After Germany and France it is the third largest producer in Europe, responsible for almost 20% of the export from the Netherlands. Linking agriculture and chemical sectors is perceived to give the Netherlands a strong business position in a new field of business activities (Dammer et al., 2013; Bos and Besseling, 2015). Also in other aspects, the Dutch economy scores well in terms of productivity, competitiveness and innovation.

The workforce is highly educated. Both the agricultural as well as the chemical sector have a strong knowledge base. Ever more farmers (both agriculture and horticulture) are highly educated. Wageningen University has a world-wide leading position as agricultural university. The chemical industry builds on several universities and applied universities providing chemistry education in various fields of expertise. Industrial biotechnology, integrating life science with chemistry is an evolving field. DSM, one of the larger Netherlands based multinationals is a key player in this field (Bos and Besseling, 2015).

A related competency is logistics. The Netherlands are a trading hub possessing excellent logistics networks via sea, air, road, rail and rivers, which provide access to all European markets. This could be a decisive advantage especially for biorefineries which need biomass that is easily available as is the case next to ports (Dammer et al, 2013). Harbours in Rotterdam and Amsterdam with a strong position in agricultural commodities, provide the Netherlands with a strong position in international trade (Bos and Besseling, 2015).

Starting from strongly developed chemicals, energy and agricultural sectors, the transition from fossil fuels to green raw materials offers major opportunities. A multitude of bio-based industries (agriculture, food industry, horticulture, paper industry) is looking for new outlets in order to diversify and develop future market position (Dammer et al., 2013). New strategic partnerships between the various sectors will be required to maintain and build upon a good position (Bos and Besseling, 2015), while issues of reducing dependency of fossil fuels and energy security provide links to nation-wide thematical coordination efforts including an 'energy agreement' covering such sectors like transport, chemistry, metal industry, food and agriculture (Van Dril, 2015).

2.2 Policy

While ambitious policies have been set by the EU and the national government, a distinctive difference can be discerned between the Netherlands and other countries in defining short term priorities in the course to the realisation of the objectives. Like elsewhere, a strong reduction in GHG emissions requires a mix of bioenergy and biobased materials development, Carbon Capture and Storage (CCS), enhanced energy efficiency and implementation of a mix of renewable energy sources including wind, solar, and bioenergy.

The Netherlands are one of a number of countries who have implemented a bioeconomy strategy. Different strategies have been found in the way the the bioeconomy is developed (OECD, 2014). The Netherlands are one of five countries (next to Germany, Estonia, Finland, and Hungary) that installed a national agency (RVO) to implement its bioeconomy policies. In total, nine countries are implementing a bioeconomy strategy; four of which developed a full strategy (Langeveld, 2015).

Key objective in the Dutch bioeconomy and biobased economy policy is sustainable biomass valorization ("value pyramid") or production of biobased materials and use residues for biofuels, electricity and heat ('co-production'). Realisation of the valorisation potential requires a strong focus on biorefineries as a key technological development (Beermann et al., 2015).

Biobased products including chemicals and biopolymers offer benefits in environmental (e.g. GHG emissions savings), social (e.g. new jobs, some of which in the rural environment) and economic terms (e.g. value-added, cascading utilisation of biomass), the so-called triple bottom line (OECD, 2014). In a survey on bioeconomy development and implementation, the Netherlands government indicated that economic drivers are the most important pillars for its policy development (Figure 2.1). Importance of eeconomic drivers on average is 4.5, as compared to 3.0 for strategic and 2.7 for mere environmental drivers. No mention was given to the need to implement the (proposed) 'EU bioeconomy strategy', 'Healthy diet' and 'Environmental protection'.

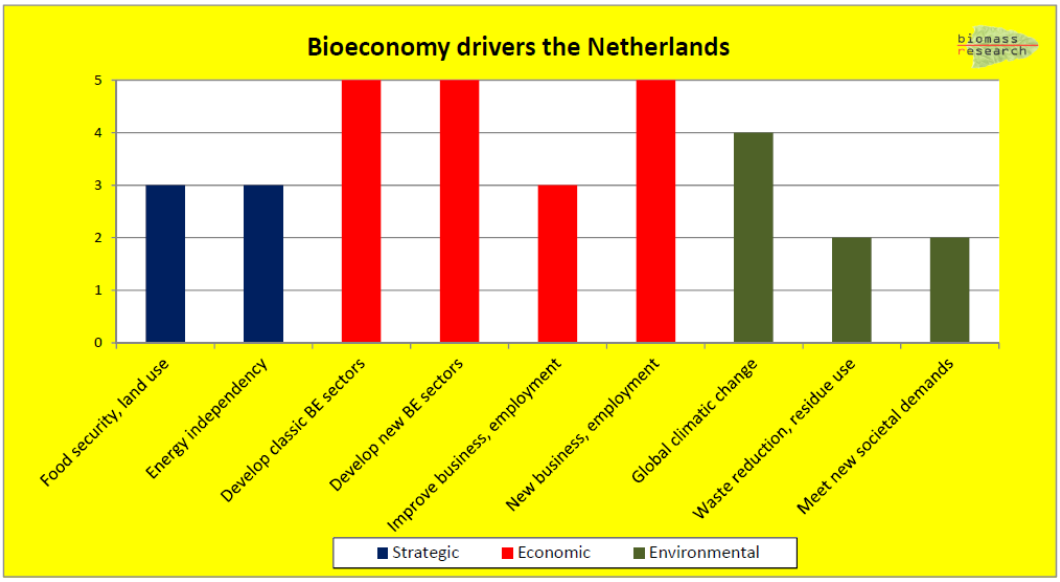

Figure 2.1 Drivers for bioeconomy policies

Source: Langeveld (2015): JRC-SCAR survey

A more detailed overview of drivers for the biobased economy since 1985 (Bos and Besseling, 2015) lists a range of economic, strategic and environmental factors including the need to introduce an improved crop rotation (phytosanitation), declining crop prices, the need for energy diversification as well as rises in oil prices and the introduction of technological innovations.

2.3 Research and development

The Dutch policy environment favours innovation, facilitates knowledge transfers, high-quality infrastructure, and high-quality education systems that responsive to business demand and provide a well-educated and skilled labour force (OECD, 2015). Public bioeconomy research and development (R&D) funding mainly focusses on agriculture (an average of €136 million per year), industrial use of biomass (€63 million) and key enabling technology (€16 million) (Langeveld, JRC-SCAR Survey, 2015).

An overview of public budgets available for biobased economy programmes in 2014 is presented in Figure 2.2. Funding is mostly focussing on fundamental and industrial research. Few programmes focussing on pilots and demonstration and market introduction. In 2019, funding for specific programmes will end (yellow figures), whereas funding for institutional programmes remains. Public funding mostly remains available for programmes focussing on fuel and energy (green and blue figures). New programme funding is expected to be developed over the next few years.

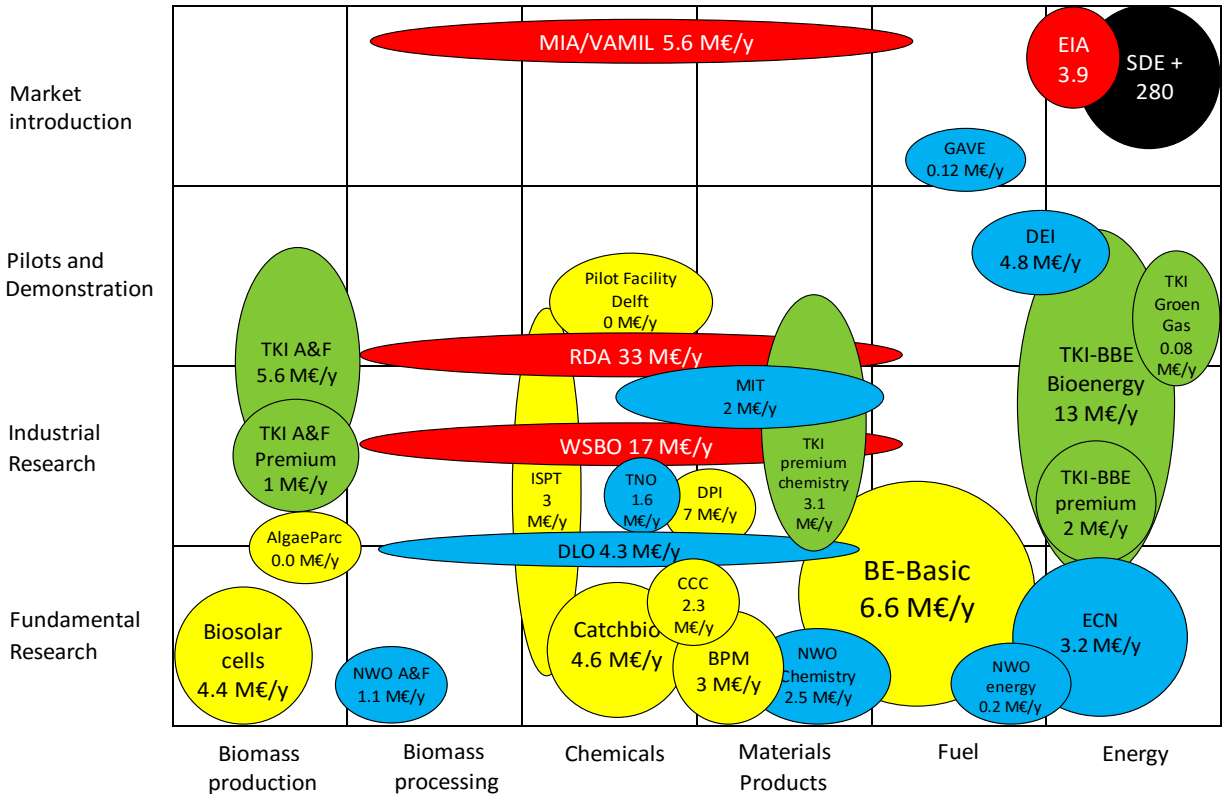

Figure 2.2. Public budget for Biobased Economy programmes in the Netherlands

Source: TKI BBE (2015)

Public research funding in the Netherlands is biased towards development and implementation of biotechnology and other so-called enabling technologies. More than 20% of all funding for 'industrial use of biomass' and 'key enabling technology' that was reported in the JRC-SCAR survey was allocated by the Dutch government (Figure 2.3). In industrial countries, most (87%) private sector biotechnology R&D is oriented towards went to health applications, with just 2% going to industrial applications (figure for 2003 reported by OECD, 2015). This may have been changed recently.

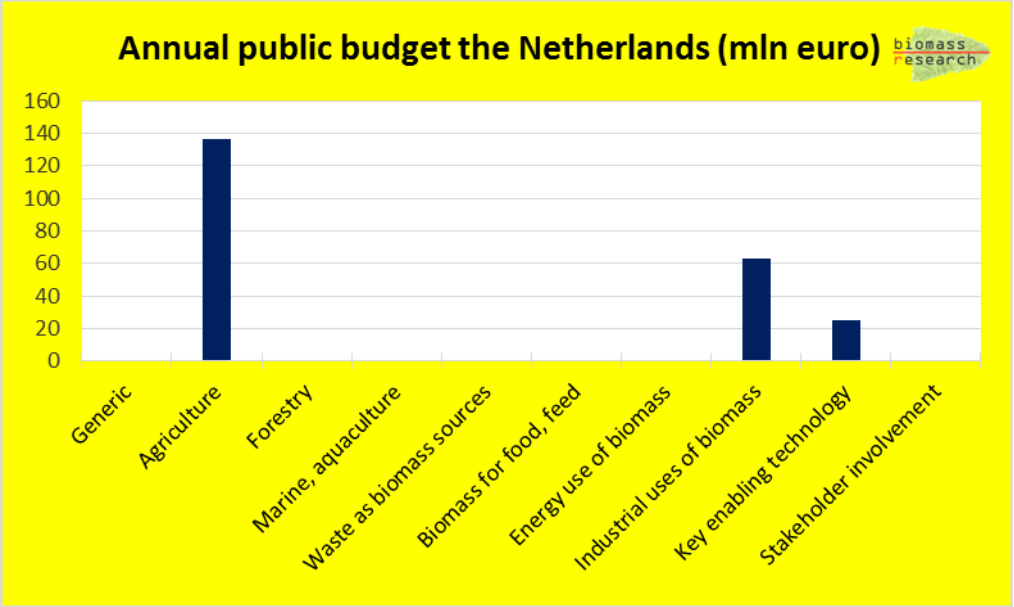

Figure 2.3. Public budget reported for different elements of the biobased economy

Source: JRC SCAR survey (Langeveld, 2015)

An overview of public funding for biobased economy companies shows a positive trend (Table 2.1). Most funds are applied via cuts of labour-related taxes for dedicated R&D staff (WBSO), matching private investments five times larger. Generally, private funding is three times higher than public support.

Table 2.1 R&D investments in biobased economy companies (2012 to 2013)

Regulation	R&D investment million Euro (incl. contribution government)		Contribution government Million Euro	
	2012	2013	2012	2013
WBSO	115	104	18.4	18.0
RDA	60	95	6.2	12.8
TKI BBE	52.4	19.2	26.2	8.5
TKI Gas – Groen	22.6	13.2	11.3	6.6
MIT BBE, A&F	0.2	7.6	0.11	3.8
TKI premium	-	0.3	-	0.3
NOW			-	3.3
TO2 institutes			14.1	14.1
Total	250	239.3	76.3	67.4

Source: RVO (2015)

Investment subsidies in 2013 have been granted to a large number of bioenergy and biobased research themes including combustion, biofuels and anaerobic digestion, algae, bioplastics, and gasification technologies (Table 2.2). Two subsidy types are discussed here; energy investment support (EIA) - mostly focussing on bioenergy installations, and environmental investments (MIA) that cover machinery for energy, manure processing and biopolymers.

Table 2.2 Categories applying for investment subsidies (EIA, MIA; 2013).

EIA	MIA
Heat and power installation fired with biomass, with the use of heat and power	Production machinery for bioplastics or for making products out of bioplastic
Biogas upgrading installation	Production machinery for (intermediate) products based on organic feedstocks
Biofuel production installation	Production installation for micro algae
	Digesting installation with algae reactor
Boiler fired with biomass	Manure processing installation with recovery of phosphate and nitrogen
Digesting installation for dry biomass	Gasification installation
Aerobic biomass reactor	Small scale manure digestion on farm level

Source: RVO (2015)

Total investment support via MIA (Milieu Investeringsaftrek) and EIA (Energie Investeringsaftrek) instruments increased to €120 million in 2013. Bioenergy remains the dominant sector profiting (biogas/anaerobic digestion, combustion and gasification) (Figure 2.4). Bioplastics and other biomaterials are emerging application fields (RVO, 2015).

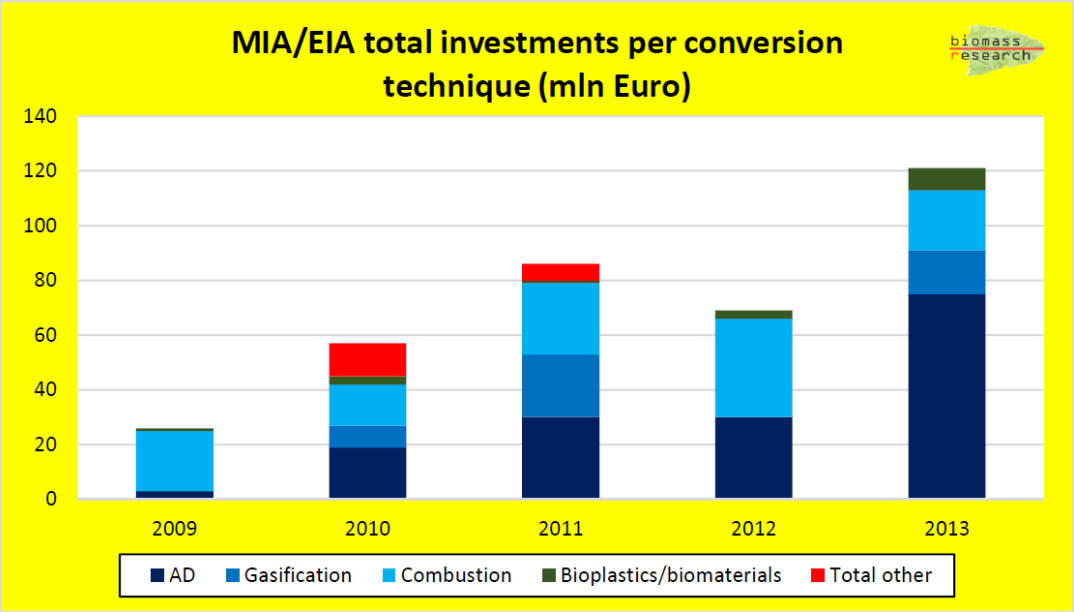

Figure 2.4 MIA/EIA total investments per conversion technique

Source: Adapted from RVO (2015)

Innovation and market development further have been stimulated by the introduction of so-called 'Green deals', some of which were oriented towards the development of the biobased economy, bioenergy and to biobased materials in the Netherlands. The focus is on improving innovative business and development, developing business cases and remove obstacles of non-technical origin (Bos and Besseling, 2015).

2.4 Education

The Dutch population benefits from a high quality eductions system, performing well in international comparison and achieving good results in terms of education and innovation skills. The Netherlands are among the top-5 OECD countries in terms of overall performance of higher eduction and training, ranking particularly high in terms of higher education quality. Companies are also among the top-5 in terms of investments in training and employee development. Quantity of eduction – in terms of enrolment rates – is comparable to OECD average (OECD, 2015).

Agricultural education is organised in close co-operation with the agricultural sector. While there are relatively few students that choose green education, market potential for students apparently is higher. Recently, enrolment has been increasing, especially at higher levels. It is concluded (OECD, 2015) that the education system offers strong degrees in agriculture, food and nature management.

Following the increasing interest for the biobased economy in policy and R&D, there is a growing need for students that are aware of the principles and practices of biobased production chains. t is expected that about 10,000 biobased experts are needed in the next ten years. Many universities and schools of applied sciences are responding to this by the development of special courses, BSc and MSc programmes. Examples can be found at the Technical University of Delft, Leiden University, Larenstein, Applied Agricultural University Den Bosch, Avans Applied Technical University, Wageningen University, Utrecht University, Hanze school of applied sciences, Technical University of Twente, University of Maastricht, Zuyd school of applied sciences, Amsterdam school of applied sciences, University of Amsterdam and Christian Agrarian school of applied sciences in Dronten.

The universities are organized in two networks. The Centre for Biobased Economy (CBBE) aims to provide experts needed for an economy that runs on biomass feedstock. Sponsored by the Dutch Ministry of Economic Affairs, it obtaines additional funding from private companies. Partners include Wageningen University, Applied Agricultural University Den Bosch, Inholland, CAH Vilentum, Van Hall Larenstein, HAN University of Applied Sciences, Avans Applied Technical University and HZ University of Applied Sciences.

Avans and HZ are also participating in the Centre Of Expertise (COE) BBE is a cooperation between Avans school of applied sciences and HZ university of applied sciences (https://www.coebbe.nl/).

Conclusion
The Netherlands traditionally are strong in higher eduction and training, which is also reflected in the way universities are responding to the need for biobased students in the near future. Two academic networks currenly are operational.

2.5 Market development

Following public support and private investments, an emerging biobased economy market is developing in the Netherlands. The role of biomass in different sectors varies strongly. Below, different applications are discussed in more detail.

Data for national wood balances are based on reports from forestry and wood industry that were collected from UNECE FAO Timber Database (UNECE, 2015). Sankey diagrams have been produced for the Netherlands and the peer countries. They are presented in the Annex. The Netherlands (Figure A.1) have a small forestry sector and large transit of paper pulp. Most wood products are imported. The wood industry is relatively small.

The use of wood for production of electricity is not yet covered in the statistics probably because electricity producers do not report to Probos on their use of wood. According to IEA, the import of wood pellets in the Netherlands was 1.28 million tonnes in 2011, compared to 0.425 million tonnes according to UNECE. The total use of wood for bioenergy was reported to be 3 million tonnes in 2011 (Meesters et al, 2013), far more than (425+134 =) 559 ktonne reported by UNECE or 1.28 million tonnes reported by IEA.

Traditionally, biomass in the Netherlands is mainly used for paper, cardboard, wood and textile-based end-products. While the demand for newspapers and journals is declining, the demand for packages is growing due to increased online sales. Paper and cardboard production is mostly based on recycled paper, but wood-based industries may be able to further innovative biobased applications for end-use in construction, etc.

Figures on the amount of biofuels produced in the Netherlands are provided in Chapter 4. According to the Netherlands Emission Authority (NEA, 2014), biofuels blended with fossil fuels in the Netherlands mostly originate from animal fat, maize, sugar beet, sugar cane, wheat, wheat straw and used cooking oil, suggesting a large variety of feedstocks. Only a part of the feedstocks is produced domestically; an average of 18% of the biofuels blended with fossil fuels is supplied by feedstocks produced in the Netherlands.

Renewables provide 10% of electricity in 2013 (up from 8.5 in the previous year)(Figure 2.5), but the role of biomass in power and heat production so far remained limited. Co-firing of biomass is second largest contributor after wind energy on land. Biogas and other biomass is playing a minor role (total less than 2%).
Bos and Besseling (2015) listed clear signals showing that production of high value chemicals and materials from biomass in the Netherlands is feasible. Production processes which proved economic feasibility include DuPont's bioplastic (Sorona) which has been on the market for over 10 years, and the biobased building block 1,3PDO, which no longer is produced from fossil feedstocks. PLA (bioplastic) is being further developed for more demanding applications than just room temperature food packaging (Bos and Besseling, 2015).

The production of biobased chemicals and biopolymers still is a lot lower than biofuel production. Biobased chemical production mainly is based on old processes involving sugars and starch. AVEBE produces 254 ktonne modified potato starch (Meesters et al, 2013). In total, 145 ktonne of vegetable oils was applied in technical applications in 2012 (Meesters et al, 2013). Forbo (linseed based flooring) and Croda are major consumers of vegetable oils. Corbion has a pilot facility, but all production sites are outside the Netherlands (Spain, Thailand). Production includes lactic acid and lactides based on sugars and starch. Other promising biobased developments have not reached the production scale yet (e.g. PEF and other biopolymers at Avantium).

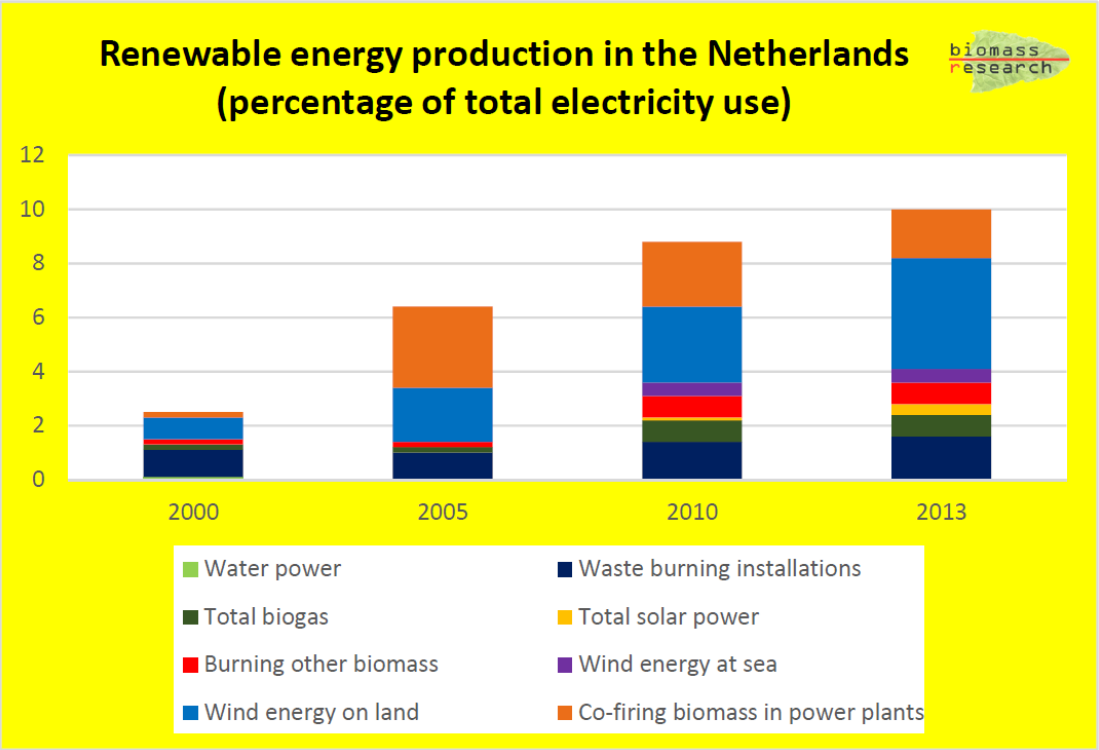

Figure 2.5. Biomass and other renewable sources in Dutch electricity

Source: ECN Energie trends (2015)

An inventory by nova-Institute (Dammer et al., 2013) concluded the Netherlands have a good starting position in bioplastics and biopolymers, listing activities of companies like Avantium, Synbra, DSM, Rodenburg and Transmare. Stakeholders in biobased chemicals production include AkzoNobel, attero, Corbion, Cosun Biobased Products, DSM and Reverdia.

Conclusion

Strong historic development of the agricultural, transport and chemical sector provides a solid basis for the implementation of a biobased economy in the Netherlands. Current production levels are mostly biofuels. Future development is expected to focus on bioelectricity, biofuels, and biobased chemicals including polymers. Many activities will require biomass imports. Main focus of policy and R&D is on providing added value via development and application of dedicated technologies.

2.6 Public and private initiatives

The government in the Netherlands is mostly operating as a kind of factilitator, providing research funds and brokering in networks of private (companies) and non-gourvernmental organisations (NGO's) (Figure 2.6).

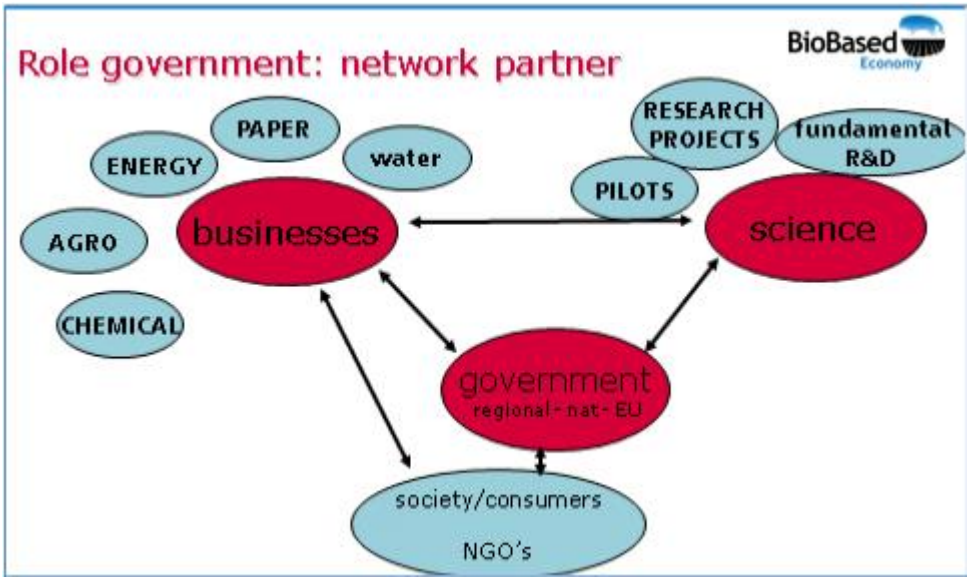

Figure 2.6. The role of the Dutch government as a network partner

Source: Bos and Besseling (2015)

Early biobased economy research has steered by public institutions. The agricultural research organisation ATO-DLO DLO (currently known as WUR-FBR), a merger of three research institutes, was founded in 1989 to stimulate development of non-food biomass applications. The Dutch board for agricultural research (NRLO) has been very infuential, publishing a long term action plan for agrification research in 1990. Another milestone was the publication of a visionary document by a platform aiming to develop and implement biomass in biobased applications in 2007 (Platform Groene Grondstoffen, 2007).

Recent (semi-)public initiatives include an advise of the social economic board (SER) on the socio-economic aspects of biobased economy development in 2010, an advise from the Rathenau Institute, also on social issues, and a public dialogue organised by the Institute on Societal Innovation (IMI) in 2011 (Bos and Besseling, 2015). Important private initiatives include the development of agrofibre reinforced composite materials in the early 90s by Mercedes while Albert Heijn, a large Dutch retailer, boosted the market for bioplastics when decision in 2005 to use organic products in three biodegradable materials only, including a number of different bioplastics.

More recently, a large number of regional initiatives for the development and implementation of the biobased economy have emerged. An overview of the most relevant regional initiatives, stakeholders involved and focus is presented in Table 2.3.

Table 2.3 Regional biobased economy initiatives in the Netherlands

Region	Cluster	Main stakeholders	Focus
South/ East	Biobased Innovation Cluster Oost Nederland	Bio-energie Cluster Oost Nederland, AkzoNobel, Prov. Gelderland en Overijssel, Oost NV	-Bioenergy (pyrolysis, fermentation) -Biobased coatings -Biobased yarns, textile and biopolymers -Valorisation of cellulose containing materials -Use of manure and sludge as biomass feedstock -Application of new biomass sources algae and duckweed

	Biobased Economy Limburg	Source B, Innovatie Centrum Greenport & biotransitie-huis Venlo, DSM, Papier & Kartonindustrie, Prov. Limburg, Liof	-Biobased performance materials & chemicals -Process technology & Biobased building blocks -Biobased horticulture applications & Agro refinement
	Biobased Business Oost Brabant	Food Tech Park Brainport, BOM, SRE, ZLTO, Biotech System Platform	-Valorisation of minerals from plant and animal waste streams towards food, feed and pharma
West	Biobased Delta	Green Chemistry Campus, Bio Base Europe, Prov. Zeeland, Brabant and Zuid-Holland, Haven Rotterdam (BioPort), Biotechpark Delft, DSM, Greenport	-Bio building blocks -Biobased aromatics -Performance materials & chemicals -Agro functionals/high value plant components -Aquatic biomass -Coatings -White biotechnology for fuels and chemicals -Bioport -Bioenergy and biofuels
North	Biobased Economy Noord Nederland	Avebe, FrieslandCampina, Cosun, Agrifirm, BioMCN, Grassa, Eemshaven, Provinces of Groningen, Drenthe and Friesland	-Valorisation of organic waste streams -Proteins and carbohydrates (food/feed/industry) -Fibres and bio polymers -Chemical building blocks -Biofuels
Centre	Flevoland	WUR/Accres, Province of Flevoland and Eneco	-Bioenergy -Cascading -BBE experimenting/testing/demonstrations
	Biobased Connections	ICL, Greenmills, Haven Amsterdam, Schiphol, Pharmafilter	-Using organic waste streams for bioenergy, biofuels and biomaterials.

Source: RVO (2015)

In a recent inventory, a total of 823 regional initiatives were identified. Total regional investments reach €1.5 bilion, two thirds is allocated to bioenergy (RVO 2015). Regional initiatives mostly focus on the final stage of the innovation cycle (Figure 2.7). Main activities relate to specific (regional) market formation. Industrial research is mostly relevant in the east and south. Initiatives located in the west of the country mostly relate to final market development and implementation.

2.7 Turnover and added value

The turnover of the biobased economy in the Netherlands has been estimated at €20 billion for 2013 (Piotrowski and Carus, 2015). The added value was earlier been estimated at €2.6 tot €3.0 billion (figures for 2011). This includes materials, chemicals and energy sectors. Together, the biobased share of these sectors generates 0.5 to 0.6% of the Dutch economy). The biobased economy in the Netherlands is dominated by the materials sector (€2 tot €2.4 billion added value), followed by the chemical sector (€ 442 million), biofuel production (€100 million), and the energy sector (€70 mln) (Smit et al., 2014). Estimations on turnover will be presented in the next chapter.

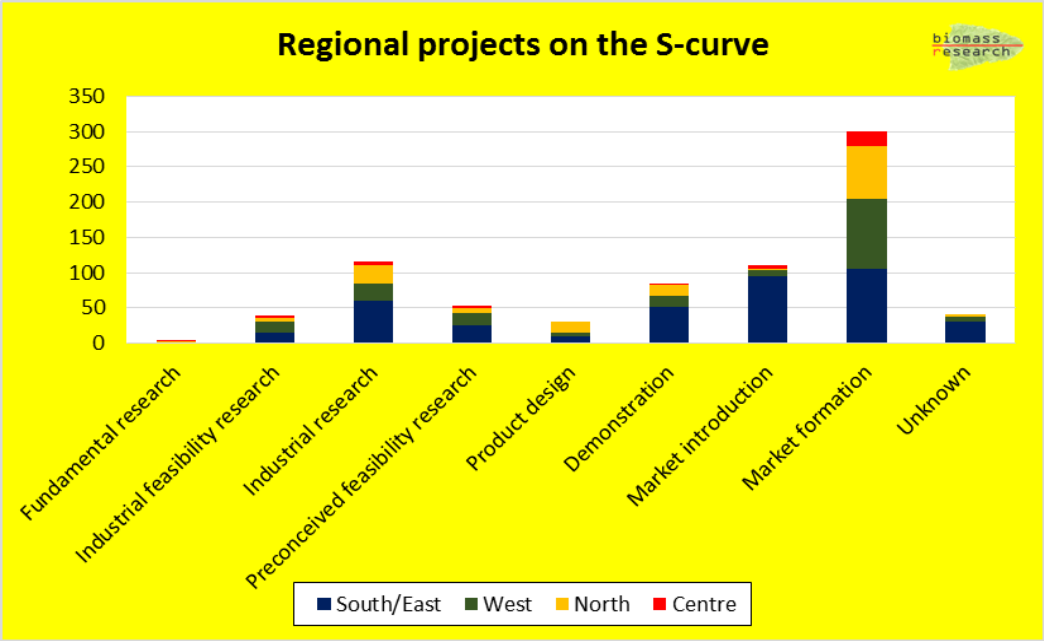

Figure 2.7 Regional products on the S-curve
Source: Adapted from RVO (2015)

In terms of employment, CE Delft estimated that 29,300 to 33,400 FTE were employed in the biobased economy in 2011 (Smit et al., 2014), although they recently lowered their estimates (12,700 to 13,800; Blom et al. 2015). Inclusion of indirect employment provides a higher estimate (44,000 to 45,000). Estimates for 2013 vary between 12,600-14,000 (Blom et al., 2015) and 80,000 (Piotrowski and Carus, 2015).

2.8 Conclusion

Following early policy and research efforts in the past, biobased policy in the Netherlands stepped up in 21st century. The government is mostly operating as a factilitator, providing research for strategic funds and brokering in networks of private (companies) and non-gourvernmental stakeholders (NGO's). Most R&D funds are implemented in the development of biorefinery and dedicated biomass conversion and application technologies. As the amount of domestic biomass available is limited, the Netherlands will remain to depend on imports of wood, biofuel feedstocks etc. Primary production is mainly based on classical agricultural production including sugar and grass. The added value in the biobased economy currently is limited (less than 1% of economic output). Employment effects may be relevant but the sector is not expected to become a large employer.

3. COMPARISON TO PEERS AND OTHER COUNTRIES

This chapter evaluates biobased economy developments in the Netherlands with developments elsewhere in Europe. The main focus is on neighbouring countries' levels ('peers': Germany, France, United Kingdom (UK), Belgium, and Denmark) which generally are experiencing similar climate conditions and economic development levels – although on an individual basis considerable differences may exist.

3.1 Policy

Figure 3.1 depicts priorities given to bioeconomy policy development in the Netherlands, peer countries and other countries in Europe. Economic drivers are given the highest priorities, with an average priority of 4.5 by the Netherlands, 4.7 by peer countries and 4.1 by other countries. Strategic and environmental drivers are given lower priority: 3.0 and 2.7 (The Netherlands), 3.7 and 3.9 (peer countries) and 3.7 and 3.7 (other countries), respectively. The Netherlands give lower priorities to strategic and environmental drivers than peer and other countries.

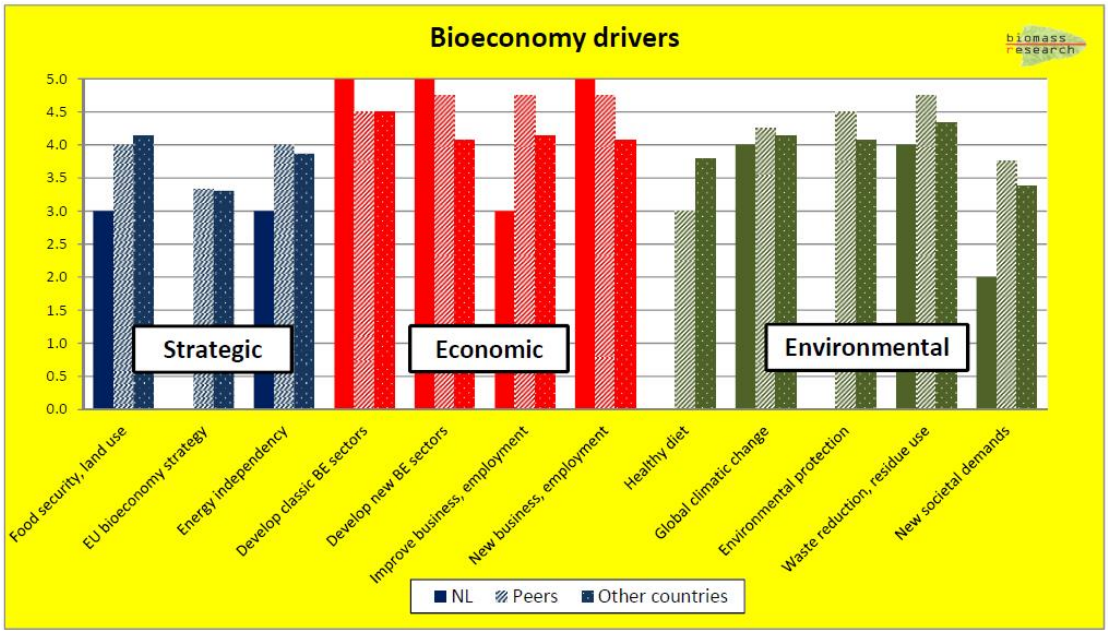

Figure 3.1 National drivers for the bioeconomy

Source: JRC-SCAR survey Q2

Early bioeconomy policy strategies have been published in the Netherlands (2007, 2012), Denmark (2009, 2012), Germany (2010, 2014), France (2012), the USA (2012), Sweden (2012) and South Africa (2013). The number of bioeconomy policies for the sectors marine and aquaculture, energy use of biomass and industrial uses of biomass in the Netherlands is comparable to the peer countries. Compared to peers, the Netherlands implement a smaller number of policies on agriculture and more policies on key enabling technology. IEA Bioenergy has presented an overview of the biobased economy and bioeconomy strategy and policies was presented in a number of

European countries (Table 3.1). Many countries implemented national strategies for the bioeconomy and/or biobased economy, be it that some countries are further in implementation. The main focus is on research and development and market development, with bioenergy still playing a dominant role in most countries.

Table 3.1. Biobased economy policies in some European countries.

Country	National bioeconomy strategy	National biobased strategy	Current focus of implementation	Role of bioenergy
Austria	No	No	R&D	Important
Belgium	No	Yes*	R&D	Less important
Denmark	High attention	Yes*	R&D, market transition	Priority
Finland	Yes	Yes	R&D, market transition	Important
France	High attention	Yes*	R&D, market transition	Important
Germany	Yes	Yes*	R&D, market, transition policies	Important
Netherlands	No	Yes*	R&D, market transition	Important
Italy	No	Yes	R&D, market transition, policies	Priority
Sweden	Yes	Yes*	R&D, market transition	Important
UK	High attention	Yes	R&D, market transition, policies	Important

Source: IEA Bioenergy Task42 (Beermann et al., 2015)
*Strategy for biobased economy, but not for biobased industries.

Some remarks related to peer countries' policies (Beermann et al., 2015) are briefly presented below. Belgium currently is lacking a Bioeconomy strategy at the national level, but a regional strategy was implemented at sub-national level (Flanders). Although in the Walloon Region there is no specific dedicated strategy, there are several on-going activities pointing to promote the bioeconomy. In Denmark, bioenergy and in particular biofuels are seen crucial in achieving profitability within industrial-scale production of biobased products.

Germany has two national bioeconomy strategies; one is a research strategy focusing on research funding, infrastructure and international cooperation. The second strategy addresses policy advice, markets, industrial implementation, and stakeholder dialogue. Several federal states established so-called BioEconomy Clusters to improve regional collaboration among research and industrial sectors.

Bioenergy is not a priority in the UK, where food production is the primary goal. Its dominant role and priority is explicitly mentioned in policy. Countries with strong forestry sectors show a strong development of bioenergy especially in Central (Austria, Germany) and Scandinavian (Sweden, Finland) countries, (but also in countries like Italy and France), mainly for decentral heating.

Conclusion

Biobased policy development in the Netherlands started relatively early. It is mostly driven by economic objectives, as strategic and environmental legislation mostly was already in place at the time. Implementation includes installation of a national policy, an implementation agency, R&D programme and regional and local implementation.

3.2 R&D funding

An overview of biobased research and development activities funded in a selection of European countries (SCAR white paper of CWG, 2015) suggests that funding often is limited to public sources; private funding being reported only in the Netherlands and the UK. Also in terms of activities (e.g. including infrastructure), instruments (loans), and participants, practices in the Netherlands may be one of the most broadly covering and generic (SCAR, 2015). This does not provide, however, an indication of the size or effectiveness of the programmes. Also, the analysis included only a limited number of programmes (especially in Belgium and the UK).

For the bioeconomy sectors 'industrial use of biomass', 'key enabling technology' and 'other', the Netherlands has allocated a large budget to R&D, much higher than was reported by peer and other countries (Figure 3.3). For the sector 'agriculture', the public budget allocated to R&D in the Netherlands can be compared to peer countries and is much higher than the budget of other countries. Pure agricultural funding reported in the survey is very uneven, with the UK contributing 40% to the total reported for all peers.

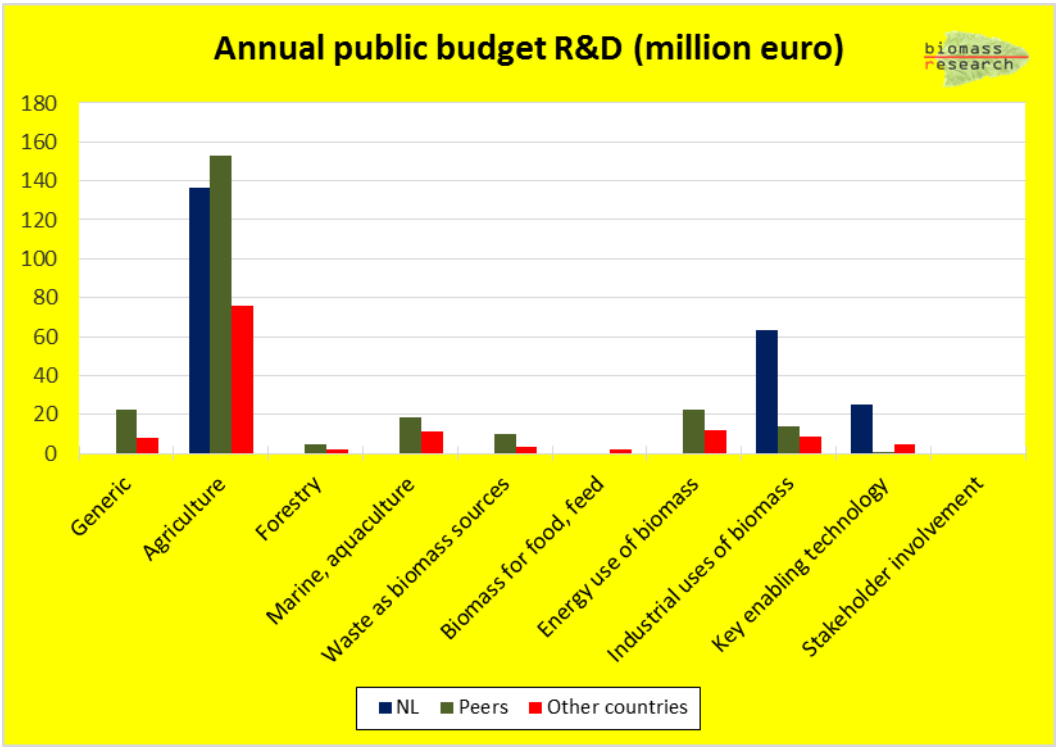

Figure 3.3. Reported public funding for biobased and bioeconomy (average figures per country).

Source: JRC-SCAR survey (2015)

Some remarks related to public funding of R&D in peer countries (Beermann et al., 2015; Langeveld, 2015; NNFCC, 2015) are briefly presented below. In Belgium, strategy-focus on R&D lies across the entire value chain (valorisation of secondary streams from biomass-related industries,

such as food, animal fodder, wood, and paper before transforming them to energy at the end of the life-cycle).

R&D in France focuses on agriculture and forests, green chemistry, and the transition to second-generation biofuels. This is not well reflected in public funding reported in the JRC-SCAR survey which is relatively low (as compared to other large European economies) and mostly focused on agricultural research. Recently awarded research funds in the UK, aiming to speed up the development of advance biofuel technology covered nearly €34 million (£25 million[2]). Main goal is to support the demonstration of new technology. making biofuels from whisky by-products, household waste and forestry waste.

An indication of the performance of national R&D activities in the European context is the success rate of individual countries in European research framework programmes like Horizon2020 and its predecessors. The European Commission (DG for Research and Innovation) presented performance and success rates of member states in the most recent Horizon 2020 and the 7th Framework Program (FP7). Results are presented below. Universities, companies and institutions from Netherlands so far submitted 398 eligible proposals to the H2020 programme, which is almost 50% above the EU28 average (293).

The Netherlands have a high number of eligible applications per capita (Figure 3.4), much higher than peer countries. 'Other countries' have more applications per capita than peer countries.

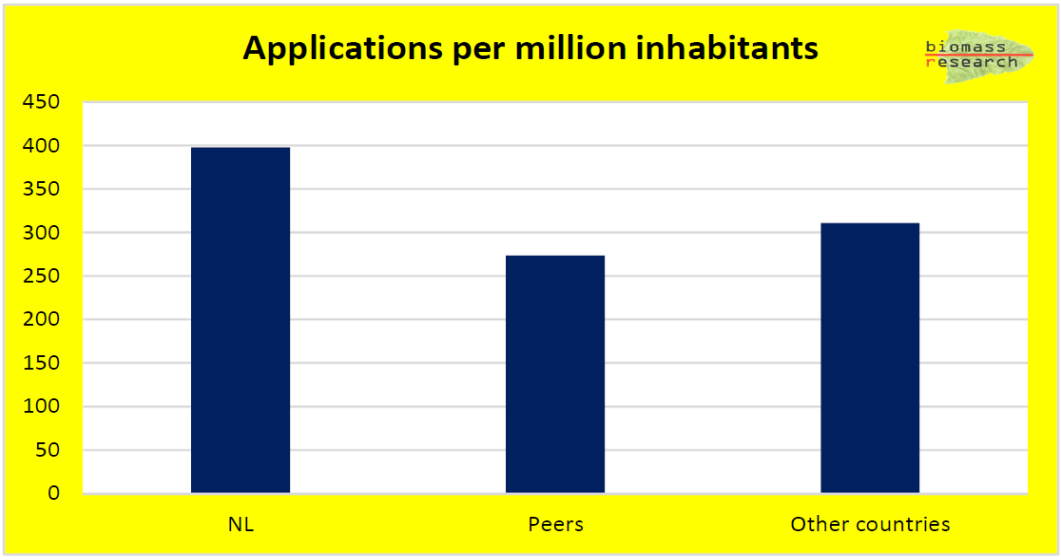

Figure 3.4 Number of eligible Horizon2020 applications per million inhabitants

Source: European Commission (2015)

The Netherlands has a relatively high success rate in EU research programmes, similar to that of its peers but considerably higher than other countries (Figure 3.5). The success rates under H2020 are lower than those of the FP7.

[2] Exchange rate of December 23rd, 2015.

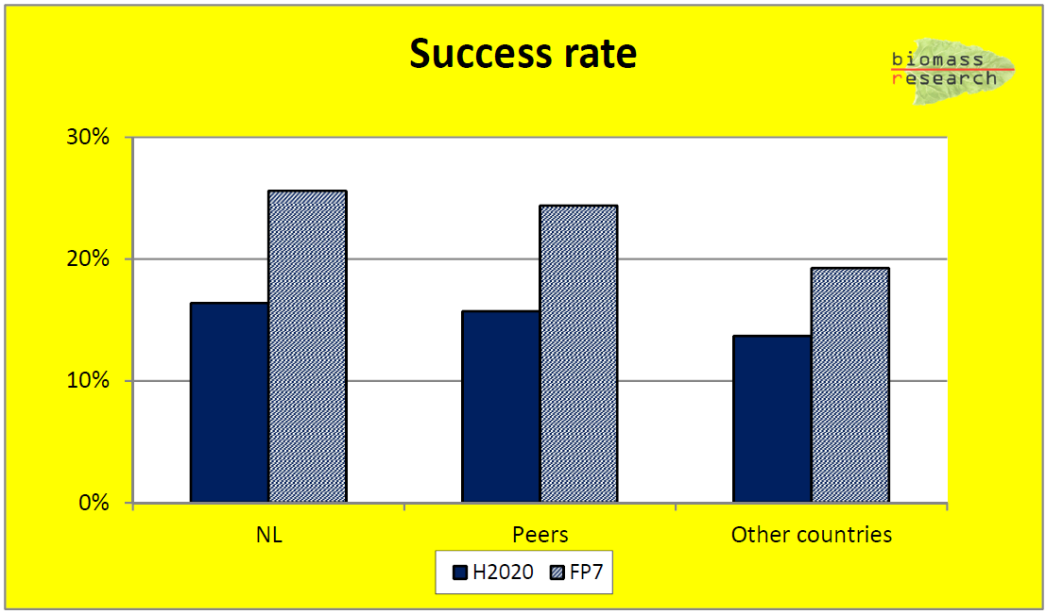

Figure 3.5. Success rate in European research programmes.

Source: European Commission (2015)

Being a small country, Dutch companies and unviversities are less frequently leading international consortia. The share of grants allocated and agreements signed is below that of peer countries, but still higher than those of 'other countries' (Figure 3.5). Success rates of the Horizon2020 programme are comparable to the those of the previous research programme FP7.

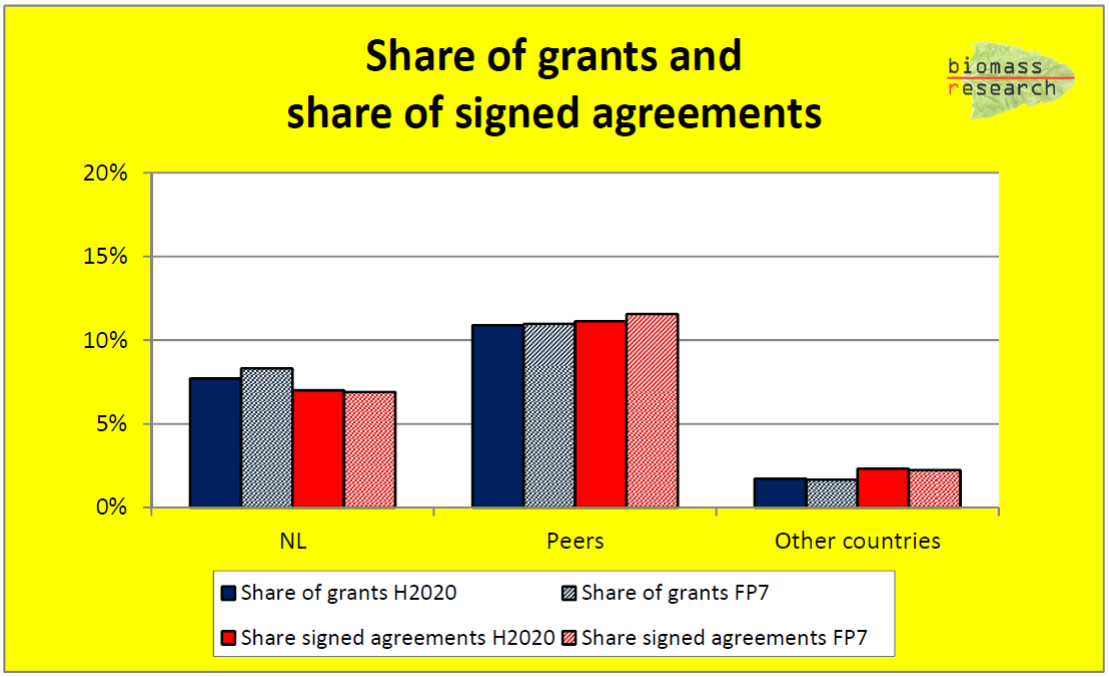

Figure 3.5. Share of grants and share of signed agreements in European research programmes.

Source: European Commission (2015)

Conclusion

Public funding in the Netherlands has a strong focus on agricultural production and (development and implementation of) dedicated conversion technologies. Dutch institutions and companies can boost on relatively high success rates in European research framework programmes, especially when results are expressed per million of inhabitants.

3.4 Education

An overview of biobased education in Europe is beyond the scope of this report. A first inventory showed biobased economy being included in the curriculum in Germany (an interdisciplinary Master's program on Bioeconomy being jointly offered by three faculties at Hohenheim University), Belgium (University of Leuven, major Bioeconomy), and the UK (Edinburough University, master in Management of Bioeconomy, Innovation and Governance). Similar programmes may be expected in many other European countries. Most universities in Denmark have pilot facilities for (applied) biotechnology research.

3.5 Market development

Production of the biobased economy mostly consists of bioenergy, wood-based related products, and liquid biofuels. Production of biochemicals and biopolymers is much smaller. In order to provide insight in the mass flows of the biobased economy, wood based products, liquid biofuels and bioenergy were looked at in more depth.

3.5.1 Bioenergy

Figure 3.6 presents data on the use of renewable resources for production of bioenergy in the Netherlands and the peer countries. Note that the scales in the right hand figures are different for each country. The numbers per inhabitant are given in Figure 3.7. Note that production in Denmark is presented on a different scale.

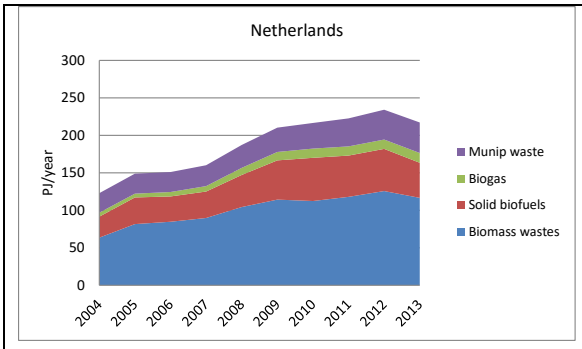

Figure 3.6A. the Netherlands

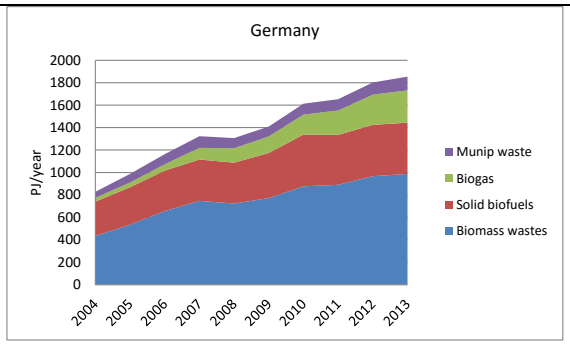

Figure 3.6B. Germany

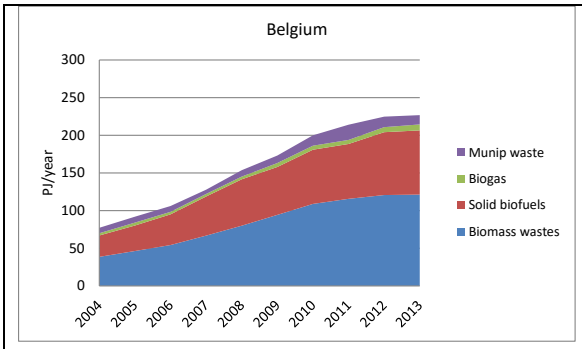

Figure 3.6C. Belgium

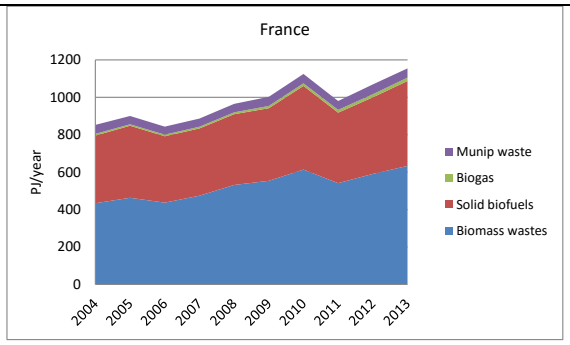

Figure 3.6D. France

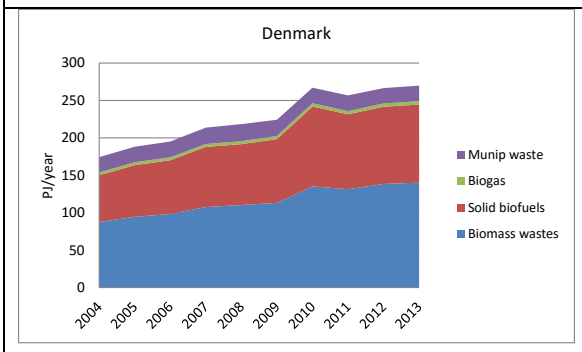

Figure 3.6E. Denmark

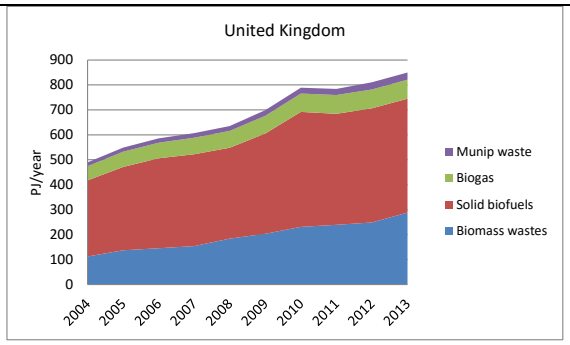

Figure 3.6F. United Kingdom

Figure 3.6. Use of renewable resources for production of bioenergy in the Netherlands and peer countries (PJ/yr)

Source: Eurostat.

The production of bioenergy increased in all countries. The increase was highest in Belgium and lowest in France (Table 3.2). Growth in the Netherlands has been below average.

Table 3.2. Increase of use of renewable resources for production of bioenergy over time period 2004-2013

	Increase
Netherlands	77%
Belgium	194%
Denmark	55%
Germany	124%
France	35%
United Kingdom	74%

Data presented in Figures 3.6 and 3.7 show that biomass wastes are an important source of bioenergy in Europe. Examples include residual wood, chicken manure and paper sludge. Wood chips and wood pellets (imported or derived from the wood industry) are not included as they are considered solid biofuels. Biomass waste generates about half of the bioenergy in the Netherlands; solid biofuels, municipal waste and biogas the other half. The situation in other small countries (Belgium, Denmark) is mostly similar to that in the Netherlands. Basically, some 200 to 250 PJ of

renewable resources is used as input for production of bioenergy. Biomass waste delivered around 100 PJ of this input.

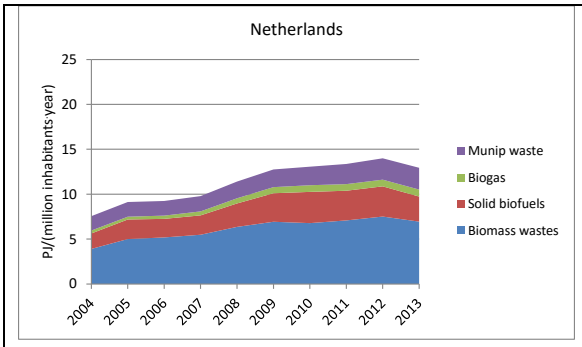

Figure 3.7A. The Netherlands

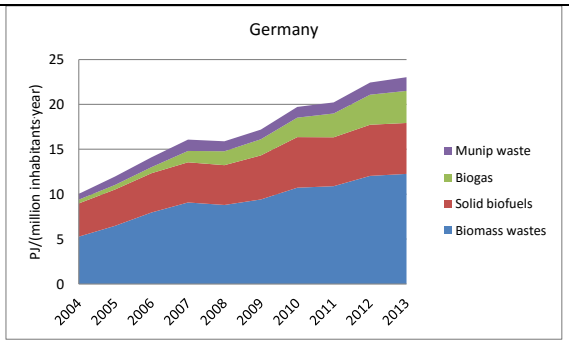

Figure 3.7B. Germany

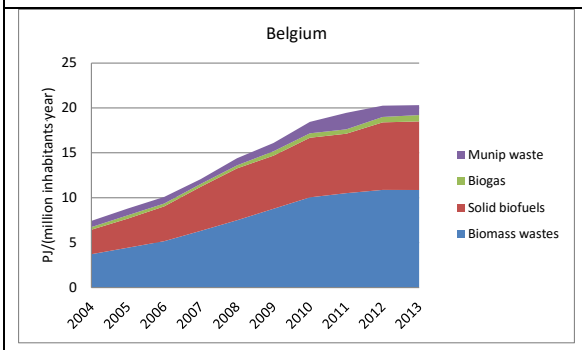

Figure 3.7C. Belgium

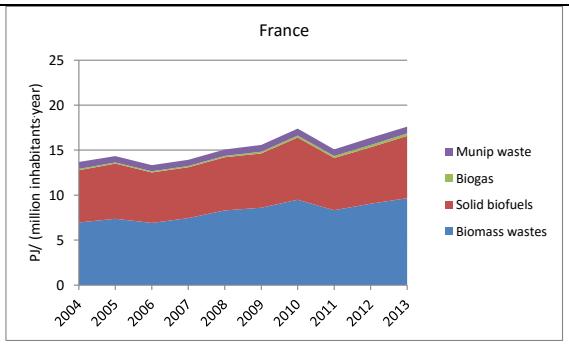

Figure 3.7D. France

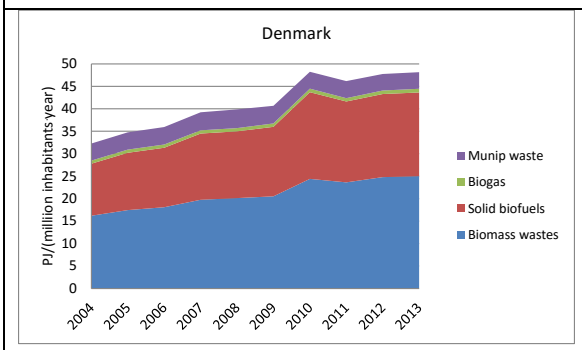

Figure 3.7E. Denmark

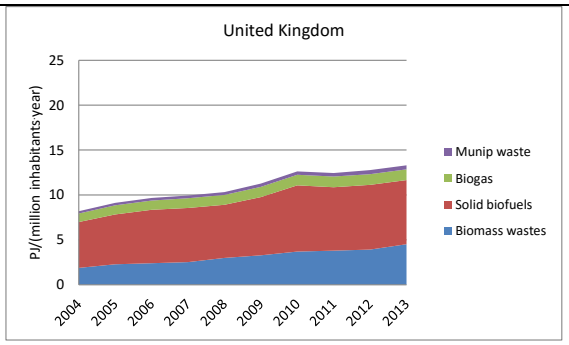

Figure 3.7F. United Kingdom

Figure 3.7. Use of renewable resources for bioenergy production in the Netherlands and peer countries (PJ/million inhabitants)

Source: Eurostat.

In comparison to the peer countries, the Netherlands have a rather high contribution of renewable energy from municipal waste. Large municipal waste incineration plants are in place. These installations are partially fed with imported municipal waste from the United Kingdom and Italy. The use of solid biofuels has recently decreased due to lower subsidies, that were not sufficient for profitable application of these raw materials.

The per inhabitant figures show that the Netherlands and the United Kingdom are behind and that Denmark is far ahead. Belgium and Denmark have mainly expanded the use of biomass waste and solid biofuels over the years. The use of bioenergy in France has grown much less than other coun-

tries. The growth of bioenergy in Germany has been very steady. Biogas has a relatively large contribution.

Conclusion

Bioenergy production in the Netherlands is generally in line with the situation in peer countries although some (Germany, Belgium, Denmark) are more effective. In all countries, most energy is derived from biomass waste like paper sludge and residual wood. Energy production from municipal waste is relatively well developed in the Netherlands.

3.5.2 Products from wood

A detailed analysis of wood balances presented in Annex 1 suggests that wood streams contracted by non-forestry, non-wood industries are probably not well monitored. Due to subsidization of renewable electricity, the use of wood in electricity production has increased over the last decade. This development is not visible in the data as these companies do not report to the Forestry and Timber agencies that gather the data for the UNECE FAO Timber Database. The balance could be improved by adding of data from other resources, such as the renewable energy statistics from Eurostat. Some countries seem to have already done that (Denmark).

In all countries a considerable amount of roundwood is used for unknown purposes, especially in Belgium, France and Denmark. As a consequence of the development of the biobased economy, a new category (wood pellets and other agglomerates of wood) was added in 2009. The statistics are not fully consistent, some countries apparently using different definitions. Belgium and the Netherlands have a closed wood residues balance, whereas Germany, France and the United Kingdom show a large inlflux of wood residues that is not specified in the statistics.

Self sufficiency of wood based materials was calculated as the ratio of harvested roundwood plus harvested wood residues over consumed paper pulp, sawn wood and wood based panels. The results are presented in Table 3.3. More densely populated countries (the Netherlands and Denmark) areas have lower self-sufficiency. France has a very high self sufficiency while the United Kingdom is relatively dependent on imports. Details for individual countries are presented in the Annex and discussed below.

Table 3.3. Wood self sufficiency.

	Self sufficiency
The Netherlands	39%
Belgium	108%
Denmark	76%
Germany	132%
France	293%
United Kingdom	68%

Belgium (Figure A.2), a country with a large forestry sector, produces considerable amounts of sawn wood and is self-sufficient in wood based panels. A larger amount of roundwood in this country is however not used by the wood industry. It is not clear what this wood is used for. Denmark has a relatively large forestry sector. The import of wood is much larger than the production from the wood industry (Figure A.3). The country relies heavily on imports of wood pellets, but data

suggest Denmark is the only country where the use of wood pellets for energy is fully included in UNECE wood statistics. Denmark reports a zero flow for recovered wood residues. From that it cannot be concluded that no wood residues are produced (there must be residues due to demolition works). It seems that these data are simply not reported to UNECE.

Germany is a net exporter of wood products (Figure A.4). Compared to Denmark and France a much smaller use of wood for production of energy (wood pellets and wood fuel) is reported. It seems that these data need to be checked and adjusted with data from other statistical sources (renewable energy statistics). The reported recovered wood residues number is far smaller than in France. As both countries are equally large and not very different this difference is larger than one would expect. A large amount of roundwood is not used by the wood industry. It is not clear what this wood is used for.

France (Figure A.5) is largely self-sufficient in wood products. The consumption of sawn wood and wood based panels are half the volumes reported by Germany. As both countries are equally large and not very different this difference is larger than one would expect. France produces large amounts of wood fuel from its own forests. A large amount of roundwood is not used by the wood industry. It is not clear what this wood is used for.

The number of inhabitants of the United Kingdom is roughly equal to the number of inhabitants in France. This is reflected in the numbers for wood consumption (Figure A.6). The surface of the United Kingdom however is 2.7 times smaller and the production of roundwood is even fourfold smaller. Therefore, the United Kingdom needs considerable imports to fulfil the domestic demand for wood products. A considerable import for wood pellets is reported, whereas France uses mainly wood fuel.

Conclusion

The data in the UNECE FAO database provide a pretty good representation of material wood flows be it that the application of wood for energy purposes is not well documented. Additional data should be added to get a complete picture. Results of material balances (round wood and wood residues), suggest individual countries use different definitions or have different statistical gaps. Statistics from UNECE FAO on energy use of biomass seem to be incomplete.

Generally, densely populated countries with little forestrly - like the Netherlands - have far lower potential to feed the biobased economy from their own forest. As would be expected, these countries also have a far smaller wood industry.

3.5.3 Biofuels

Two main liquid biofuels are produced in Europe: bioethanol and biodiesel. Statistical data were collected from Eurostat (2015). The data are presented in ktonne per year (Figure 3.7) and in ktonne per million inhabitants (Figure 3.8). The data on population were taken from Eurostat. Monitoring of biofuel production in small countries sometimes may appear incomplete due to issues of confidentiality. If only two producers are identified in one country, detailed data generally will not be reported in order not to break confidentiality. This explains the zero values in early years for the Netherlands and Denmark when only one or two companies were active.

The US Energy Information Administration publishes data on bioethanol and biodiesel production in European countries and seems to be not dependent on confidentiality issues (EIA, 2015). They

provide actual figures in cases where Eurostat reports zeros. The data from EIA are largely in congruence with the Eurostat data, but are not updated as often as the Eurostat data.

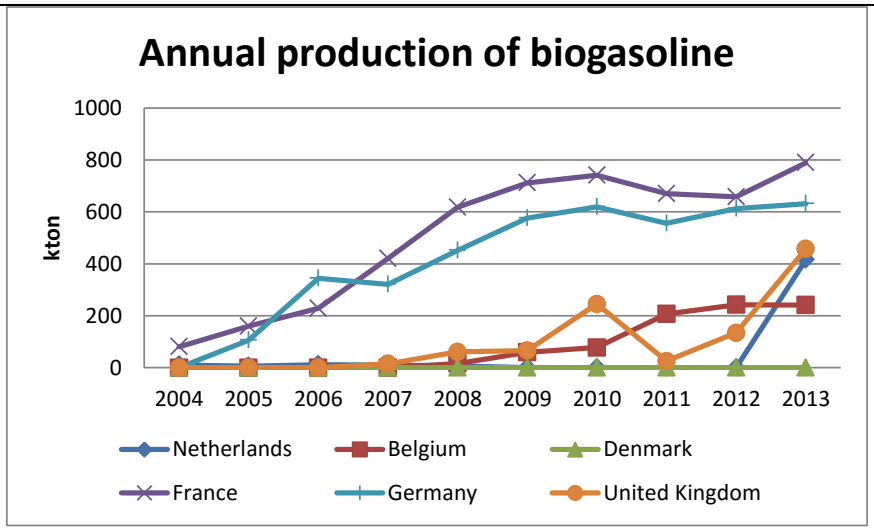

Figure 3.7A. Biogasoline

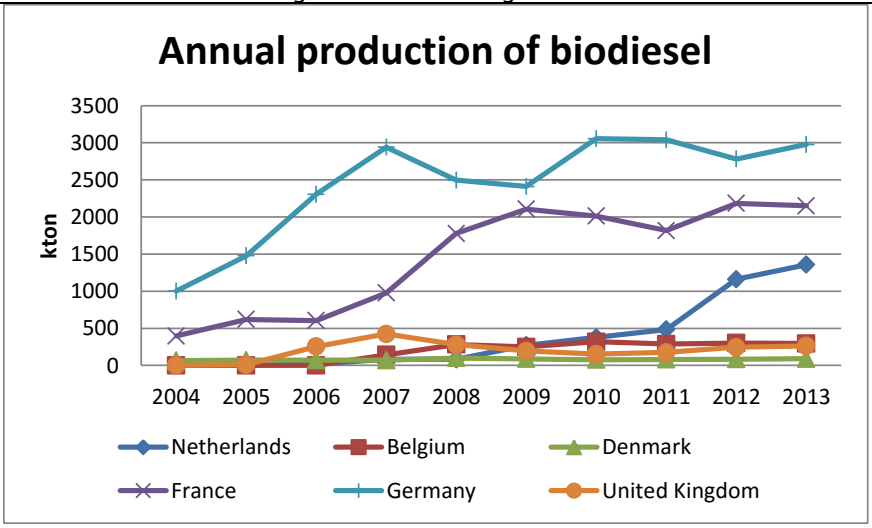

Figure 3.7B. Biodiesel

Figure 3.7. Production of biogasoline and biodiesel in the Netherlands and peer countries (ktonne/yr)

Source: Eurostat.

Biogasoline (bioethanol, MTBE, etc.) and biodiesel production in the Netherlands and peer countries is depicted in Figure 3.7A and Figure 3.7B, respectively. Production in the Netherlands took off recently, with Abengoa producing bioethanol from starch (wheat, tapioca) in 2009, followed by Nesté producing biodiesel from vegetable oils (mainly palm oil). As is the case with fossil fuels, the Netherlands provide fuels that are further exported to the rest of the continent. Belgium (also a country with a large harbour) has a relatively very large production of biogasoline. Production of biofuels in the United Kingdom is very low. Production of biogasoline increased very rapidly over the last two years.

Production per inhabitant in the Netherlands (Figure 3.8) is very high due to processing of imported raw materials as is the case in Belgium. Germany and France remain relatively large producers.

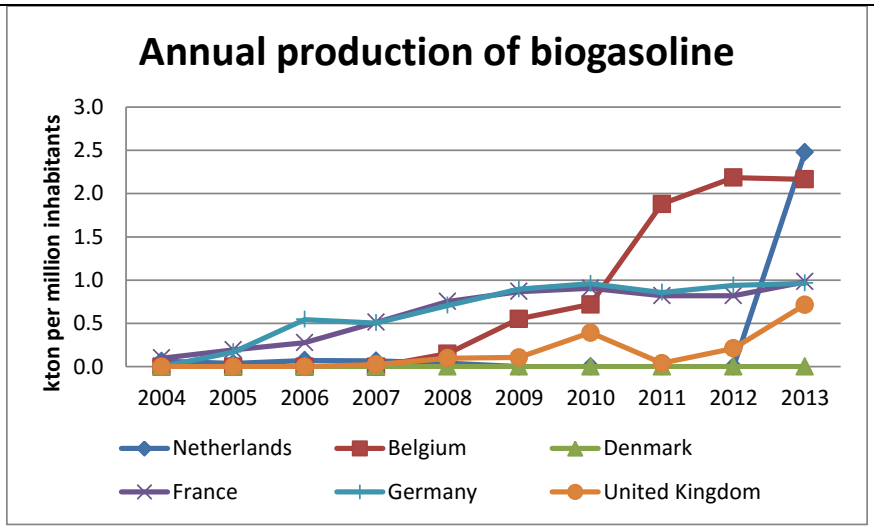

Figure 3.8A. Biogasoline

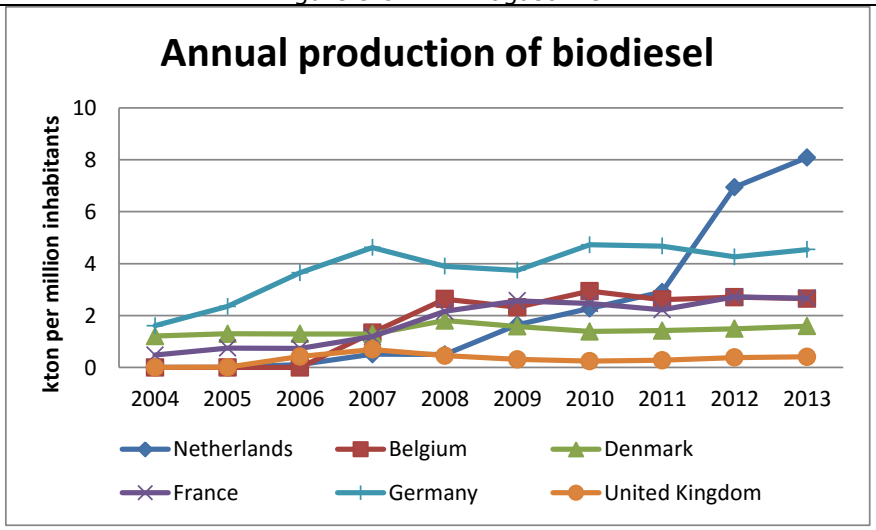

Figure 3.8B. Biodiesel

Figure 3.8. Production of biogasoline and biodiesel per million inhabitants in the Netherlands and peer countries

Source: Eurostat.

Biofuels are mostly made from a limited number of feedstocks. Ethanol in the EU is mostly made from wheat (approximately 50% of the supply), corn (30%) and barley (20%) (FAPRI, 2012). Rapeseed oil (85%) is the dominant feedstock for biodiesel production, followed by soybean and sunflower oil. In comparison, biofuels in the Netherlands seem to be produced from a larger variety of feedstocks (NEA, 2014) but precise figures have not been provided.

Conclusion

Biofuel production started early in France and Germany, initially lagging behind in other peer countries. France and Germany still are large producers. Production more recently also developed in Belgium, the Netherlands and the UK. Production per million inhabitants is relatively high in Belgium and the Netherlands which both are providing for export to the remainder of the region.

3.5.4 Electricity

Production of heat and power in Europe is showing large regional and national differences. Wood still is an important source of (domestic) heat production in many countries of the central and eastern part of the continent whereas coal, natural gas and oil are dominant fuels elsewhere. Figure 3.9 provides a comparison of electricity fuels showing a dominance of nuclear power in France and Belgium and renewable sources in Norway. Other countries generally depend on fossil fuels (coal, lignite and natural gas).

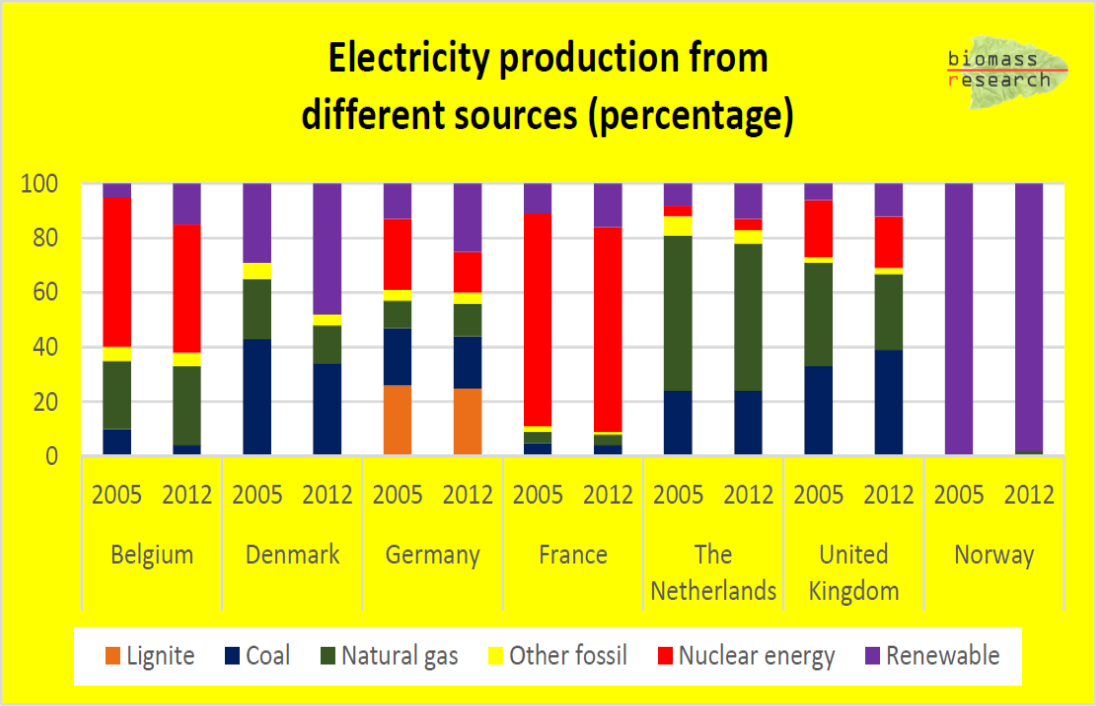

Figure 3.9. Feedstocks for electricity production.

Source: ECN Energie trends (2015)

Details on bioenergy production are sometimes lacking. According to EIA, bioenergy in Denmark contributes some 18% of total energy consumed, mainly in decentral heating. In France, bioenergy makes up 15% in final electricity consumption, plus 1% in heating and 7% in transport (figures for 2012). Germany reported 8% of total consumed energy to originate from bioenergy, mainly for decentral heating. Biofuels made up 5.7% of total fuels consumed (Beermann et al., 2015).

Conclusion

Detailed figures on bioelectricity and bioheat production are not always available. Bioenergy may contribute up to 20% of electricity, while locally it may play an important role in heating. In the Netherlands, bioenergy is not playing a significant role.

3.5.5 Biobased chemicals and polymers

Subsidies and mandatory blends have created a market for biobased fuels and bioenergy. Without these measures, these markets would not have grown to the present scale. In some niches, the chemical and polymer industry offer possibilities to use renewable resources without such

measures. For large scale substitution of fossil based polymers such as PE and PP in low added value products (garbage bags), policy measures will be needed however (especially at the very low current oil prices).

Four reasons may be indicated why some niches may develop without policy measures:

1. Biobased resources often provide us with substrates with several functional groups (carbonates, alcohols, amines, sulfides). Adding such groups to fossil based substrates is expensive, so a relatively high price of the biochemical is acceptable. Here we see the largest group of current developments (Succinic acid, BDO, FDCA).
2. Quality of biobased products may be better than the quality of fossil based products. With fuels this is much more difficult as all current machines are optimized for fossil fuels. It is not easy to adapt only some of them to a new fuel, as very large investments in infrastructure will be needed and owners will be hesitant (cars and fuel stations).
3. Biobased resources often provide us with chiral substrates. Production of chiral pure products from fossil oil is difficult and therefore the biobased substrate has an important advantage. Unfortunately the market for these products is very small and therefore these markets will not really contribute to the reduction of GHG emissions. The largest chiral pure products are D-and L-actic acid, MSG and L--lysine. MSG is mainly produced for the food market (as flavour enhancer): L-lysine is mainly added in feed to overcome L-lysine deficiency. From a GHG emission point of view, this is very efficient, be it via an indirect way. L-lysine improves the conversion efficiency of feed and thus reduces the need for protein rich feed (reducing land use).
4. Chemicals and polymers are often used to produce packaging materials. For most products, the cost of packaging is relatively small compared to the cost of the product itself. Therefore higher costs of biobased materials are more acceptable. Especially if the seller may advertise their product as 'packed with fully renewable material'.

Often more of these reasons play a role, which makes the development of these products very robust and the chance of large scale application much higher.

Three different types of feedstocks presently are used:

1. Carbohydrates (sugars, starch, cellulose, hemicellulose, inulin, glycerol - from vegetable oils)
2. Fatty acids (vegetable oils)
3. Lignin

The analysis was started from relevant EIA documents. Many times, this search revealed that the information in the EIA reports is already outdated. Extra internet research was needed to confirm outdated information. Often plans for new plants turned out to not have been executed or plants were built in different countries than initially foreseen. Companies with head offices in the peer countries had their production facilities in other European countries or even further away. This could be in the USA (using governmental subsidies aiming at the introduction of large scale biofuels production), in Brazil or Thailand and other countries in Asia (where substrates and labour are cheap).

All European facilities that were found during the research are listed below. Due to the time constraint, however, the list below is far from complete. Conclusions on peers may not be drawn. Generally, production of biochemicals still is much smaller in comparison to production of biofuels and

bioenergy. In order to get a first grip on the largest volumes of biochemicals, a proper review of the traditional products (modified starches, oleochemicals) should be made. Much more time than available in the current project will be needed to execute this task.

As is the case in the Netherlands, the largest examples of renewables in Germany are traditional products: Südstärke produces 150,000 tonne per year of potato starch (Südstärcke, 2015). Their products are used in paper industry and chemical industry, but also in food applications. Emsland group processes 1.6 million tonnes of potatoes per year (Emsland-Group, 2015). Modified potato starch is sold to the food industry, but also applied in textile, paper, building and environmental applications. Also starch from wheat and maize is processed. In total 13% of 1.5 million tonnes (=195 ktonne) was used for industrial processes (chemistry, fermentation) (GTAI, 2015).

Biowert (Brensbach), produces 2,500 tonnes of cellulose fibres per year (Bio-based.eu, 2015). These fibres are applied in composite plastics and insulation materials. Several pilot facilities are reported. Biomer has a pilot facility that can produce 1,000 tonne/year of PHB (E4tech, 2015). Bioliq has a pyrolysis pilot plant. Global bioenergies signed a contract for commissioning of a 100 tonne/year pilot for production of isobutene (Greenchemicalsblog.com, 2015). Evonik has facilities to produce biobased chemicals in Hungary and Slovakia.

In the UK, Johnson Matthey-Davy Technologies produced bio BDO and THF from succinic acid from Myriant (E4tech, 2015). Production in Denmark includes Lysine production for the domestic market by VitaLys (starch.dk, 2015). Inbicon converts 30,000 tonne of lignocellulosic biomass to ethanol per year. France based Roquette annually produces 20,000 tonnes of isosorbide from starch (SpecialChem4bio.com, 2015). Tavaux hosts a demo plant that was to produce 10,000 tonne per year of epichlorohydrin in 2007 (Chemengonline, 2015). Further, Global Bioenergies reported succesful fermentative production of industrial isobutene (Global Bioenergies, 2014). No facilities for production of biochemicals were reported for Belgium.

Elsewhere in Europe, Evonik produces 30,000 tonne L-threonine per year (2013) in Hungary and unknown amounts of L-threonine and tryptophan in Slovakia (Evonik, 2015). Bio-on will build a PHA plant fed with potato waste of 2,000 tonne/year in Italy (Green Chemicals Blog, 2015), which also hosts a 10,000 tonnes of succinic acid per year facility run by DSM and Roquette (biofuelsdigest, 2015). Biobased insulation based on soy is produced in Ireland (Biobasedinsulation,2015). Europe also hosts a 30,000 tonne/year lactic acid and lactide Galactic production facility (E4tech, 2015).

Conclusion

Production of biochemicals still is small compared to production of biofuels and bioenergy. An assessment of biobased chemicals produced in Europe would require a more detailed review of the traditional products (modified starches, oleochemicals). This will require more time than was available in the current project.

3.6 Turnover and added value

Turnover of the bioeconomy in the EU28 has been calculated by nova-Institute (Piotrowski and Carus, 2015) at €2.1 trillion in 2013. Most of this (69%) is associated with agriculture and food production (including beverages). Paper, pulp and other forestry production contribute some 18%. The remainder is related to textiles, biofuels and other bioenergy plus pharmaceuticals. Turnover (ex-

cluding food, beverages and tobacco) amounts to €1 trillion. Biofuels and other bioenergy make up some 8%; biobased chemicals and biopolymers 5%. Exclusion of the traditional primary sectors (agriculture, forestry, fishery, food, beverages and tobacco), the authors estimate total biobased turnover at €600 billion. The 'old' biobased sectors still prevail. Forest based products, paper, paper products and pharmaceuticals together still make up nearly half of this.

Three countries dominate the biobased market. Germany, Italy and France together are realising half of the turnover (€135, €110 and €55 billion in 2013, respectively). Smaller players including the UK, Spain, Sweden, Finland, Poland, Austria, and the Netherlands, together generate some 190 billion Euro or nearly one third of the total. Turnover in the Netherlands is calculated at some €20 billion which is similar to that of Poland and Austria but significantly lower than countries like (for example) Sweden, Spain or the UK.

Nova-Institute does not provide data on added value. Estimations by CE Delft (€1.6-€1.8 billion Euro in 2013; Blom et al., 2015) suggest modest margins for biobased production. Given the large discrepancy between estimates for biobased employment (80,000 by nova-Institute compared to 15,000 by CE Delft), it must be concluded that methodological issues still may exist. Compare, for example, turnover in Finland reported by IEA Bioenergy (€60 billion) to estimates by nova-Institute (€25 billion). Differences may partly be attributed to indirect effects which may be up to three times higher than indirect effects (e.g. Blom et al., 2015).

Total EU employment in biobased economy is calculated at 3.2 million (figure for 2013). Again, forest-based production, paper and textiles dominate.

IEA Bioenergy (Beermann et al., 2015) sheds some light on the variation of the role biobased economy and the bioeconomy around Europe. Development of the bioeconomy in Finland is based on the synergy between agriculture, forestry and industry; identifying opportunities for technologies that can develop innovative markets for biobased materials including natural fibres, wood materials and biobased chemicals. In Belgium, most biomass is used for bioenergy but in Flanders, production of paper, wood, bioplastics and biobased chemicals is generating five times more added value and ten times more employment than bioenergy.

Given its dominant position in agriculture, logistics and chemistry in the Netherlands, one might have antivipated a stronger take-off of the biobased economy which may however be hampered by lack of a significant forestry industry and a small internal market for biobased products. Also, the estimated biobased share of chemicals and chemical products in the Netherlands (less than 5% in 2013) is expected to play a role.

Conclusion

Two thirds of the bioeconomy market development is related to the production of agricultural commodities and food. Biobased economic activity is dominated by more traditional production based on forest outputs including paper, paper products, and pharmaceuticals. Germany, Italy and France are dominant producers. Biobased development in the Netherlands so far has been modest.

4. DISCUSSION AND CONCLUSIONS

Introducing remarks

Policy

An overview of bioeconomy and biobased economy policies in OECD members showed that the bioeconomy may be an important part of national transition strategies (60%), with bioenergy policies still dominating. While most countries have a bioeconomy vision, measurable targets are mostly still missing. Market development mostly is still related to R&D, with two thirds of the countries also focussing on transition policies (Beermann et al., 2015).

In the fossil industry, chemicals generally have better margins than fuels and there is no reason to expect that this will be different for biobased production (OECD, 2014). A further shift towards integrated biorefining, leading to an increasing role of biobased chemicals in the so-far bioenergy oriented biobased industry, will require a highly evolved and supportive policy regime relating biorefineries, bio-based chemicals and plastics.

Research and development

Since the US Department of Energy (DoE) published its report on the potential production of building block chemicals from sugars in 2004, several biobased production breakthroughs have been reported in the chemical industry (see nova-Institut, 2015 for details). In recent years, the biobased chemical subsector, although small, has grown much faster than the petrochemical sector, and is predicted to continue to do so (OECD, 2014; nova-Institut, 2015).

In order to realise the full potential of biobased economy, public spending in biotechnology R&D must be reoriented towards primary production and industry. The focus should be towards the development of those biobased products that provide the highest margins including pharmaceutical products.

Market development

The biobased industry has a large potential and is projected to show considerable growth (e.g. OECD, 2014; 2015). A first projection (2008) estimated the market size in 2025 to reach a size of $549 billion, of which half related to chemicals ($253 billion), biobased commodities and biopolymers each representing 12% ($68 billion)(calculated from USDA). Recent figures presented by nova-Institut show the biobased turnover in the EU28 amounted to €600 billion in 2013, of which over 400 billion Euro for (paper, wood or textile-based) commodities, €90 billion for energy and fuels and another €48 billion for biobased chemicals (Piotrowski and Carus, 2015).

The market share of biobased chemicals and products is expected to grow with some 6.5% per year up to 2020. Specific functional advantages of biobased alternatives (e.g. being stronger, lighter or having better barrier properties) are major drivers (OECD, 2014). Biobased epoxides, PBAT, polyurethanes (PUR) and bioamides recently showed the strongest growth (nova-Institute, 2015).

Biopolymer production potentially is a useful element of the bioeconomy as they can help realise policy goals like climate change mitigation, job creation, landfill diversion, and rural regeneration. Bioplastics currently account for a very small proportion of overall plastics production. Few countries have policies specifically targeting the bioplastics sector, while bioenergy and biofuels policies may place bioplastics at a relative disadvantage (OECD, 2014).

Current biobased polymer turnover is estimated at some €11 billion in 2014. Annual increase is some 11%, but there are major differences. Global production capacity is estimated at 1.7 million tonnes. Its increase so far has been modest, but it is expected to growth with 20% in 2015; capacity is expected to double between 2014 and 2017 (nova Institute, 2015). Europe currently is hosting some 15% of global production capacity. Several companies and initiatives, e.g. Avantium, Bio-Based Joint Undertaking, are developing new capacity.

The Netherlands

Policy

Policies for the bioeconomy and biobased economy have been installed quite early, identifying measurable targets and indicating an agency and ministries for implementation. They are aiming at the enhancement of existing economic structures based in agriculture, food production and chemistry.

Research and development

Public funding for R&D in the Netherlands is mostly oriented towards primary production and enabling biotechnologies allowing industry to realise higher outputs and margins on the final production. Large-scale research programs involving industry as well as other stakeholders are set in place, allowing productive and efficient production chains to be developed.

Market development

Strong agricultural, transport and chemical sector provide a good basis for the implementation of a biobased economy in the Netherlands. Current production mostly refers to bioenergy and biofuels. Development in the bioplastic and biopolymer sectors can build on a considerable number of market players most of which have a clear international profile. Notwithstanding this, development of biobased economic activities so far has been modest.

Several factors may be (partially) responsible including a small forest (product) market, and an uneven playing field due to discrepancies in subsidies and funding for biobased products on the one hand and bioenergy on the other hand. Also, biobased materials fight an uphill battle with their fossil competitors while consumers still seem to have very limited knowledge of biobased alternatives.

There appears to be a lack of risk capital funding new biobased industries which may, combined with a lack of consistent supporting policies, prevent industries to invest in demonstration or flagship factories in the Netherlands. Companies appear careful not to attract negative press, e.g. related to the food vs fuel debate when using plastics made from starch or sugar (Dammer and Carus, 2014).

Comparison

Policy

Bioeconomy is playing a significant role in half of the national transition strategies presented by OECD members. Implementation is mostly top-down, with a dominant role for energy production and bioenergy (Beermann et al., 2015). Several countries have introduced biobased economy roadmaps in the EU, but in practice the number of concrete supportive measures is limited (Dammer and Carus, 2014).

There are large differences in the development and implementation of policies, for example between Belgium (where a national Bioeconomy strategy is lacking but regional initiatives have developed), Denmark (focussing on biofuels as a stepping stone in achieving a viable biobased product industry), and the UK (food production being the primary goal). Dutch biobased policy is in line with its peers. Policies were installed quite early, identifing targets, and indicating an agency and ministries for implementation.

Research and development

Large variations in national R&D efforts have been found (see, for example, Beermann et al., 2015; Langeveld, 2015). They are basically mirrored by the patterns of market development that has been observed by nova-Institute (2013, 2015), OECD (2014), and IEA Bioenergy (Beermann et al., 2015). Funding for biobased R&D so farm mostly seems limited to public sources although private investments have been reported as well (Germany, France, the UK and the Netherlands).

Size and effectiveness of investments have not been studied in detail, while reporting in some cases seems to be incomplete. Large differences further seem to occur in the orientation and targeting of public funding where the Netherlands have taken a strong position with respect to funding of 'industrial use of biomass' and 'key enabling technology'.

Market development

The quantification of existing biomass use in bioenergy, materials, chemicals or polymer production chains is an essential step in the evaluation of biobased economy development in a given country (Beermann et al., 2015). A detailed evaluation was not possible for all sectors in all countries but data presented for a number of peer countries in the north-west of the continent show strong developments in bioenergy and biofuels production while the situation in wood-based biobased products, bioheat and bioelectricity is showing large variations among different countries.

Market development in the Netherlands has been strong in bioeconomy and biofuels, the latter showing a strong export-focussed orientation. Good perspectives have been reported for biobased chemicals and biopolymers but here still important restricting factors have been identified that require attention as they seem to hamper a real take-off in these sectors.

Conclusion

The Netherlands seem to have a good starting position to develop a competitive biobased sector, supported by strong economic performance in agriculture and chemistry. Timely implementation of a biobased policy, availability of a viable internationally recognized private sector, implementation of broad multi-actor funding programmes ('green deals'), as well as a strong regional commitment

and education involvement certainly have added to an atmosphere of 'can-do' in which biobased chain development has emerged. This is reflected in a good starting position also when compared to other peer countries in the region.

However, some serious restrictions and barriers including the lack of a large forestry sector (providing lignocellulosic feedstocks and serving existing markets for wood and paper products), unexpected policy change, lack of strong public support and unfavourable subsidy conditions especially for non-bioenergy applications. Consequently, biobased economic growth has been modest for wood products, biobased products, biobased chemicals and biopolymers.

It seems too early, however, to draw strong conclusions on the preliminary analyses currently available. Methodologies for the calculation of biomass use and biobased share in industrial production still needs to be improved. This also applies to the analysis of biobased turnover and employment. The challenge remains to consolidate and compare existing statistical data sources, both within and between countries. The current study has taken a few first steps in this direction. Hopefully, it contributes to a further strengthening of data collection and analysis in the biobased economy and bioeconomy as a whole in the Netherlands and other countries.

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ANNEXES

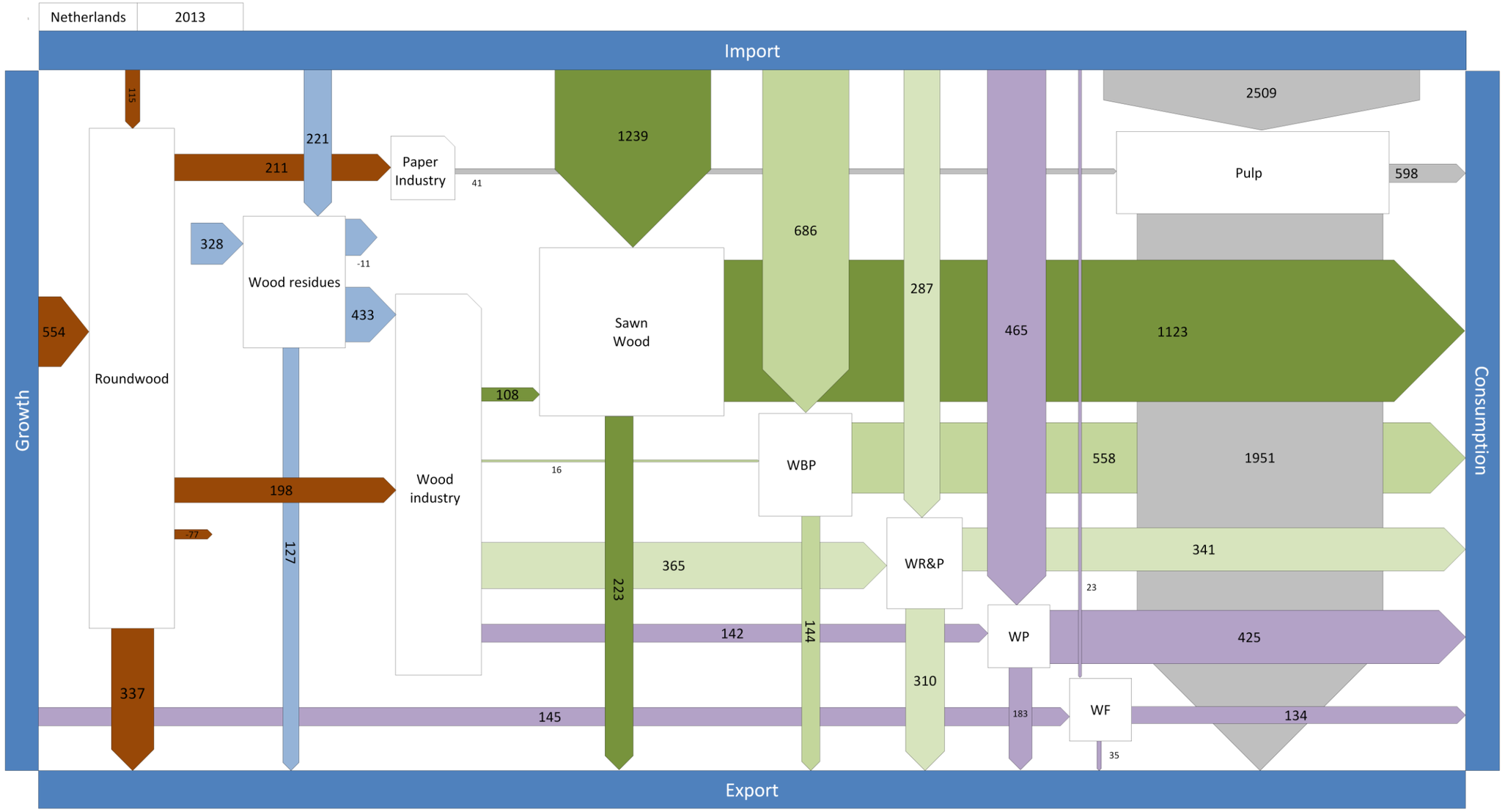

Figure A.1. Wood balance of the Netherlands in 2013 (ktonne dry matter per year)

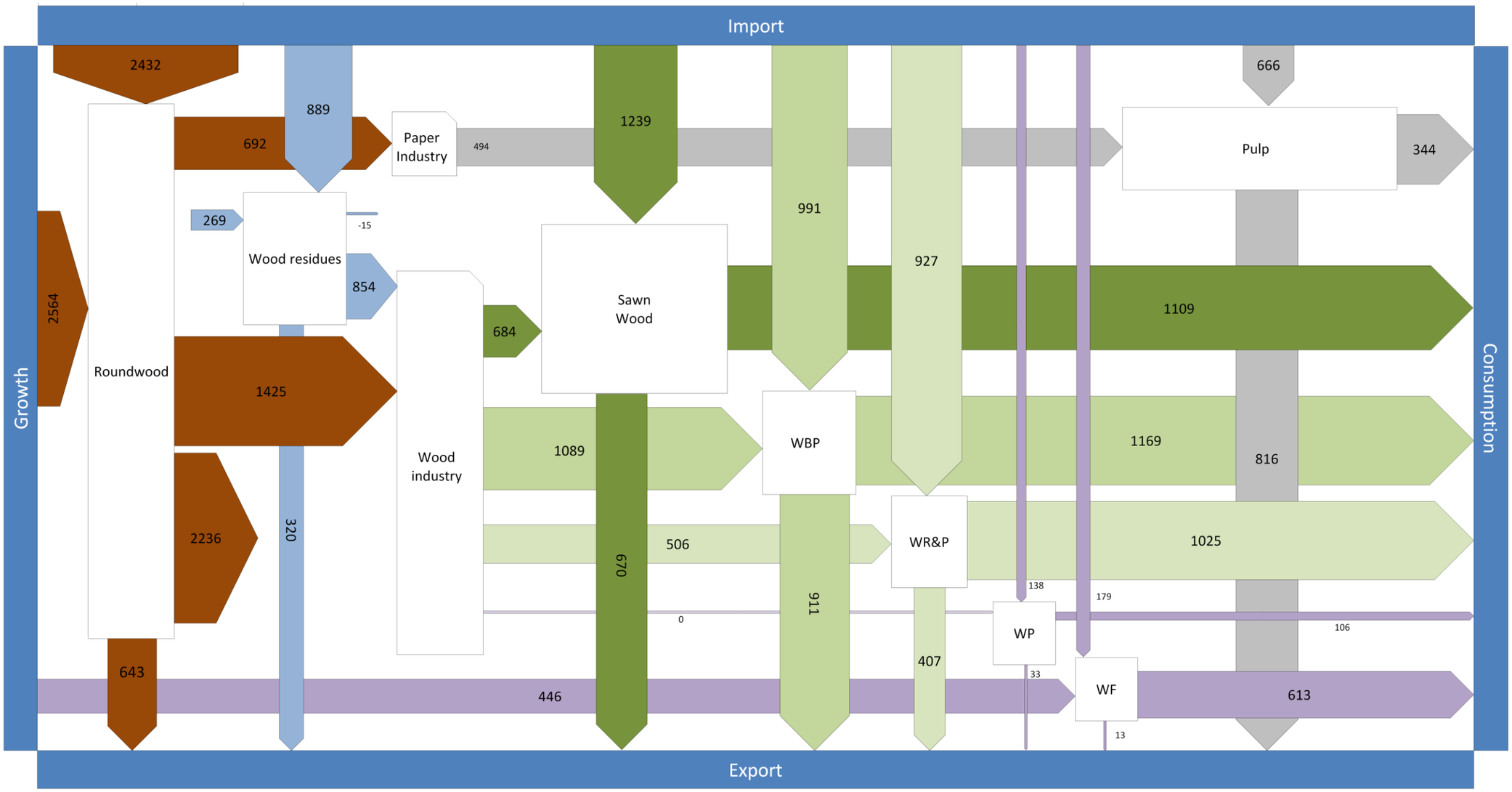

Figure A.2. Wood balance of Belgium in 2013 (ktonne dry matter per year)

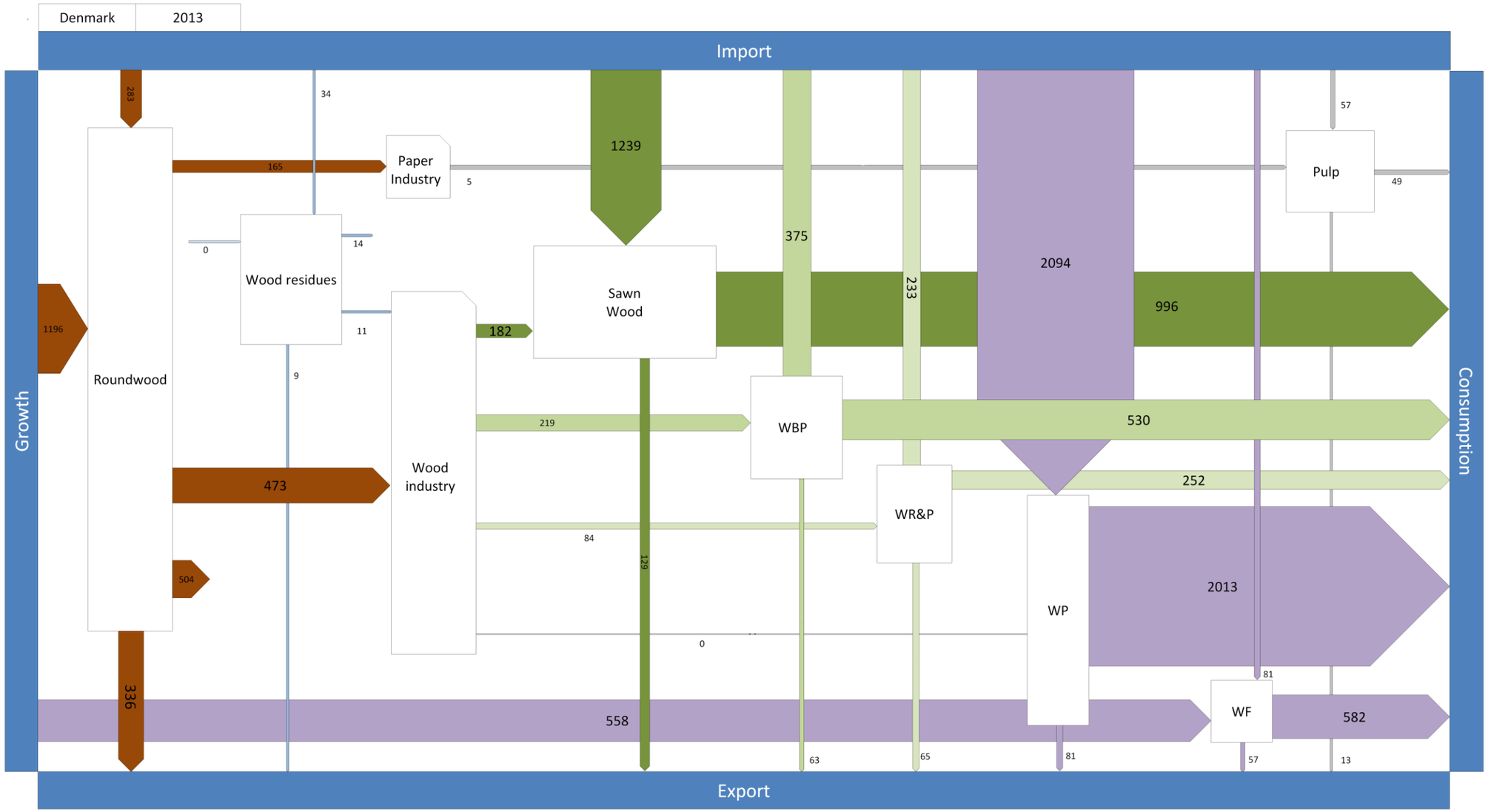

Figure A.3. Wood balance of Denmark in 2013 (ktonne dry matter per year)

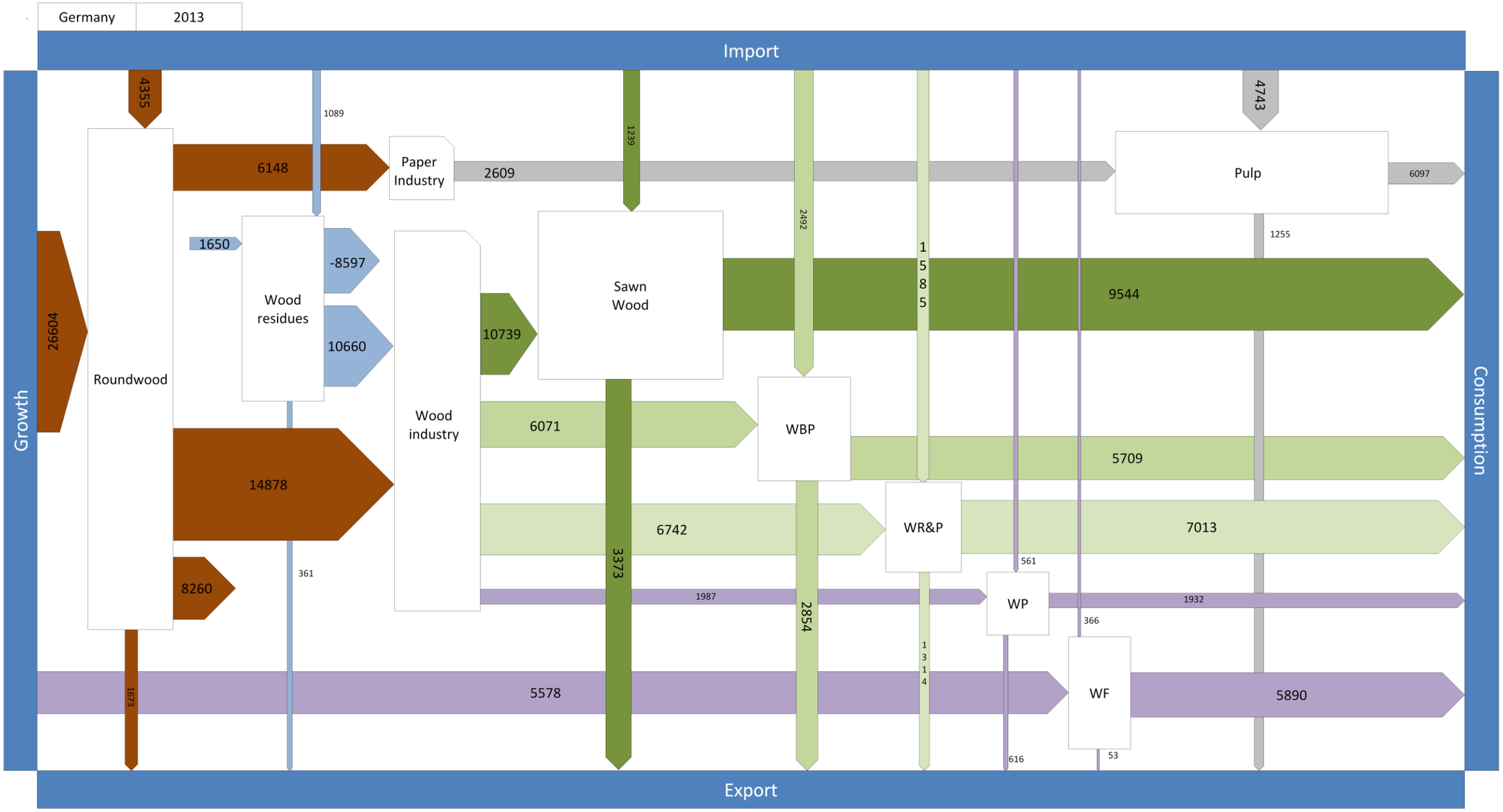

Figure A.4. Wood balance of Germany in 2013 (ktonne dry matter per year)

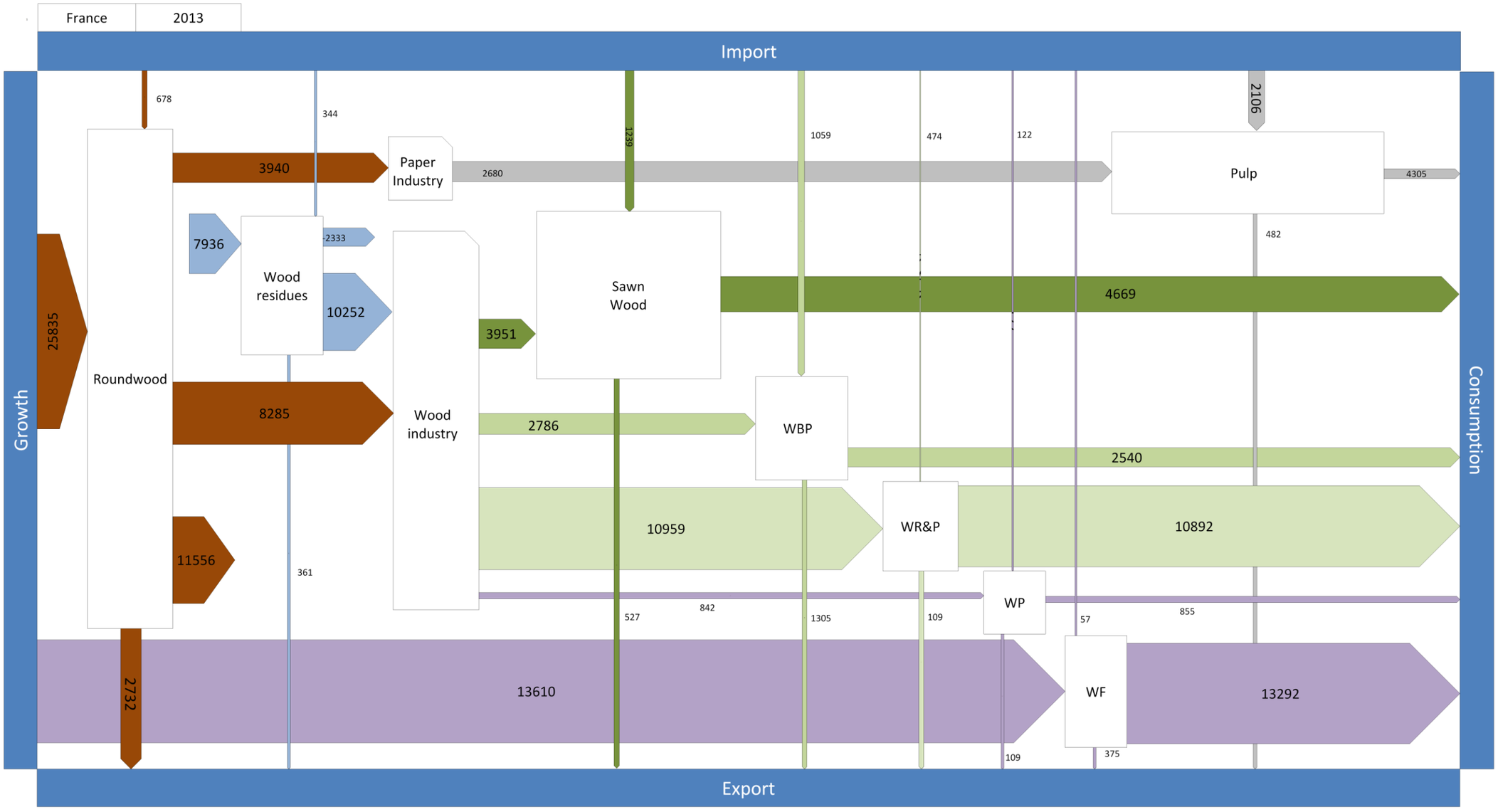

Figure A.5. Wood balance of France in 2013 (ktonne dry matter per year)

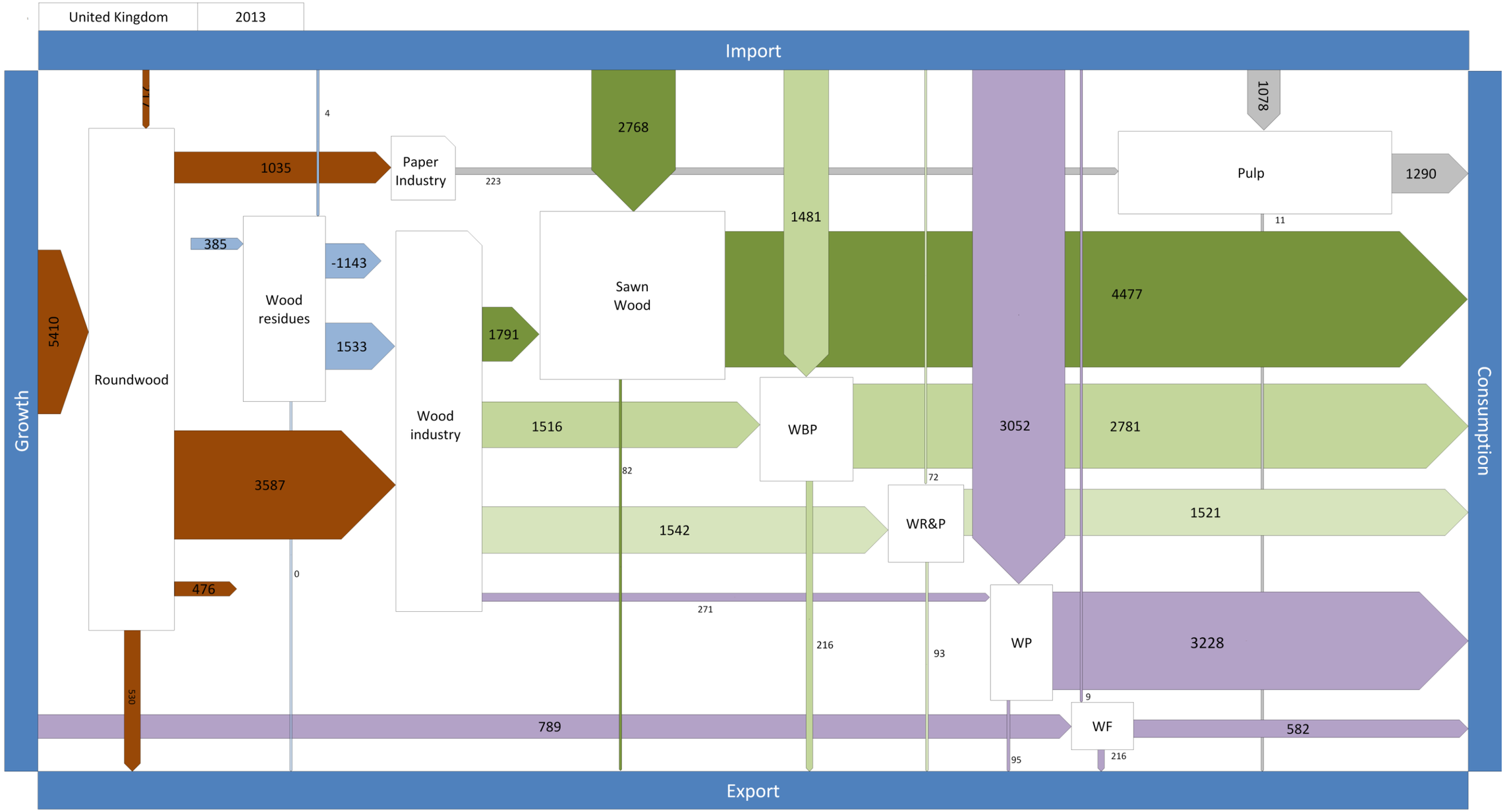

Figure A.6. Wood balance of the United Kingdom in 2013 (ktonne dry matter per year)