NL Agency
Ministry of Economic Affairs

The Bio-based Economy in the Netherlands

IA Special

Netherlands office for Science and Technology

>>Focus on international business and cooperation

Preface

Dear reader,

Hereby, The Netherlands Offices for Science and Technology (NOST) Network presents to you a Special Report about the R&D developments in The Netherlands regarding the Biobased Economy.

The NOST Network is present in 15 countries and is part of the Ministry of Economic Affairs.
The NOST network supports Dutch innovative companies, knowledge institutes and government by informing about the state-of-the-art developments in foreign countries and by introducing them to relevant foreign parties with the aim of stimulating international scientific and technological cooperation. Doing so, we create new (business of scientific) opportunities for Dutch industry and academia…and possibly for you as well!

Reading through this Special Report, we are convinced that you will be inspired by scientific and technological developments, relevant Dutch players (companies, research institutes), Public-Private R&D Partnerships and our governmental policy towards the BioBased Economy.

If you would like to receive more information about the above, or would like to be introduced to relevant parties in the area of BioBased Economy, then please do not hesitate to contact us. You will find our contact details at the end of this Special Report; Alternatively, you can contact you local Science & Technology Attaché..

Enjoy reading!

NOST - Central Office
The Hague

The Bio-based Economy in the Netherlands

Introduction

The bio-based economy is an economy in which plastics, transport fuels, electricity, heat, and all kinds of everyday products are made from vegetable raw materials (instead of from fossil fuels such as petroleum, coal or natural gas). Due to smart cooperation between companies, all parts of the plant are used optimally, and cycles can be closed.

In the Netherlands, the bio-based economy has been widely adopted in the last 10 years. The most important motives behind this adoption were: Striving for more sustainability (reduction of CO_2 emissions, circular economy), the awareness of the finite nature of fossil fuels, and the economic opportunities offered to Dutch businesses through the use of renewable biological resources and residues.

The Netherlands possesses an agri-food-chemical sector that is on par with global industry leaders. For instance, the Netherlands is the second largest exporter of agricultural and food products worldwide (1). Over the past 10 years, the Dutch chemical sector has expanded its turnover by 30% by introducing new products in the market, increasing labour productivity by more than 30%, and reducing energy consumption per ton of product by 25%(2). The Netherlands also has a well-developed energy sector. Add to that a large number of innovative small and medium enterprises, an international port linked to a close-knit logistics network, a sizeable hinterland, and a high-quality education and knowledge institutes, and it becomes clear that the Netherlands is in a strong position to make the bio-based economy a success. Consequently, the government as well as the business world have made the bio-based economy their priority.

Industry and agriculture

Biomass production and optimisation of cultivation

The Netherlands has two million hectares of agricultural land. The added value of the overall agri-complex is approximately 50 billion euros (2010), being approximately 9% of the added value of the Dutch economy(3). The Dutch production per hectare is the highest in Europe.

The Netherlands is a global leader in the breeding of new plant varieties. The processing sector generates an annual turnover of 2 billion euros. The sector counts approximately 8,000 to 10,000 employees and approximately 300 companies. The processing sector includes companies involved in the improvement and adaptation of cultivated plants as far as specific properties are concerned, the increase and trade in seed stock, and the rearing of young plants. The sector is investing 15% of its turnover in innovation. The Netherlands has

Table 1. Use of arable land in the Netherlands in 2012

Type	Most important applications	Hectares	Total hectares
Arable farming			520,803
	Grains	213,832	
	Potatoes	149,932	
	Sugar beets	72,724	
Horticulture			101,248
	Outdoor	86,421	
	Greenhouse cultivation	9,962	
Grassland and fodder crops			1,224,513
	Grassland	986,524	
	Fodder crops (namely corn silage)	237,989	

(source: Statistics Netherlands (CBS))

a strong global position in the field of seed stocks (seeds, bulbs, tubers, cuttings, and young plants). For instance, 60% of the global trade in seed potatoes and 35% of the global trade in vegetable seeds originate in the Netherlands. The Green Genetics Centre of Excellence (Topinstituut Groene Genetica, TGG) supports public-private cooperation projects. A few prominent processing companies that are resolutely focussing on R&D in the Netherlands are Rijk Zwaan, Nunhems, Enza, KeyGene, Syngenta, and Novartis (4).

Biorefinery

The processing and upgrading of residues within the agricultural sector is increasingly improving. From time immemorial, it has been possible to sell a part of the residues as livestock feed. Various consortia are analysing the protein-rich residues to see if the protein can be harvested as a raw material for human food. They are also trying to find out if enzymes can be extracted that can be used in the chemical industry. An example of this is the Grassa consortium that has developed a mobile system for grass refinery, which not only upgrades the protein but also produces a fibre for the paper and cardboard industry (5). Another consortium active in this field is HarvestaGG(6), which wants to grow grass as a rotating crop. Its business case is based on a combination of protein upgrades and green gas. The company NewFoss(7) has developed an aerobic treatment suitable for harvesting fibres from low-value residues such as grass and foliage. The cardboard manufacturer Solidpack(8) has built a pilot plant to refine natural grass, in which the fibre is used as a raw material in the production of cardboard. Avebe produces a high-quality protein for human food from residues generated in processing starch potatoes(9).

In Roosendaal, Cosun has built a pilot plant for upgrading beet pulp. This has resulted in a few successful business cases, for which the preparations for commercial production have now been initiated. The Dutch Grown Polymers consortium, consisting of Synbra, Purac, and Suikerunie, is investigating the feasibility of a production chain in the Netherlands for the conversion of sugar beets into PLA bioplastics.

The horticulture sector is also actively involved in upgrading residues. A good example of this is a tomato box developed by SmurfitKappa(10) using fibres from the tomato stalks. In addition to upgrading residues, the horticulture sector is a producer of high-quality and complex extractives for applications in pharmaceutics and cosmetics. For instance, the horticultural area of Emmen/Klazienaveen is working together with a German pharmaceutical company to develop vegetable materials for cardiac insufficiency(11). In addition, a few horticultural businesses are involved in the production of algae for proteins, fatty acids, antioxidants, and colouring agents.

Fermentation is also an important theme in the agricultural sector. Typical flows of biomass used for this purpose are animal manure, residues from the food industry, silt from water treatment, KGW, and to a lesser extent energy crops such as corn. The primary product of a fermentation process, biogas consists mainly of CH_4 (approx. 60%) and CO_2. A (large) part of the CO_2 still remains to be removed from the biogas before it is suitable for injection into the natural gas network. Nowadays, various technologies are commercially available for this biogas upgrade. In 2012, approximately 130 digestion plants were operational, of which approximately 100 at agricultural companies. In addition, 10 systems produced green gas and supplied it to the natural gas network. Those systems were 4 landfill gas systems, 2 KGW digesters, 2 waste water treatment plants, and 2 co-digesters. The capacity ranged from 25 to 750 Nm3/h and amounted to 3750 Nm3/h in total. All systems are supported by subsidies from the government. Together with the Dutch paper industry and four large processors of agricultural crops, the umbrella organisations for primary agricultural production have established the Dutch Biorefinery Cluster (DBC). Together, they represent 18,000 crop farmers and 18,000 dairy farmers, and they process 10 million tons of sugar beets (Cosun), more than 8 million tons of milk (FrieslandCampina), 3 million tons of starch potatoes (Avebe), 1 million tons of potatoes for consumption (LambWeston/Meijer), and 3.2 million tons of biomass for the production of paper and cardboard (20 companies). The objective of the DBC is to jointly develop new high-quality, bio-based products and to close cycles.

Bioenergy and biofuels

Biomass is currently already being used on a large scale in the energy sector. This development is being driven by the European objective of 14% renewable energy(12) in 2020 and the raised objective of 16% of the Dutch government. Biomass is anticipated to contribute significantly to this objective in 2020(13). The Dutch government is encouraging the generation of renewable electricity, heat, and green gas with subsidies, because green energy (whether or not from biomass) cannot be produced in the Netherlands in an economically viable way. Energy producers are anticipating the obligations in the Renewable Energy Directive (2009/28/EC) and are building their power stations now in order to be able to perform more auxiliary firing of biomass in the future. Moreover, new power stations are being built that run exclusively on biomass. Delta has plans to convert its coal-fired power plant in Borssele, so that it will be able to run entirely on biomass in the future(14). As far as pretreatment of biomass through torrefaction is concerned(15), the Netherlands has a solid position with ECN and companies such as Topell Energy, Foxcoal, etc.

In the transport sector, the use of renewable energy is achieved by requiring fuel suppliers to blend fuels with biofuels. In 2012, the mandatory share of renewable energy in transport amounted to 4.50%. This share will continue to expand in the next years(16). There are various biofuel projects that are in the idea or start-up phase. At the end of 2012, Woodspirit, a joint venture between BioMCN, Siemens Nederland, Linde, and Visser & Smit Hanab, received a commitment of 199 million euros in European subsidies for the construction

of a biomethanol plant in Delfzijl(17). DSM has entered into a joint venture with POET for the production of second-generation ethanol(18). Finally, since recently, KLM is flying from New York to Amsterdam on kerosene containing a portion of bio-kerosene derived from used frying oil(19). Figure 1 shows the devolopment of bioenergy production (20) since 2005.

Bio-based chemicals and materials

The substitution of fossil resources with biomass is an important development in the chemical sector. The benefit of biomass for the chemical sector is that it is a renewable resource, that its origin is not limited to a small number of countries, and that biomass can significantly reduce CO_2 emissions when used efficiently. The chemical industry has set a target of consuming 50% less fossil fuels in the next 25 years. Global players such as Shell, DSM, and AkzoNobel are based in the Netherlands and are actively involved in the development and production of bio-based chemicals. For instance, DSM produces bio-based building blocks (Reverdia, a joint venture with Roquette for the production of succinic acid), bio-based polymers and resins and bioethanol (joint venture with POET). BioMCN produces biomethanol, namely for the biofuels market. Other companies that produce bio-based building blocks for chemicals and polymers are CRODA, Nuplex Resins, and PURAC. An interesting newcomer is Avantium, which has a pilot plant in Geleen for the production of bio-based FDCA, a chemical building block for the production of terephthalic acid, often used in the production of PET. For this development, Avantium has entered into partnerships with Coca-Cola, Danone, Solvay, Rhodia, and Tejin-Aramid. Producers of bio-based plastics and composites are Synbra (foams), NSP, and Rodenburg Biopolymers, among other manufacturers. In addition, there are multiple producers of bio-based coatings, packaging materials, and construction materials.

Knowledge infrastructure

The Netherlands counts a number of public-private joint ventures that conduct targeted research programmes. In the area of the bio-based economy, the following initiatives are important (table 2).

Regional clusters

A number of strong bio-based clusters have arisen at the regional level. In all of these clusters, there is cross-sector cooperation. The local authorities (provinces) and the development companies often fulfil a facilitating and promoting role in that respect. The clusters in the border regions are increasingly looking for cooperation with bio-based clusters in neighbouring countries (Biobased Delta is working together with BioBase Europe Gent in Belgium, Biobased Limburg has a joint venture with RWTH Aachen and Fraunhofer in Germany, and Biobased Economy Noord-Nederland is partnering with Niedersachsen in Germany).

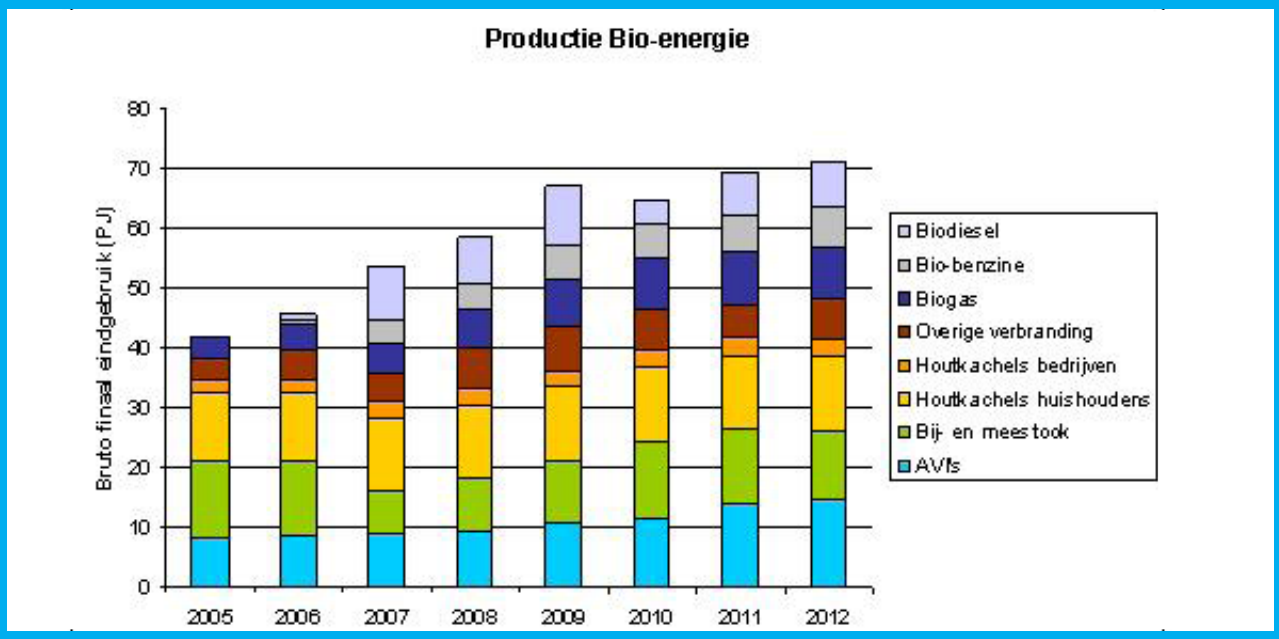

Figure 1 (The development of Bioenergy [PJ] from various sources in the Netherlands (2005-2012). AVI = waste incineration plant (afvalverbrandingsinstallatie).

Table 2: list of public-private cooperation programmes in the Netherlands.

PPP	Focus	Partners
ACCRES	Applied research centre for sustainable energy and green resources since 2007. Application-oriented research, testing site for prototypes, space for demonstration projects.	Wageningen University and Research Centre Plant and Environment Field Studies (WUR Praktijkonderzoek Plant & Omgeving), WUR Animal Sciences Group
AlgaeParc	Research centre for aquatic biomass. Comparative research among various photobioreactors.	WUR - open to the business world
BioSolar Cells (21)	Research programme for the production of energy carriers and raw materials. Research into photochemical and phototropic processes in micro-organisms.	Leiden University, WUR, 19 companies from the food, chemical, and biofuel sectors.
Green Genetics Centre of Excellence (Topinstituut Groene Genetica,TGG)	TGG promotes the cooperation between research institutions and the processing sector.	Technological centre of excellence, established in 2007.
Knowledge Centre of Vegetable Substances (Kenniscentrum Plantenstoffen, KP)	Knowledge centre focused on upgrading residues from horticulture and the production of high-quality extractives in horticultural crops. KP provides incentives for innovation projects, scans, and provides assistance in regulations (certification and admission).	Knowledge centre established by the government and the Commodity Board for Horticulture (Productschap Tuinbouw, PT) in 2011.
CatchBio	Research programme for biocatalysis. Research into catalytic processes for the production of chemicals, biofuels, and pharmaceutics.	WUR, UvA, UU, TUD, TU/e, UT, Radboud University, ECN, 11 companies (UU coordinates CatchBio)
BE-Basic	Industrial and environmental biotechnology focused on the development of biochemicals and biomaterials. Research programme and Bioprocess Pilot Facility (multipurpose facility for research into scaling up bioprocesses).	12 Dutch and 3 foreign knowledge institutes, 14 companies (TUD coordinates BE-Basic)
Dutch Polymer Institute & DPI Value Centre	Pre-competitive research into polymers and their applications. DPI promotes demand-driven research and the Value Centre promotes upgrading and network-building.	Technological centre of excellence, established in 1997.
Bio-based Performance Materials	Application-oriented research into new polymers and improving the performance of existing polymers.	WUR, TU/e, UU, RUG, approx. 40 companies (WUR coordinates BPM).
Carbohydrate Competence Centre (CCC)	CCC promotes research into synthesis, modification and/or degradation of carbohydrates for healthy nutrition and conversion into chemicals, materials, and biofuels.	19 companies and 6 knowledge institutes.
BIOCAB	Cooperative project in the Northern Netherlands, focused on the development of technology for the production of fibres (BIOFIB), chemicals (BIOSYN), and minerals (BIONPK) from agricultural residues.	WUR, RUG, and approx. 10 companies.
ISPT	Promotes research and innovation concerning sustainable process technology, such as upgrading residues that contain ligno-cellulosic material and proteins from agricultural residues.	Joint venture between the process industry and knowledge institutes.
AMIBM *currently being established*	Research institute for bio-based materials. Key focus: cellulose fibres, starch, bio-based additives, rubber, chemical building blocks, and medical applications.	Chemelot Campus, Maastricht University, RWTH Aachen, Fraunhofer
Chemelot Institute for Science and Technology *Currently being established*	Research institute focused on biomedical materials and process technology for the production of chemical building blocks.	DSM and TU Eindhoven.
Shared Research Centre Biobased Aromatics *Currently being established*	Application-oriented research into bio-based aromatics.	Green Chemistry Campus, TNO, VITO

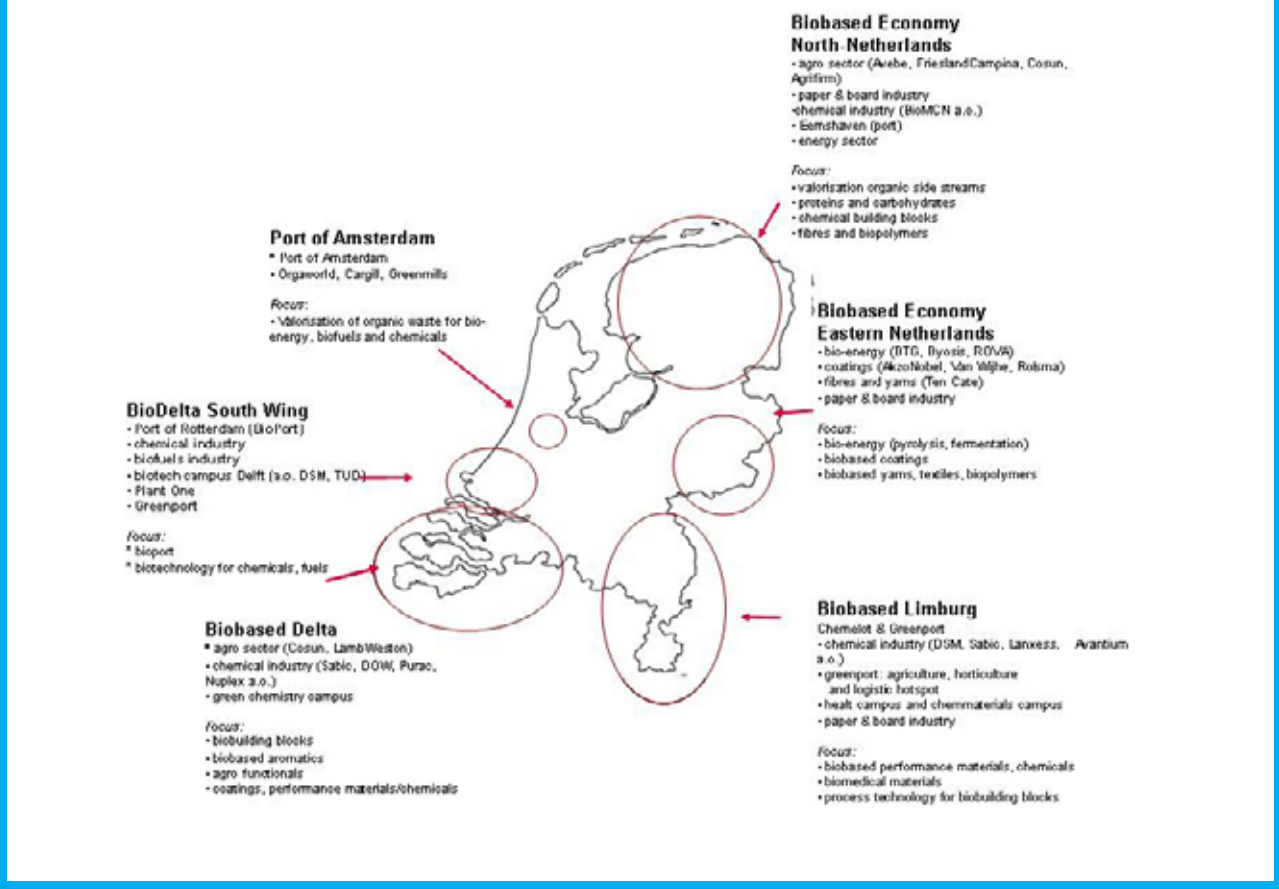

Figure 2: regional bio-based clusters in the Netherlands.

Policy

The Dutch government has been closely involved in promoting the bio-based economy for approximately 10 years. Initially, its role was mainly limited to setting the agenda and establishing relationships. For instance, a specific Bio-Based Economy Programme Management was set up within the Ministry of Economic Affairs (led by Roel Bol), which has a coordinating role in respect of "bio-based policy" at the various Dutch ministries. At the level of the EU, the Netherlands has been working together with France and Germany on an EU-wide approach to the bio-based economy. This has contributed to the publication of the EU Vision document "Strategy for a Sustainable Bioeconomy in Europe".
The Netherlands encourages knowledge development and innovation through the policy on top sectors. 9 top sectors have been specified: agriculture and food, chemical, energy, life sciences and health, horticulture and seed stock, logistics, high-tech systems and materials, creative industry, and headquarters. Bio-based economy has been designated as the common theme with its own programme and a Knowledge & Innovation Top Consortium (Topconsortium voor Kennis en Innovatie, TKI).

In addition, the Ministry of Economic Affairs has always promoted the cooperation in the "golden triangle": the business world, knowledge institutes, and the government. In doing so, the ministry facilitates two platforms focused on generating new bio-based business cases: the Biorenewables Business Platform and the Agri-Paper-Chemical Platform.
Through so-called 'green deals' (agreements between the government and the business world), the government supports the implementation of the bio-based economy by removing bottlenecks. These bottlenecks often reside in the area of laws and regulations, the joint creation of pilots for sustainable procurement or the creation of room for experiments. The government has concluded a green deal with the polymer chemistry sector in order to achieve certification of the use of biomass as a raw material for the production of polymers. Finally, the government encourages the implementation of bio-energy through subsidies and tax instruments.
Overall, the Netherlands has a strong initial position for a bio-based economy, as far agriculture and industry as well as the knowledge infrastructure is concerned. Moreover, the bio-based economy is a focal point of the policy on innovation.

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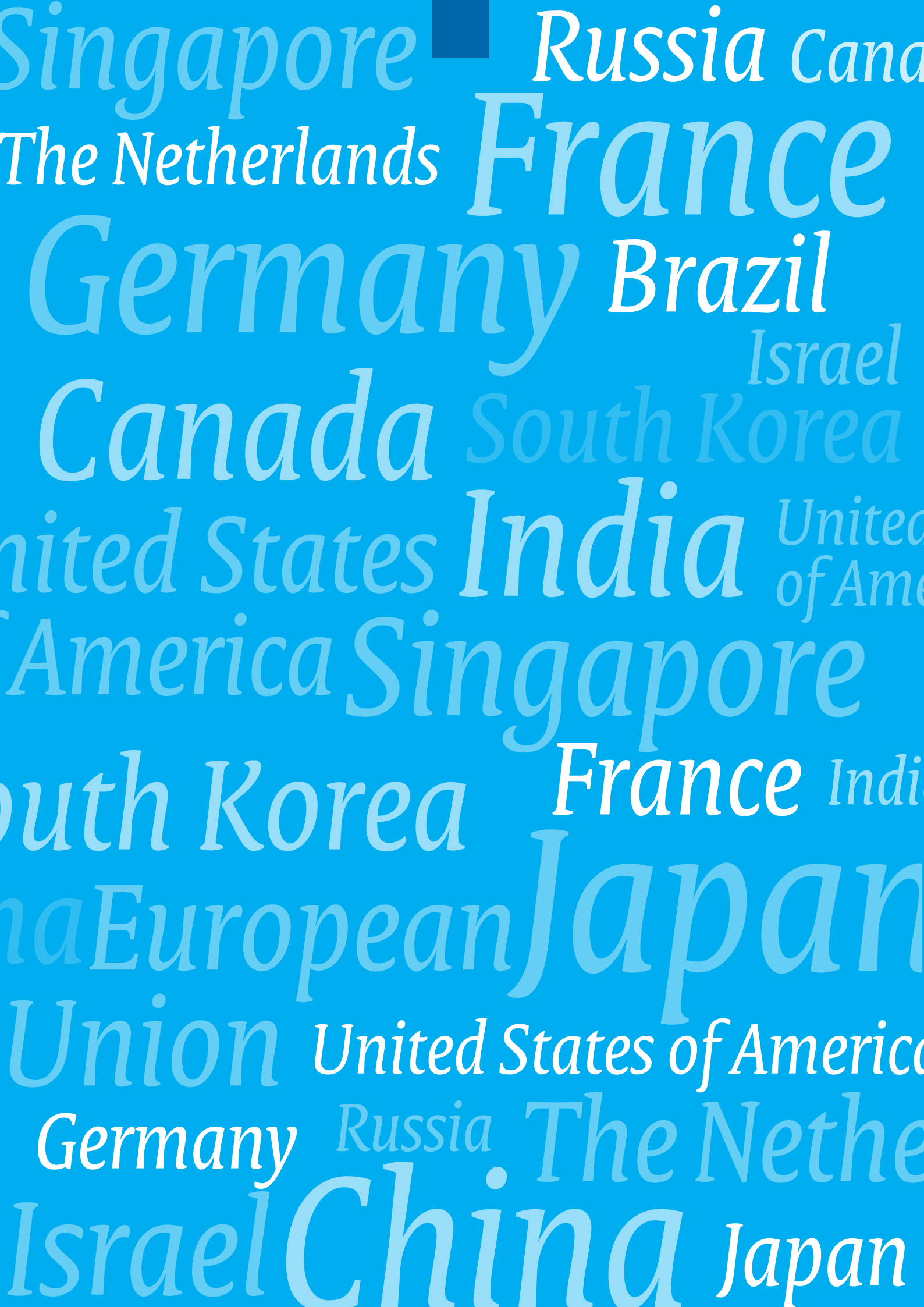
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