



Luonnonvara- ja biotalouden tutkimus 2/2021

Vertaileva selvitys eri maiden biotalousstrategioista

Markus Lier, Katriina Soini ja Matleena Kniivilä

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Luonnonvarakeskus, Helsinki 2021

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Tiivistelmä

Markus Lier, Katriina Soini ja Matleena Kniivilä

Luonnonvarakeskus (Luke)

Tässä raportissa esitellään yhdeksän maan biotalousstrategioiden keskeinen sisältö. Selvityksen kohteena oli kuusi Euroopan maata (Alankomaat, Italia, Itävalta, Ranska, Saksa, Suomi) sekä Etelä-Afrikka, Kanada ja USA. Analyysi oli ensisijaisesti laadullinen ja vertaileva ja se tehtiin ATLAS.TI -ohjelmistoa käyttäen. Analyysi kohdistui erityisesti seuraaviin teemoihin: biotalouden määrittely, tavoitteet ja seuranta, biotalouden sektorit, resurssit, tuotteet ja arvoketjut, biotalouteen liittyvä koulutus, kasvatusta ja tutkimus, biotaloustietoisuuden lisääminen yhteiskunnassa sekä biotalouden edistämisen politiikkakeinot ja yhteydet kestäväan kehitykseen. Strategiat olivat luonteeltaan ja laajuudeltaan erilaisia. Muutamien teemojen osalta voidaan nähdä yhteneväisyyttä sisältöjen osalta, vaikkakin yksityiskohtien tasolla maiden välillä on eroja runsaasti. Raportti koostuu suomenkielisestä yhteenvedosta sekä alkuperäisestä englanninkielisestä analyysistä, joka on tämän raportin liitteenä. Liitteen taulukot antavat lisätietoa eroista eri maiden välillä. Raportin tuloksia voidaan käyttää biotalousstrategioiden ja -politiikan laadinnassa. Selvitys on tehty maa- ja metsätalousministeriön rahoituksella Suomen biotalousstrategian päivitystyön tueksi.

Asiasanat: biotalous, biotalousstrategia, biokierto, kestävä kehitys, politiikka

Abstract

This report reviews bioeconomy strategies of nine countries: six European countries (Austria, France, Finland, Germany, Italy and the Netherlands) and South-Africa, Canada and USA for comparison. The results are based on a computer-assisted qualitative content analysis of national bioeconomy strategies using ATLAS.TI software. The report focuses on the following themes: existing national bioeconomy definitions, goals, objectives or targets and their progress monitoring, bioeconomy resources, sectors and products and bio-based supply and/or value chains; bioeconomy related science and research, education and training, bioeconomy awareness raising, the role of regions in bioeconomy; policy instruments and links to sustainable development. The studied strategies are different in terms of scope and extent. Some similarities can be found in some topics, although they differ at the level of details. The results of this report can support the development of national bioeconomy strategies and policies. The study and the report have been funded by the Ministry of Agriculture and Forestry to support the revision of the Finnish Bioeconomy Strategy.

Keywords: bioeconomy, bioeconomy strategy, circular bioeconomy, sustainable development, policy

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1. Johdanto

Biotalous voidaan määritellä hieman eri tavoin, mutta yleensä sillä tarkoitetaan toimintaa ja taloutta, joka perustuu uusiutuviin biologisiin resursseihin ja prosesseihin sekä näissä prosesseissa syntyvien tuotteiden, jätteiden ja sivuvirtojen käyttöön ruokana, rehuna, energiana sekä palveluina. Biotalous nähdään yhä keskeisempänä keinona kestävän kehityksen tavoitteiden saavuttamisessa, kiertotalouden ja vihreän siirtymän vauhdittamisessa, sekä ilmastonmuutoksen hillitsemisessä [1].

Varsinaisia kansallisia biotalousstrategioita alettiin julkaista vasta 2010 -luvun alussa, vaikka monet maat olivat laatineet erilaisia politiikkaohjelmia bioteknologian edistämiseksi ja biomassojen käyttöön liittyen jo aiemmin. Vuoteen 2020 mennessä yli neljäkymmentä maata Euroopassa ja muualla maailmassa on laatinut kansallisen strategian vauhdittaakseen biotalouden kehitystä omassa maassaan [2,3,4,5]. Määrän voidaan olettaa kasvavan, sillä monet Itä-Euroopan maat ovat myös ryhtyneet laatimaan omia strategioitaan. Samaan aikaan on käynnistynyt strategioiden päivittyminen: Euroopan Unioni päivitti oman biotalousstrategiansa vuonna 2018 ja jäsenmaista Saksa on päivittänyt jo oman strategiansa. Suomen strategian päivittyminen valmistuu vuoden 2021 alussa vastaamaan toimintaympäristön muutoksiin ja voimassa olevan hallitusohjelman tavoitteisiin. Voidaan olettaa, että myös monet muut Euroopan Unionin maat ryhtyvät päivittämään strategioitaan. Strategioiden lisäksi monilla mailla on käynnissä muita biotalouden edistämiseen liittyviä politiikkatoimia.

Tässä raportissa kuvataan ja vertaillaan eri maiden biotalousstrategioita Suomen biotalousstrategian päivittämisen taustaksi. Työssä keskitytään kuuteen Euroopan Unionin jäsenmaahan: Alankomaat, Italia, Itävalta, Ranska, Saksa, Suomi. Vertailuun otettiin mukaan myös Kanada, Etelä-Afrikka ja USA, jotka edustavat erilaisia talousjärjestelmiä (Etelä-Afrikka ja USA) ja joilla on myös samankaltaisuutta luonnonvaroissa ja niiden käytössä (USA ja Kanada). Aineiston valita tehtiin yhdessä projektin ohjausryhmän kanssa.

Strategiat poikkeavat huomattavasti niin laajuudeltaan: laajin raportti oli 94 sivua pitkä (Italia) ja suppeimmat raportit alle 10 sivua (Ranska ja Alankomaat) (Taulukko 1.). Strategioilla ei ollut yhtenäistä tarkastelu- tai lähestymistapaa, vaan kukin maa oli valinnut oma lähestymistapansa, mikä teki vertailusta joidenkin teemojen osalta vertailusta epätasaisen.

Selvitys kohdistui erityisesti seuraaviin kysymyksiin:

- miten biotalous määritellään;
- millaisia tavoitteita biotaloudelle annetaan ja miten tavoitteiden toteutumista seurataan;
- millaisia tuotteita, palveluita, sektoreita, arvoketjuja strategioissa tarkastellaan;
- miten biotaloutta edistetään kasvatuksella, koulutuksella ja tutkimuksella;
- millaisia politiikkoihin biotalous kytetään;
- miten kestävän kehityksen tavoitteet otetaan huomioon biotalousstrategioissa;
- miten biotaloustietoisuutta edistetään.

Aineistosta tehtiin vertaileva sisällönanalyysi. Työssä hyödynnettiin tietokoneavusteista laadullisen tutkimuksen ohjelmaa (Atlas.ti), joka mahdollistaa aineistojen systemaattisen läpikäynnin, erilaisten teemojen ja niiden välisten suhteiden analysoinnin eri dokumenttien välillä, mutta myös määrälliset tarkastelut. Aineiston koodausta ohjasivat teemat, joista oli sovittu ohjausryhmän kanssa. Seuraavassa tarkastelemme aineistoa tutkimusteemoittain.

Taulukko 1. Tutkimusaineisto. USA:n osalta tarkasteltiin kahta eri raporttia.

| Country | Title | Publisher | Pages | Year |
|-----------------------------------|--|--|-------|------|
| Austria [6] | Bioeconomy: A Strategy for Austria | Federal Minister for Education, Science and Research | 71 | 2019 |
| Canada [7] | Canada's Bioeconomy Strategy: Leveraging our Strengths for a Sustainable Future | Bioindustrial Innovation Canada | 68 | 2019 |
| Finland [8] | Sustainable Growth from Bioeconomy: The Finnish Bioeconomy Strategy | Prime Minister's Office, Ministries of Employment and Economy, Agriculture and Forestry, Environment, Education and Culture, Social Affairs and Health, Finance, administrative branches under these Ministries, VTT Technical Research Centre, Finnish Innovation Fund Sitra. | 32 | 2014 |
| France [9] | A Bioeconomy Strategy for France | Ministry for Agriculture and Food | 8 | 2018 |
| Germany [10] | The German National Bioeconomy Strategy | Federal Ministry of Education and Research, Federal Ministry for Food and Agriculture | 68 | 2020 |
| Italy [11] | BIT II—Bioeconomy in Italy: A Unique Opportunity to Reconnect the Economy, Society and the Environment | Government of Italy | 94 | 2019 |
| NL [12] | The position of the bioeconomy in the Netherlands | Ministry of Economic Affairs and Climate Policy | 8 | 2018 |
| South Africa [13] | The Bio-economy Strategy | Department of Science and Technology (DST) | 48 | 2013 |
| USA [14] | The Bioeconomy Initiative: Implementation Framework (referred in the text to USA) | Biomass Research and Development Board | 74 | 2018 |
| USA II [15] | Bioeconomy Research and Development Act (referred in the text to USA II) | U.S. Senate | 27 | 2020 |

2. Tulokset

2.1. Biotalousmäärittely

Ennen vuotta 2015 kansallisissa biotalousstrategioissa käytettiin erilaisia termejä biotalouden rinnalla, kuten biopohjainen talous tai vihreä talous. Nyt puhutaan yhä useammin kestävästä biotaloudesta ja/tai biokiertoaloudesta (circular bioeconomy) [5]. Viimeaikaiset biotalousstrategiat eivät keskity ainoastaan luonnonvarojen kestäväan käyttöön, vaan siihen, miten uusiutumattomat luonnonvarat korvataan uusiutuville kaikilla sektoreilla ja kaikissa prosesseissa. Lisäksi tavoitteena on vähentää resurssi-intensiivisiä prosesseja ja tehostaa materiaalien kierrätystä: *“to accelerate the deployment of a sustainable European bioeconomy... maximise its contribution towards the 2030 Agenda and its Sustainable Development Goals (SDGs), as well as the Paris Agreement.”* and to *“respond to new European policy priorities, in particular the renewed Industrial Policy Strategy, the Circular Economy Action Plan and the Communication on Accelerating Clean Energy Innovation, all of which highlight the importance of a sustainable, circular bioeconomy to achieve their objectives.”* [1]

Yleensä ottaen biotalous nähdään tarkastelluissa strategioissa sekä kiertoalouteen ja kestävyteen vahvasti kytkeytyvänä ja tärkeänä toimena vastattaessa (globaaleihin) sosiaalisiin ja ympäristöllisiin kestävyshaasteisiin. Italia, Alankomaat ja Kanada määrittelevät biotaloutensa EU:n biotalousstrategian [1] mukaan (LIITE 1: Taulukko 7): *“The production of renewable biological resources and the conversion of these resources and waste streams into value added products, such as food, feed, bio-based products and bioenergy. To be successful, the bioeconomy needs to have sustainability and circularity at its heart. This will drive the renewal of our industries, the modernization of our primary production systems, the protection of the environment and will enhance biodiversity.”* Kanadan ja Alankomaiden strategioihin sisältyy paitsi biotalouden määritelmä myös kiertoalouden määritelmä. Kanadan biotalousmääritelmässä on myös eurooppalainen ulottuvuus: *“this Strategy will adopt this definition of the bioeconomy (EU Bioeconomy Strategy 2018) but will rely on biotechnology as a competitive advantage. Europe is recognized as having the most stringent genetically economy, society and the environment, modified organisms (GMO) regulations in the world. With Canada’s history of biotechnology innovation, there is a competitive advantage to further streamline and adapt Canada’s regulatory framework so that it supports a thriving bioeconomy.”*

Biotalousmäärittely lähti usein liikkeelle biotalouden resursseista, luonnon biologisista prosesseista ja niiden perustalle rakentuvasta taloudesta (LIITE 1: Taulukko 7 ja 8): *“Bioeconomy’ refers to the production, exploitation and use of biological resources, processes and systems to provide products, processes and services in all economic sectors within the framework of a sustainable economic system. (Saksa); “It is the photosynthesis economy, and more generally the living world economy.” (Ranska).* Huomio on ensisijaisesti alkutuotannon (maatalous, metsätalous, vesiviljely ja kalatalous) prosesseissa tuotetuissa tuotteissa. Useimpien maiden määrittelyissä esiintyvät myös fossiilisten resurssien korvaaminen, uusiutuvat luonnonvarat sekä niihin liittyvät teollisuudenalat. *“Bioeconomy stands for an economic concept that aims to replace fossil resources (raw materials and energy sources) with renewable raw materials in as many areas and applications as possible (Itävalta).* Määrittelyihin kytetään usein myös monet ympäristölliset ja yhteiskunnalliset haasteet kuten ilmasto, ympäristön saastuminen, kestävyys, kierrätettävyys, monimuotoisuus ja väestönkasvu.

Etelä-Afrikan biotalousmääritelmässä korostuu innovaatiolähtöinen toiminta: *“Bio-economy” refers to activities that make use of bio- innovations, based on biological sources, materials and*

processes to generate sustainable economic, social and environmental development. In the bio-economy the entire innovation system/network, ranging from ideas, research, development, productisation and manufacturing to commercialisation, should be used to its full potential in a coordinated manner." USA:n biotalouden määritelmän ytimessä oli taas globaali näkymä ja siirtymä uusiutumattomien luonnonvarojen käyttöön: *"A general definition of the bioeconomy is: The global industrial transition of sustainably utilizing renewable aquatic and terrestrial biomass resources in energy, intermediate, and final products for economic, environmental, social, and national security benefits."* Taloudellinen kehitys mainittiin Itävallan strategiassa, Suomen strategiassa puhuttiin taloudellisesta kasvusta ja Etelä-Afrikan strategiassa uudesta taloudesta. Muiden maiden määritelmässä biotaloudesta puhuttiin talouden osana vain yleisesti. Kestävyys tai kestävä kehitys oli mainittu kaikkien maiden määritelmässä paitsi Itävallan. Palvelut mainittiin eksplisiittisesti vain Saksan, Suomen ja Kanadan määrittelyissä.

2.2. Biotalouden päämäärät ja tavoitteet

Biotaloutta koskevat tavoitteet kuvataan eri tavoin, joko hyvin konkreettisina askeleina tai laajempina ideoina. EU:n maiden osalta voidaan otaksua, että ne noudattelevat EU:n aiemman ja uudistetun strategian linjauksia koskien esimerkiksi kilpailukykyä, riippuvuuden vähentämistä uusiutumattomista luonnonvaroista, ilmastonmuutokseen sopeutumista ja hillitsemistä, ruokaturvan varmistamista ja luonnonvarojen kestävää käyttöä [5] Määrällisesti tarkasteltuna biotalouden tavoitteiden määrittelyssä toistuivat usein miten seuraavat asiat (LIITE 1: Taulukko 8): taloudellinen kehitys (8 maata), kestävä kehitys (7), tuotteet (7) biodiversiteetti (6), innovaatiot (6), uusiutuvat luonnonvarat (6). Kun tarkastellaan tarkemmin tavoitteiden sisältöjä, voidaan löytää hieman erilaisia painotuksia (LIITE 1: Taulukko 9). Näistä voidaan hahmottaa karkeasti kolmentyyppisiä kokonaisuuksia (kts. alla). Ne voivat sisältää myös päällekkäisiä tavoitteita. Suluissa on mainittu maa/maat, joiden strategioissa nämä painotukset ovat erityisen ilmeisiä.

- 1) *Kestävään luonnonvaratalouteen pohjautuva kansallinen ja kansainvälinen biotalous*
 - Riippuvuuden vähentäminen uusiutumattomista luonnonvaroista; ilmastotavoitteiden saavuttaminen ja kestävä transformaaation edistäminen; biotalouden edistäminen poikkisektoraaalisen (teknologia, tieteellinen, taloudellinen, poliittinen, sosiaalinen) yhteistyön kautta. (Itävalta)
 - Ekologisia rajoja kunnioittava kansalliseen ja kansainväliseen yhteistyöhön perustuva biotalous, joka pohjautuu kestävään raaka-ainetuotantoon ja tekee Saksasta johtavan biotalousinnovaatioiden maan. (Saksa)
- 2) *Liiketoimintalähtöinen kestävä biotalous*
 - Uusia tuotteita ja palveluja ja niiden myötä taloudellista kasvua ja työpaikkoja; biotalous globaalien ongelmien ratkaisemiseksi. (Suomi)
 - Arvoketjut ja yritystoiminta mukaan lukien biomassan tarjonta sekä kestävä innovaatioekosysteemit; sääntely, standardit ja globaaleihin arvoketjuihin pääseminen. (Kanada)
 - Ekologiset reunaehdot, yhteistyö arvoketjun sisällä; pitkäjänteinen tutkimus- ja innovaatio-ohjelma sekä politiikkajohdonmukaisuus. (Alankomaat)

3) *Kansallista ja paikallista kehitystä laaja-alaisesti palveleva biotalous*

- Ruokaturvan ja muiden ekosysteemipalveluiden varmistaminen; alueellisesti tehokas ja muutosjoustava (resilient), kiertotalouteen pohjautuva ja tuottava biotalous; yleistä yhteiskunnallista kehitystä palveleva biotalous. (Ranska)
- Koulutukseen, kasvatukseen ja tiedonsiirtoon nojaava biotalous, joka parantaa alkutuotantoa ja kiertotaloutta ja tuottaa työpaikkoja, edistää paikallista kehitystä ja sosiaalista yhteenkuuluvuutta. Paikallinen, kansallinen ja EU-tason yhteistyö biotalouden edistämiseksi. (Italia)
- Ruokaturva, työpaikat ja vähähiilinen vihreä talous (ml. esimerkiksi terveys ja ympäristö). (Etelä-Afrikka)

4) *Tieteeseen perustuva biotalous*

- Tieteidenvälinen tutkimus (erityisesti biotekniikan alalla) yhtäältä luonnonteiden ja tietojenkäsittelytieteiden välillä; yhteiskunnallinen tutkimus sekä käyttäytymiseen ja talouteen liittyvä tutkimus; tieteellisen ymmärryksen ja teknologisten innovaatioiden tutkimus sekä tutkimus- ja kehitystoiminnan kaupallistaminen. (USA I ja II)

2.3. Biotalous seuranta ja indikaattorit

Biotalous tavoitteiden toteutumisen seuranta olisi hyödyllistä [5]. Seurannalla voidaan arvioida saavutuksia suhteessa asetettuihin tavoitteisiin, vauhdittaa biotalouden toimeenpanoa sekä tuottaa biotalouden edistymisestä tietoa eri sektoreiden ja kansalaisten käyttöön. Seurantatiedon pitäisi olla helposti saatavilla, luotettavaa ja harmonisoitua. Lisäksi sen pitäisi antaa käsitys kestävyuden toteutumisesta biotalouden eri sektoreilla ja tunnistaa mahdollisia ristikkäisiä tavoitteita ja vaikutuksia: *"The inherent complexity of the bioeconomy and the high ambition of national and regional bioeconomy strategies means progress towards the bioeconomy needs to be regularly monitored, based on indicators with easily available, reliable, and harmonized data and information. This provides a holistic view of all the dimensions of sustainability in every bioeconomy sector and highlights the eventual trade-offs between them."* [5].

Biotalous seuranta voi olla lähtökohtaisesti laadullista tai määrällistä. Taulukossa 2 tarkastellaan niitä maita, jotka ovat asettaneet joko tavoitetason ja/tai indikaattoreita biotalouden seurantaan. Taulukosta havaitaan, että vain Suomi ja Italia ovat asettaneet selkeitä määrällisiä tavoitteita ja niihin sidottuja indikaattoreita. (kts. myös LIITE 1. Taulukko 10). Itävallalla ei ollut määrällisiä tavoitteita, mutta alustavia ajatuksia indikaattoreista (tieteelliset julkaisut, projektit, patentit). Kanadalla ja USA:lla ei ollut lainkaan määrällisiä tavoitteita ja indikaattoreita. USA:lla on kuitenkin alustavia suunnitelmia määrällisten tavoitteiden ja indikaattoreiden kehittämiseksi. Kanada aikoi tarkastella sitä, miten omalla toiminnallaan voi vahvistaa monikansallisten yhtiöiden (esim. Lego ja Ikea) biotalouden vauhdittamista. Taulukossa ei laadullisia tavoitteita kuten esimerkiksi, uusia biotalouden työpaikkoja vuoteen 2030 mennessä.

Taulukko 2. Biotalouden tavoitteet ja mittarit.

| Maa | mitattava kohde ja tavoitetaso | muita indikaattoreita (tavoitteeseen sidotut indikaattorit alleviivattu) |
|---------------------------|--|--|
| Itävalta | ei määrällisiä tavoitteita | tieteelliset julkaisut, projektit, patentit |
| Suomi | Vuoteen 2025 Biotalouden arvo kasvaa 60 miljardista 100 miljardiin 100 000 uutta työpaikkaa | raaka-aineiden määrä; raaka-ainevirtojen lisäarvo; kasvihuonekaasujen vähentäminen; luonnonvarojen kokonaiskäyttö; metsävarojen kasvu ja hakkuumäärät; viljojen kasvu ja sadon määrä; kalakantojen kasvu ja saalis; uhanalaiset lajit: kaupunkialueiden jäte; ekosysteemipalvelut; ympäristö ja resurssitehokkuus |
| Saksa | Ilmastoneutraali tuotanto 1,5, asteen tavoitteeseen pääsemiseksi; luomutuotantoalan kasvu 20%:iin viljelyalasta vuoteen 2030 | ei indikaattoreita |
| Italia | yhdyskuntajätteen uusiokäytön ja kierrätyksen kasvu (55%:iin vuoteen 2020; 60%:iin vuonna 2030 ja 65%:iin vuoteen 2035 mennessä) valmistautuminen ruokahävikin puolittamiseen vuoteen 2030 mennessä | maatalouden biomassatuotanto ja tuonti; sinisen biomassan tuotanto ja tuonti; metsäbiomassan tuotanto ja tuonti; biotalousyritysten määrä; innovatiiviset start-up yritykset; työllisyys biotalouden sektoreilla; koulutus; R&D työllisyys kaikilla biotalouden sektoreilla |
| Etelä- Afrikka | ei määrällisiä tavoitteita | 46 indikaattoria, esimerkiksi: tieteelliset julkaisut/asukas; biotalous-innovaatioiden työvoima kaikesta tutkimus- ja teknologia- toiminnasta; tutkimuskeskukset, teknologia-alustat, monitieteellinen tutkimus ja kehitysohjelmat; biotalouden tutkimus ja kehitys; myönnetty patentit; yhteistyö tuotteiden kehittämisessä, teknologian kehittämistä palveleva infrastruktuuri; uusien terveystuotteiden hyväksyntä; life- science tuotteiden, prosessien ja palveluiden myynti; GMO kenttäkoeket; bio-innovaatio yritykset; pääomasijoitukset biotalouteen, yhteisyritykset ja strateginen yhteistyö paikallisten biotalousinnovaatiot yritysten ja kansainvälisten kumppaneiden kanssa; monikansallisten yritysten paikalliset tutkimus ja kehitysyhtiöt; bioteknologian monipuolinen käyttö |

2.4. Biotalouden resurssit, sektorit ja tuotteet

Biotalouden resurssien sektoreiden ja tuotteiden määrittely oli keskeinen osa strategioita (kts. Taulukko 3. alla ja LIITE 1. Taulukot 11-14). Melkein kaikissa analysoiduissa strategioissa biotalouden resursseina mainittiin maatalouden, metsätalouden, vesiviljelyn ja kalatalouden biologiset resurssit, ja niiden tuottamat tuotteet ja palvelut. Näiden lisäksi Saksan strategiassa mainittiin myös hiilidioksidi ja mikrobit. Biotaloussektoreita olivat edellä mainittujen alkutuotannon sektoreiden lisäksi puutuotteiden jatkojalostus, puiset huonekalut, paperin jalostus, biopohjaiset kemikaalit ja lääkkeet, bioenergia, biokaasu, bionesteet, biomateriaalit ja -muovit, rakennusmateriaalit, kuidut, ruoka ja rehu; pakkaukset, paperi ja selluloosa. Saksassa myös autoteollisuus laskettiin biotalouden sektoriksi. Biotalouden tuotteista bioenergia, biokaasu ja bionesteet saivat eniten mainintoja, biopohjaiset kemikaalit ja biomateriaalit/-muovit toiseksi eniten. Itävalta oli määritellyt myös toimenpiteitä, miten biotalouden eri sektoreita, resursseja ja tuotteita voidaan vahvistaa. (Kts. LIITE 1. Taulukko 13.)

Taulukko 3. Yhteenveto biotalouden resursseista, sektoreista ja tuotteista eri maissa (kts. myös LIITE 1: taulukot 11–14).

| Country | Resources, sectors and products considered | Examples |
|---------|--|--|
| Austria | resources | from agriculture, forestry, water management, residuals, by-products, wastes |
| | sectors | encompasses all industrial and economic sectors that produce, process, handle or use biological resources |
| | products | bio-based chemicals, bioenergy, bioplastics, fibres, food and feed, gaseous biomass, liquid biomass, paper and pulp |
| Canada | resources | animals, plants, micro-organisms and derived biomass, including organic waste, their functions and principles, land and marine ecosystems |
| | sectors | agriculture, forestry, fisheries and aquaculture, industrial sectors that use biological resources and processes to produce food, feed, bio-based products, energy and services |
| | products | bioenergy, biofuels, biochemicals and biomaterials; concrete examples: cellulosic sugar producers, aviation biofuels, packaging for water bottles |
| Finland | resources | agriculture, aquaculture, fisheries, forestry, wastes, industrial side streams |
| | sectors | agriculture, forestry, fishing and aquaculture, manufacture of food, manufacture of wood products and furniture, manufacture of paper, manufacture of bio-based chemicals, pharmaceuticals, plastics and rubber (excl. biofuels), manufacture of liquid biofuels, health sector, nature tourism, water treatment and distribution, biomass harvesting technologies |
| | products | bio-based products, biochemical methods, pulping technologies and enzyme production for refining of biomass, wood-based transport fuels, side streams from agriculture and food industry, wood for construction |
| France | resources | biomass production and processing activities in forestry, farming or aquaculture, focusing at production of food, feed, biobased products and renewable energy |
| | sectors | agriculture, forestry, food processing, wood industries, energy production, production of materials and molecules, biowaste conversion |
| | products | agrifood co-products to produce animal feed, energy, new materials and molecules from agricultural and forestry biomass, innovative molecules concrete examples: construction using hempcrete, cellulose pulp mill into a lignocellulose biorefinery, methanization, production of energy and fertilizer using locally available resources |
| Germany | resources | animals, by-products and residues, CO ₂ , microbes, plants and soils, water |
| | sectors | agriculture, automobile industry, chemistry, construction, consumption, energy, food, mechanical engineering, pharma, textiles |
| | products | biogenic materials, such as construction materials and new materials used in durable industrial goods |
| Italy | resources/ sectors | agriculture, forestry, fisheries, food and beverages production, paper, pulp, tobacco industries, textiles from natural fibres, leather, bio-pharmaceuticals, green chemistry, biochemicals and bioenergy, waste recovery |

| | | |
|--------------|-----------------------|---|
| | products | compostable carrier bags and waste bags, compostable bags, gloves for fruit & vegetables and labels, compostable products for foodservice, compostable packaging, food packaging, biogas, new functional cold pressed oils, bio-innovation in recipes |
| NL | resources | production of renewable biological resources and their conversion into food, feed, bio-based products and bioenergy |
| | sectors | agriculture, forestry, fishing, aquaculture, food production, paper and pulp, chemical, biotechnological and energy production sectors; including biotechnology, nanotechnology and ICT |
| | products | biorefining products for medical applications, chemical products, polymers, electricity/heating powered by biomass that cannot be used for other applications |
| South Africa | sectors | agriculture, aquaculture, health, industrial and environmental |
| | products | food, biofuels, animal vaccines, biofertilizers, bio-based chemicals and materials, water and waste |
| USA | resources/ sectors | agriculture, forestry, manufacturing, waste, biotechnology, chemicals, fuels, heat, and power industries |
| | products | starch-based ethanol, biodiesel from plant and waste oil; heat and power from biomass, advanced biofuels, including renewable diesel, jet, and gasoline, renewable chemicals and chemical intermediates |

2.5. Biotalous arvojen ketjut

EU:n biotalousstrategian mukaan kestävä ja kiertotalouteen pohjautuva biotalous perustuu ensisijaisesti kansallisiin uusiutumattomiin luonnonvaroihin vahvistaen biotaloussektoreiden kilpailukykyä ja uusien arvoketjujen luontia [1]. Eri maiden strategioissa on pohdittu, miten voidaan lisätä resurssien käytön tehokkuutta ja vaikuttavuutta poikkisektorialisen yhteistyön myötä koko arvoketjun läpäisevästi ja samalla vahvistaa kuluttajien ja tuottajien välistä suhdetta sekä julkisen ja yksityisen sektorin välisiä kumppanuuksia (PPP). Tulokset voidaan tiivistää seuraavasti (kts. myös LIITE 1. Taulukko 15):

Resurssien tehokasta ja vaikuttavaa käyttöä arvoketjuissa korostettiin erityisesti Itävallan ja Saksan biotalousstrategioissa. Itävallan strategiassa tehokkuuden lisäämisen yhteydessä puhuttiin sivuvirroista, sivutuotteista, jätteistä ja uusien raaka-aineiden kuten levien tuotannosta. Saksassa uusien arvoketjujen nähtiin pohjautuvan uusiutuvien ja uusiutumattomien luonnonvarojen säästeliääseen ja aiempaa tehokkaampaan käyttöön ja kierrätykseen "niin pitkälti kuin se on taloudellisesti ja teknisesti mahdollista" sekä erityisesti sinisen biotalouden mahdollisuuksiin (levät, vesikasvit ja bakteerit). Ranskassa puhuttiin myös erilaisista tavoista käyttää biomassaa biojalostusketjussa. Paikallisen teollisuuden kilpailukykyä vahvistaminen nähtiin tärkeäksi Etelä-Afrikassa.

Kuluttajien ja tuottajien lähentämisestä arvoketjussa oli mainintoja useammankin maan strategiassa. Esimerkiksi Ranskassa lisääntyvän kysynnän nähtiin perustuvan kuluttajien parempaan tietoisuuteen biotaloustuotteista. Työkaluina nähtiin erilaiset sertifiointit ja standardit erityisesti ympäristövaikutuksiin liittyen. Suomessa ja Itävallassa biotalouden arvoketjujen nähtiin syntyvän ennen kaikkea kuluttajien tietoisuuden lisääntymisestä ja käyttäytymisen muutoksesta: "bioeconomy development is driven by changing consumer behavior and a need to secure the preconditions for human well-being..." [8]. Alankomaissa peräänkuulutettiin biotalouden parempaa näkyvyyttä kuluttajille ja eri sektoreiden välillä. Sillä

uskottiin olevan merkitystä paitsi kysynnän vahvistamisessa, myös uusien innovaatioiden synnyttämisessä. Ranskassa puhuttiin joustavista biotalousketjuista.

Italiassa korostettiin *julkisten ja yksityisten toimijoiden yhteistyötä* erityisesti paikallisesti. USA:n biotalousstrategia toimii puolestaan esimerkkinä julkisen ja yksityisen sektorin kumppanuudesta. Strategian mukaan yksityisiä investointeja tarvitaan kehittämään infrastruktuuria ja tarjontaketjuja hallituksen tuella: *“government has worked to encourage private-sector project funding through initial project financial assistance, loans, loan guarantees, and support of public-private collaboration and partnerships aimed at reducing risk and fostering investor confidence”*[14]. Myös Kanadassa julkisen sektorin tuki arvoketjujen kehittämisessä nähtiin keskeisenä esimerkiksi biotaloustuotannon ja -tuotteiden kaupallisessa kehittämisessä, uusien biotaloustuotteiden ja verkostojen luomisessa sekä T&K toiminnassa ja koulutuksessa.

2.6. Kasvatus ja koulutus, tiede ja tutkimus

Biotalouden vahvistamiseksi tarvitaan uudenlaisia taitoja, *kasvatusta ja koulutusta* kaikilla eri tasoilla [1]. Peruskoulutuksessa huomio on kestävyysnäkökulmien integroinnissa ja tieteidenvälisessä oppimisessa. Ammatillisessa koulutuksessa painopiste on työssäoppimisessa ja korkeakoulutuksessa laajasti. Esimerkiksi USA:n strategiassa mainitaan biotekniikka, bioteollisuus, bioprosessitekniikka ja tietojenkäsittelytiede näihin aloihin sovellettuna unohtamatta eettisiä, juridisia, terveydellisiä, turvallisuuteen liittyviä sekä muita yhteiskunnallisia näkökulmia. Italiassa huomiota kiinnitettiin erityisesti nuorten yrittäjien kouluttamiseen maatalouden ja metsätalouden aloilla, mutta myös paikallisten viranomaisten koulutukseen oman biotalouteen liittyvän kompetenssin vahvistamiseksi. Etelä-Afrikassa oli tunnistettu tarve kehittää teknologiayrittäjyyttä (*technopreneurs*), erilaisten teknologioiden hyödyntäminen tuote- ja palveluinnovaatioiksi. Ranskassa koulutus ymmärrettiin myös taitoina käyttää uusia biomateriaaleja. (LIITE 1. Taulukko 16).

Tieteen ja tutkimuksen osalta yleisenä piirteenä oli tieteen ja biotalouteen liittyvän teollisuuden välisen yhteistyön vahvistaminen (LIITE 1. Taulukko 16). Tämä voi tapahtua esimerkiksi erilaisten huippututkimusyksiköiden, osaamiskeskusten -ja klustereiden (Italia, Itävalta, USA) sekä start-up -yritysten sekä pienten ja keskisuurten yritysten (Kanada) myötävaikutuksella. Tarvitaan myös investointeja tutkimusrahoitukseen (Saksa, Etelä-Afrikka, USA) sekä innovaatio toiminnan yleistä tukemista (Kanada). Tutkimusrahoituksen ohjaaminen voi olla hyvinkin laaja-alaista kuten Saksan biotalousstrategia osoittaa: tutkimusaloina mainitaan biologiset tieteet, poikkitieteellinen yhteistyö (esim. nanoteknologia, digitalisaatio, automaatio ja tekoäly), ekosysteemien rajojen ja mahdollisuuksien tutkimus, teknologian siirto, mutta myös biotalouteen liittyvän sosiaalisen vuorovaikutuksen ja konfliktien tutkimuksen. Ranskassa korostettiin systeemisiä lähestymistapoja, jotka tarkastelevat yhdessä taloudellisia, ympäristö- ja sosiaalisia vaikutuksia. Alankomaissa laaditaan biotalouden edistämiseksi pitkäjänteinen tutkimusohjelma, joka sisältää myös suunnitelman rahoituksen allokoinnista, rahoituksen tehokkaasta käytöstä sekä kaikille avoimen julkisen tutkimus- ja innovaatio rahoituksen.

2.7. Biotalous ja alueellinen kehitys

Alueet voidaan nähdä keskeisinä ajureina siirryttäessä kestäväan ja kiertotalousperustaiseen biotalouteen. Vastaavasti biotalous tarjoaa mahdollisuuksia alueelliselle kehitykselle, uusien tarjontaketjujen muodostamiselle tai olemassa olevien ketjujen vahvistamiselle ja optimoinnille). Alueet voidaan tyypitellä sen mukaan, mikä nähdään pääasiallisena ajurina

niiden biotalouden kehittämisessä: 1) alueiden luonnonvaroista ja kulttuuriperinnöstä ponnistava biotalous; 2) tutkimuslähtöinen biotalous; 3) orastava arvoketjuun pohjautuva biotalous 4) kehittynyt arvoketjuun pohjautuva biotalous 4) teolliseen biotekniikkaan perustuva biotalous; 5) integroitunut ja kehittynyt biotalous. [16]. Alueiden valmiudet biotalouden kehittämiseen voivat olla hyvin erilaisia. Esimerkiksi Saksassa, biotalouden tuotantoprosessien sääntelyssä, biotaloustuotteiden kierrätyksessä, sekä uusien tuotteiden hyväksymisprosesseissa voi olla alueellisia eroja.

- Strategioissa käsitellään sitä, miten alueellista biotaloutta voidaan kehittää. Seuraavia lähestymistapoja on löydettävissä (kts. LIITE 1. Taulukko 17):
- biotalouden kehittäminen sektoreittain, esim. maatalous, metsätalous, tarjonta (Itävalta);
- alueelliset konsulttityyppiset tieto- ja innovaatioverkot (*hubs*) (Itävalta, Etelä-Afrikka, USA), jotka lisäävät tietoisuutta esim. alueen biotalouden resursseista ja innovoivat uusia ratkaisuja;
- alueelliset osaamisklusterit (Kanada);
- biotalouden tarjontaa kehittävät paikallisten toimijoiden ja alueellisten viranomaisten verkostot (Saksa, Alankomaat);
- poikkisektoraalisen ja alueidenvälisen yhteistyön lisääminen (Italia)

Alueellisia biotalousstrategioita on ainakin Suomella (Arktisen biotalouden kehittämisohjelma, 2018; Oulun biotalousstrategia, 2014; Satakunnan bio- ja kiertotalouden kasvuohjelma, 2019) sekä Saksalla (Sustainable bioeconomy for Baden-Wurtemberg, 2019). Suomen lisäksi Ranskalla, Saksalla ja Italialla sekä USA:lla on muita alueelliseen biotalouteen liittyviä ohjelmia ja strategioita. (LIITE 1. Taulukko 18).

2.8. Biotalouden edistämisen politiikkakeinot

Siirtymää lineaarisesta kestäväan ja kiertotalousperustaiseen biotalouteen voidaan edistää monilla eri politiikkakeinoilla. Tällöin on tärkeää huolehtia keinojen koherenssista: Eri politiikkakeinojen (strategiat, politiikat, säädökset ja aloitteet) välisiä mahdollisia ristiriitoja tai ristikkäisvaikutuksia on ehkäistävä, mutta ennen kaikkea on löydettävä synergioita niin päämäärien tasolla kuin konkreettisissa toimissa. Kaiken kaikkiaan dokumenteista oli löydettävissä jopa kaksikymmentä eri politiikkasektoria energia- ja kiertotaloudesta, ilmastonmuutokseen ja kestävyteen (Taulukko 4). Yksittäisistä maista eri politiikkasektoreihin eniten viittauksia oli Saksan strategiassa, yhteensä 11. Tarkastellut politiikkaohjelmat olivat kansainvälisiä, eurooppalaisia tai kansallisia (LIITE 1. Taulukko 19).

Taulukko 4. Biotalouden kytkeytyminen eri politiikkasektoreihin. Taulukko esittelee biotalouteen liittyvät politiikkasektorit, jotka oli mainittu strategioissa.

| Policy sectors | Austria | Canada | Finland | Germany | Italy | NL | South Africa | USA |
|-------------------|---------|--------|---------|---------|-------|----|--------------|-----|
| agriculture | ■ | | | ■ | | | | |
| agriculture/rural | | | | | | | | ■ |
| biodiversity | | | | ■ | | | | |
| biotechnology | | | | | | | ■ | |
| bioeconomy (EU) | | ■ | ■ | | ■ | ■ | | |

| | | | | | | | | |
|----------------------|---|---|--|---|---|---|---|---|
| circular economy | ■ | | | ■ | ■ | ■ | | |
| climate change | ■ | | | ■ | ■ | | | |
| development | | | | | | | ■ | |
| economics | | ■ | | | | | | |
| education | | | | ■ | | | | |
| energy | ■ | ■ | | ■ | | ■ | | ■ |
| environment | | | | ■ | | | | ■ |
| forestry | | | | ■ | ■ | | | |
| industrial | | | | ■ | | | | |
| marine/fisheries | | | | ■ | ■ | | | |
| research | | | | | ■ | | | |
| smart specialisation | | | | | ■ | | | |
| sustainability | ■ | | | ■ | ■ | | | |
| waste | | | | | ■ | | | |

2.9. Biotalous ja kestävä kehitys

Biotalousmääritelmä on viimeisen vuosikymmenen aikana kehittynyt suhteellisen kapeasta taloudellisesta toiminnasta (jonka tavoitteena on korvata fossiilisia resursseja uusiutuville luonnonvaroilla) laajempaan, kestäväan ja kiertotalousperustaiseen biotalouteen [5]. Laajan biotalousmääritelmän mukaan tavoitteena on myös vähentää materiaalien käyttöä, kierrättää sekä kehittää uusia tapoja elintarvikkeiden ja muiden tuotteiden ja materiaalien tuottamiseksi ja kuluttamiseksi terveissä ekosysteemeissä.

Kestävyyttä tarkastellaan hyvin eri tavoin eri maiden strategioissa. Seuraavassa esitellään erilaisia näkökulmia (kts. myös LIITE 1: Taulukko 21):

- luonnonvarojen kestävä käyttö ja kestävä maankäyttö:
 - maatalousmaan ja joutomaiden tehokkaampi käyttö (Itävalta, Ranska)
 - luonnonvarojen kestävä käyttö ja ilmastomuutoksen hillitseminen (Suomi)
 - ilmastoviisas metsätalous ja puutuotteet (Itävalta)
- taloudellinen kestävyys
 - eri sektoreiden ja teollisuusalojen symbioosit ja sivuvirrat (Suomi)
 - kestävä kasvu ja hyvinvointi (Suomi)
 - kestävyys markkinoiden ja kysynnän ajurina (Kanada)
 - kestävät innovaatioekosysteemit, jotka lisäävät kansainvälistä kilpailuetua mukaan lukien koulutuksen (Kanada)
 - joustavat arvoketjut (Ranska)
 - oikeudenmukainen ja kestävä kaupankäynti, globaali vastuu (Itävalta, Alankomaat)
- yhteiskunnalliset näkökulmat
 - maaseutualueiden kehitys (Saksa)
 - digitalisaation hyödyntäminen biotalouteen siirtymisessä (Saksa)

- kestävä ja muutosjoustava (paikallinen ja globaali) luonnonvaratalous (Suomi), mukaan lukien inhimillinen sosiaalinen pääoma ja sosiaaliset innovaatiot (Italia)
- planetaariset rajat huomioiva resurssien käyttö: innovaatiot ja kulutustottumusten muuttaminen, ympäristön, ekosysteemien tilan palauttaminen ja ruoantuotannon parantaminen, veden saatavuuden turvaaminen (Alankomaat)
- sosiaalinen kestävyys: uudet yritykset ja työpaikat luonnonvara-aloilla, maanomistusoikeuksien ja ihmisoikeuksien huomioiminen
- kokonaisvaltaiset näkökulmat
 - kestävyysmurroksen (societal transformation) edistäminen: teknologian ja tieteen integrointi talouteen, poliittiset ja sosiaaliset näkökulmat; tietoisuuden vahvistuminen yhteiskunnassa (Itävalta)
 - eri kestävyysulottuvuudet laajasti (USA)

Kolme, vuoden 2015 jälkeen julkaistua strategiaa (Itävalta, Saksa ja Italia) olivat sisällyttäneet strategiaansa YK:n kestävän kehityksen tavoitteet (Taulukko 5.).

Taulukko 5. Kestävän kehityksen tavoitteiden esiintyminen kolmessa, vuoden 2015 jälkeen julkaistussa biotalousstrategiassa.

| UN Sustainable Development Goals (SDGs) | Austria | Germany | Italy |
|--|---------|---------|-------|
| 1. No poverty | | | |
| 2. Zero hunger | ■ | ■ | ■ |
| 3. Good health and well-being | ■ | ■ | |
| 4. Quality education | ■ | | |
| 5. Gender equality | ■ | | |
| 6. Clean water and sanitation | ■ | ■ | ■ |
| 7. Affordable and clean energy | ■ | ■ | ■ |
| 8. Decent work and economic growth | ■ | ■ | ■ |
| 9. Industry, innovation and infrastructure | ■ | ■ | ■ |
| 11. Sustainable cities and communities | ■ | ■ | ■ |
| 12. Responsible consumption and production | ■ | ■ | ■ |
| 13. Climate action | ■ | ■ | |
| 14. Life below water | ■ | ■ | ■ |
| 15. Life on land | ■ | ■ | ■ |
| 16. Peace, justice and strong partnership | ■ | | |
| 17. Partnerships for the goals | ■ | | |

2.10. Biotalousstrategioiden laadintaan osallistuneet instituutiot, organisaatiot ja sidosryhmät

Biotalousstrategioiden laatiminen voidaan nähdä yhtenä keinona poikkisektoraalisen yhteistyön vahvistamisessa biotalouden kehittämiseksi. Strategioiden laadinnasta ovat yleensä vastuussa se/ne ministeriö/ministeriöt, jonka/joiden toimialaan biotalous kuuluu. Sen lisäksi strategioiden laadintaan voi osallistua hyvin monenlaisia muita tahoja, kuten muita ministeriöitä, tiedesäätiöitä, tutkimuslaitoksia, rahastoja sekä erilaisia kehittämisorganisaatioita. Muun muassa seuraavat tahot/sectorit ovat osallistuneet strategioiden laatimiseen: luonnonvara-ala; elintarvikkeet ja lääkkeet; energia; ympäristö; terveys; talous, taloudellinen kehitys, rahoitus; teknologia, teollisuus; sekä tiede ja kasvatustieteet. Biotalousstrategioiden laatimiseen on osallistettu erilaisia sidosryhmiä, kuten tuottajia, yrityksiä, teollisuuden edustajia, tiedeyhteisöjä, alueellisia toimijoita, kansalaisia, rahoituksen toimijoita, maatalous- ja ympäristöjärjestöjä ja muita järjestöjä. Osallistamisen mahdollistamiseksi toimijoille on järjestetty erilaisia kokouksia, konferensseja ja työpajoja, tai heitä on konsultoitu virtuaalisesti. (kts. tarkemmin LIITE 1: Taulukko 23).

2.11. Biotalous-tietoisuuden lisääminen yhteiskunnassa

Kuten aiemmissa luvuissa on jo käynyt ilmi, yksi biotalouden kehittämisen kulmakivistä on biotaloustuotteiden kysyntä ja laajempi biotaloustietoisuus kuten Saksan biotalousstrategiassa raportissa on muotoiltu: *“A good information base is vital to create the conditions required for an informed public discussion about the bioeconomy.”* [10] Toistaiseksi kuitenkin biotalous näyttää olevan jokseenkin tuntematon useimmissa maissa. Yhteiskunnan vaatimukset ja odotukset biotalouden kehittämisen osalta täytyy huomioida. Tutkimuksen tulee olla avointa ja läpinäkyvää ja julkisella rahoituksella tehdyn tutkimuksen avointa. Kasvatuksellisilla instituutioilla kuten museoilla ja kasvitieteellisillä puutarhoilla on tärkeä merkitys, samoin kuin kansalaistieteellä (Saksa).

Analysoitujen strategioiden pohjalta tietoisuuden edistämiseksi voidaan erottaa erilaisia lähestymistapoja (kts. myös LIITE 1. Taulukko 24):

- yleisen tietoisuuden parantaminen kysynnän lisäämiseksi ja hyväksyttävyyden parantamiseksi koskien seuraavia aiheita: biotaloustuotteet (Itävalta, Kanada, Italia), jakamistalous (Ranska); kierrätys ja jätteet (Kanada); tuotteiden ympäristö-, talous- ja hyvinvointihyödyt (Itävalta, Italia), biotalouden kehittämisen haasteet (Saksa), ekologiset reunaehdot (Suomi); biopolttoaineita koskevat faktat, vaikutukset ja hyödyt (USA) sekä menestystarinat (USA)
- biopohjaisten tuotteiden näkyvyyden lisääminen (Alankomaat, Itävalta); tutkijat, journalistit ja julkinen sektori
- tietoisuuden kuluttajavalintojen tekeminen: esim. merkinnät kierrätyskelpoisuudesta
- erilaiset tuet ja kannustimet jakamistalouden sekä korjaus- ja ylläpitopalvelujen (Itävalta) ja biopohjaisten tuotteiden kysynnän kasvattamiseksi (Italia)

Saksassa on luotu alusta eri sidosryhmien (teollisuus, järjestöt, tiede ja yhteiskunta) dialogille. Tässä dialogissa pyritään tunnistamaan biotalouden kehittämisen esteitä ja ongelmia sekä kehittämään niihin yhdessä ratkaisuja. Yhdysvalloissa korostetaan myös myyjän vastuuta (esim. autokauppa).

3. Yhteenveto

Olemme tarkastelleet yhdeksän maan biotalousstrategioita ja esitämme seuraavassa keskeiset huomiomme:

- Biotalousstrategiat ovat niin luonteeltaan, laajuudeltaan kuin sisällöltään hyvin erilaisia: ei ole yhtä tapaa laatia biotalousstrategiaa.
- Biotalousstrategioiden määrittely: Määrittelyt kuvaavat usein kunkin maan ensisijaisia resursseja, niiden käyttöä ja biotalouden mahdollisuuksia erilaisten kansallisten ja/tai globaalien ympäristöllisten ja sosiaalisten haasteiden ratkaisemisessa sekä biotalouden tutkimuksen ja kehittämisen näkymiä. Usein miten määrittelyt puhuvat vain tuotteista ja materiaaleista, vain kolme maata oli maininnut palvelut.
- Biotalousstrategioiden tavoitteet: Biotalousstrategioiden tavoitteet heijastelevat kunkin maan luonnonolosuhteita ja sosio-ekonomisia piirteitä. Yleisesti ottaen strategioiden korostuvat sosio-ekonomiset tavoitteet, uusiutuvien luonnonvarojen kestävä käyttö, innovaatiot ja tiedon siirto. Usein maat olivat määrittelleet myös alatavoitteita tai -prioriteetteja.
- Biotalousstrategioiden seuranta: Biotalousstrategioiden tavoitteet ovat usein miten laadullisia. Vain Suomen ja Italian strategioiden tavoitteita, joita mitataan määrällisillä indikaattoreilla. Muutamilla mailla on biotalouden kehitystä kuvaavia indikaattoreita, joita seurataan, mutta niitä ei ole kytketty biotalouden tavoitteisiin. Joillakin mailla on suunnitelmia indikaattoreiden kehittämiseksi.
- Biotalousstrategioiden resurssit, sektorit ja tuotteet: Lähes kaikissa strategioiden maa-, metsä-, ja kalatalouden sekä vesiviljelyn uusiutuvat biologiset resurssit nähtiin ensisijaisina resursseina. Saksa mainitsi myös hiilidioksidin ja mikrobit. Sektoreiden määrittely oli sen sijaan monipuolisempaa. Mukaan laskettiin paitsi luonnonvara-alat, myös ruoan jatkojalostus, virkistysjuomat (viinintuotanto) ja tupakka, biopohjaiset tekstiilit, puutuotteiden jatkojalostus, paperiteollisuus, kemikaali- ja lääketieteellinen, muovi- ja kumiteollisuus sekä sähköntuotanto. Muista poikkeavina esimerkkeinä voidaan mainita terveys- ja hyvinvointiala sekä autoteollisuus (Saksa). Yksittäisinä tuotteina ja tuoteryhminä mainittiin biopohjaiset kemikaalit ja lääkkeet, bioenergia, biokaasu ja bionesteet, biomateriaalit/biomuovit, rakennusmateriaalit, kuidut, ruoka ja rehut, pakkaukset, paperi ja sellu. Tuotteet liittyen bioenergiaan, biokaasuun ja bionesteisiin on mainittu useimmin, seuraavaksi biopohjaiset kemikaalit ja biomateriaalit ja -muovit.
- Biotalousstrategioiden arvoketjut: Arvoketjujen kehittämisessä keskeisinä toimina nähtiin poikkisektorialaisen yhteistyön vahvistaminen, tehokkuus ja vaikuttavuus. Tuottajien ja kuluttajien välistä yhteistyötä samoin kuin julkisen ja yksityisen yhteistyötä korostettiin. Kuluttajien rooli biotalouden edistämässä nähtiin keskeisenä tärkeänä.
- Biotalousstrategioiden koulutus, kasvatusta ja tutkimusta: Biotalousstrategioiden liittyvä koulutus ja kasvatusta nähtiin pitkälti kestävyysnäkökulmien integrointina yli eri oppiaineiden peruskoulussa, ammatillisessa koulutuksessa ja täydennyskoulutuksessa sekä korkeakoulutuksessa. Lisäksi erityisesti nuorten yrittäjien tukeminen niin maa- ja metsätaloudessa sekä teknologiayrittäjyydessä nähtiin keskeisenä. Tieteen ja tutkimuksen osalta korostettiin yhteistyön luomista ja vahvistamista tutkimuksen ja biotalouden teollisuudenalojen kanssa, huippututkimusyksiköiden tai biotalousklustereiden, start-up -yritysten kanssa, sekä niin pienten ja keskisuurten yritysten kuin laajojen monikansallisten yritysten kanssa. Osaamiskeskittymät, investoinnit tutkimukseen ja innovaatioiden tukeminen nähtiin biotalouden kasvun edellytyksenä.
- Biotalous ja alueellinen kehitys: Alueet nähdään biotaloudessa tärkeinä ajureina, kun siirrytään lineaarisesta biotaloudesta kestävään kiertotalouteen pohjautuvaan

biotalouteen. Vastaavasti, biotalous tarjoaa mahdollisuuksia alueelliselle kehitykselle (uusien biotalouspohjaisten tarjontaketjujen luomisessa, olemassa olevien tarjontaketjujen vahvistamisessa ja optimoinnissa). Strategiat tunnustivat myös maan eri alueiden erilaiset potentiaalit biotaloudessa. Alueellisen biotalouden edistämiseksi keskeisiä lähestymistapoja olivat alueellisten konsultointi-hubien perustaminen, klustereiden ja verkostojen rakentaminen, sekä alueiden välisten poikkisektoraalisten arvoketjujen edistäminen.

- Biotalous edistämisen politiikkakeinot: Biotalous liittyvät politiikkakeinot vaihtelevat kansainvälisistä, eurooppalaisiin ja kansallisiin keinoihin. Tarkastelu osoittaa, että biotalouden kehittäminen koskettaa monia politiikkasektoreita, enimmäkseen oli mainittu yksitoista eri politiikkasektoria ja yhteensä kaikissa raporteissa viitattiin kahteenkymmeneen eri politiikkasektoriin.
- Biotalous ja kestävä kehitys: Kestävä kehitys määriteltiin biotalousstrategioissa eri tavoin laajasta kestävyysmurroksesta ja globaalista vastuusta luonnonvarojen kestäväan käyttöön, työpaikkojen lisäämiseen, hyvinvoinnin lisäämiseen ja digitalisaatioon. Kestävä biotalous voi edistää useita YK:n kestävyystavoitteita. Kolme maata, jotka ovat julkaisseet biotalousstrategiansa YK:n Kestävän kehityksen toimintaohjelman (Agenda2030) julkaisemisen jälkeen (2015,) ja mainitsivat YK:n Kestävän kehityksen tavoitteet eksplisiittisesti.
- Biotalousstrategioiden laatiminen: Biotalousstrategioiden laatimiseen osallistuvat lukuisat eri tahot biotalouden eri sektoreilta: ministeriöt, instituutiot, kehittämisorganisaatiot, tiedeyhteisö, rahoitus, säätiöt. Sidosryhmiä on osallistettu paitsi yleiseen keskusteluun yhteisillä keskustelufoorumeilla, kokouksissa ja konferensseissa myös konsultoimalla yksittäisiä tahoja.
- Biotalous tietoisuuden lisääminen: Tietoisuuden lisääminen nähtiin ratkaisevana toimena kokonaisvaltaisessa siirtymässä kohti biotalousyhteiskuntaa. Tietoisuuden lisäämiseen liittyvät toimet voidaan ryhmitellä seuraavasti: kuluttajien tietoisuuden lisääminen; biotuotteiden näkyvyyden lisääminen; kierrätettävien tuotteiden merkinnät; ymmärryksen lisääminen jakamistaloudesta sekä biotalouteen liittyvistä haasteista ja ekologisista reunaehdoista.

Liite/Annex 1. Alkuperäisen analyysin tulokset. Results of the original analysis.

4. Introduction

Currently, more than 40 countries have developed strategies to promote their bioeconomy [2,3,4,5]. It can be expected that this list will be expanded in the following years by countries that are currently in the process of formulating their bioeconomy strategies. National bioeconomy strategies issued before 2015 used diverse terms, such as bio-based economy, bioeconomy, or green economy. A couple of EU Member States (EU MS) are either in the process of reviewing the national Bioeconomy strategy (Finland), or have published a renewed version of the national Bioeconomy strategy (Germany).

This Annex presents the original results of the comparative content analysis of existing bioeconomy strategies for six EU MS (Austria, Finland, France, Germany, Italy, and the Netherlands), and Canada, South Africa, and the USA. The USA has two documents that have been reviewed: "The Bioeconomy Initiative: Implementation Framework", published by the Biomass Research and Development Board, and "Bioeconomy Research and Development Act", published by the U.S. Senate. (see Table 1)

This Annex covers descriptions of different national bioeconomy definitions, goals, objectives or targets, and their progress monitoring. It also distinguishes what bioeconomy sectors and products are considered, what bio-based supply and/or value chains are considered, how bioeconomy-related science and research, and education and training are foreseen, and what role regions have within a bioeconomy. It presents the variety of bioeconomy-related policy instruments, and the different national considerations of sustainability, including the Sustainable Development Goals (SDGs). Finally, it presents an overview on what institutions, organisations and relevant stakeholders have participated in the formulation of national bioeconomy strategies, and what measures countries foresee to undertake for raising awareness of the bioeconomy among society.

The results are based on a computer-assisted qualitative content analysis of national bioeconomy strategies using ATLAS.TI software. The computer-assisted qualitative content analysis technique allows one to sort, structure and query the content with the aim of discovering patterns and relations within the same or between different documents. Using this process, sentences, paragraphs or chapters (also called quotations) were highlighted and selected that might fit under a pre-defined list of topics (codes) of interest provided by the Finnish inter-ministerial working group of the bioeconomy. Quotations were searched to find the following codes: (1) bioeconomy definition, goals, objectives and/or targets and related progress monitoring; (2) bioeconomy sectors and products; (3) bioeconomy-related science and research, bioeconomy-related education and training; (4) forms of bioeconomy co-operation and networks; (5) sustainability of the bioeconomy, including the Sustainable Development Goals (SDGs); (6) institutions, organisations and relevant stakeholders of the bioeconomy; and (7) measures for raising awareness of the bioeconomy among society.

The results can support the development or the review of a national bioeconomy strategy of countries that have similar bioeconomy socio-economic and ecological settings and circumstances, or countries that would like to achieve a certain level of bioeconomy-readiness.

5. Results

5.1. Bioeconomy definition

A bioeconomy, or bio-based and/or circular economy, is defined by the studied countries as focusing not only on the sustainable use of natural resources, and the replacement of non-renewables by renewables in all sectors and processes, but also on reducing resource intensive processes and the cascading use of materials. The development of a bioeconomy, which is both circular and sustainable, is seen in many of the studied countries as important for tackling societal and environmental challenges to achieve the UN SDGs. A closer look at the definition of a bioeconomy of national bioeconomy strategies (Table 6 and Table 7) reveals that, in most cases, they first describe the primary resource of a country, how this resource is used and manufactured, how a bioeconomy can tackle future societal challenges, and how research and development is foreseen within the bioeconomy of a country. Additionally, global demission is often mentioned in the studied bioeconomy strategies.

Table 6. Overview of studied countries and their main focus of a bioeconomy definition within a national bioeconomy strategy. Score given if at least one of the subtopics is included.

| Country | Primary sources (sub-topics e.g. Agriculture, Forestry, Aquaculture, Fisheries) | Manufacturing primary products (sub-topics e.g. bio-based, feed, food, energy productions, novel products, processes, waste) | Future challenges (sub-topics e.g. replacing fossil, climate, pollution, sustainability, circularity, biodiversity, increasing population, benefits, economic growth) | Research and development (sub-topics e.g. science-based, knowledge, bio-technology, developing) |
|--------------|---|--|---|---|
| Austria | ■ | ■ | ■ | ■ |
| Canada | ■ | ■ | ■ | ■ |
| Finland | ■ | ■ | ■ | ■ |
| France | ■ | ■ | | |
| Germany | ■ | ■ | ■ | ■ |
| Italy | ■ | ■ | ■ | |
| Netherlands | ■ | ■ | ■ | ■ |
| South Africa | ■ | ■ | | |
| USA | ■ | ■ | ■ | |

The bioeconomy strategies of Italy, the Netherlands, and Canada define their bioeconomies according to the definition of a bioeconomy following the EU Bioeconomy Strategy 2018 [1]. The Canadian bioeconomy strategy presents not only a definition for bioeconomy, but also a national definition for industrial biotechnology, natural capital and circular economy (applies also for the Netherlands). The global dimension of a national bioeconomy is also mentioned in the Canadian bioeconomy strategy: *“this Strategy will adopt this definition of the bioeconomy (EU Bioeconomy Strategy, 2018) but will rely on biotechnology as a competitive advantage.*

Europe is recognized as having the most stringent genetically economy, society and the environment, modified organisms (GMO) regulations in the world. With Canada's history of biotechnology innovation, there is a competitive advantage to further streamline and adapt Canada's regulatory framework so that it supports a thriving bioeconomy". Such a statement is very much in line with the European Green Deal [\[17\]](#) that aims to minimise the import of products on EU markets that do not comply with EU standards and regulations by "foster(ing) new business models and set minimum requirements to prevent environmentally harmful products from being placed on the EU market. Extended producer responsibility will also be strengthened"

Table 7. Overview of studied countries and their bioeconomy definition within a national bioeconomy strategy.

| Country | Definitions |
|---------|--|
| Austria | <p><i>“Bioeconomy stands for an economic concept that aims to replace fossil resources (raw materials and energy sources) with renewable raw materials in as many areas and applications as possible. It covers all industrial and economic sectors that produce, process, handle or use biological resources. The bioeconomy thus offers a great opportunity to tackle global challenges, such as increasing climate change, food and water scarcity or growing environmental pollution, while at the same time strengthening economic development. In order to make the step towards the implementation of the hitherto knowledge-based bioeconomy – involving the relevant stakeholders and using all political instruments, the Government has undertaken in the government programme and #mission2030 to create a strategy for bioeconomy in Austria.”</i></p> |
| Canada | <p><i><u>bioeconomy</u>: “The European Commission provided this functional definition of the bioeconomy in October 2018: The bioeconomy covers all sectors and systems that rely on biological resources (animals, plants, micro-organisms and derived biomass, including organic waste), their functions and principles. It includes and interlinks: land and marine ecosystems and the services they provide; all primary production sectors that use and produce biological resources (agriculture, forestry, fisheries and aquaculture); and all economic and industrial sectors that use biological resources and processes to produce food, feed, bio-based products, energy and services. “To be successful, the European bioeconomy needs to have sustainability and circularity at its heart. This will drive the renewal of our industries, the modernization of our primary production systems, the protection of the environment and will enhance biodiversity.”</i></p> <p><i><u>circular economy</u> “The circular economy is a comprehensive framework for how materials and energy would flow in a fully sustainable, low- carbon economy...Canada has begun taking steps to support investors in clean technology, taking advantage of this once-in-a-generation economic opportunity and investing in emission-reducing technologies that lay the foundation of a Canada’s bioeconomy...In Europe, bioeconomy strategies are now being combined with circular economy strategies to more fully address the issues of climate change and resource consumption. This evolution is understandable in a society that is more densely populated and lacks the abundance of natural resources available in Canada. Canadian discussions on the circular economy have emphasized climate change and clean growth. Both approaches focus on a low-carbon economy, economic growth, innovation and new technologies, but the circular economy responds to a broader set of factors including design, recycling and reuse. The circular economy looks for a deeper, systems-scale level of innovation for business...”</i></p> |
| Finland | <p><i>“Bioeconomy refers to an economy that relies on renewable natural resources to produce food, energy, products and services. The bioeconomy will reduce our dependence on fossil natural resources, prevent biodiversity loss and create new economic growth and jobs in line with the principles of sustainable development”</i></p> |
| France | <p><i>“It is the photosynthesis economy, and more generally the living world economy. It encompasses all biomass production and processing activities, whether in forestry, farming or aquaculture, directed at the production of food, feed, biobased products and renewable energy. That definition covers a wide variety of sectors: agriculture, forestry, processing in the food and wood industries, energy production from biomass, production of materials and molecules and biowaste conversion”</i></p> |

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| | |
|--------------|---|
| Germany | <p>“bioeconomy’ refers to the production, exploitation and use of biological resources, processes and systems to provide products, processes and services in all economic sectors within the framework of a sustainable economic system. The bioeconomy aims to provide solutions to the great challenges of the 21st century. It addresses the basic questions that face the world of tomorrow: • How can we ensure the security of food and resources for an increasing global population while at the same time protecting the climate, the environment and biological diversity? • How can we successfully link ecology and the economy while ensuring an equitable distribution of the associated opportunities and challenges? • How can we transform our current economic system in- to a sustainable system that will also safeguard future prosperity? • What must we do to make sure that the bioeconomy can contribute as quickly and as effectively as possible to the international climate protection goals outlined in the Paris Agreement?”</p> |
| Italy | <p>The European Commission defines the bioeconomy as “the production of renewable biological resources and the conversion of these resources and waste streams into value added products, such as food, feed, bio-based products and bioenergy. To be successful, the bioeconomy needs to have sustainability and circularity at its heart. This will drive the renewal of our industries, the modernization of our primary production systems, the protection of the environment and will enhance biodiversity”. The bioeconomy comprises those parts of the economy that produce and use renewable biological resources from land and sea - such as crops, forests, fish, animals and micro-organisms - to provide food, materials and energy (Europe’s bioeconomy Strategy, European Commission, 2018)</p> |
| Netherlands | <p>Bioeconomy: “European Commission defines the bioeconomy as follows: ‘The production of renewable biological resources and their conversion into food, feed, bio-based products and bioenergy.’ This includes agriculture, forestry, fishing, aquaculture, food production, paper and pulp, as well as sections of the chemical, biotechnological and energy production sectors. These sectors have massive potential for innovation as a vast range of scientific disciplines and technologies (including biotechnology, nanotechnology and ICT) are involved with these sectors and they make use of local user knowledge.”</p> |
| | <p>Circular economy: “The bioeconomy is all about sustainable production and the use of biomass, while the circular economy is about sustainable use and reuse of products and closing the loop within key cycles. There is plenty of overlap – or more accurately, synergy – between the objectives of both economies: • Feeding the world population • Preventing resources from being exhausted • Preventing environmental pollution • Combating climate change The circular economy strives to meet these objectives via reuse, recycling and closing loops, while the bioeconomy focuses on renewable raw materials.”</p> |
| South Africa | <p>“Bio-economy” refers to activities that make use of bio- innovations, based on biological sources, materials and processes to generate sustainable economic, social and environmental development. In the bio-economy the entire innovation system/network, ranging from ideas, research, development, productisation² and manufacturing to commercialisation, should be used to its full potential in a coordinated manner. The Bio-economy Strategy provides an economic engine for the new economy that will, in turn, provide a basis for future growth. These science-based “bio-solutions” can, for instance, be used to: • manufacture high-value protein products such as biopharmaceuticals and vaccines; • produce biofuels; • improve and adapt crops; • remedy industrial and municipal waste;</p> |
| USA | <p>“A general definition of the bioeconomy is: The global industrial transition of sustainably utilizing renewable aquatic and terrestrial biomass resources in energy, intermediate, and final products for economic, environmental, social, and national security benefits. Within this definition, the Bioeconomy Initiative focuses on biofuels, bioproducts, and biopower produced from renewable biomass material and wastes.”</p> |

5.2. Bioeconomy goals and/or objectives and/or priorities

Within a bioeconomy strategy, a country can describe either the objectives and/or the goals and/or the priorities of the bioeconomy. For the studied strategies of EU Member States, it can be assumed that the five EU Bioeconomy Strategy 2018 [1] objectives – “creating jobs and maintaining competitiveness in bioeconomy sectors, reducing dependence on non-renewable resources, mitigating and adapting climate change, ensuring food security, and managing natural resources sustainably” – are at least partly included. This assumption is supported by a recent study [18] and becomes clearer when analysing the different strategies in detail.

Table 8 and Table 9 present **country-specific goals, objectives and priority areas**. Socio-economic aspects, a consideration of overall sustainability, the sustainable use of renewable resources for new products, and an innovative knowledge creation and transfer, are the most mentioned issues among the bioeconomy goals and/or objectives of the studied countries.

Table 8. Overview of the issues mentioned in studied national bioeconomy strategies and their goals and/or objectives and/or priority. *As for Finland, mentioning of global challenges.

| | Austria | Canada | Finland | France | Germany | Italy | NL | South Africa | USA and USA II |
|------------------------------|---------|--------|---------|--------|---------|-------|----|--------------|----------------|
| agriculture/food systems | ■ | | | | | | ■ | ■ | |
| biodiversity | | | ■ | ■ | ■ | ■ | ■ | | ■ |
| biomass supply | | ■ | ■ | | | | | | |
| circular economy | | | | ■ | | ■ | | | |
| climate change | ■ | | (■)* | | | | ■ | ■ | |
| economic development | ■ | | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| education/knowledge/research | | ■ | | | ■ | ■ | | ■ | ■ |
| forestry | ■ | | | | | | | | |
| health | | | | | | | | ■ | |
| innovation | ■ | ■ | | ■ | ■ | | ■ | ■ | |
| local/rural/regional | | ■ | | | ■ | ■ | ■ | | |
| policy coherence | | ■ | | | | ■ | ■ | | |
| products | ■ | ■ | ■ | | ■ | | ■ | ■ | ■ |
| renewable resources | ■ | ■ | ■ | | ■ | | ■ | | ■ |
| resilience | | | | ■ | | ■ | | | |
| social transformation | ■ | | ■ | | ■ | ■ | ■ | | ■ |
| sustainability | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| value chains | | ■ | ■ | | ■ | | ■ | ■ | |

The goals and/or objectives and/or priority areas can be summarised in detail for the six EU MS, and Canada, South Africa, and the USA.

For Austria: to achieve climate goals and reduce dependence on non-renewable resources, and to promote innovation, economic development and sustainable societal transformation. As for the latter, this is expected to be achieved by linking technical, scientific, economic, political and social aspects. For Canada: to establish biomass supply and stewardship (innovative industry flagships), strong companies, value chains and sustainable innovation ecosystems. Here, focus is, inter alia, set on improved and new regulations and standards for biotechnology and bioproducts to also support access to global value chains. For France: to guarantee food security while conserving natural resources ecosystem functions, and to develop an inclusive, regional efficient, resilient, circular and productive bioeconomy. For Germany: to recognise and harness the ecological boundaries of bioeconomy potential; to develop and apply bioeconomy solutions for the sustainability agenda; to provide a sustainable raw material base for industrial, national and international collaboration; and to promote Germany as the leading location for bioeconomy innovation. For Italy: to recognise and harness the ecological boundaries of bioeconomy potential, a strong cross-disciplinary education and training, and knowledge transfer; to improve primary production; and to increase circularity, creating jobs, social cohesion and knowledge-based policy making, and local, national and EU cooperation. For the Netherlands: to recognise and harness the ecological boundaries of bioeconomy potential, to reduce climate change; to provide a sustainable use of natural resources, a regional and rural development, social inclusiveness, a collaboration along the value chain, a long-term research and innovation agenda, and policy coherence. For South Africa: food security, the creation of sustainable jobs and a low-carbon green economy are among the key sectors (agricultural, health and industrial and environmental sectors). As for the USA, the Bioeconomy Implementation has no clear objectives and/or goals as not being a strategy paper “*not a policy or budget document*”. However, the USA mentioned several objectives among research at the intersection of biological, physical, chemical, data, and computational sciences; social and behavioural sciences and economics research in engineering biology; to accelerate scientific understanding and technological innovation in engineering biology, and the commercialisation of engineering biology research and development by the private sector.

Table 9. Overview of the studied national bioeconomy strategies and their goals and/or objectives and/or priority areas within a national bioeconomy strategy. France: only goals and for Italy: aims presented in the strategy.

| Country | Goals and/or objectives and/or priority areas | Summary of sub-goals and/or sub-objectives and/or sub-priorities |
|---------|---|--|
| Austria | achieving climate goals | carbon sequestration and de-carbonisation |
| | promoting economic development | innovative bio-based products and services |
| | promoting innovation | transdisciplinary projects and patents |
| | promoting sustainable societal transformation | link technical, scientific, economic, political and social aspects |
| | reducing dependence on non-renewable resources | sustainable agricultural and forestry production intensification |
| | securing and creating jobs | growth of green jobs |
| Canada | building strong companies and value chains | critical business paths, valuation, credit-worthiness for bio-products/biomaterials; support entering global market/national bio-procurement |
| | building strong sustainable innovation ecosystems | reskilling, skills development for bioeconomy employment; promoting indigenous bio-business |

| | | |
|---------|--|--|
| | creating agile regulation and government policy | improved and new regulations/standards for biotechnology and bioproducts; support to enter global value chains |
| | establishing biomass supply and stewardship | innovative industry technologies (flagships); knowledge on resource location, quantity, quality |
| Finland | generate new economic growth and new jobs from an increase in bioeconomy business and from high added value products and services | a competitive operating environment for the bioeconomy, new business from the bioeconomy, a strong bioeconomy competence base |
| | competitive and sustainable bioeconomy solutions for global problems will be created in Finland | |
| | new business will be generated both in the Finnish and international market, thus boosting the welfare of the whole of Finland | |
| | securing the operating conditions for the nature's ecosystems | accessibility and sustainability of biomasses |
| France | effective, affordable, capable and innovative solutions addressing diverse human needs | |
| | focus on general public; local regions, contributing to the development of economic value and jobs | |
| | guarantee food security and sustainable living standards for current and future generations by conserving natural resources and the ecosystemic functions of habitats, | |
| | long efficient, resilient, circular and productive bioeconomy | |
| Germany | develop bioeconomy solutions for sustainability agenda | UN SDGs 2,3,6-9,11-15; in particular food security for world, climate-neutral production towards 1.5-degree goal, protect, maintain/use biodiversity |
| | enhance and apply biological knowledge | interdisciplinarity; innovative process engineering concepts for bio-based production systems; |
| | involve society intensify national and international collaboration | dialogue with society; social sciences in bioeconomy; European and international collaboration |
| | promote Germany as the leading location for bioeconomy innovation | clusters and model regions; start-ups and small and medium-sized enterprises; research transfer bioeconomy business models |
| | provide sustainable raw material base for industry | novel cycles for production, processing, recycling of biogenic resources and by-products |
| | recognise and harness ecological boundaries of bioeconomy potential | minimize conflicting objectives and interactions; economical and ecological holistic approaches; comparative sustainability assessments |
| Italy | boosting sustainable local growth; bridging research and sectors; emphasis on SMEs | |
| | cross-disciplinary education and training; informal learning, tertiary education and technology/knowledge transfer | |
| | ensuring that bioeconomy reconciles technological advances and progress without undermining environment conservation and resilience of ecosystems | |
| | improve Mediterranean primary production and bioindustry potential; creating jobs, social cohesion and political stability | |
| | increasing circularity | |
| | knowledge-based economic activities and policy making | |
| | supporting alignment of EU, national, regional policies, regulations, coordination of local stakeholders | |
| NL | collaboration in value chain | between sectors/value chains for innovative products |
| | long-term research/innovation agenda | potential and vulnerability of resources; socioeconomic/technological research |
| | production for people | sustainable, new and innovative products, business models and production processes |
| | reducing climate change | reduce greenhouse gas; increase carbon capture/storage; replace fossil raw materials, |

| | | |
|--------------|---|--|
| | regional strategy and rural development | high-quality regional production for revitalised regions |
| | stable and predictable legal framework | coherent, transparent and predictable policy; removing organisational uncertainty to encourage investors |
| | sustainable resource management | resilient ecosystems; biodiversity, food systems; preventing local/global deforestation/land degradation |
| | using resources within planetary | efficient use of natural resources, biodegradability and smart consumption |
| South Africa | general: competitive internationally; sustainable jobs; enhance food security; create greener economy, low-carbon economy; specific strategic objectives in key sectors (agricultural, health and industrial and environmental sectors) | |
| | agricultural | strengthen agricultural biosciences innovation to ensure food security, enhance nutrition, improve health; job creation; expansion/intensification of sustainable agricultural production/processing |
| | health | manufacture pharmaceutical ingredients, vaccines, biopharmaceuticals, diagnostics and medical devices; ensuring secure supply of essential therapeutics/prophylactics |
| | industrial and environmental sectors | research, development and innovation in biological processes of goods and services; enhancing water and waste-management practices |
| USA | general: research and development algae; feedstock genetic improvement; feedstock production and management; feedstock logistics; conversion; transportation, distribution infrastructure, and end use; analysis; and sustainable bioeconomy. | |
| USA II | research at intersection of biological, physical, chemical, data, and computational sciences; biomanufacturing research; support of risk research | |
| | social and behavioural sciences and economics research in engineering biology; improvement of understanding engineering biology | |
| | novel tools and technologies to accelerate scientific understanding and technological innovation in engineering biology | |
| | expansion of researchers, educators, and students with engineering biology training | |
| | commercialization of engineering biology research and development by private sector | |
| | interagency planning and coordination of federal government engineering biology activities | |

5.3. Measurable targets and related bioeconomy progress monitoring

As measurable targets, this report refers to objectives and goals with a clear measurable outcome, for example, to increase the number of jobs to a certain number by a certain year. A country might also present qualitative targets in the respective bioeconomy strategy, however such information is not presented here. Table 10 presents country-specific **quantitative targets and monitoring indicators** for those studied countries where such information was presented. For Austria, one quantitative target related to aiming to increase scientific publications, projects and patents. No indicators were presented for Austria, however it is stated in the bioeconomy strategy that *“adaptation and improvement suggestions are to be worked out on an ongoing basis and possible evaluation results are to be considered in the best possible way”* [6]. Such statements on the intention or started process to develop bioeconomy monitoring indicators are also found in the bioeconomy strategy of Germany and the USA (... will be monitored periodically using key metrics and indicators that measure progress... would likely include assessing feedstock production, product production and consumption, markets, jobs, sales and revenues, and indirect value added from the bioeconomy... in analysing impacts and measuring expansion

resulting from increased use of biomass for energy, chemicals, and other bioproducts... relevant as the bioeconomy evolves in support of agriculture and forestry and in enhancing rural communities).

No direct quantitative targets and indicators were presented for Canada, only those which are considered indirect by referring to the quantitative targets of several companies: “*IKEA, Lego, Volvo and Michelin have made their KPIs and corporate sustainability goals public. For example: Michelin plans to reduce its industrial carbon footprint by 50% by 2050 and Lego launched a range of plant-based plastic toys in 2018. Canada’s Bioeconomy Strategy demonstrates that Canada is the place to help these companies achieve their goals*” [7]. In none of the other studied bioeconomy strategies can a concrete reference to inviting a company to invest be detected. The aim of this approach might be to directly attract bioeconomy investors to Canada. For Finland, two socio-economic quantitative targets (output and employment) and related indicators are presented. In addition, several socio-economic and ecological indicators are presented. In Germany, two quantitative targets are presented, namely those related to climate change and organic farming. Italy is among the studied bioeconomy strategies, the country with the most quantitative targets which are recycling and waste-related targets. These targets have respective indicators. In addition, 26 socio-economic and ecological indicators are presented for Italy. South Africa does not present quantitative targets, but rather 46 indicators.

Table 10. Overview of the studied national bioeconomy strategies and their targets and monitoring indicators. Modified after [5] and completed with information for Austria, Canada, Finland and Germany.

| Country | Examples of quantitative targets | Specific bioeconomy monitoring indicators (target related indicator underlined) |
|---------|---|---|
| Austria | the number of scientific publications as well as transdisciplinary projects and patents in the area of bioeconomic (e.g. biorefineries, resource efficiency, new products and services, etc.) is to be doubled compared to 2017 | |
| Canada | no quantitative targets and indicators mentioned. However “ <i>IKEA, Lego, Volvo and Michelin have made their KPIs and corporate sustainability goals public. For example: Michelin plans to reduce its industrial carbon footprint by 50% by 2050 and Lego launched a range of plant-based plastic toys in 2018. Canada’s Bioeconomy Strategy demonstrates that Canada is the place to help these companies achieve their goals.</i> ” | |
| Finland | bioeconomy output will grow to EUR 100 billion from its current level of EUR 60 billion (+share of bio-based products to increase to one half export earnings by 2030) 100,000 new jobs will have been created in the bioeconomy by 2025 | <u>Bioeconomy output</u> ; <u>bioeconomy value added</u> ; <u>the number employed</u> ; <u>the share of bioeconomy employed in the national economy</u> ; raw material inputs; value added to raw material streams; raw material inputs used; greenhouse gas emissions avoided; total use of natural resources; growth and harvested volumes of standing timber; growth and harvested volumes of cereal crops; growth and harvested volumes of fish bag; endangered species; urban waste; ecosystem services; environmental and resource efficiency |
| Germany | climate-neutral production to achieve 1.5 degree goal; agricultural land dedicated to organic farming to increase to 20% by 2030 | |

| | | |
|--------------|--|--|
| Italy | by 2025, preparing re-use and recycling of municipal waste shall be increased to a minimum of 55% by weight, by 2030 shall be increased to a minimum of 60% by weight, and by 2035 shall be increased to a minimum of 65% by weight; by 2030, preparing for reduction of 50% in food waste | Agricultural biomass production—import of agricultural biomass; blue biomass production—import of blue biomass; forestry biomass production—import of forestry biomass; <u>waste biomass production—import of waste biomass</u> ; firms in total bioeconomy sectors; firms in bioeconomy subsectors; innovative start up in total bioeconomy sectors; innovative start up in bioeconomy subsectors; employment in total bioeconomy sectors; employment in bioeconomy subsectors; tertiary education; r&d employment in total bioeconomy sectors; |
| South Africa | Number of publications and citations in high impact journals per capita; size of bio-innovation workforce as percentage of science and technology workforce; number of research chairs, centres of excellence, technology platforms and multi-disciplinary research and development programmes supported; bio-economy research and development as a percentage of gerd; number of patents granted; number of collaborative product development partnerships; availability of technology development and assimilation infrastructure; number of technology-transfer transactions; availability of incubation facilities of bioinnovation firms; number of regulatory approvals for health products; revenues/sales of life science products, processes and services; number of field trials with GMO crops; number of bio-innovation firms, including dedicated bio-innovation firms by sector; venture capital invested in bio-innovation firms; technology balance of payment of bioinnovation outputs; number of joint ventures and strategic alliances between local bio-innovation firms and international partners; multinational corporations in bio-economy sectors locating research and development facilities locally; types of biotechnology used | |
| USA | no quantitative targets and indicators mentioned. However, a reference to the development of an indicators set is mentioned: <i>... will be monitored periodically using key metrics and indicators that measure progress... would likely include assessing feedstock production, product production and consumption, markets, jobs, sales and revenues, and indirect value added from the bioeconomy... in analyzing impacts and measuring expansion resulting from increased use of biomass for energy, chemicals, and other bioproducts... relevant as the bioeconomy evolves in support of agriculture and forestry and in enhancing rural communities.</i> | |

5.4. Bioeconomy primary resources, bioeconomy sectors and related products

According to [1] “bioeconomy encompasses all sectors and activities of the economy that focus on the production of renewable biological resources and the conversion of these resources and waste streams into value added products, such as food, feed, bio-based products and bioenergy”. This section and Tables 11, 12, 13 and 14 present an overview of the explicit mentioned bioeconomy-related primary resources, sectors and products as described in the studied bioeconomy strategies.

As for **primary resources**, in almost all of the bioeconomy strategies, renewable biological resources from agriculture, forestry, aquaculture, and fisheries were mentioned. It can be assumed that agriculture includes, e.g., non-perennial and perennial crops, animal production, hunting and related service activities; forestry includes round and energy wood, and wild growing non-wood products; and aquaculture and fisheries includes, e.g., fish, crustaceans and molluscs [NACE]. As for Germany, CO₂ and microbes are mentioned as a resource.

Sectors that are mentioned in the studied bioeconomy strategies are in alphabetical order: agriculture, forestry, fishing and aquaculture, manufacture of food, beverages and tobacco,

manufacture of bio-based textiles, manufacture of wood products and wooden furniture, manufacture of paper, manufacture of bio-based chemicals, pharmaceuticals, bio-plastics and rubber, production of bioelectricity, bioeconomy-related services, and the waste sectors (Table 11). In South Africa and Finland, the health sector is considered as being part of the bioeconomy, and in Germany the automotive sector. When it comes to the health sector, South Africa mentioned to “develop the ability to manufacture drugs, vaccines and other biologics locally, to improve the health sector’s bio-economy and to help the country achieve its public health goals”, and Finland mentioned that the “health sector is one of the most rapidly growing fields in the world. Finnish biotechnology expertise promotes the generation of new business from pharmaceutical research, health technology, individualised health care solutions and health sector service innovations” [13]. Similar to Germany, the development of harvesting technologies is mentioned in Finland. In addition, Finland considers the sector nature tourism, and water treatment and distribution/water management as being part of the bioeconomy, while in Austria, water management is part of the bioeconomy. For Germany, no concrete example was mentioned related to the components and parts used by the automotive sector that could be made out of bio-based materials in the future.

Table 11. Overview of mentioned examples of bioeconomy sectors considered in the studied national bioeconomy strategies. Bioeconomy sectors after NACE Rev.2 codes [19]

| Sectors | Austria | Canada | Finland | France | Germany | Italy | NL | South Africa | USA and USA II |
|---|---------|--------|---------|--------|---------|-------|----|--------------|----------------|
| Agriculture | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Forestry | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | ■ |
| Fishing and aquaculture | ■ | ■ | ■ | | | ■ | ■ | ■ | |
| Manufacture of food, beverages and tobacco | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | |
| Manufacture of bio-based textiles | ■ | ■ | | | ■ | ■ | | | |
| Manufacture of wood products and furniture | | ■ | ■ | ■ | | | | | |
| Manufacture of paper | ■ | ■ | ■ | | | ■ | | | |
| Manufacture of bio-based chemicals, pharmaceuticals, plastics and rubber (excl. biofuels) | ■ | | ■ | | ■ | ■ | | | ■ |
| Manufacture liquid biofuels | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | ■ |
| Activities related to the manufacture of cars | | | | | ■ | | | | |
| Harvesting technologies | | | ■ | | | | | | |
| Human health and social work activities/health sector | | | ■ | | | | | ■ | |
| Nature tourism | | | ■ | | | | | | |
| Water treatment and distribution/water management | ■ | | ■ | | | | | | |

When looking, for example, at national definitions of a bioeconomy, the sector and related products definition is presented in more detail. According to Germany [10], a bioeconomy is

“central to global food security and supplies the renewable resources necessary for a wide range of applications. Its interdisciplinary toolbox consists not only of biotechnological processes, but also of concepts borrowed from engineering and data science. Bio-based products manufactured for industry and end consumers are set to prevail on the market... such products are also ideal for integration into material cycles ... crucial for the attainment of more efficient future business practices ... reduction of our consumption of resources”. Additionally, the circularity of bioeconomy sectors is focused on in the studied bioeconomy strategies, as in the example for the Netherlands: “circular economy focuses on closing loops in key cycles, limiting losses and value creation involving residual flows from the agri-food sector. This involves the entire chain from primary production to end products and their end-of-life processes. The transition to a circular and bio-based economy is creating opportunities to make more careful and effective use of natural resources, connect new markets and boost competitiveness” [12].

Products that are mentioned in the studied bioeconomy strategies are in alphabetical order: bio-based chemicals and bio-based medicals; bioenergy, gaseous biomass, liquid biomass; biomaterials /bioplastics; construction material; fibres, food and feed; packaging and paper and pulp (Table 12 and Table 14). Consequently, products related to bioenergy, gaseous biomass, liquid biomass are mentioned the most, followed by bio-based chemicals and biomaterials /bioplastics. Challenges for bio-based produces are mentioned by Germany: “introduction and establishment of innovative bioeconomy products and processes on the market represents a major challenge as they must compete with products that are already familiar to users and benefits from established marketing channels, recognition and infrastructure... the initial demand for bio-based product alternatives is frequently not sufficiently high for their production to be economically viable” [10].

Table 12. Overview of explicit mentioned products in the studied national bioeconomy strategies. NL = Netherlands

| Products | Austria | Canada | Finland | France | Germany | Italy | NL | South Africa | USA and USA II |
|---|---------|--------|---------|--------|---------|-------|----|--------------|----------------|
| bio-based chemicals | ■ | ■ | ■ | | | | ■ | ■ | |
| bio-based medicals | | | ■ | | | | ■ | ■ | |
| bioenergy , gaseous biomass, liquid biomass | ■ | ■ | ■ | ■ | | ■ | ■ | ■ | ■ |
| biomaterials /bioplastics | ■ | ■ | ■ | ■ | ■ | | | | |
| construction material | | | ■ | ■ | ■ | | | | |
| fibres, food and feed | ■ | | ■ | ■ | | | | ■ | |
| packaging | | ■ | | | | ■ | | | |
| paper and pulp | ■ | | ■ | | | | | | |

Table 13 presents a concrete example of **Austria** and the mentioned bioeconomy sectors, related products and related actions, e.g. on expert advice on cultivation and subsidies (agriculture); on raising awareness of consumers through labels, certificates or quality marks (manufacture of food); communicating the environmental benefits of bio-based products (bioplastics); and expansion and improvement of comprehensive biorefinery concepts (bio-based chemicals)

Table 13. Example of Austria [6]: bioeconomy sectors, related products and related actions. Bioeconomy sectors presented in NACE Rev.2 codes [18]. A01 Agriculture, C10 Manufacture of food, C17 Manufacture of paper, C20*’Manufacture of bio-based chemicals (excl. biofuels), C22* Manufacture of bio-based plastics and rubber (incl. biofuels)

| Country | Sectors | Products | Related actions |
|---------|---|---------------------|--|
| Austria | agriculture | fibres | extension of arable land for fibre plants to obtain relevant production quantities; expert advice on cultivation and subsidies, training and education of consultants for cultivation and production; development of reliable standards for heterogeneous starting materials |
| | manufacture of food | food and feed | role model effect of the public sector through the increased use of bio-based products; raising awareness of consumers through labels, certificates or quality marks; reducing volume losses through improved harvest and post-harvest technologies; development of unavoidable waste as raw materials; prevention of food waste in households, commerce and in the out-of-home consumption sector; reduction of feed imports through co-products of biofuel production and development of new protein sources (for example, insects) ; raising awareness with regard to production conditions |
| | manufacture of paper | paper and pulp | development of new products from waste and by-products; increased use of regional added value; ensuring and improving the quality of education in bioeconomy-relevant areas; standardisation of state aid framework conditions for plants at European level |
| | manufacture of bio-based chemicals (excl. biofuels) | bio-based chemicals | expansion and improvement of comprehensive biorefinery concepts; use of bio-based platform chemicals for b2b; marketing of bio-based products with a broad impact |
| | manufacture of bio-based plastics and rubber (incl. biofuels) | bioplastics | communicating the environmental benefits of bio-based products; compensation of the additional costs of bio-based production through market intervention |
| | | liquid biomass | expanding research activity on second generation biofuels (or higher); use of liquid biomass of high energy density as storage medium; increasing the level of blending of liquid biofuels |
| | | gaseous biomass | preferential dispatching of bio-based energy into the grids; development of new raw materials for biogas from agriculture, waste/com post and wastewater management; perception of biogas plants as an intermediate stage within a recycling chain |
| | | bioenergy | increase in the share of renewable energy sources; implementation of the requirement of renewables in the area of space heating (#mission2030); establishing clear medium and long-term signals and incentives for early exit from fossil fuels |

Table 14. Overview of mentioned examples of bioeconomy resources and sectors considered and explicit mentioned products in the studied national bioeconomy strategies. NL = Netherlands

| Country | Resources, sectors and products considered | Examples |
|---------|--|--|
| Austria | resources | from agriculture, forestry, water management, residuals, by-products, wastes |
| | sectors | encompasses all industrial and economic sectors that produce, process, handle or use biological resources |
| | products | bio-based chemicals, bioenergy, bioplastics, fibres, food and feed, gaseous biomass, liquid biomass, paper and pulp |
| Canada | resources | animals, plants, micro-organisms and derived biomass, including organic waste, their functions and principles, land and marine ecosystems |
| | sectors | agriculture, forestry, fisheries and aquaculture, industrial sectors that use biological resources and processes to produce food, feed, bio-based products, energy and services |
| | products | bioenergy, biofuels, biochemicals and biomaterials; concrete examples: cellulosic sugar producers, aviation biofuels, packaging for water bottles |
| Finland | resources | agriculture, aquaculture, fisheries, forestry, wastes, industrial side streams |
| | sectors | agriculture, forestry, fishing and aquaculture, manufacture of food, manufacture of wood products and furniture, manufacture of paper, manufacture of bio-based chemicals, pharmaceuticals, plastics and rubber (excl. biofuels), manufacture of liquid biofuels, health sector, nature tourism, water treatment and distribution, biomass harvesting technologies |
| | products | bio-based products, biochemical methods, pulping technologies and enzyme production for refining of biomass, wood-based transport fuels, side streams from agriculture and food industry, wood for construction |
| France | resources | biomass production and processing activities in forestry, farming or aquaculture, focusing at production of food, feed, biobased products and renewable energy |
| | sectors | agriculture, forestry, food processing, wood industries, energy production, production of materials and molecules, biowaste conversion |
| | products | agrifood co-products to produce animal feed, energy, new materials and molecules from agricultural and forestry biomass, innovative molecules concrete examples: construction using hempcrete, cellulose pulp mill into a lignocellulose biorefinery, methanization, production of energy and fertilizer using locally available resources |
| Germany | resources | animals, by-products and residues, CO ₂ , microbes, plants and soils, water |
| | sectors | agriculture, automobile industry, chemistry, construction, consumption, energy, food, mechanical engineering, pharma, textiles |
| | products | biogenic materials, such as construction materials and new materials used in durable industrial goods |
| Italy | resources/sectors | agriculture, forestry, fisheries, food and beverages production, paper, pulp, tobacco industries, textiles from natural fibers, leather, bio-pharmaceuticals, green chemistry, biochemicals and bioenergy, waste recovery |
| | products | compostable carrier bags and waste bags, compostable bags, gloves for fruit & vegetables and labels, compostable products for foodservice, compostable packaging, food packaging, biogas, new functional cold pressed oils, bio-innovation in recipes |

| | | |
|--------------|-----------------------|---|
| NL | resources | production of renewable biological resources and their conversion into food, feed, bio-based products and bioenergy |
| | sectors | agriculture, forestry, fishing, aquaculture, food production, paper and pulp, chemical, biotechnological and energy production sectors; including biotechnology, nanotechnology and ICT |
| | products | biorefining products for medical applications, chemical products, polymers, electricity/heating powered by biomass that cannot be used for other applications |
| South Africa | sectors | agriculture, aquaculture, health, industrial and environmental |
| | products | food, biofuels, animal vaccines, biofertilisers, bio-based chemicals and materials, water and waste |
| USA | resources/ sectors | agriculture, forestry, manufacturing, waste, biotechnology, chemicals, fuels, heat, and power industries |
| | products | starch-based ethanol, biodiesel from plant and waste oil; heat and power from biomass, advanced biofuels, including renewable diesel, jet, and gasoline, renewable chemicals and chemical intermediates |

5.5. Bioeconomy value chains

While section 5.4 presented an overview of the bioeconomy primary resources, bioeconomy sectors and related products that were mentioned in the studied bioeconomy strategies, this section presents examples of value chains/supply chain in the studied national bioeconomy strategies. The data in Table 15 presents country-specific examples on how to advance **value chains/supply chains** and can be summarised as increasing the effectiveness and efficiency and cross-sectoral cooperation along the whole value chain, increasing the relationship between consumers and producers, and enhancing public-private partnership.

When it comes to examples on how to advance value chains/supply chains, one example can be found in Germany: *"promoting the establishment of new supply chains, existing bioeconomy supply chains must be optimised to reduce raw material consumption, protect the environment and climate by reducing the use of non-renewable raw materials, and improve their overall economic competitiveness... organisational and technical concepts are to be further developed at enterprise level and in downstream logistics chains...optimise the production, storage and initial processing of renewable raw materials and so contribute to the more efficient use of biogenic resources.... greater efforts should be made to ensure a cascade use of resources, to maintain biogenic raw materials in a circular material cycle for as long as is economically and technically possible"*. [10]

Examples for increasing the relationship between consumers and producers can be found in France, where there is a *"need to make consumers and users more aware of these products. Their quality must be guaranteed through certification and normative standards, and their positive externalities highlighted, especially for the environment..."* [9], and in Finland, where *"bioeconomy development is driven by changing consumer behaviour and a need to secure the preconditions for human well-being... concern over the environment and scarcity of non-renewable raw materials, including metals and oil, the use of biomasses in the economy and across society will increase"*. [8]

The USA presents some aspects related to increasing public-private partnership, where the *"key challenge to realizing the bioeconomy vision is the large private-sector financial investment required to develop the necessary infrastructure and supply chains...government has worked to encourage private-sector project funding through initial project financial assistance, loans, loan*

guarantees, and support of public-private collaboration and partnerships aimed at reducing risk and fostering investor confidence". [14]

Table 15. Examples of how to advance value chains in the studied national bioeconomy strategies.

| Country | Value chains |
|--------------|--|
| Austria | increase efficiency at all value chain levels , from raw material generation, logistics and material use to energy recovery, as well as rethinking of consumer behaviour with regard to extending the lifetime of products ; exploitation of all renewable raw material sources through use of residues, by-products, wastes and production of new raw materials , such as algae; |
| Canada | need for government support commercial development and adoption of bioproducts + networks , such as user-producer relationships , strategic alliances, R&D consortia and collaborative training and marketing schemes |
| Finland | new value-chains : services associated with industrial products and immaterial value creation, in particular for SMEs, and encourage cooperation and partnerships between companies; focus on e.g. services based on wood products and side streams, tourism services, construction sector services (sustainable construction and urban planning), water and landscape management, energy recovery |
| France | strengthen dialogue and synergy between producers and processors of biomass, + between the various ways of using biomass, along biorefinery lines ; focus on flexible value chains |
| Germany | innovative supply chains around increased use of biogenic raw materials derived from aquatic systems such as algae, cyanobacteria and aquatic plants ; use of aquatic resources strongly promoted to broaden the raw material base |
| Italy | interconnecting effectively sectors, across sustainable value chains , embracing the production of bioresources their processing and valorization of final products, as well as the public and private stakeholders in local communities |
| NL | collaboration between sectors and value chains ; scaling up processes earlier stage; increasing visibility for consumers and between sectors to encourage innovation and cultivate demand for new products that tackle major social challenges |
| South Africa | capacity and capabilities of previously established initiatives assessed in order to enhance their potential to facilitate and support sustainable bioprospecting activities ; competitive advantage for local manufacturing industries may then be strengthened and relevant bioprospecting initiatives consolidate |
| USA | value chain success stories from across to educate industry, investors, and general public about how key technology development research is reducing technology uncertainty and overall risk to private industry and financiers of the bioeconomy |

5.6. Bioeconomy related education and training, and science and research

An innovation-driven transformation towards a knowledge-based bioeconomy requires also bioeconomy-related education and training, and science and research to close existing bioeconomy-related knowledge and technology gaps.

Table 16 presents aspects of **education and training** mentioned in the studied bioeconomy strategies can be summarised as an integration of sustainable development aspects of a bioeconomy in cross-disciplinary school-based education, a continuing vocational education and training (e.g., job training and skills development), and an academic education (e.g., "engineering biology, biomanufacturing, bioprocess engineering, and computational science

applied to engineering biology and in the related ethical, legal, environmental, safety, security, and other societal issues” [14]. In addition, focusing, for example, on young entrepreneurs in agri-food and in forest-wood sectors (Italy); and a “need to develop “technopreneurs” who can develop diverse technologies into innovative products and services at the downstream end of the value chain” [13] was mentioned.

Aspects of science and research mentioned in the studied bioeconomy strategies can be summarised as establishing or enhancing the cooperation of science and bio-based industries (the USA; Austria: Centres of Excellence) or bioeconomy collaboration clusters (Italy: research network and enterprises, and Canada: start-ups, small and medium-sized enterprises SMEs] and large corporations); establishing or enhancing competence centres (Germany); improving and enhancing research investment (Germany, South Africa, USA II); and focusing on the support of innovators to ensure success and growth of businesses (Canada). As for bioeconomy-related research funding, Germany focuses on following topics: i) biological knowledge as key to the bioeconomy; ii) cross-disciplinary collaboration by, for example, exploiting the nanotechnology, miniaturisation, digitisation, automation and artificial intelligence for the bioeconomy; iii) limits and potentials of ecological systems; iv) technology transfer; v) interactions and conflicting goals of the bioeconomy and society; and vi) global research co-operation. The same document describes that “it is essential that research funding be transparent and that it include different forms of participation, especially when it comes to defining problems and gaps in our knowledge, but also to develop proposals for actions and measures. Research creates the prerequisites necessary to shape the current transition towards a bioeconomy so that it is in line with the demands of society and with sustainability objectives”. [10]

Table 16. Examples of bioeconomy related education, training, science and research in the studied national bioeconomy strategies.

| Country | Education, training, science and research | Specific mentioned |
|---------|---|--|
| Austria | education and training | integration of bioeconomy in school-based and academic education + continuing vocational trainings |
| | science and research | strategic development of framework conditions for humanities, social and cultural sciences; cooperation platforms dedicated to the process chains “agriculture – food – biotechnology“ and “forestry – timber industry“ as well as the links between the resource flows; Centres of Excellence for cooperation of science and industry; bio-based industry (BBI), cooperation of applied research organisations with companies which emphasises on biogenic raw materials and networking of stakeholders |
| Canada | education and training | emphasis on value chain creation, job training and skills development |
| | science and research | focus on multi-sector collaboration clusters (start-ups, small and medium-sized enterprises (SMEs), and large corporations), open innovation, business services, and partnerships with researchers, post-secondary institutions, community leaders and other innovators to ensure success and growth of businesses |
| Finland | education and training | awareness increasing; further education, qualifications and re-training to reinforce innovation, product development and business skills; cooperation between universities and research institutes in a multi-annual development process; opportunities for business development besides the research, development and innovation activities |

| | | |
|--------------|------------------------|---|
| | science and research | incorporate bioeconomy to themes and priorities of the Strategic Research Council; research cooperation that crosses sectoral boundaries and accelerating the exploitation of research results; exploit international research by encouraging actors to take part in international research networks; promoting international mobility of scientists and students |
| France | education and training | training for using new bio-based materials |
| | science and research | systemic approaches that focus on economic, environmental and social impacts |
| Germany | education and training | vocational training for sustainable development + aspects of bioeconomy in the training and in the continuing education of the educational staff and the operational management |
| | science and research | build clusters, competence centres and regional networks; research funding focusing on i) biological knowledge as key to bioeconomy, ii) cross-disciplinary collaboration by e.g. exploiting nanotechnology, miniaturisation, digitisation, automation and artificial intelligence for the bioeconomy, iii) limits and potentials of ecological systems, iv) technology transfer, v) interactions and conflicting goals of bioeconomy and society, vi) global research co-operation |
| Italy | education and training | cross-disciplinary education and training for researchers + technical careers; young entrepreneurs in agri-food and forest-wood sectors in less favoured areas; academic and advanced-education programs on new economic and productive scenarios; local administrations in enforcing their knowledge and competences on bioeconomy through dedicated training courses and expertise acquisition; |
| | science and research | National Technological Clusters for permanent dialogue between public research network and enterprises |
| Netherlands | science and research | investment subsidies and financial support for research programmes; long-term research agenda is established, including the allocation of appropriate financial resources; effective coordination will prevent unnecessary duplication of work; free and open access to publicly funded research and innovation |
| South Africa | education and training | scientists, engineers and technicians; need to develop “technopreneurs” who can develop diverse technologies into innovative products and services at the downstream end of the value chain |
| | science and research | development and innovation in biological processes for the production of goods and services, while enhancing water and waste-management practices in support of a green economy; improve research investment into the basic scientific disciplines that underpin biotechnological development, including bioinformatics, systems biology, synthetic biology, structural biology and functional genomics |
| USA | education and training | education and job-training initiatives; and partnerships with producers, contractors, and specialty personnel. |
| | science and research | federal agencies, in collaboration with universities, industry, stakeholders, and non-governmental organizations, will need to continue to conduct R&D in support of technology transfer to the bioeconomy industry; due to the challenges of biomass supply and access, sustainability, high costs, and financial and ecological risks, targeted R&D can improve technologies and processes to sustainably and reliably produce, supply, and use large quantities of biomass for biofuels, bioproducts, and biopower |
| USA II | education and training | undergraduate and graduate students in engineering biology, biomanufacturing, bioprocess engineering, and computational science applied to engineering biology and in the related ethical, legal, environmental, safety, security, and other societal issues |
| | science and research | new research directions and technology goals, improve interagency coordination and planning processes, drive technology transfer to the private sector, and help ensure optimal returns on the Federal investment. |

5.7. Regional dimension in a bioeconomy

Regions are considered by bioeconomy strategies as the main driver for a successful transformation from a linear towards a sustainable and circular bioeconomy, and, vice versa, a bioeconomy provides potentials for regional development (e.g., establishing new bio-based supply chains, or enhancing and optimising existing bioeconomy supply chains can offer regions new market opportunities).

Within the studied bioeconomy strategies, different concepts of how to enhance the regional dimension of a bioeconomy are introduced. These can be summarised into the following aspects: concepts that focus on establishing regional consulting hubs (Austria, South Africa), establishing clusters (Canada) or networks to advance regional supply chains, e.g., "development of regional bioeconomy concepts involving local actors and regional administrations... local processing of biogenic raw materials to higher-quality materials suitable for subsequent processing stages...supporting regional forms of product marketing adapted to local conditions" [10]; or a concept that focuses on cross-sectoral, cross-regional and interregional value chains (Italy). (Table 17)

Table 17. Concept examples to enhance the regional dimension of bioeconomy in the studied national bioeconomy strategies.

| Country | Concept examples to enhance the regional dimension of bioeconomy |
|----------------|---|
| Austria | agriculture: promote origin of food, regional focus and seasonal availability most important purchasing criteria; inter-company cooperation models forestry (incl. bioenergy): importance for regional added value supply chains: quality, health and climate-related aspects in public-sector nutrition management with focus on regional supply options and practicable concepts for waste reduction towards a lower consumption of land central hub: regional consulting programmes about climate protection, resource efficiency and renewable raw materials |
| Canada | employment and value chains: value chain creation, job training and skills development, a multi-nodal and geographically-diverse group of clusters that build on regional strengths facilitating significant opportunities for commercial enterprises at the regional level; ensuring that a national competitive advantage is achieved; linkages between regional and national workforce development agencies to increase access to market information and data and ensure a thorough understanding of the sector's needs and support programs that will ensure those needs are being met |
| Finland | decentralised, resource-efficient bioeconomy solutions to enhance the viability of regions and rural areas (increase value-added); interaction between industrial sectors and new services that support the exploitation of surplus materials to enable efficient use of materials; nutrient use more efficient by various closed cycle systems, thus reducing dependence on imported nutrients while gaining environmental and climate benefits; local food production that responds to expanding consumer demands |
| France | general: regions, contributing to the development of economic value and jobs; concrete example: conversion of a cellulose pulp mill into a lignocellulose biorefinery |
| Germany | development and establishment of regional biogenic supply chains can be achieved through greater networking amongst established players in individual supply chains; development of regional bioeconomy concepts involving local actors and regional administrations > e.g. local processing of biogenic raw materials to higher-quality materials suitable for subsequent processing stages; supporting regional forms of product marketing adapted to local conditions |
| Italy | sectors: food chain wastes and by-products, development and increase of crops production in marginal and underutilized agricultural areas and increase of intermediate crops, bio-refineries for the production of bioproducts and biochemicals from local renewable sources |

| | |
|---------------------|---|
| | concept: building cross territorial links and interregional value chains with respect to blue economy, agro-food and bio-based industry |
| Netherlands | boost regional economic attractiveness, better use of available biomass and agricultural land, while sustainable management of resources ensure, new opportunities for high-quality regional production, revitalization of countryside |
| South Africa | regional agro-innovation hubs for collective enhancement of production, agro-processing and marketing by farmers, scientists and innovators |
| USA | concrete example: increased regional knowledge of available resources, such as water, climate, available land, sun, nutrients, and CO2 required; ability to characterize algal biomass, intermediates, biofuel, bioproducts, contaminants, ideal storage and transportation conditions, weather impacts, stability, and end-product variability will be critical for algae to contribute to bioeconomy |

In the studied bioeconomy strategies no particular regional bioeconomy strategies was mentioned, however a web search revealed that regional bioeconomy strategies are existing (Table 18).

Table 18. Examples of regional bioeconomy strategies and of regional bioeconomy related strategies in the studied national bioeconomy strategies

| Country | Examples of regional bioeconomy strategies | Examples of regional bioeconomy related strategies |
|----------------|--|--|
| Finland | Lapland Arctic bioeconomy development programme 2018, Bioeconomy development strategy Oulu 2014, Growth programme for circular bioeconomy 2019 Satakunta | Regional programme Kainu 2017, Carbon neutral road map Kymenlaakso 2019, Climate and Energy Programme North Karelia 2012 |
| France | | Circular economy action plan Pays de la Loire 2018 |
| Germany | Sustainable bioeconomy for Baden-Württemberg 2019 | Regional Innovation Strategy Sachsen 2013, Sustainability Strategy Thüringen 2011 |
| Italy | | Rural programme Campania 2014, Smart specialization strategy Emilia Romagna and Tuscany 2015 |
| USA | | California's Biostrategy 2020 |

5.8. Bioeconomy related policy instruments

A transition from a linear economy towards a sustainable and circular bioeconomy requires a coherent political framework between bioeconomy-related instruments (e.g., strategies, policies, regulations and initiatives), in order to avoid contradictions and trade-offs, but, most of all, in order to find synergies in goals, aims and targets. Table 19 and Table 20 present an overview of bioeconomy-related instruments mentioned in the studied national bioeconomy strategies, which can be grouped under international, European, and national bioeconomy-related policy instruments. These include up to eleven different policy sectors in a country (Germany) to about 19 different policy sectors in all countries from energy, and circular economy, to climate change and sustainability.

Table 19. Overview of mentioned bioeconomy related policy instruments in the studied national bioeconomy strategies. France no specific bioeconomy related strategies mentioned.

| Policy sectors | Austria | Canada | Finland | Germany | Italy | NL | South Africa | USA |
|----------------------|---------|--------|---------|---------|-------|----|--------------|-----|
| agriculture | ■ | | | ■ | | | | |
| agriculture/rural | | | | | | | | ■ |
| biodiversity | | | | ■ | | | | |
| biotechnology | | | | | | | ■ | |
| bioeconomy (EU) | | ■ | ■ | | ■ | ■ | | |
| circular economy | ■ | | | ■ | ■ | ■ | | |
| climate change | ■ | | | ■ | ■ | | | |
| development | | | | | | | ■ | |
| economics | | ■ | | | | | | |
| education | | | | ■ | | | | |
| energy | ■ | ■ | | ■ | | ■ | | ■ |
| environment | | | | ■ | | | | ■ |
| forestry | | | | ■ | ■ | | | |
| industrial | | | | ■ | | | | |
| marine/fisheries | | | | ■ | ■ | | | |
| research | | | | | ■ | | | |
| smart specialisation | | | | | ■ | | | |
| sustainability | ■ | | | ■ | ■ | | | |
| waste | | | | | ■ | | | |

Table 20. Mentioned bioeconomy related instruments in the studied national bioeconomy strategies

| Country | Policy sectors | Policy instrument mentioned |
|----------------|--|---|
| Austria | agriculture | EU CAP |
| | bioeconomy | Bioeconomy RTI Strategy; EU Bioeconomy Strategy 2012, 2018 |
| | circular economy | regulations on plastic-ban, construction, waste and new materials |
| | climate change | Integrated Climate and Energy strategy; Paris Agreement |
| | energy | Integrated Climate and Energy strategy |
| | sustainability | UN SDGs |
| Canada | economics | Economic Sector Strategy |
| | energy | Clean Fuel Standard (CFS) Regulatory Design Paper |
| Finland | bioeconomy | EU Bioeconomy strategy 2014 |
| | environment | UN Environment Programme |
| France | no specific bioeconomy related strategies mentioned | |
| Germany | general: industry policy, energy policy, agricultural, forestry and fisheries policy, environmental policy | |
| | biodiversity | German National Strategy on Biodiversity |
| | bioeconomy | National Research Strategy BioEconomy 2030 |

| | | |
|--------------|----------------------|--|
| | circular economy | German Circular Economy Act |
| | climate change | Climate Action Plan, Paris Agreement |
| | education | National Action Plan on Education for Sustainable Development |
| | forestry | Charter for Wood 2.0 |
| | sustainability | UN SDGs |
| Italy | circular | EU Circular Economy Action Plan, Circular Economy Package |
| | climate change | EU Climate change strategy |
| | forests | EU Forest Strategy of 2013 |
| | marine | Marine Strategy Framework Directive |
| | research | National Research Plan 2015-2020 |
| | smart specialisation | National Smart Specialisation Strategy |
| | sustainability | UN SDGs |
| | waste | Waste Framework Directive |
| NL | bioeconomy | European Bioeconomy Stakeholders Manifesto; EU Bioeconomy Strategy 2012, 2018 |
| | circular economy | Nationwide Circular Economy Programme 2050 |
| | energy | Energy Agenda |
| South Africa | biotechnology | National Biotechnology Strategy; Industrial Policy Action Plan; Advanced Manufacturing Technology Strategy |
| | development | National Development Plan |
| USA | agriculture/rural | Farm Security and Rural Investment Act |
| | energy | Energy Independence and Security Act |
| | environment | National Environmental Policy Act |
| USA II | business | Small Business Act |

5.9. Sustainability within a bioeconomy

According to [5] “the bioeconomy focus has shifted in the last decade from a relatively narrow economic concept that aims to replace fossil resources with renewable raw materials to a wider sustainable and circular bioeconomy concept. The aim of this wider concept is also to reduce and recycle renewable bio-based raw materials and to improve and innovate the way food, products, and materials are produced and consumed within healthy ecosystems”.

In Austria, the **concept of sustainability** is taken into account by promoting a sustainable societal transformation that links systemically technical and scientific aspects with economic perspectives, political and social views with ecological, as well as ethical positions. In addition, this includes sustainable trade, e.g., “price and competitive advantages that result from ecologically and socially unacceptable production must be scrutinised and included in trade agreements and consumer decisions” [6]. Global responsibility is also part of the sustainability concept of the Netherlands. Canada sees sustainability as a market driver, where customers demand more sustainably-sourced products. Germany presents action areas for a sustainable bioeconomy from reducing pressure on land, to the establishment of bio-based products, processes and services, and the exploitation of potential inherent for the development of rural areas. (Table 21)

Table 21. Overview on how the concept of sustainability is taken into account in the studied national bioeconomy strategies

| Country | Sustainability | Concrete examples |
|----------------|--|---|
| Austria | promoting sustainable societal transformation | link systemically technical and scientific aspects with economic perspectives + political and social views with ecological/ ethical positions; knowledge transfer to public >understand and support goals, measures and recommendations for action |
| | fair and sustainable trade | global responsibility |
| | preservation of agricultural land | use of soil for other purposes reduced, zoning and increased brownfield management |
| | intact, climate-friendly forests for more wood products | yield per hectare increased by site-adapted tree species or forest ecosystems, improving vitality and resilience of forest through adequate forest management and thinning measures |
| Canada | sustainability as market driver | consumer demand more sustainably-sourced products toward more validated sustainable biomass supply; biomass industries transform resource management and development for production, conversion and management |
| | sustainable innovation ecosystems | emphasis on value chain creation, job training and skills development; a multi-nodal and geographically-diverse group of regional facilitating significant opportunities for commercial enterprises, ensuring national competitive advantage. |
| Finland | accessibility and sustainability of biomasses | symbiotic relationships between forest, energy, technology, chemical and construction industries; wastes and industrial side streams as raw materials to reduce negative environmental impacts |
| | sustainable bioeconomy solutions | sustainable solutions for global efforts to mitigate climate change and use of natural resources; generate new, sustainable economic growth and well-being |
| France | effective, innovative/sustainable industry | synergy between producers and processors of biomass, flexible value chains |
| Germany | action areas for sustainable bioeconomy | reduce pressure on land, sustainable production/supply of biogenic raw materials, establishment/development of bioeconomy supply chains/networks, market launch/establishment of bio-based products, processes and services, exploitation of potential inherent for development of rural areas, exploitation of the potential of digitalisation |
| Italy | sustainable agriculture, forestry and aquaculture | boost sustainable and resilient primary production, improve resource management; sustainable, competitive, innovative manufacture, human and social capital and social innovation |
| NL | resources within the planetary boundaries | efficient use, biodegradability and smart consumption, innovation and changing people's lifestyles; prevention of local and global degradation, recovery of ecosystems and improvement of food production/water security |
| | production for people | new enterprise and guarantee jobs in the agricultural, fishing, aquaculture and forestry sectors, not detract from land rights, human rights or the availability of food and water |
| USA II | advance societal wellbeing, national security, sustainability, and economic productivity and competitiveness | |

A sustainable bioeconomy can contribute to several of the 17 UN Sustainable Development Goals [20]. In particular, increasing demand for bioeconomy products may lead to increased employment and thus higher household income, therefore reducing poverty (SDG1); all bioeconomy sectors depend on sustainable production and may pave the way for a changing

consumption behavior (SDG12); a bioeconomy may provide opportunities for new business models and expanding global markets (SDG 17). Of the studied bioeconomy strategies that were published after 2015, Austria, Germany and Italy mentioned SDGs explicitly (Table 22).

Table 22. Overview if and which SDGs are taken into account in the studied national bioeconomy strategies

| UN Sustainable Development Goals (SDGs) (short from) | Austria | Germany | Italy |
|--|---------|---------|-------|
| 1. No poverty | | | |
| 2. Zero hunger | ■ | ■ | ■ |
| 3. Good health and well-being | ■ | ■ | |
| 4. Quality education | ■ | | |
| 5. Gender equality | ■ | | |
| 6. Clean water and sanitation | ■ | ■ | ■ |
| 7. Affordable and clean energy | ■ | ■ | ■ |
| 8. Decent work and economic growth | ■ | ■ | ■ |
| 9. Industry, innovation and infrastructure | ■ | ■ | ■ |
| 11. Sustainable cities and communities | ■ | ■ | ■ |
| 12. Responsible consumption and production | ■ | ■ | ■ |
| 13. Climate action | ■ | ■ | |
| 14. Life below water | ■ | ■ | ■ |
| 15. Life on land | ■ | ■ | ■ |
| 16. Peace, justice and strong partnership | ■ | | |
| 17. Partnerships for the goals | ■ | | |

5.10. Institutions, organisations and relevant stakeholders involved within a bioeconomy strategy development

Table 23 presents an overview on which ministries, institutions, organisations and stakeholders have been involved or mentioned in the studied bioeconomy strategies. The Ministries involved usually represent the sectors that are considered important to a bioeconomy at national level (Chapter 5.4), while other stakeholders involved range from industry, academia and research, interest groups, environmental organisations, and the civil society. Stakeholders participated either in workshops, or via online-consultations.

Table 23. Institutions, organizations and relevant stakeholders involved within a bioeconomy strategy development

| Country | Ministries, institutions, organizations | Other stakeholders involved |
|----------------|---|--|
| Austria | Federal Ministry for Sustainability and Tourism, Education, Science and Research, Transport, Innovation and Technology | |
| Canada | Bioindustrial Innovation Canada, BioDesign (BIOTECanada, FPIInnovations and Forest Products Association of Canada) | producers, companies, academic institutions, other stakeholders in 7 provinces; |
| Finland | Prime Minister’s Office, Ministries of Employment and Economy, Agriculture and Forestry, Environment, Education and Culture, Social | stakeholders representing the bioeconomy also gave their inputs to strategy preparation. |

| | | |
|---------------------|--|--|
| | Affairs and Health, Finance, administrative branches under these Ministries, VTT Technical Research Centre, Finnish Innovation Fund Sitra. | |
| France | Ministries for ecology, research, industry, agriculture and forestry, other stakeholders not mentioned | |
| Germany | Federal Ministries of Education and Research, Food and Agriculture, Foreign Office, Federal Government, Federal Ministries of Education and Research, Food and Agriculture, Finance, Environment, Nature Conservation and Nuclear Safety, Transport and Digital Infrastructure, Economic Affairs and Energy, Economic Cooperation and Development | conferences, workshops and consultations with representatives from business, research, politics and civil society |
| Italy | Ministries for Economic Development. Agriculture, Food, Forestry and Tourism, Education, University and Research, Environment, Land and Sea, Committee of Italian 21 Regions, Italian Technology Clusters for Green Chemistry SPRING, Agri-Food CLAN, and Bluegrowth BIG | workshops and consulted in the near future for the implementation of the present strategy; citizens and all those interested in the topic invited to comment via a website |
| Netherlands | Ministry of Economic Affairs and Climate Policy | no particular stakeholders mentioned |
| South Africa | Department of Science and Technology, guided and monitored by interdepartmental stakeholder groups | government departments implementing agencies relevant stakeholders developed implementation frameworks |
| USA | U.S. Departments of Energy and Agriculture and currently consists of senior decision makers from the DOE, USDA, U.S. Departments of Transportation, of the Interior, of Defence , U.S. Environmental Protection Agency National Science Foundation, and the Office of Science and Technology Policy within the Executive Office of the President | stakeholder forums from six sectors, academia, industry, state governments, workforce development, finance, agricultural, and environmental organizations |
| USA II | National Science Foundation, Departments of Commerce, Energy, Defence, National Aeronautics and Space Administration Agriculture, Environmental protection Agency, Health and Human Services, National Institute of Health, Food and Drug Administration advisory committee on engineering biology research and development: research, and academic institutions, industry, and nongovernmental entities | |

5.11. Raising awareness of the bioeconomy among society

Raising awareness of the bioeconomy among society is seen as crucial for a successful transformation to a biobased society. Table 24 presents an overview of mentioned awareness-raising on the bioeconomy in the studied national bioeconomy strategies, which can be grouped under the following: promoting the awareness of bio-based customer choices (Canada, Italy, South Africa, the USA); increasing the visibility of bio-based products (the Netherlands); increasing the labelling of recyclable products (Austria); increasing the understanding of a shared economy (Austria, France); understanding the challenges of a bioeconomy (Germany); and understanding the ecological boundaries of a bioeconomy (Finland). A concrete example on how to raise the awareness on the sellers' and customers' side is presented by the USA: *“strive to ensure that auto dealerships selling new and used cars*

understand the science of biofuels, do not promote myths, and can inform consumers on fuel choice and availability in the local market” [14].

Table 24. Overview of mentioned awareness raising on bioeconomy in the studied national bioeconomy strategies

| Country | Awareness raising |
|---------------------|--|
| Austria | intensified image campaigns for bio-based products to communicate environmental and economic benefits, enhancing the presence of bio-based products in the public sphere; customer-friendly labelling of the recyclability of products • targeted support of the sharing economy with the aim of reducing the consumption of goods; expansion of repair and maintenance services |
| Canada | biotechnology traditional industries and new companies need support to gain public awareness, understanding, interest and acceptance; public becomes more aware the challenges of plastic waste and recycling |
| Finland | driven by changing consumer behaviour and a need to secure the preconditions for human well-being; increasing concern over the environment and scarcity of non-renewable raw materials, including metals and oil, the use of biomasses in the economy and across society |
| France | dialogue with society for a genuinely shared bioeconomy |
| Germany | dialogue platform with representatives of industry, associations, science and society: obstacles and problems encountered in converting the economy to a sustainable bio-based economy discussed in order to develop joint solutions |
| Italy | promoting communication and information to consumers to increase their awareness of biobased products, highlighting their positive impacts in social and environmental terms (green jobs, social acceptance, energy efficiency, reduced GHG emissions, lower extraction rate of non-renewable resources, benefits for land and terrestrial ecosystem and biodiversity conservation), adjusting fiscal measures and policies in order to increase private demand for biobased products; |
| Netherlands | increasing visibility for consumers and between sectors to encourage innovation and cultivate demand for new products to tackle the major social challenges |
| South Africa | promoted understanding and empowered scholars, journalists and the public sector to make informed choices on biotechnology issues. |
| USA | public messaging on biofuel facts, impacts and benefits, success stories, technology readiness, and progress among federal agencies, as well as opportunities to deploy and use bioproducts and biofuels |

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