Study on the long-term linkages between climate objectives, international trade and investment

Annexes

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- Annexes

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In association with:

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Annex 1: List of EU climate-relevant policies and of impacted products

Table 1 List of EU policies related to the mitigation of climate change and of their potential impact on the EU consumption

Economic area	Policy	Impacted product groups	Impacted products	Expected impact on EU consumption
Overarching	- Regulation (EU) 2021/1119 European Climate Law[35] - Effort-Sharing Regulation (EU) 2018/842 & Amending Regulation[36]	These policies addresses all emissions sources. Therefore, no product or product group in particular is affected. The expected impact on EU consumption is that goods and services requiring less emissions attain a competitive edge and are consequently consumed more frequently. Equivalently, consumption of competing goods and services requiring more emissions will decrease.		+/-
Renewable and low carbon energy	- Renewable Energy Directive 2018/2001 and preliminary agreement for review[37] - Innovation Fund[38] - Modernisation Fund[39] - LIFE Clean Energy Transition[40] - Horizon Europe[41] - New Industrial Strategy EC/2023[42]	Renewable energy and underlying products	Products related to generation and production (including renewable energy sources, renewable fuels of non-biological origin and biofuels, bioliquids and biomass fuels complying with relevant sustainability and greenhouse gas emissions saving criteria)	+
	- REPowerEU Plan 2022	Fossil fuels in general	Fossil fuels from Russia (short term) All fossil fuels (medium to long term)	-

		In the short-term, fossil fuels from countries other than Russia; Renewable energy	Fossil fuels from countries other than Russia (short term) Products related to generation and production (including renewable energy sources, renewable fuels of non-biological origin and biofuels, bioliquids and biomass fuels complying with relevant sustainability and greenhouse gas emissions saving criteria)	+
	- REPowerEU Plan 2022 - New Industrial Strategy EC/2023 - Proposal for the Gas Package - Innovation Fund - Modernisation Fund - LIFE Clean Energy Transition - Horizon Europe - New Industrial Strategy EC/2023	Renewable fuels, low-carbon fuels, basic products using renewable fuels and low-carbon fuels s	E.g., basic chemicals, fertilisers, steel and liquid or gaseous synthetic fuels for transport, manufactured from renewable hydrogen	
Products for storage and transport of renewable and low carbon energy	- New Industrial Strategy EC/2023 - Innovation Fund - Modernisation Fund - Horizon Europe - LIFE Clean Energy Transition	Net-zero products; Products related to Renewable Energy; Raw materials required for the green transition	"Green products" themselves and products throughout their value chains	+
	- Proposal for a Battery Regulation 2019/1020[43]	Batteries	Portable batteries; automotive batteries; electric vehicle batteries; industrial batteries; and	+/-

			batteries incorporated/added to other products	
	- EU Strategic Energy Technology (SET) Plan[44]	Products related to renewable and low carbon energy	Products related to: offshore wind, PV, deep geothermal, ocean energy, concentrated solar power/solar thermal electricity, energy systems, energy efficiency in buildings & industry, batteries, renewable fuels and bioenergy, CCS, CCU, nuclear safety	+
Energy efficiency across sectors	- "Energy Efficiency First Principle" Commission Recommendation 2021/1749[45] - Energy Efficiency Directive (based on proposal of the recast)[46]	Products enhancing energy efficiency	E.g., Energy efficient machinery, processes, heating and cooling systems; insulation materials and equipment	+
	- Energy Labelling Directive 2017/1369[47], including Registry[48]	Energy-related products	(see footnote)[49]	+/-
High GHG emissions sectors: Electricity Manufacturing Transport Housing	- EU Emissions Trading System Directive 2018/2003[50]	Products manufactured or services delivered with currently a high GHG emissions intensity	Heat; electric energy; refined petroleum products; coke; pig iron & steel; non-ferrous metals; cement; glass; ceramics; pulp, cardboard and paper; intra-EU air, sea and (upcoming: land) transport;	+/-

			(upcoming) domestic heating	
	- Carbon Border Adjustment Measures – CBAM[51]	GHG-emissions intensive products at risk of carbon leakage	Cement, iron, steel, aluminium, fertilisers, electricity and hydrogen	+/-
	- Energy Performance of Buildings Directive 2010/31/EU & recast proposal[52]	Products related to buildings & building energy consumption	E.g., building & insulation material; heating & cooling systems; lighting; windows; meters	+/-
	- Sustainable and Smart Mobility Strategy[53]	Products related to sustainable transport	Electric vehicles and other zero-emission road transport options; high-speed trains; low emission fuels; automated mobility; zero-emission marine vessels; and zero-emission aircrafts	+
	- Amending Regulation 2019/631 on CO_2 Emissions from Cars and Vans[54]	Fossil fuel-based road vehicles	Cars and vans with an internal combustion engine and products related to them	-
	- Fuel Quality Directive 2009/ Directive 2009/30/EC[55]	Fuels for road transport, particularly used with positive ignition and compression ignition engines	Petrol; diesel; biofuels and electricity are also addressed	-
Manufacturing based on mineral materials	- Raw Materials Initiative[56] - Action Plan on Critical Raw Materials[57] - Proposal of Critical Raw Materials Act[58] - Proposal of the Net Zero Industry Act[59]	Inputs for the green transition	Rare earth elements; lithium; cobalt; magnets; batteries; electric motors; raw & advanced materials for energy conversion and storage in (non-) stationary applications; Preference for a supply from	+

			Canada, Latin America and Africa	
	- Proposal for a new Ecodesign for Sustainable Products Regulation[60]	All manufactured products	Products having been the target of a specific Implementation Regulation of the existing Ecodesign Directive (see footnote)[61]	+/-
	- Proposal for a Review of the Construction Products Regulation 2022/0094[62]	Construction products and 3D-printer equipment	(See footnote)[63]	+/-
Biotic materials	- Sustainable Agriculture objectives of the CAP[64] & Farm to Fork Strategy[65]	Products linked to environmental degradation and unsustainable farming	E.g., soya gown on deforested land; illegal fish products; products with long supply chains; products associated with forest degradation/deforestation; animal products related to certain antibiotics,	-
		Products linked to sustainable farming	E.g., EU-grown plant proteins; alternative feed materials; and organic/sustainable products	+
	- Renewable Energy Directive 2018/2001 and preliminary agreement for review[66]	Bio-fuels	Advanced biofuels using new sources of biomass	+
	- EU Fertilising Products Regulation 2019/1009[67]	Organic fertilisers	Organic fertilisers and soil improvers	+

	- Forest Strategy for 2030[68]	Products related to unsustainable forest bio-economy	E.g., Certain types of timber	-
		Products related to sustainable forest bio-economy	E.g., Eco-tourism and long-lived wood products	+
	Proposal for a Deforestation Regulation[69]	Products causing deforestation in third countries	Products covered are related to: cocoa, cattle, coffee, oil palm, soya, rubber and wood[70]	-
Investment in all economic areas	EU Taxonomy Regulation 2020/852[71]	Investment in activities defined as providing a 'significant contribution' to at least one environmental objective, while causing 'no significant harm' to all the others and to social conditions of work	Products resulting from activities rated as 'sustainable', in the following sectors: forestry, manufacturing, energy, water and waste management, transport, infrastructure, buildings, IT and certain services	+
Investment in infrastructure	LIFE Clean Energy Transition Sub-Programme	Products with high energy efficiency	E.g., Heat pumps; smart readiness buildings; insulation product; and home appliances	+
	Sustainable and Smart Mobility Strategy	Transport infrastructure related to renewable energy	E.g., High-speed trains and related infrastructure	+
	Modernisation Fund	Projects modernising energy systems or enhancing energy efficiency	E.g., renewable energy & energy efficiency-related products; modernisation of energy networks; just transition projects	+
	Global Gateway[72]	Infrastructure using or related to renewable energy	Highly dependent on which agreements are	+

			made under this framework	
Investment in innovation	Innovation Fund	Innovative products reducing GHG emissions	E.g., CCU; CCS; renewable energy-related products and energy storage	+
	Horizon Europe	Innovations supporting strategic targets	Very broad scope, all innovative technologies contributing to the implementation of EU policies are in principle eligible	+
Areas affecting land use	EU Land Use, Land Use Change and Forestry (EU-LULUCF) Regulation 2018/841[73]	No direct impact expected on specific products		0

Legend:

+ = the EU policy is expected to **increase** the consumption of the product

- = the EU policy is expected to **decrease** the consumption of the product

+/- = the EU policy is expected to **increase** the consumption of the more sustainable variants of the product, and to decrease the consumption of the less sustainable variants

0 = the EU policy is expected to **have no effect** on the consumption of the product

Annex 2: Full list of climate-relevant products

Table 31 Overview of the selected products under each category of biotic products

Category	Selected products HS code, label
Animal or vegetable fats and oils (incl. residues from oil)	150910 Virgin olive oil and its fractions obtained from the fruit of the olive tree solely by mechanical or other physical means under conditions that do not lead to deterioration of the oil 151190 Palm oil and its fractions, whether or not refined (excl. chemically modified and crude) 151219 Sunflower-seed or safflower oil and their fractions, whether or not refined, but not chemically modified (excl. crude) 1201 Soya beans, whether or not broken 1205 Rape or colza seeds, whether or not broken(2002-2500);Rape or colza seeds, whether or not broken(1988-2001) 230400 Oilcake and other solid residues, whether or not ground or in the form of pellets, resulting from the extraction of soya-bean oil
Coffee and cocoa	090111 Coffee (excl. roasted and decaffeinated) 090121 Roasted coffee (excl. decaffeinated) 180100 Cocoa beans, whole or broken, raw or roasted
Dairy produce; birds' eggs; natural honey; edible products of animal origin	040620 Grated or powdered cheese, of all kinds 040120 Milk and cream of a fat content by weight of > 1% but <= 6%, not concentrated nor containing added sugar or other sweetening matter 040610 Fresh cheese "unripened or uncured cheese", incl. whey cheese, and curd 040310 Yogurt, whether or not flavoured or containing added sugar or other sweetening matter, fruits, nuts or cocoa 04050010 Butter and other fats and oils derived from milk, of a fat content by weight of =< 85 %

Edible vegetables	071310 Dried, shelled peas "Pisum sativum", whether or not skinned or split 071320 Dried, shelled chickpeas "garbanzos", whether or not skinned or split 071333 Dried, shelled kidney beans "Phaseolus vulgaris", whether or not skinned or split 071334 Dried, shelled bambara beans "Vigna subterranea or Voandzeia subterranea", whether or not skinned or split 071340 Dried, shelled lentils, whether or not skinned or split
Fish and crustaceans, molluscs and other aquatic invertebrates	030420 Frozen fish fillets 0303 Frozen fish (excl. fish fillets and other fish meat of heading 0304) 0306 Crustaceans, whether in shell or not, live, fresh, chilled, frozen, dried, salted or in brine, even smoked, incl. crustaceans in shell cooked by steaming or by boiling in water; flours, meals and pellets of crustaceans, fit for human consumption 0307 Molluscs, fit for human consumption, even smoked, whether in shell or not, live, fresh, chilled, frozen, dried, salted or in brine; flours, meals and pellets of molluscs, fit for human consumption
Live animals	0101 Live horses, asses, mules and hinnies 0102 Live bovine animals 0103 Live swine 0104 Live sheep and goats 0105 Live poultry, "fowls of the species Gallus domesticus, ducks, geese, turkeys and guinea fowls"

Meat and edible offal	0203 Meat of swine, fresh, chilled or frozen 0201 Meat of bovine animals, fresh or chilled 0207 Meat and edible offal of fowls of the species Gallus domesticus, ducks, geese, turkeys and guinea fowls, fresh, chilled or frozen 0205 Meat of horses, asses, mules or hinnies, fresh, chilled or frozen 160241 Hams of swine and cuts thereof, prepared or preserved 160100 Sausages and similar products, of meat, offal or blood; food preparations based on these products
Rubber	4001 Natural rubber, balata, gutta-percha, guayule, chicle and similar natural gums, in primary forms or in plates, sheets or strip
Sugars	170191 Refined cane or beet sugar, containing added flavouring or colouring, in solid form

Table 32 Overview of the selected products under each category of abiotic products

Category	Selected products HS code, label
Aircrafts	880240 Aeroplanes and other powered aircraft of an of an unladen weight > 15.000 kg (excl. helicopters and dirigibles) 880390 Parts of aircraft and spacecraft, n.e.s. 841191 Parts of turbojets or turbopropellers, n.e.s. 841111 Turbojets of a thrust <= 25 kN 880230 Aeroplanes and other powered aircraft of an unladen weight > 2.000 kg but <= 15.000 kg (excl. helicopters and dirigibles)
Cement, glass, ceramics and other insulation materials	252329 Portland cement (excl. white, whether or not artificially coloured) 690722 Ceramic flags and paving, hearth or wall tiles, of a water absorption coefficient by weight > 0,5 % but <= 10 % (excl. refractory, mosaic cubes and finishing ceramics) 690723 Ceramic flags and paving, hearth or wall tiles, of a water absorption coefficient by weight > 10 % (excl. refractory, mosaic cubes and finishing ceramics)

Critical raw materials, batteries[18]	854590 Articles of graphite or other carbon, for electrical purposes (excl. electrodes, carbon brushes) 250410 Natural graphite in powder or in flakes 250490 Natural graphite (excl. in powder or in flakes) 810520 Cobalt mattes and other intermediate products of cobalt metallurgy; unwrought cobalt; cobalt powders 810530 Cobalt waste and scrap (excl. ash and residues containing cobalt) 810590 Articles of cobalt, n.e.s. 260500 Cobalt ores and concentrates 282520 Lithium oxide and hydroxide 850650 Lithium cells and batteries (excl. spent) 280470 Phosphorus 252921 Fluorspar containing by weight <= 97% calcium fluoride 252922 Fluorspar containing by weight > 97% calcium fluoride
Critical raw materials, photovoltaic	811090 Articles of antimony, n.e.s. 261710 Antimony ores and concentrates 811020 Antimony waste and scrap (excl. ash and residues containing antimony) 811010 Unwrought antimony; antimony powders 811292 Unwrought hafnium "celtium", niobium "columbium", rhenium, gallium, indium, vanadium and germanium; powders and waste and scrap of these metals 811299 Articles of hafnium "celtium", niobium "columbium", rhenium, gallium, indium, vanadium and germanium, n.e.s. 280461 Silicon containing >= 99,99% by weight of silicon 280469 Silicon containing < 99,99% by weight of silicon

Critical raw materials, others	280519 Alkali or alkaline-earth metals (excl. sodium and calcium)(2002-2500);Alkali metals (excl. sodium)(1988-2001) 280530 Rare-earth metals, scandium and yttrium, whether or not intermixed or interalloyed 261590 Niobium, tantalum or vanadium ores and concentrates 810320 Unwrought tantalum, incl. bars and rods of tantalum obtained simply by sintering; tantalum powders 810330 Tantalum waste and scrap (excl. ash and residues containing tantalum) 810390 Articles of tantalum, n.e.s.
Iron and steel	720812 Flat-rolled products of iron or non-alloy steel, of a width >= 600 mm, in coils, not further worked than hot-rolled, not clad, plated or coated, of a thickness >= 4,75 mm and <= 10 mm and having a minimum yield point of 355 MPa 721430 Bars and rods, of non-alloy free-cutting steel, not further worked than hot-rolled, hot-drawn or hot-extruded (excl. containing indentations, ribs, grooves or other deformations produced during the rolling process or twisted after rolling) 721440 Other bars and rods of non-alloy free-cutting steel, not further worked than hot-rolled, hot-drawn or hot-extruded, containing by weight < 0,25% of carbon "ECSC" (excl. those containing indentations, ribs, grooves or other deformations produced during the rolling process, and free-cutting steel) 721450 Other bars and rods of iron or non-alloy steel, not further worked than hot-rolled, hot-drawn or hot-extruded, containing by weight >= 0,25% and < 0,6% of carbon "ECSC" (excl. those containing indentations, ribs, grooves or other deformations produced during the rolling process, and free-cutting steel) 721460 Other bars and rods of iron or non-alloy steel, not further worked than hot-rolled, hot-drawn or hot-extruded, containing by weight >= 0,6% of carbon "ECSC" (excl. those containing indentations, ribs, grooves or other deformations produced during the rolling process, and free-cutting steel) 721931 Flat-rolled products of stainless steel, of a width of >= 600 mm, not further worked than cold-rolled "cold-reduced", of a thickness of >= 4,75 mm 721932 Flat-rolled products of stainless steel, of a width of >= 600 mm, not further worked

	than cold-rolled "cold-reduced", of a thickness of >= 3 mm but < 4,75 mm 721933 Flat-rolled products of stainless steel, of a width of >= 600 mm, not further worked than cold-rolled "cold-reduced", of a thickness of > 1 mm but < 3 mm 721934 Flat-rolled products of stainless steel, of a width of >= 600 mm, not further worked than cold-rolled "cold-reduced", of a thickness of >= 0,5 mm but <= 1 mm 721935 Flat-rolled products of stainless steel, of a width of >= 600 mm, not further worked than cold-rolled "cold-reduced", of a thickness of < 0,5 mm 721990 Flat-rolled products of stainless steel, of a width of >= 600 mm, hot-rolled or cold-rolled "cold-reduced" and further worked 720711 Semi-finished products of iron or non-alloy steel containing, by weight, < 0,25% of carbon, of square or rectangular cross-section, the width measuring < twice the thickness 720719 Semi-finished products of iron or non-alloy steel containing, by weight, < 0,25% of carbon, of circular cross-section, or of a cross-section other than square or rectangular 720720 Semi-finished products of iron or non-alloy steel containing, by weight, >= 0,25% of carbon
Lighting related products	940540 Electric lamps and lighting fittings, n.e.s. 940511 Chandeliers and other electric ceiling or wall lighting fittings, solely for light-emitting diode "LED" light sources (excl. for lighting public open spaces or thoroughfares)

Motor vehicles, motorcycles, rail	870323 Motor cars and other motor vehicles principally designed for the transport of <10 persons, incl. station wagons and racing cars, with only spark-ignition internal combustion reciprocating piston engine of a cylinder capacity > 1.500 cm^3 but <= 3.000 cm^3 (excl. vehicles for travelling on snow and other specially designed vehicles of subheading 8703.10) 870331 Motor cars and other motor vehicles principally designed for the transport of <10 persons, incl. station wagons and racing cars, with only diesel engine of a cylinder capacity <= 1.500 cm^3 (excl. vehicles for travelling on snow and other specially designed vehicles of subheading 8703.10) 870332 Motor cars and other motor vehicles principally designed for the transport of <10 persons, incl. station wagons and racing cars, with only diesel engine of a cylinder capacity > 1.500 cm^3 but <= 2.500 cm^3 (excl. vehicles for travelling on snow and other specially designed vehicles of subheading 8703.10) 870322 Motor cars and other motor vehicles principally designed for the transport of <10 persons, incl. station wagons and racing cars, with only spark-ignition internal combustion reciprocating piston engine of a cylinder capacity > 1.000 cm^3 but <= 1.500 cm^3 (excl. vehicles for travelling on snow and other specially designed vehicles of subheading 8703.10) 870421 Motor vehicles for the transport of goods, with compression-ignition internal combustion piston engine "diesel or semi-diesel engine" of a gross vehicle weight <= 5 t (excl. dumpers for off-highway use of subheading 8704.10 and special purpose motor vehicles of heading 8705) 870120 Road tractors for semi-trailers 870333 Motor cars and other motor vehicles principally designed for the transport of <10 persons, incl. station wagons and racing cars, with only diesel engine of a cylinder capacity > 2.500 cm^3 (excl. vehicles for travelling on snow and other specially designed vehicles of subheading 8703.10) 840820 Compression-ignition internal combustion piston engine "diesel or semi-diesel engine", for the propulsion of vehicles of chapter 87 870422 Motor vehicles for the transport of goods, with compression-ignition internal combustion piston engine "diesel or semi-diesel

	engine" of a gross vehicle weight > 5 t but <= 20 t (excl. dumpers for off-highway use of subheading 8704.10 and special purpose motor vehicles of heading 8705) 870423 Motor vehicles for the transport of goods, with compression-ignition internal combustion piston engine "diesel or semi-diesel engine" of a gross vehicle weight > 20 t (excl. dumpers for off-highway use of subheading 8704.10 and special purpose motor vehicles of heading 8705) 860711 Driving bogies and bissel-bogies for railway or tramway locomotives or rolling stock 8711 Motorcycles, incl. mopeds, and cycles fitted with an auxiliary motor, with or without side-cars; side-cars
Electric vehicles	870380 Motor cars and other motor vehicles principally designed for the transport of <10 persons, incl. station wagons and racing cars, with only electric motor for propulsion (excl. vehicles for travelling on snow and other specially designed vehicles of subheading 8703.10)
Mineral fuels and derivatives – Various aromatic hydrocarbons	270710 Benzol 'benzene' containing > 50% of benzene 270720 Toluol 'tolene' containing > 50% of tolene 270730 Xylol 'xylenes' containing > 50% of xylenes 270740 Napthalene containing > 50% of napthalene 270750 Aromatic hydrocarbon mixtures of which >= 65% by volume

Mineral fuels and derivatives – Coal	270112 Bituminous coal, whether or not pulverized, non agglomerated 270119 Coal, whether or not pulverized, non agglomerated 270120 Briquettes, ovoids and similar solid fuels manufactured from coal 270300 Peat, incl. Peat litter whether or not agglomerated 270400 Coke, and semi-coke of coal, of lignite or of peat, whether or not agglomerated 270500 Coal gas, water gas, producer gas, lean gas and similar gases 270600 Tar distilled from coal, from lignite or from peat, and other mineral tars, whether or not dehydrated or partially distilled 270799 Oils and other products of the distillation of high temperature coal tars 270810 Pitch obtained from coal tars or mineral tars 270820 Pitch coke obtained from coal tar or from other mineral tars 271011 Light oils and preparations, of petroleum or bituminous minerals which >= 90% 270210 Lignite, whether or not pulverized, non agglomerated 270220 Agglomerated lignite
Mineral fuels and derivatives - Oil	270900 Petroleum oils and oils obtained from bituminous minerals, crude 271000 Petroleum oils and oils obtained from bituminous minerals, (excl. Crude) 271011 Light oils and preparations, of petroleum or bituminous minerals which >=90% by volume 271012 Light oils and preparations, of petroleum or bituminous minerals which >=90% by volume (excl. Containing 271019 Medium oils and preparations, of petroleum or bituminous minerals 271020 Petroleum oils and oils obtained from bituminous minerals (other than crude)
Mineral fuels and derivatives - Gas	271121 Natural gas in gaseous state 271111 Natural gas liquefied

Other ores and concentrates	26 Ores, slag and ash 260300 Copper ores and concentrates 260111 Non-agglomerated iron ores and concentrates (excl. roasted iron pyrites) 260112 Agglomerated iron ores and concentrates (excl. roasted iron pyrites) 260700 Lead ores and concentrates 260800 Zinc ores and concentrates 260900 Tin ores and concentrates
Organic chemicals	290121 Ethylene 290122 Propene "propylene"
Other energy and storage-related products	850760 Lithium-ion accumulators (excl. spent) 841490 Parts of : air or vacuum pumps, air or other gas compressors, fans and ventilating or recycling hoods incorporating a fan, n.e.s. 853650 Switches for a voltage <= 1.000 V (excl. relays and automatic circuit breakers) 903289 Regulating or controlling instruments and apparatus (excl. hydraulic or pneumatic, manostats, thermostats, and taps, cocks and valves of heading 8481) 841181 Gas turbines of a power <= 5.000 kW (excl. turbojets and turbopropellers)
Plastics and articles thereof	39 Plastics and articles thereof 392520 Doors, windows and their frames and thresholds for doors, of plastics 392010 Plates, sheets, film, foil and strip, of non-cellular polymers of ethylene, not reinforced, laminated, supported or similarly combined with other materials, without backing, unworked or merely surface-worked or merely cut into squares or rectangles (excl. self-

	adhesive products, and floor, wall and ceiling coverings of heading 3918) 392329 Sacks and bags, incl. cones, of plastics (excl. those of polymers of ethylene) 392310 Boxes, cases, crates and similar articles for the conveyance or packaging of goods, of plastics 392330 Carboys, bottles, flasks and similar articles for the conveyance or packaging of goods, of plastics 392350 Stoppers, lids, caps and other closures, of plastics
Ships and boats	890392 Motor boats and motor yachts, for pleasure or sports (other than outboard motor boats)
Solar power	848620 Machines and apparatus for the manufacture of semiconductor devices or of electronic integrated circuits 854143 Photovoltaic cells assembled in modules or made up into panels 841950 Heat-exchange units (excl. those used with boilers) 854140 Photosensitive semiconductor devices, incl. photovoltaic cells whether or not assembled in modules or made up into panels; light emitting diodes (excl. photovoltaic generators)
Wind power	850231 Generating sets, wind-powered(2002-2500); Generating sets, wind-powered(1996-2001) 761090 Structures and parts of structures, of aluminium, n.e.s., and plates, rods, profiles, tubes and the like, prepared for use in structures, of aluminium, n.e.s. (excl. prefabricated buildings of heading 9406, doors and windows and their frames and thresholds for doors) 841391 Parts of pumps for liquids, n.e.s. 848210 Ball bearings

Annex 3: Short-listing top products with the most relevant product categories based on trade and production values

In order to identify the areas where climate policies may have the greatest monetary impact on EU international trade and production, all the products at PRODCOM 8-digit level that would fall under the most relevant product categories identified in the previous step were considered for further analysis. In total, approximately 900 products were listed and ranked based on a) the average extra EU-trade value[12] and b) average EU- production value (sold production) of each product, computed over the period between 2010 and 2019. This approach underlined the most relevant products (within the categories identified in 3.2.1) and provided an indication of the relative magnitude of the impact that climate policies could have on them. In addition, consolidating the list of products and associated PRODCOM-label facilitates access to physical units for the next phase of this study. As a result of this step, a list of products was compiled including the top 50 products based on their average extra EU trade value between 2010 and 2019, as well as the top 50 products based on their EU production value. These Tables can be found in chapter *6 Annex*

Refining product categories to include non-manufacture products

To complete the preparation of the product categories and selection of the most relevant products, a final step involved incorporating products under § 3.2.1 not included in the PRODCOM data base. PRODCOM only includes manufactured goods carried out by enterprises on the national territory of the reporting EU27-countries, which means that it does not cover products that are manufactured outside the EU or products that fall outside the specified industrial activity code. For instance, products linked to A in the NACE Rev.2 classification (Agriculture, forestry and fishing) are not included. This includes, for example, products related to crop and animal production such as *live animals* or *soya beans*. In addition, the PRODCOM database does not include data on energy products-that are relevant for the purpose of this study (i.e., with high GHG emissions such as the production of coal and refined petroleum products). Finally, all the products in the categories related to *Critical materials* were included for further analysis because they are used in value chains of high economic or strategic value, are difficult to substitute for, or their sources are geographically concentrated in unstable or rival economically countries or regions). The outcome of this step of the analysis is presented in section *3.3 List of most meaningful products*

Annex 3: Products generating the largest extra-EU trade values and EU production

Table 62. Top 50 products based on average extra EU trade value (million EUR) between 2010 and 2019. Source PRODCOM.

Product (PRODCOM label)	Trade value[87]
Motor vehicles with only petrol engine > 1 500 cm³ (including motor caravans of a capacity > 3 000 cm³) (excluding vehicles for transporting >= 10 persons, snowmobiles, golf cars and similar vehicles)	81 507
Aeroplanes and other aircraft of an unladen weight > 15 000 kg, for civil use	55 006
Motor vehicles with only diesel or semi-diesel engine > 1 500 cm³ but <= 2 500 cm³ (excluding vehicles for transporting >= 10 persons, motor caravans, snowmobiles, golf cars and similar)	37 359
Vehicles with only spark-ignition engine of a cylinder capacity <= 1 500 cm³	23 972
Parts for all types of aircraft excluding propellers, rotors, under carriages, for civil use	22 017
Parts of turbojets or turbo-propellers, for use in civil aircraft	19 170
Turbojets and turbo-propellers, for civil use	13 377
Motor vehicles with only diesel or semi-diesel engine > 2 500 cm³ (excluding vehicles for transporting >= 10 persons, motor caravans, snowmobiles, golf cars and similar vehicles)	10 587
Goods vehicles with a diesel or semi-diesel engine, of a gross vehicle weight <= 5 tonnes (excluding dumpers for off-highway use)	9 791
Photosensitive semiconductor devices ; solar cells, photodiodes, phototransistors, etc.	9 574
Machines and apparatus for the manufacture of semiconductor devices or of electronic integrated circuits	7 545
Lithium-ion accumulators (excl. spent)	7 087
Oilcake and other solid residues resulting from the extraction of soya-bean oil	6 642
Copper ores and concentrates	6 394
Motor vehicles with only diesel or semi-diesel engine <= 1 500 cm³ (excluding vehicles for transporting >= 10 persons, snowmobiles, golf cars and similar vehicles)	6 348
Vehicle compression-ignition internal combustion piston engines (diesel or semi-diesel) (excluding for railway or tramway rolling stock and wheeled agricultural or forestry tractors)	6 225
Iron ores and concentrates. Non-agglomerated (excl. roasted iron pyrites)	6 057
Road tractors for semi-trailers	5 564

Motorboats and motor yachts, for pleasure or sports (excluding outboard motor boats)	5 350
Electric lamps and lighting fittings, of plastic and other materials, of a kind used for filament lamps and tubular lamps, including lighting sets for Christmas trees and LED lamps	5 065
Motor vehicles, with only electric motor for propulsion	4 804
Ceramic tiles and flags	4 547
Parts of air and vacuum pumps, of air and gas compressors, of fans, and of hoods	4 400
Grated, powdered, blue-veined and other non-processed cheese (excluding fresh cheese, whey cheese and curd)	4 339
Flat-rolled products of iron or non-alloy steel, of a width >= 600 mm, simply hot-rolled, not clad, plated or coated, in coils	4 312
Electrical apparatus for switching electrical circuits for a voltage <= 1 kV (including push-button and rotary switches) (excluding relays)	4 214
Aeroplanes and other aircraft of an unladen weight > 2 000 kg, but <= 15 000 kg, for civil use	4 160
Instruments and apparatus, regulating or controlling, n.e.c.	4 151
Parts of pumps for liquids and for liquid elevators	4 018
Frozen pig meat (excluding carcases and half-carcases, hams, shoulders and cuts thereof with bone in)	3 872
Iron ores and concentrates. Agglomerated (excluding roasted iron pyrites)	3 853
Goods vehicles with compression-ignition internal combustion piston engine (diesel or semi-diesel), of a gross vehicle weight > 20 tonnes (excluding dumpers designed for off-highway use)	3 618
Frozen fish fillets	3 582
Motorcycles with reciprocating internal combustion piston engine > 50 cm^3	3 580
Chandeliers and other electric ceiling or wall lighting fittings (excluding those used for lighting public open spaces or thoroughfares)	3 355
Hot-dipped metal coated sheet and strip of a width >= 600 mm	3 265
Frozen whole salt water fish	3 214
Gas turbines (excluding turbojets and turboprops)	3 123
Crustaceans frozen, dried, salted or in brine	3 025
Cold-rolled sheet, plate and wide strip of a width of 600 mm or more (of stainless steel)	2 976
Flat semi-finished products (of non-alloy steel)	2 862
Parts of locomotives or rolling-stock	2 798
Heat exchange units	2 676
Molluscs (scallops, mussels, cuttle fish, squid and octopus), frozen, dried, salted or in brine	2 629
Lead, zinc and tin ores and concentrates	2 604
Generating sets, wind-powered	2 569

Crude palm oil and its fractions (excluding chemically modified)	2 548
Virgin olive oil and its fractions (excluding chemically modified)	2 434
Naphthalene and other aromatic hydrocarbon mixtures (excluding benzene, toluene, xylene)	2 434
Transistors, other than photosensitive transistors	2 375

Table 63 Top 50 products based on average production value (million EUR) between 2010 and 2019. Source PRODCOM

Product (PRODCOM label)	Production value
Motor vehicles with only petrol engine > 1 500 cm^3 (including motor caravans of a capacity > 3 000 cm^3) (excluding vehicles for transporting >= 10 persons, snowmobiles, golf cars and similar vehicles)	109 634
Motor vehicles with only diesel or semi-diesel engine > 1 500 cm^3 but <= 2 500 cm^3 (excluding vehicles for transporting >= 10 persons, motor caravans, snowmobiles, golf cars and similar vehicles)	92 483
Vehicles with only spark-ignition engine of a cylinder capacity <= 1 500 cm^3	47 603
Parts for all types of aircraft excluding propellers, rotors, under carriages, for civil use	26 659
Grated, powdered, blue-veined and other non-processed cheese (excluding fresh cheese, whey cheese and curd)	25 258
Goods vehicles with a diesel or semi-diesel engine, of a gross vehicle weight <= 5 tonnes (excluding dumpers for off-highway use)	22 756
Plastic parts and accessories for all land vehicles (excluding for locomotives or rolling stock)	20 414
Sausages and similar products of meat, offal or blood and food preparations based thereon (excluding liver sausages and prepared meals and dishes)	19 702
Fresh or chilled pig meat (including fresh meat packed with salt as a temporary preservative; excluding carcases and half-carcases, hams, shoulders and cuts thereof with bone in)	17 834
Fresh or chilled cuts, of beef and veal	13 581
Motor vehicles with only diesel or semi-diesel engine <= 1 500 cm^3 (excluding vehicles for transporting >= 10 persons, snowmobiles, golf cars and similar vehicles)	12 741
Road tractors for semi-trailers	12 677
Motor vehicles with only diesel or semi-diesel engine > 2 500 cm^3 (excluding vehicles for transporting >= 10 persons, motor caravans, snowmobiles, golf cars and similar vehicles)	11 830
Vehicle compression-ignition internal combustion piston engines (diesel or semi-diesel) (excluding for railway or tramway rolling stock and wheeled agricultural or forestry tractors)	11 604
Milk and cream of a fat content by weight of > 1 % but <= 6 %, not concentrated nor containing	11 265

added sugar or other sweetening matter, in immediate packings of a net content <= 2 l	
Hot-dipped metal coated sheet and strip of a width >= 600 mm	10 633
Fresh or chilled cuts of chicken	10 503
Flat-rolled products of iron or non-alloy steel, of a width >= 600 mm, simply hot-rolled, not clad, plated or coated, in coils	10 398
Fresh or chilled carcases, half-carcases and quarters with bone in, of beef and veal	10 258
Ceramic tiles and flags	10 193
Fresh or chilled carcases and half-carcases, of pig meat (including fresh meat packed with salt as a temporary preservative)	10 152
Aeroplanes and other aircraft of an unladen weight > 15 000 kg, for civil use	10 100
Spark-ignition reciprocating internal combustion piston engines, for the vehicles of HS 87 (excluding motorcycles), of a cylinder capacity > 1 000 cm^3	10 040
Plastic doors, windows and their frames and thresholds for doors	9 884
Portland cement	9 835
Roasted coffee, not decaffeinated	9 784
Parts of turbo-jets or turbo-propellers, for use in civil aircraft	9 579
Unripened or uncured cheese (fresh cheese) (including whey cheese and curd)	9 388
Fresh or chilled hams, shoulders and cuts thereof with bone in, of pig meat (including fresh meat packed with salt as a temporary preservative)	8 844
Generating sets, wind-powered	8 431
Ethylene	8 366
Other plates..., of polymers of ethylene, not reinforced, thickness <= 0,125 mm	8 207
Aluminium structure and parts of structures..., n.e.c.	8 190
Refined white cane or beet sugar in solid form	7 779
Goods vehicles with a diesel or semi-diesel engine, of a gross vehicle weight > 5 tonnes but <= 20 tonnes (including vans) (excluding dumpers for off-highway use, tractors)	7 765
Flavoured liquid yoghurt or acidified milk (curdled milk; cream; yoghurt and other fermented products flavoured or containing added fruit; nuts or cocoa)	7 734
Virgin olive oil and its fractions (excluding chemically modified)	6 980
Butter of a fat content by weight <= 85 %	6 822
Sacks and bags of polymers of ethylene (including cones)	6 796
Goods vehicles with compression-ignition internal combustion piston engine (diesel or semi-diesel), of a gross vehicle weight > 20 tonnes (excluding dumpers designed for off-highway use)	6 741

Machines and apparatus for the manufacture of semiconductor devices or of electronic integrated circuits	6 486
Propene (propylene)	6 477
Prepared or preserved meat of swine: hams and cuts thereof (excluding prepared meals and dishes)	6 432
Plastic boxes, cases, crates and similar articles for the conveyance or packing of goods	6 337
Parts of locomotives or rolling-stock	6 326
Hams, shoulders and cuts thereof with bone in, of swine, salted, in brine, dried or smoked	6 316
Plastic carboys, bottles, flasks and similar articles for the conveyance or packing of goods, of a capacity <= 2 litres	6 211
Plastic stoppers, lids, caps, capsules and other closures	6 031
Fresh or chilled whole chickens	5 946
Hot-rolled concrete reinforcing bars	

Annex 4: Detailed results from the assessment for the macro-categories of most meaningful products

Assessment of biotic macro-categories

Table 64 Overview of the evolution of extra- EU trade and EU production between (2010-2019) for selected biotic products

Category	Top countries of import origin of selected products (2010-2019) (% of trade covered by this group)	Top EU export destinations of selected products (2010–2019) (% of trade covered by this group)	Total value of in 2019 (Imp/exp)** in billion EUR (% of the most important HS code imp/exp)	Average trade balance[88] (2010-2019) In billion EUR (Min; Max)	Total extra-EUand imports growth (2010-2019) (Growth in EU trade from largest import origin)	Total extra- EU - exports growth (2010-2019) (Growth in EU exports to most important destination)	Average EU production growth (per sub-product category) (2010-2019)[89]
Animal or vegetable fats and oils (incl. residues from oil)	1. Brazil 2. US 3. Argentina 4. Ukraine 5. Canada 6. Indonesia (79%)	1. US 2. UK 3. Brazil 4. Japan 5. Switzerland 6. Russia (64%)	€14.07/€3.09 40% 230400/67% 150910[90]	- €11.66 - €12.81 (2014) - €9.93 (2010)	18% -5% Brazil	57% 89% US	• Crude palm oil and its fractions (35%) • Virgin oil and its fractions (-8%)[91] • Oilcake and other residues resulting from soya-bean oil extrac. (-27%)
Coffee and cocoa	1. Côte d'Ivoire 2. Brazil 3. Switzerland 4. Vietnam 5. Ghana 6. Honduras (63%)	1. UK 2. Russia 3. US 4. Switzerland 5. Ukraine 6. Australia (66%)	€11.40/€1.62 51% 090111/85% 090121[92]	- €10.29 - €11.82 (2011) - €8.71 (2013)	19% 79% Côte d'Ivoire	160% 174% UK	• Roasted coffee (18%)

Dairy produce; birds' eggs; natural honey; edible products of animal origin	1. UK 2. Switzerland 3. Norway 4. Bosnia and Herzegovina 5. Turkey 6. Serbia (99%)	1. UK 2. China 3. Switzerland 4. South Korea 5. Japan 6. US (70%)	€0.46/€2.31 48% 040120/49 % 040610[93]	€1.40 €0.92 (2010) €1.85 (2019)	95% 104% UK	99% 37% UK	• Grated, powdered, blue-veined and other non-processed cheese (34%) • Milk and cream of a fat content by weight of > 1 % but <= 6 % (5%) • Unripened or uncured cheese (45%) • Butter of a fat content by weight <= 85 % (55%) • Flavoured liquid yoghurt or acidified milk (-10%) •
Edible vegetables	1. US 2. Canada 3. Argentina 4. China 5. Ukraine 6. Mexico (77%)	1. UK 2. Norway 3. Turkey 4. Switzerland 5. Serbia 6. Pakistan (42%)	€0.66/€0.14 49% 071333/56% 071310[94]	- €0.50 - €0.6 (2014) - €0.36 (2016)	29% 78% US	101% 305% UK	(PRODCOM data not available, as explained in section 3.2)
Fish and crustaceans, molluscs and other aquatic invertebrates	1. Morocco 2. India 3. Ecuador 4. UK 5. Argentina 6. Greenland (41%)	1. China 2. Nigeria 3. UK 4. Morocco 5. US 6. Japan (44%)	€8.59/€2.68 41% 0306/67% 0303[95]	- €5.24 - €6.57 (2017) - €4.04 (2013)	44% 115% Morocco	73% 285% China	• Frozen fish fillets (51%) • Frozen whole salt water fish (52%) • Crustaceans frozen, dried, salted/brine (51%) • Molluscs, frozen, dried, salted or in brine (28%)[96]
Live animals	1. UK 2. US 3. Switzerland 4. Iceland 5. Norway 6. Canada (97%)	1. UK 2. US 3. Algeria 4. Libya 5. Turkey 6. Russia (60%)	€0.52/€2.94 75% 0101/42% 0102[97]	€1.90 €1.10 (2010) €2.46 (2018)	74% 94% UK	110% 52% UK	(PRODCOM data not available, as explained in section 3.2)

Meat and edible offal	1. UK 2. Argentina 3. Brazil 4. Uruguay 5. Ukraine 6. US (88%)	1. UK 2. China 3. Japan 4. South Korea 5. US 6. Hong Kong (67%)	€2.63/€13.70 61% 0201/58% 0203[98]	€7.96 €5.34 (2010) €11.08 (2019)	29% 19% UK	86% 43% UK	• Sausages and similar products of meat, offal or blood and food preparations thereon (23%) • Fresh or chilled cuts, of beef and veal (28%) • Fresh or chilled carcases, half-carcases and quarters with bone in, of beef and veal (15%) • Prepared or preserved meat of swine: hams and cuts thereof (15%) • Hams, shoulders and cuts thereof with bone in, of swine (30%) • Frozen pig meat (97%) • Fresh or chilled pig meat (56%) • Fresh or chilled carcases and half-carcases, of pig meat (30%) • Fresh or chilled hams, shoulders and cuts thereof with bone in, of pig meat (61%) • Fresh or chilled whole chickens (14%) • Fresh or chilled cuts of chicken (75%)
Rubber	1. Indonesia 2. Thailand 3. Côte d'Ivoire 4. Malaysia 5. Vietnam 6. Nigeria (90%)	1. South Korea 2. UK 3. Russia 4. Turkey 5. Morocco 6. Switzerland (60%)	€1.68/€0.02 100% 4001 for both[99]	- €2.23 - €4.28 (2011) - €1.48 (2016)	-39% -38% Indonesia	-44% 176730% South Korea[100]	(PRODCOM data not available, as explained in section 3.2)
Sugars	1. UK 2. US 3. Mauritius 4. Mexico 5. Norway 6. China (87%)	1. UK 2. Norway 3. Switzerland 4. DRC 5. Japan 6. US (73%)	€0.003/€0.02 100% 170191 for both[101]	€0.01 €0.0018 (2014) €0.015 (2019)	54% 53% UK	60% 49% UK	• Refined white cane or beet sugar in solid form (-26%)

Animal or vegetable fats and oils (incl. residues from oil)

In this analysis, the category Animal or vegetable fats and oils consists of 6 key products, virgin olive oil, palm oil, sunflower seed or oil, soya beans, rape or colza seeds and oilcake[102]. Overall, the EU has had a trade deficit over the entire period. The value of exports has increased from €1.97 billion in 2010 reaching its maximum level in 2017 (€3.27 billion) and after a slight decrease, has remained stable since 2018 at 3.09 bn. The value of imports has increased over the period from €11.90 billion to €14.07 billion, although after a significant increase from 2010 to 2012 (€15.20 billion), imports value has been decreasing since then. Throughout the whole period, virgin olive oil has been the most important category for exports, while oilcake has been the most important category for imports.

The most important import origins are Brazil, US, Argentina, Ukraine, Canada and Indonesia, together the average annual share of imports covered by these countries is 79%. However, important to note that Brazil, while still leading by a large margin, has seen its imports to the EU-27 decrease by 5% over the period: after registering a spike increase from €4.5 billion in 2011 to €5.8 billion in 2012. In 2019, the total value of imports from Brazil was €4.2 billion, followed by the United States at €2.5 billion. The most important export destination is the United States. In 2019, the total value of exports to the United States is €0.7 billion, followed by the United Kingdom at €0.6 billion.

In terms of the EU average production growth of the products selected in this category between 2010 and 2019, the data shows that crude palm oil showed the highest growth rate 38%, suggesting an increasing demand in the EU market. In contrast, the production of oil cake and virgin oil experienced a decline of 27% and 8%.

Coffee and cocoa

In this analysis, the category Coffee and cocoa includes three key products, coffee, roasted coffee and cocoa beans[103]. Overall, the EU has had a trade deficit over the entire period, the value of exports has been steadily slightly increasing from €0.6 billion to €1.62 billion. The value of imports has also been increasing over the period from €9.6 billion to €11.4 billion, albeit some relevant fluctuations have been observed with imports value reaching their peak at €12.6 billion in 2011. Throughout the entire duration, the most important import category has been coffee and the most important export category has been roasted coffee. In 2019, the total import value for coffee was €5.9 billion and the total export value of roasted coffee was €1.4 billion.

The most important import origins are Côte d'Ivoire, Brazil, Switzerland, Vietnam, Ghana and Honduras, together the average annual share of imports covered by these countries is 63% with Côte d'Ivoire and Brazil leading by a significant margin. We note though that the imports value from these two countries have been following opposed paths, with Brazil significantly decreasing from 3.04 billion in 2011 to 1.9 billion in 2019 and Côte d'Ivoire increasing from 1.2 billion to 2.02 over the same period. The most important export destination is the United Kingdom with a total value of exports in 2019 of €0.4 billion, followed by Russia at €0.2 billion.

In terms of the EU average production growth of the products selected in this category between 2010 and 2019, the data shows that roasted coffee has had the highest growth rate of 18%.

Dairy produce; birds' eggs; natural honey; edible products of animal origin

In this analysis, the category dairy produce consists of five key products including grated cheese, milk, fresh cheese, yogurt and butter[104]. Overall, the EU has had a large and stable trade surplus over the entire period. The value of imports has been increasing (with some exceptions in 2015, 2016 and 2019) from €0.24 billion to €0.46 billion. Similarly, the value of exports has been constantly increasing every year with the exception of 2018 and reached €2.31 billion in 2019. Throughout the whole period, milk and fresh cheese represented (with 49% for both) the most important categories for imports and exports value respectively. In 2019, the total import value for milk was €0.2 billion and the total export value of fresh cheese was €1.1 billion.

The most import origins are the United Kingdom, Switzerland, Norway, Bosnia and Herzegovina, Turkey and Serbia, together covering 99% of the annual share of imports. The most important export destinations are the United Kingdom, China, Switzerland, South Korea, Japan and the United States together the average annual share of exports covered by these countries is 87%. However, the United Kingdom is at the same time and by far the most important country of origin and export destination. In 2019, the total value of imports from the United Kingdom was €0.4 billion, followed by Switzerland at €0.04 billion. In 2019, the total exports value to the United Kingdom was €0.9 billion, followed by China at €0.3 billion. Exports value to China have been significantly increasing over the period, led by milk exports, from €0.002 billion in 2010 to €0.213 billion in 2019.

In terms of the EU average production growth of the products selected in this category between 2010 and 2019, the data shows that butter showed the highest growth rate of 55%, followed by fresh cheese and grated cheese with a growth rate of 45% and 34% respectively. In contrast, the production of yogurt experienced a decline of 10%.

Edible vegetables

In this analysis, the category Edible vegetables consists of five key products including, dried peas, chickpeas, kidney beans, Bambara beans and lentils[105]. Overall, the EU has had a trade deficit over the entire period. The value of exports has been increasing over the period (with a few exceptions in 2013, 2014, 2017 and 2018), from €0.07 billion to €0.14 billion. Similarly, the value of imports has also been increasing over the period from €0.51 billion to €0.66 billion, albeit with yearly decreasing exceptions in 2013, 2016

The most important import origins are United States, Canada, Argentina, China, Ukraine and Mexico, together the average annual share of imports covered by these countries is 77%. United States and Canada are leading by a large margin. In 2019, the total value of imports from these two countries was €0.13 billion and €0.12 billion respectively. The most important export destination is the United Kingdom. In 2019, the total value of exports to the United Kingdom was €0.03 billion, followed by Norway at €0.02 billion.

Fish and crustaceans, mollusks and other aquatic invertebrates

In this analysis, the category consists of 4 key products including frozen fish fillets, frozen fish, crustaceans and mollusks[106]. Overall, the EU has had a trade deficit over the entire period. The value of exports has been slightly increasing (except in 2013) and totaled to €2.68 billion in 2019. with a significant spike from €17.22 billion in 2018 to €21.22 billion in 2019. The value of imports has also increased over the same period, but has decreased yearly in between 2011 and 2013 and again since 2017, going from €8.98 billion to €8.59 billion in 2019. Throughout the entire duration, the most important imports value category has been crustaceans, while the most important

export value category has been frozen fish. In 2019, the total import value of crustaceans was €3.52 billion and the total export value of frozen fish was €1.8 billion.

The most important import origins are Morocco, India, Ecuador, the United Kingdom, Argentina and Greenland, together counting for 41% of the average annual share of imports. The first four countries are relatively close in terms of imports value, in between €0.57 billion (UK) and €0.71 billion (Morocco), while Greenland is at €0.42 billion. However, Greenland has witnessed a significant increase in 2019, while imports from both Morocco and India have been decreasing since 2017. The most important destination country is by far China, which has been increasing since 2010 and the value of imports has more than doubled since 2016. In 2019, the total value of exports to China is €0.7 billion, followed by Nigeria at €0.2 billion.

In terms of the EU average production growth in this category between 2010 and 2019, data show that all selected products have been increasing. Frozen fish showed the highest growth rate of 52%, immediately followed by frozen fish fillets and crustaceans with a growth rate of 51%.

Live animals

In this analysis, the category Live animals consists of five key products including live horses, live bovine animals, live swine, live sheep and live poultry[107]. Overall, the EU has had a trade surplus over the entire period. The value of exports has been steadily increasing over the considered period, with a few yearly exceptions in 2013, 2014 and in 2019, reaching €2.94 billion. The value of imports has also been slightly increasing with the only exception of 2018, getting to €0.52 billion in 2019. Throughout the entire duration, the most important category in value of imports has been by far live horses, with a total import value of €0.39 billion in 2019. Live bovine animals has been the most important export value category, totaling €1.22 billion in 2019.

The most important import origins are the United Kingdom, the United States, Switzerland, Iceland, Norway and Canada, together covering 97% of the average annual share of imports. The United Kingdom leads by a large margin with a total value of imports from the UK in 2019 of €0.44 billion, followed by the United States at €0.05 billion. The main export destinations are the UK, the US, Algeria, Libya, Turkey and Russia, amounting for 60% of the average annual share. The United Kingdom and the United States are the main export destination with €0.5 billion and €0.38 billion in 2019. It is interesting to note the great fluctuations in export value to Turkey, with two peaks in 2011 (highest export value overall) and 2017, followed by swift decreases: the export value went from €0.48 billion in 2017 to €0.2 billion in 2019.

Meat and edible offal

In this analysis, the category meat and edible offal consists of six key products including meat of bovine animal, meat of swine, sausages and similar products, hams of swine, meat of horses and meat of fowls[108]. Overall, the EU has had a trade surplus over the entire period. The value of exports has been increasing between 2010 and 2019, except for stable three-year period from 2012 and 2014 and a slight decrease in 2018, which was followed by a spike in 2019, from €11.41 billion to €13.70 billion. The value of imports has also been essentially stable, with a slight overall increase from €2.04 billion in 2010 to €2.63 billion in 2019. Throughout the entire analysed timeframe, the most important export value category has been parts meat of swine, which accounted for €7.95 billion in 2019. Concerning import values, the most important category has been the meat of bovine animals, with €1.6 billion in 2019.

The most important countries of origins are the United Kingdom, Argentina, Brazil, Uruguay, Ukraine and the United States. The most important destination countries are the United

Kingdom, China, Japan, South Korea, the United States and Hong Kong. Together these groups of countries cover 88% of the annual share of imports and 67% of the annual share of exports respectively. It is interesting to note that the United Kingdom leads both groups of countries. In 2019 the total value of imports from the UK was €0.96 billion, while the total value of exports was €4.3 billion. On the export side, the UK is followed by China, which registered a significant increase from €1 billion in 2018 to €3.34 billion in 2019.

In terms of the EU average production growth, all selected products under this category registered an increase between 2010 and 2019. Frozen pig meat showed the highest growth rate of 97%, followed by fresh cuts of chicken (75%) and fresh hams (61%).

Rubber

In this analysis, the category Rubber consists of one key product, natural rubber[109]. Overall, the EU has a trade deficit over the entire period. The value of exports has been decreasing from already very low numbers throughout the period, from €0.04 billion in 2010 to €0.02 billion in 2019. Similarly, the overall trend of imports has been decreasing over the period, despite fluctuations over the years and yearly increased volumes in 2011 and 2017. In particular, the trade value of imports went from €2.73 billion in 2010 to €1.68 billion in 2019.

The most important country of origins are Indonesia, Thailand, Côte d'Ivoire, Malaysia, Vietnam and Nigeria. Together they cover 90% of the annual share of total imports. It is interesting to note that all countries followed the same evolution of import value: they all registered a peak in 2011, with Indonesia leading by a significant margin, followed by a decline until 2016, after which a new temporary peak was registered in 2017 to then decrease again in 2019 with the only exception of Thailand. Indonesia is still leading, but with a significantly reduced margin. In 2019, the total value of imports from Indonesia was €0.49 billion, followed by Thailand at €0.41 billion.

The most important export destination are South Korea, the United Kingdom, Russia, Turkey, Morocco and Switzerland. All the countries have fluctuations over the period. In 2019, the total value of exports to South Korea was €0.006 billion, followed by the United Kingdom at €0.004 billion.

Sugars

In this analysis, the category Sugars consists of one key product, Refined cane or beet sugar[110]. Overall, the EU has a trade surplus over the entire period. The value of exports has been increasing over the time frame, from €0.01 in 2010 to €0.02 billion in 2019. However, some fluctuations were registered with lowest values of €0.001 in 2011 and 2015, each followed by two peaks in 2012 and 2018. Imports have also slightly increased over the years, from €0.002 billion to €0.003 billion. Import value registered a peak of €0.009 billion in 2014, which corresponded to the lowest fluctuation in exports value.

The most important import origins are the United Kingdom, the Unites States, Mauritius, Mexico, Norway and China, representing 73% of the average annual import value. The UK leads the group with €0.002 billion followed by the United States at €0.0007 billion. The most important export destinations are the United Kingdom, Norway, Switzerland, the Democratic Republic of Congo, Japan and the United States. In 2019, the total value of exports to the United Kingdom was €0.005 billion, followed by Norway and Switzerland at €0.002 billion

In terms of the EU average production growth, the data shows that the selected product had a negative growth rate of -26%.

Assessment of abiotic macro-categories

Table 65 Overview of the evolution of extra- EU trade and EU production between (2010-2019) for selected abiotic products

Category	Top countries of import origin of selected products (2010 – 2019) (% of trade covered by this group)	Top EU export destinations of selected products (2010 – 2019) (% of trade covered by this group)	Total value of (Imp/exp)** in 2019 in billion EUR (% of the most important HS code imp/exp)	Average trade balance [111] (2010-2019) In billion EUR (Min; Max)	Total extra-EU imports growth (2010-2019) (Growth in EU trade from largest import origin)	Total extra- EU - exports growth (2010-2019) (Growth in EU exports to most important destination)	Average EU production growth (per sub-product category) (2010-2019)[112]
Aircrafts	1. US 2. China 3. Canada 4. UK 5. Brazil 6. Switzerland (88%)	1. US 2. China 3. UK 4. India 5. Japan 6. Singapore (50%)	€38.81/€71.25 50% 880240/72% 880240[113]	€27.56 €16.86(2011) € 37.06 (2015)	113% 129% US	103% 118% US	• Parts for all types of aircraft (127%) • Aeroplanes and other > 15 t (50%) • Parts of turbo-jets-propellers (91%) • Turbo-jets and turbo-propellers (152%) • Aeroplanes > 2 t but <= 15 000 kg, for civil use (-26%)
Cement, glass, ceramics and other insulation materials	1. Türkiye 2. Ukraine 3. India 4. China 5. Viet Nam 6. Switzerland (61%)	1. UK 2. US 3. Russia 4. Morocco 5. Switzerland 6. Saudi Arabia (44%)	€0.26/1.64 50% 252329/38% 690723[114]	€0.68 €0.31 (2010/11) €1.38 (2019)	91% 19% Turkey	272% 310% UK	• Ceramic tiles and flags (-8%) • Portland cement (-5%)

Critical raw materials, batteries	1. United States 2. China 3. Kazakhstan 4. United Kingdom 5. Canada 6. Japan (53%)	1. United Kingdom 2. United States 3. China 4. South Korea 5. Switzerland 6. Canada (64%)	€ 1.47/ 0.56 28% 810520/36% 810520[115]	€-0.79 €-1.24 (2019) €-0.61 (2010)	60% 45% US	84% 66% UK	• Articles of graphite (5%)
Critical raw materials, photovoltaic	1.Norway 2.China 3. United States 4.Brazil 5.South Africa 6. Russia (73%)	2. China 3. Singapore 4. Japan 5. United States 6. Taiwan 7. United Kingdom (84%)	€ 0.99/0.90 61% 280469/83% 280461[116]	€0.14 €-0.09 (2019) €0.40 (2012)	-19 % 54% Norway	-35% -9% China	• Silicon (-41#)
Critical raw materials, others	1. China 2. United States 3. United Kingdom 4. Thailand 5. Japan 6. Hong Kong (83%)	1. United States 2. Switzerland 3. Russia 4. United Kingdom 5. El Salvador 6. Viet Nam (85%)	€ 0.11/€0.06 32% 810320/34% 810320[117]	€-0.08 €-0.18 (2011) €-0.03 (2017)	-39% -42% China	19% 34% US	(PRODCOM data not available, as explained in section 3.2)

Iron and steel	1. Taiwan 2. South Korea 3. India 4. South Africa 5. Turkey 6. Vietnam (41%)	1. UK 2. Turkey 3. China 4. US 5. Switzerland 6. South Korea (57%)	€2.65/€1.87 24% 721933/20% 721933[118]	- €0,30 - €0.78 (2018/19) €0.65 (2012)	37% 7% Taiwan	-16% 9% UK	• Metal coated sheet and strip (66%) • Flat-rolled products (16%) • Flat semi-finished products (of non-alloy steel) (-24%)
Lighting related products	1. China 2. UK 3. US 4. Taiwan 5. South Korea 6. Viet Nam (91%)	1. US 2. UK 3. Switzerland 4. Norway 5. Russia 6. Saudi Arabia (53%)	€2.82/€1.94 100% 940540 for both cases[119] (only product with trade data available within this category)	- €0.68 - €0.98 (2016) - €0.23 (2010)	136% 167% China	102% 229% US	• Electric lamps and lighting fittings (9%) • Chandeliers and other electric ceiling or wall lighting fittings (19%)
Motor vehicles, bikes and motorcycles	1. UK 2. Turkey 3. Japan 4. US 5. Mexico 6. South Africa (82%)	1. UK 2. US 3. China 4. Switzerland 5. Japan 6. South Korea (63%)	€52.45/€136.98 23% 870332/49% 870323[120]	€86.67 €53.40 (2010) €104.14 (2015)	52% 5% UK	56% 41% UK	• Motor vehicles only petrol engine (10%) • Motor vehicles only diesel or semi-diesel engine (av. -27%) • Goods vehicles w. a diesel or semi-diesel engine, <= 5 t (84%) • Goods vehicles w. compression-ignition internal combustion piston

							engine (diesel or semi-diesel), > 20 t (96%) • Road tractors for semi-trailers (116%) • Vehicles with only spark-ignition engine of a cylinder capacity <= 1 500 cm^3 (115%) • Spark-ignition reciprocating internal combustion piston engines (42%) • Parts of locomotives or rolling-stock (94%) • Motorcycles with reciprocating internal combustion piston engine > 50 cm^3 (64%)
Electric vehicles	1. US 2. South Korea 3. UK 4. China 5. Japan 6. Switzerland (100%)	1. UK 2. Norway 3. US 4. China 5. Switzerland 6. Canada (92%)	€4.96/€4.61 For both cases 100% 870380[121] (only one product considered within this category)	€0.51 - €0.36 (2019) €1.16 (2017)	990% 7381% US	185% 191% UK	• Motor vehicles, with only electric motor for propulsion (280%)[122]
Mineral fuels and derivatives – Various aromatic hydrocarbons	1. United Kingdom 2. Russia 3. Turkey 4. Norway 5. Israel 6. Ukraine (79%)	1. Canada 2. US 3. China 4. Singapore 5. Malaysia 6. Switzerland (72%)	€1.44/€1.15 89% 270750/86% 270750[123]	€0.85 - €0.29 (2019) €2.06 (2017)	56% 28% UK	20% 91% Canada	• Naphthalene and other aromatic hydrocarbon mixtures (4%)
Mineral fuels and derivatives – Coal	1. Russia 2. Australia 3. US 4. Colombia 5. UK 6. Canada (82%)	1. Singapore 2. UK 3. Gibraltar 4. US 5. India 6. Saudi Arabia (39%)	€14.99/€5.17 67% 270112/75% 270799[124]	- €8.46 - €12.63 (2017) €5.31 (2011)	-71% -35% Russia	-432% 93% Singapore	(PRODCOM data not available, as explained in section 3.2)

Mineral fuels and derivatives - Oil	1. Russia 2. Saudi Arabia 3. UK 4. Nigeria 5. Iraq 6. Kazakhstan (62%)	1. US 2. UK 3. Nigeria 4. Switzerland 5. Gibraltar 6. Turkey (46%)	€276.57/€79.45 77% 270900/54% 271019[125]	- €216.80 - €301 (2012) - €128.92 (2016)	0% -25% Russia	18% 22% US	(PRODCOM data not available, as explained in section 3.2)
Mineral fuels and derivatives - Gas	1. Russia 2. Algeria 3. Norway 4. Qatar 5. Nigeria 6. US (85%)	1. Ukraine 2. Switzerland 3. UK 4. United Arab Emirates 5. Japan 6. Bangladesh (68%)	€36.57/€1.24 78% 271121/88% 271121[126]	- €38.99 - €52.29 (2011) - €24.37 (2016)	-25% -15% Russia	56% 100% Ukraine	(PRODCOM data not available, as explained in section 3.2)

Other ores and concentrates	1. Brazil 2. Canada 3. Ukraine 4. US 5. South Africa 6. Russia (57%)	1. China 2. Saudi Arabia 3. UK 4. Norway 5. Turkey 6. US (72%)	€16,40/€2,92 36% 260111/41% 260112[127]	- €14.36 - €18,56 (2011) - €10,38 (2016)	-4% -31% Brazil	115% 195% China	• Copper ores and concentrates (23%)[128] • Lead, zinc and tin ores concentrates (79%)
Organic chemicals	1. UK 2. Norway 3. US 4. Ukraine 5. Brazil 6. Saudi Arabia (82%)	1. Indonesia 2. China 3. UK 4. Taiwan 5. Singapore 6. Morocco (70%)	€2,02/€0.29 64% 290121/71% 290121[129]	- €1.29 - €1,73 (2019) - €0.89 (2014)	20% -4% UK	39% 1419% Indonesia	• Ethylene (-12%) • Propene (5%)
Other energy and storage-related products	1. China 2. South Korea 3. US 4. Japan 5. UK 6. Switzerland (75%)	1. US 2. China 3. UK 4. Russia 5. Switzerland 6. Turkey (53%)	€14.58/€14.56 39% 850760/23% 903289[130]	€2.08 - €0.02 (2019) €3.29 (2013)	164% 447% China	72% 120% US	• Lithium-ion accumulators[131] • Parts of heat pumps (…) (8%) • Electrical apparatus for switching electrical circuits for a voltage (18%) • Instruments and apparatus, regulating or controlling (23%) • Gas turbines (excluding turbojets and turboprops) (-57%) • Transistors, other than photosensitive transistors (165%)

Plastics and articles thereof	1. UK 2. China 3. Turkey 4. US 5. Switzerland 6. South Korea (72%)	1. UK 2. US 3. China 4. Turkey 5. Switzerland 6. Russia (58%)	€8.16/€16.88 51% 870899/63% 870899[132]	€9.68 €8.71 (2019) €10.34 (2013)	42% 49% UK	11% 4% UK	• Plastic parts and accessories for all land vehicles (37%) • Plastic doors, windows and their frames and thresholds for doors (19%) • Other plates..., of polymers of ethylene (13%) • Sacks and bags of polymers of ethylene (8%) • Plastic boxes, (...) articles for the conveyance or packing of goods (49)% • Plastic carboys, bottles, flasks and similar articles for the conveyance or packing of goods (22)% • Plastic stoppers, lids, caps, capsules and other closures (20) %[133]
Ships and boats	1. UK 2. US 3. Mexico 4. Turkey 5. Norway 6. Switzerland (33%)	1. US 2. UK 3. Norway 4. Turkey 5. Switzerland 6. Japan (28%)	€3.15/€5.27 100% 890392 for both cases[134]	€1.79 €0.40 (2011) €3.18 (2017	58% 423% UK	116% 396% US	• Motorboats and motor yachts, for pleasure or sports (...)(17%))
Solar power	1. China 2. South Korea 3. Japan 4. Taiwan 5. UK 6. US (75%)	1. US 2. UK 3. Singapore 4. China 5. Switzerland (56%)	€7.56/€1,69 100% 854140 for both cases[135]	- €7.25 - €22.38 (2010) - €2.25 (2015)	-68% -66% China	10% 84% US	• Photosensitive semiconductor devices; solar cells, photo-diodes, photo-transistors, etc. (-88%) • Heat exchange units (8%)

Wind power	1. China 2. UK 3. US 4. Japan 5. Switzerland 6. Turkey (79%)	1. US 2. UK 3. China 4. Turkey 5. Switzerland 6. Russia (50%)	€3.94/€8.12 37% 848210/36% 841391[136]	€4.49 €3.81 (2010) €4.91 (2016)	63% 169% China	30% 46% US	• Generating sets, wind-powered (48%) • Aluminium structure and parts of structures..., n.e.c. (21%) • Parts of pumps for liquids and for liquid elevators (45%)

Aircrafts

In this analysis, the category *Aircraft* consists of five key products including parts of aircraft and spacecraft, parts of turbojets and turbo propellers, turbojets of a thrust <= 25 kN and aeroplanes and other powered aircraft of an unladen weight > 2.000 kg but <= 15.000 kg, aeroplanes and other powered aircraft of an of an unladen weight > 15.000 kg .[137] Overall, the EU has a trade deficit over the entire period, the value of exports has been steadily increasing (albeit a few exceptions in 2011, 2014) with a spike from €65.63 billion in 2018 to €71.25 billion in 2019. Similarly, the value of imports has also been steadily increasing (albeit with exceptions in 2011, 2013 and 2014), with an increase from €35.70 billion in 2018 to €38.8 billion in 2019. Throughout the entire duration, in both cases, the most important category has been aeroplanes and other powered aircraft of an of an unladen weight > 15.000 kg. In 2019, the total import value for aeroplanes and other powered aircraft of an unladen weight > 15.000 kg was €19.52 billion, followed by parts of turbojets and turbo propellers at €16.97 billion. In 2019, the total export value for aeroplanes and other powered aircraft of an unladen weight > 15.000 kg was €51.2 billion, followed by parts of turbojets and turbo propellers at €16.6 billion.

The most important import origins are United States, China, Canada, United Kingdom, Brazil and Switzerland, together the average annual share of imports covered by these countries is 88%. However, important to note that the United States is leading by a large margin. In 2019, the total value of imports from the United States was €27.7 billion, followed by China at €1.9 billion. Similarly, the most important export destination is the United States. In 2019, the total value of exports to the United States is €14.7 billion, followed by China at €10.26 billion.

In terms of the EU average production growth of the products selected in this category between 2010 and 2019, the data shows that turbo-jets and turbo-propellers showed the highest growth rate of 152%, suggesting an increasing demand for these aircraft engines in the EU market, followed by 'parts for all types of aircraft' and 'parts of turbo-jets and propellers' with a growth rate of 127% and 91% respectively. In contrast, the production of smaller aeroplanes (weighing more than 2 tons but less than 15) experienced a decline of 26%, suggesting a reduced demand for such aircraft during this period in the EU market.

Cement and ceramics

In this analysis, the category *Cement and ceramics* contains three key products, these include Portland cement, Ceramics of a water absorption coefficient by weight > 0,5 % but <= 10 %, Ceramics of a water absorption coefficient by weight > 10 %.[138] Overall, the EU has a trade surplus over the entire period, with both the value of exports and imports showing an increasing trend with some fluctuations. The value of exports increased from €0.98 billion in 2018 to €1.64 billion in 2019. Similarly, the value of imports increased from €0.14 billion in 2018 to €0.26 billion in 2019.

The most important product is Portland cement, for both imports and exports nearly throughout the period. It is important to note that ceramics of a water absorption coefficient by weight > 0,5 % but <= 10 % has data available only from 2017 to 2019 and ceramics of a water absorption coefficient by weight > 10 % has data available only for 2019. In 2019, value of imports for Portland cement is €0.13 billion, followed by ceramics of a water absorption coefficient by weight > 10 % at €0.09 billion and ceramics of a water absorption coefficient by weight > 0,5 % but <= 10 % at €0.04 billion. In contrast, in 2019, the value of exports for ceramics of a water absorption coefficient by weight > 10 % is €0.62 billion, followed by Portland cement at €0.56 billion and ceramics of a water absorption coefficient by weight > 0,5 % but <= 10 % at €0.45 billion.

The most important import origins are Turkey, Ukraine, India, China, Vietnam and Switzerland, together the average annual share of imports covered by these countries is 61%. All countries show an overall increasing trend, with Turkey leading by a significant margin. In 2019, the total value of imports from Turkey is €0.11 billion, this is followed by Ukraine at €0.03 billion

The most important export origins are United Kingdom, United States, Russia, Morrocco, Switzerland and Saudi Arabia, together the average annual share of exports covered by these countries is 44%. Similarly, all countries show an increasing trend, with the United Kingdom and United States leading by a significant margin (for both countries there is a significant spike in volumes from 2018 to 2019). In 2019, the total value of exports to the United Kingdom is €0.33 billion, followed by the United States at €0.28 billion

In terms of the EU average production growth of the products selected in this category between 2010 and 2019, the data shows that Portland cement experienced a decline of 8%, suggesting a reduced demand for these types of products during this period in the EU market.

Critical raw materials

In this analysis, there are three categories of products that are associated with *Critical raw materials,* 'batteries', 'photovoltaic', and 'others'[139]. In the case of products used for batteries, between 2010-2019 *natural graphite*[140] was the most imported product to the EU while *cobalt mattes*[141] was the top exported. Overall, the EU had a relatively constant trade deficit over the entire period for the products included under this category, with UK being the main destination country of EU exports, and China and United States the main countries of origin of imports.

For the critical raw materials use for photovoltaic applications, silicon products[142] were dominated both the imports and exports during the entire period. Imports of these products from Norway have shown a consistent upward trend since 2010, expect for the period between 2016 and 2018. Conversely, China has been the primary destination for these products during the same period. Based on the total value reported of EU-imports, there was a significant increase of 15 774% of EU imports of antimony waste and scrap[143]; nevertheless, data gaps prevent the identification of any particular country contributing to this surge with certainty.

Finally, in the case of the products grouped under 'others' (referring to their wider use in other applications different to those mentioned above), tantalum led the imports and exports. Imports of these products from the top partners China and United States have steadily decrease since 2013. Meanwhile, the United States has been the main destination country of EU exports over the entire period. Notably, throughout the period under analysis, there was a substantial increase of EU- exports (2 217%) of niobium, tantalum or vanadium ores and concentrates to Vietnam[144] and of unwrought tantalum[145] (763%) to Russia. In the case of imports, a substantial increase (6 465%) was observed for imports from the UK of alkali or alkaline-earth metals[146] of niobium, tantalum or vanadium ores and concentrates from the United States[147] (3 949%), and of unwrought tantalum from Thailand (3 004%)[148].

Wind power products

The category *Wind Power* consists of four products which showed the highest production and trade values between 2010 and 2019. This includes wind-powered generating sets, aluminium structures and their parts, parts of liquid pumps & and liquid elevators and ball bearings.[149] Since 2010, both imports and exports of these products have been steadily increasing in value, albeit at low rates and with some exceptions, for example, in 2013. Over the entire period the EU had a trade surplus, fluctuating between €4-5 billion.[150] The most important HS codes for imports were ball bearings and parts of pumps.[151]Regarding exports pumps and generating sets are leading.[152]. Importantly, as only category, generating sets played essentially no role in imports into the EU, across the entire period. However, it is critical for the expansion of wind energy, as it contains the unit generating electrical energy.

The most important import partner, is by far China. In 2019 imports had a value of approximately €4 billion, of which China covered €1.55 billion (38.75%). No other import origin exceeds the mark of €0.5 billion. Furthermore, all other trading partners experienced a stagnation of their sales into the EU market. With respect to exports to third countries the picture is more diversified. The top six export destinations only have an annual average share of 50% in total exports. The three most important ones are the US, the UK and China. Diversification also shows in a much lower share of the top export destination (US), than the top import origin. Notable is the strong decrease of exports to the UK from 2017 onwards.

The production of all products but ball bearings has increased. Ball bearings are also one of the most important imported products, interestingly together with parts for pumps and liquid elevators which despite a strong production increase did not decrease in imports. Generating sets grew by 48%, which is a possible explanation for the low import rate of this product throughout the entire period.

Other Energy and Storage-related products

The grouping *Other Energy and Storage-Related Products* subsumes seven products, lithium-ion accumulators, equipment to compress gas, electrical switches, regulating instruments, gas turbines below 5000kW,transistors with a dissipation rate above 1W and heat-exchange units.[153] Imports were lower than exports in 2010. However, over the period in question this trade surplus constantly decreased and vanished in 2019. The main driver of the growth in imports are Lithium-ion accumulators.[154] Trade of these products started in 2012 and then increases from €0.82 billion to €5.64 billion in 2019. This product plays only a small role in exports. Furthermore, export growth in exports is spread across the different HS codes.

The biggest import origin for the selected products is China. It has increased significantly in importance since 2017 and supplied 33% of import value (€4.78 billion) in 2019. This is slightly less than the following partners, South Korea, the US and Japan, together. Besides China, it is notable that, South Korea was the smallest importer in this group in 2010 but is now on the second place, even overtaking the US in 2017. With respect to European exports the most relevant partners from 2010 to 2019 are the US and China. In 2019, the export value was €2.68 billion for the US and €2.16 billion for China. Both countries have increased since 2014, whereas other partners largely stagnated. Exports are more diversified than imports, as the selected six partners only make up 53% of exports. However, within this group there is concentration on China and the US.

Production of goods in this category has increased for all but one product. However, apart from non-photosensitive transistors, which grew by 165% growth rates are small. The product that decreased are gas turbines, specifically by 57%. The remaining products have increased by 6-23%. Interestingly, the products with low production growth rates are the most important for exports, namely, electrical switches and parts of heat pumps.

Solar power products

The analysis of products related to *Solar Power* focuses on one HS code, photosensitive semiconductors, as there is no data available for the HS code for photovoltaic cells in modules or panels.[155] Importantly, photovoltaic cells are also included in the HS code for photosensitive semiconductors. The EU has a trade deficit across the entire period, however, from 2013 until 2019 it is significantly smaller than from 2010 to 2012. To illustrate the development of trade in photosensitive semiconductors, in 2010 imports of them amounted to €23.91 billion. In 2013, trade of these semiconductors decreased to €5.23. Exports were worth €1.53 billion in 2010 and €1.69 in 2019. A peak was reached in 2015 with €2.85 billion.

The most important import origin is China. This is most notable in 2010 and 2011, before the imports of photosensitive semiconductors started to decline. From 2013 to 2018 import value from China is close to that of other partners, however, started to steeply increase in 2019 again. All other partners remained stagnant over the entire period. The most important export destinations are the US, China and the UK. Importantly, the US and the UK showed strong fluctuations, most notably a strong increase and subsequent decrease in exports to the UK from 2014 to 2018. In 2019, the US and China are fairly close to each other, with China overtaking the UK in this year.

European production of photosensitive semiconductors strongly decreased, by 88%,

Organic chemicals

The category *Organic Chemicals* consists out of two key products for the chemical industry ethylene and propene (also known as propylene), both falling into HS 29.[156] Imports and exports

of the selected products are close to each other over the entire period, however since 2014, the EU has a trade deficit. Generally, imports and exports of ethylene are more important than trade in propylene and has been driving growth. Consequently, the trade deficit increased in 2019, as exports of ethylene have decreased by more than half.

The most important import origin over the entire period is the UK. Highly notable is that imports to the UK increased in 2017, following Brexit. However, in 2019 imports decrease by €0.25 billion (21%) and imports from the US increased by €0,27 billion. Despite this decrease, the UK supplied roughly 50% of all imports in 2019. Another important partner is Norway, which had low but steady growth rates since 2016. With respect to exports, historically the most important partners are Indonesia, China and UK. Notable there is an extreme increase of export value in 2012, followed by an equivalent drop in 2013/2014. It is noted, however, that the observed drop might be associated with data gaps, as data regarding certain key export partners (most notably China between 2012 and 2014) is missing.

With respect to production figures, despite ethylene being the more important trading good, production decreased by 12% over the entire period. Contrary to that, production of propene increased marginally by 5%.

Ores, slag and ash

The group *Ores, Slag and Ash* of selected products consists of certain types of copper, iron, lead, zinc and tin.[157] All selected products are associated with the HS2 code 26. There is a trade deficit for the EU over the entire period analysed for both the HS2 category and the selected products. In both cases, the deficit decreased from 2011 until 2016 but started to increase again afterwards. The decrease until 2016 is largely due to a decrease of imports of non-agglomerated iron. Regarding imports and exports, the most important products are copper and non-agglomerated iron.[158] Growth for both trade flows is generally incremental over the entire period, except exists for imports, which rapidly grew in 2017.

The top six import partners deliver 57% of the total value of imports, showing a greater diversification than in other groups. Nevertheless, trade with the two leading partners (Brazil and Canada) has a much higher value than with other countries. Together these partners deliver 57% of the total value of imports. Important to note is that whilst Brazil remains the leader, trade has significantly decreased since the peak in 2011. In turn, imports from the second and third most important importers (Canada and Ukraine) have grown since 2016. Particularly, Canada is starting to become more important. By far the most important export destination is China. The following five are all roughly of similar and rather low value. In 2019, €1.16 billion (40%) went to China. In comparison, only €0.27 billion (9%) went to Saudi Arabia, the second biggest export market. Exports to China have risen since 2014, with a strong increase in 2018. Notable is also the decrease in exports to Norway beginning in 2018.

Production has increased for all products for which data is available. Cooper increased over the entire period by 23%. Lead, zinc and tin are grouped together and increased overall by 79%. Despite this strong growth these products do not play a significant role in exports, indicating a large share of domestic consumption. Unfortunately, no data is available for iron, which is, together with copper, a important trading good for imports and exports.

Plastics and articles thereof

Plastics and Articles Thereof consists of seven products, which have been highly traded and produced during the period of analysis. This includes plastic parts for land vehicles, plastic doors,

windows and their frames, polymers of ethylene (including sacks and bags), some plastic articles for the conveyance or packing of goods (e.g., carboys, bottles and others), and plastic closures (e.g., plastic stoppers, lids, caps, capsules and other closures)[159] The selected products (excl. plastic parts for land vehicles) are responsible for 8% of imports and 9% of exports of the commodity group 'Plastics and articles thereof' (HS-39). For HS 39, the EU has a trade surplus over the entire period in question, the same holds true for the products short-listed which amounted in 2019 for €7,45 billion of imports and €14,82 billion of exports. In both cases the most important HS code is parts for land vehicles.[160] In 2019 it made up 53% of imports and 72% of exports.

The most important import origins of the macro-category are somewhat diversified. The UK, China and Turkey all have large shares, however, the UK leads over the entire period with a pronounced gap to China. In 2019, it was responsible for 28% of all imports. Overall, imports from all partners are increasing, strongest for China, with a total growth of 53%. A notable increase across import origins occurred in 2014 and 2015, with imports from several countries growing by more than 20%. The most important export destinations for the selected products are the UK and the US. The UK is the leading export destination throughout the entire period. In 2019, 21% of EU exports went to this destination, showing a relatively diversified export profile. Exports generally increase of the entire period as well, albeit with a maximum of 30% for China. However, for Turkey exports have decreased by 5%. Despite China experiencing the strongest growth it remains on the third place.

In this category virtually all products experienced production growth in the EU. This is strongest for plastic articles for the conveyance or packing of goods, which increased by 49%. However, it does not play a major role in imports nor exports. The production of plastic parts for land vehicles is important for trade and has increased in production by 37%. Interestingly, its growth in export value is less evident than the growth in import value, indicating that despite domestic production growth, demand is still higher. Export value even decreased when comparing only 2010 to 2019.

Mineral fuels and derivatives – Coal

The product selection for C*oal* consists of 12 HS codes, bituminous coal, coal, briquettes and other fuels manufactured from coal, coal gas and other gases, tar distilled from coal or other materials, oils and other products of the distillation of high temperature coal tars or similar products, pitch obtained from coal or other mineral tars, pitch coke from coal or mineral tars, light oils or preparations for it, lignite, agglomerated lignite and peat.[161] In 2010 and 2011 the EU had a trade surplus in this selection, however, since 2012 the trade deficit has been very stable. Furthermore, overall trade value declined strongly in 2012 and never fully recovered. However, the explanation for this deficit might be the unavailability of data for light oils from 2012 onwards, which were of extremely high importance for both imports and exports. Beyond light oils, bituminous coal played an important role for imports throughout the entire period. Since 2017, a change of exports can be observed as oils and other products distilled from tars have significantly increased in value, however, in no way resembling the importance of light oils.

Crucial importers are Russia, Australia and the US. However, from 2017 many partners start to decline, which also began to affect Russia and the US in 2019. Together the top six importers make up 82% of import value. For exports the picture is very different, as the top six only cover 39%. Furthermore, most have been stagnant at fairly low export values below €1 billion.

Mineral fuels and derivatives – Natural Gas

The category N*atural Gas* is made up out of two HS codes, natural gas in gaseous state and liquified natural gas.[162] From 2010 to 2019 the EU is at a trade deficit in this group which shrunk from 2011 until 2016 to then grow again. This trend is due to changes in imports, as exports remain flat throughout the relevant period. Imports are historically dominated by gaseous gas, however, in 2018/2019, liquified gas started to play a bigger role. Regarding export the pattern fluctuates. In some years, such as 2013/2014 liquified gas is more important than gaseous gas and in other years, such as 2017 and 2019 the opposite is the case.

Most important import origin is Russia followed by Algeria. In 2016, imports from Russia were equivalent in value to imports from Algeria but increased afterwards again while Algeria stagnated. In 2019 trade with almost all partners decreases save the US. The six biggest importers provide an annual average of 85% of all imports. The picture of exports is highly volatile. Exports to several countries have been highly important in certain years, only to then decrease substantially in the next year. In 2019, the most important export destination was by far Ukraine. Historically, the UK and Switzerland have also been vital.

Mineral fuels and derivatives – Oil

The category *Oil* consists out of the selected products crude petroleum oil from bituminous minerals, certain types of further refined petroleum oil from bituminous minerals, different types of light oils and preparations of petroleum oil or bituminous minerals, medium oils and preparations of petroleum oil from bituminous minerals and refined petroleum oils and oils obtained from bituminous minerals and preparations.[163] Oil is the most important mineral fuel with respect to value of trade, the EU imported the selected products for €363 billion and exported them for €103 billion. On average, the selected products make up 76% of imports and 79% of exports subsumed under the HS code for mineral fuels. This trade deficit is observable throughout the entire period. Both imports and exports are highly concentrated on a few products. With respect to imports, crude petroleum oils dominate.[164] In exports it is medium and light oils.[165] In both cases, other products essentially play no role, throughout the entire period.

The single most important import origin is Russia, however, due to the total value of the category, other importers are between €10-20 billion. The pattern of all importers is similar. They increase until 2013, decrease strongly until 2016 and then slightly increase until 2018. In the case of Russia, the decrease is by more than €60 billion. With respect to exports there is less strong concentration on a single partner, nevertheless, over the entire time the US is the leading destination. Two trends are notable, a decrease across many partners from 2013 until 2016 and a subsequent increase that is sustained until 2019.

Mineral fuels and derivatives – Various aromatic hydrocarbons

The selection of the group V*arious Aromatic Hydrocarbons* is different types of benzol, toluol, xylol, naphthalene and aromatic hydrocarbon mixtures.[166] Unlike the other mineral fuel categories the EU is at a trade surplus throughout most of the period in question. This surplus significantly increased in 2016 and 2017 but then shrunk again and turned into a slight deficit in 2019. Aromatic hydrocarbon mixtures dominate imports as well as exports.[167] Before 2015, benzol also played an important role for imports.[168] Other than this exception, the other products have not played a major role in affecting the trade value. The remarkable increase in the trade surplus is almost entirely due to an increase in exporting aromatic hydrocarbon mixtures.

The most important import origin is historically the UK. Imports from here strongly increased until 2012 to then equivalently decrease. Since then the UK and Russia have a comparable value. In 2019, Turkey sharply increased as a import origin and is closely behind Russia. The top six import origins cover an annual average of 70%, whereas they cover 82% of all exports. Until 2018, China was the most important export destination. Since that year, however, most partners sharply dropped in value and only exports to Canada increased in value. Notable is also a strong increase in exports to Singapore in 2016, which vanished in the subsequent year again.

Lighting

In this analysis, the category *Lighting* consists of two key products, this includes electric lamps and light fittings and chandeliers and other electric lighting fittings, solely for LED light sources (however, the chandeliers and electric ceiling code has no data available in COMEXT).[169] Overall, the EU has a trade deficit during the entire period. The value of imports has been steadily increasing over the years, from €1.20 billion in 2010 to €2.82 billion in 2019. Similarly, the value of exports has also been steadily increasing from €0.96 billion in 2010 to €1.94 billion in 2019.

The most important import origins of the electric lamps and light fittings are China, the UK and the US, together the average annual share of total imports covered by the countries are 91%. However, important to note that China is leading by a large margin. In 2019, the total value of imports for China was €2.34 billion, followed by the United Kingdom at €0.15 billion. Similarly, the most important export destinations are United States, United Kingdom, Switzerland, Norway, Russia, Saudi Arabia, together the average annual share of exports covered by these countries are 53%. In 2019, the EU export volumes to the United States was €0.29 billion, followed by the United Kingdom at €0.28 billion in 2019.

In terms of the EU average production growth of the products selected in this category between 2010 and 2019, the data shows that chandeliers and other electric ceiling or wall lighting fittings had a higher growth rate of 19%, suggesting an increased demand for these products in the EU market, compared to electric lamps and light fittings that have a growth rate of 9%.

Ships and boats

In this analysis, the category *Ships and Boats* consists of one key product I.e., motorboats and motor yachts, for pleasure or sports.[170] Overall, the EU has a trade surplus over the entire period, the value of exports has been rather steadily increasing (except for the year 2013), for instance, the trade value of exports increased from €4.81 billion in 2018 to €5.27 billion in 2019. Similarly, the overall trend for the value of imports has been increasing, despite there being fluctuations over the course of the year. The trade value of imports has fluctuated between approximately €1-2 billion from 2010 to 2018, it then spiked up from €1.79 billion in 2018 to €3.15 billion in 2019. In 2019, the total import value for motorboats and motor yachts was € 3.15 billion and the total export value was € 5.2 billion.

The most important import origins are UK, which is leading, followed by US, Mexico, Turkey, Norway, Switzerland, together the average annual share of total imports covered by the countries is 33%. The UK is leading by a significant margin. In 2019, the total value of imports for

the UK was €1.10 billion, followed by the United States at €0.13 billion. The most important export destinations are the US, which is leading, followed by the UK, Norway, Turkey, Switzerland and Japan. All the countries (except for Japan and Turkey that have remained relatively stable throughout) have fluctuations during the entire duration, ranging from €0.03 billion to €0.93 billion however, show an overall trend of increasing export values. In 2019, the total value of exports to the United States was €0.73 billion, followed by the UK at €0.18 billion.

In terms of the EU average production growth of motorboats and motor yachts, the data shows that they have a growth rate of 17% in the EU market.

Motor vehicles, motorcycles, bicycles and rail

In this analysis, the category, *Motor vehicles, motorcycles, bicycles and rail* consists of 12 key products. The most significant products include motor cars vehicles (with only diesel engine of a cylinder capacity > 1.500 cm^3 but <= 2.500 cm^3), motor cars and other motor vehicles (with only diesel engine of a cylinder capacity > 1.500 cm^3 but <= 3.000 cm^3), motor cars and other motor vehicles (with only spark ignition internal combustion engine of a cylinder capacity > 1.500 cm^3 but <= 3000 cm^3).[171]

Overall, the EU has a trade surplus over the entire period. The value of exports has been steadily increasing from €87.8 billion in 2010 to €151.5 billion in 2015, then it remains relatively stable fluctuating between €151.5-154 billion from 2015 to 2017. This is followed by a notable decline from €154 billion in 2017 to €136.9 billion in 2019. Similarly, regarding the value of imports, there are slight fluctuations ranging from €34.4 billion in 2010 to €39.4 billion in 2014, this is then followed by a notable increase to €55.3 billion in 2017, followed by a slight decline to €52.4 billion in 2019.

The products with the most significant import values are motor cars and vehicles (with only diesel engine of a cylinder capacity > 1.500 cm^3 but <= 2.500 cm^3), followed by motor cars and other motor vehicles (with only diesel engine of a cylinder capacity > 1.500 cm^3 but <= 3.000 cm^3). In 2019, the total import values for motor cars and vehicles (with only diesel engine of a cylinder capacity > 1.500 cm^3 but <= 2.500 cm^3) was €11.9 billion and for motor cars and other motor vehicles (with only diesel engine of a cylinder capacity > 1.500 cm^3 but <= 3.000 cm^3) was €11.16 billion.

Similarly, the products with the most significant export values are motor cars and other motor vehicles (with only spark ignition internal combustion engine of a cylinder capacity > 1.500 cm^3 but <= 3000 cm^3), which leads by a significant margin, followed by motor cars and other motor vehicles (with only diesel engine of a cylinder capacity > 1.500 cm^3 but <= 2.500 cm^3). In 2019, the total export values for motor cars and other motor vehicles (with only spark ignition internal combustion engine of a cylinder capacity > 1.500 cm^3 but <= 3000 cm^3) was €66.7 billion and for motor cars and other motor vehicles (with only diesel engine of a cylinder capacity > 1.500 cm^3 but <= 2.500 cm^3) was €20.1 billion.

The most important import origins are United Kingdom, Turkey, Japan, United States, Mexico and South Africa, together the average annual share of total imports covered by these countries

is 82%. The lead import origin is the United Kingdom, however, important to note that there has been a consistent decline in trade volumes from €16.30 billion in 2016 to €10.1 billion in 2019, this is followed by the Turkey that has an overall increasing trend in trade volumes, however there is a slight decline from €9.51 billion in 2018 to €8.80 billion in 2019.

The most important export destinations are United Kingdom, United States, China, Switzerland, Japan, South Korea, together the average annual share of total exports covered by these countries is 63%. The lead export origin is the United Kingdom, that like import volumes, also has a decline in export volumes from €45.10 billion in 2016 to €35.72 billion in 2019, this is followed by the United States, that also has a decline in export volumes from €26.52 billion in 2017 to €22.79 billion in 2019.

In terms of the EU average production growth of the products selected in this category between 2010 and 2019, the data shows that road tractors for semi-trailers had the highest growth rate of 116%, suggesting an increasing demand for this product in the EU market, followed by vehicles of only spark-ignition engine of a cylinder capacity <=1500 cm^3 at 115%. In contrast, motor vehicles with only diesel or semi diesel engine > 2500 cm^3 experienced a negative decline of 31%, suggesting a reduced demand for these types of vehicles during this period in the EU market.

Electric vehicles

In this analysis, the category, *Electric vehicles* contains one key product, motor cars and other motor vehicles principally designed for the transport of <10 persons, with only electric motor for propulsion.[172] It is important to note that for this category there is data available only for the years 2017, 2018 and 2019. Overall, the EU has a trade surplus during the entire period, with both the values of imports and exports increasing during the three-year time span. The value of imports increased from €0.46 billion in 2017 to €1.25 billion in 2018 to €4.96 billion in 2019, similarly, the value of exports increased from €1.6 billion in 2017 to €1.9 billion in 2018 to €4.6 billion in 2019.

The most important import origins are United States, South Korea, United Kingdom, China, Japan and Switzerland, together the average annual share of total imports covered by the countries is 100%. The lead import origin is the United States, with trade volumes increasing from €0.05 billion in 2018 to €3 billion in 2019, this is followed by South Korea, whose trade volumes increased from €0.37 billion in 2018 to €1.04 billion in 2019.

The most important export destinations are United Kingdom, Norway, United States, China, Switzerland and Canada, together the average annual share of total imports covered by the countries is 92%. The lead export destination is the United Kingdom, with trade volumes increasing from €0.50 billion in 2018 to €1.45 billion in 2019, this is followed by Norway, with trade volumes increasing from €0.79 billion in 2018 to €1.26 billion in 2019.

In terms of the EU average production growth of electric vehicles between 2017 and 2019, the data shows that they have a significant growth rate of 280% in the EU market.

Iron and steel

In this analysis, the category *Iron and steel* contains 14 key products, all of which fall under the associated HS2 code that covers all products related to iron and steel. The most significant products include flat rolled products of steel (of a thickness of > 1 mm but < 3 mm), flat rolled products of steel (of a thickness of >=0.5 mm but <= 1 mm), semi-finished products of iron or non-alloy steel (width measuring < twice the thickness), flat rolled products of steel (of a thickness of >=3 mm but <4.75 mm).[173]

Overall, there is a trade deficit for the entire period for both the 14 key products analysed, as well as the HS2 code. There are fluctuations in the overall trends for both import and export values. The import values show an overall increasing trend with values ranging between €28 billion in 2010 to €33 billion in 2019 (except for the year 2018). The export values show a slight decline in the last five years of this period, with values ranging between €30 billion in 2010 to €29 billion in 2019.

The products with most significant import values include flat rolled products of steel (of a thickness of > 1 mm but < 3 mm), flat rolled products of steel (of a thickness of >=0.5 mm but <= 1 mm), semi-finished products of iron or non-alloy steel (width measuring < twice the thickness). In 2019, the total import values for flat rolled products of steel (of a thickness of > 1 mm but < 3 mm was €0.63 billion, followed by flat rolled products of steel (of a thickness of >=0.5 mm but <= 1 mm) at €0.61 billion, followed by semi-finished products of iron or non-alloy steel (width measuring < twice the thickness) at €0.5 billion.

Similarly, the products with the most significant export values include flat rolled products of steel (of a thickness of > 1 mm but < 3 mm), flat rolled products of steel (of a thickness of >=3 mm but <4.75 mm). In 2019, the total export values for flat rolled products of steel (of a thickness of > 1 mm but < 3 mm) was €0.36 billion, followed by flat rolled products of steel (of a thickness of >=3 mm but <4.75 mm) at €0.27 billion.

The most important import origins are Taiwan, South Korea, India, South Africa, Turkey, Vietnam, together the average annual share of total imports covered by these countries is 41%. Overall, all the countries have increasing trade volumes with fluctuations throughout the period. The lead import origin is Taiwan with trade volumes declining from €0.39 billion in 2018 to €0.31 billion in 2019, this is followed by South Korea, whose trade volumes remained consistent at €0.26 billion from 2018 to 2019, India follows closely behind with a spike in trade volumes from €0.18 billion in 2016 to €0.34 billion in 2019.

The most important export destinations are United Kingdom, Turkey, China, United States, Switzerland, South Korea, together the average annual share of total exports covered by these countries is 57%. Overall, all the countries have increasing trade volumes with fluctuations throughout the period, except for Turkey, which appears to have a slight decline in trade volumes. The lead export origin is the United Kingdom, with trade volumes declining from €0.36 billion in 2018 to €0.33 billion in 2019, this is followed by Turkey, with trade volumes declining from €0.25 billion in 2018 to 0.23 billion in 2019, this is followed by the United States, with trade volumes declining from €0.35 billion in 2018 to €0.24 in 2019.

In terms of the EU average production growth of the products selected in this category between 2010 and 2019, the data shows that hot-dipped metal coated sheet had the highest growth rate of 66%, suggesting an increasing demand for this product in the EU market. In contrast, flat semi-finished products (of non-alloy steel) had a negative decline of 24%, suggesting a reduced demand for these types of products in the EU market during this period.

Annex 5: Detailed methodology to anticipate the consumption volume (in functional units) in 2050

To estimate the trade value for each product in 2050, the following methodology was employed:

a. *For products related to the transport sector, for which the long-term strategu (LTS provide data on % annual demand growth, baseline (2015-2030 and 2030-2050), and activity change to the 2050 baseline for the different scenarios.*

1. Collection of data. For each product, data was collected including:
    - Data about annual growth rates (2015-2030 and 2030-2050), extracted for passenger transport activity by 2050 in the baseline scenario (average growth rates per year) and in the scenarios reaching -80% to net zero emissions by 2050 (percentage changes relative to the baseline in 2050)[1] . For instance, annual demand growth for road passenger transport activity, baseline (2015-2030) is predicted to be 0.7%
    - Data on the percentage changes in activity in 2050 compared to the baseline (e.g., -3% for road transport in the 1.5TECH LTS compared to the baseline in 2050)
    - Data on the shares (%) of different drive train technologies in the total vehicle stock for the baseline, 1.5TECH and 1.5LIFE LTS (e.g., electric cars share predicted to be 80% by 2050 for 1.5 TECH LTS)
    - Data of trade volumes and quantities in 2019: Data on the volume of imports i.e. quantities (IMPQNT), exports (EXPQNT), and production (PRODQNT) for all products in the list. QNTUNIT, which provides the unit in which the volume data is available.
2. Estimation of EU demand in 2019 of each product. The EU demand in 2019 (EU DEMAND) for each product was estimated using apparent consumption, which is calculated by adding production and imports while subtracting exports. Note the limitations of this approach, including the possibility of negative figures, as mentioned in the PRODCOM user's manual2:

    EU DEMAND 2019 = IMPQNT + PRODQNT – EXPQNT.

    The total demand in 2019 for product groups, such as passenger transport, was estimated by aggregating the demand for relevant products within each group. This involved summing the individual demands for specific products like petrol vehicles and diesel vehicles, considering their respective contributions to the overall demand within the passenger transport category.
3. Estimation of proportions of exports, imports, and production over demand in 2019 Computed the proportions of exports, imports, and production over demand in 2019 for each product by dividing the respective volume data (IMPQNT, PRODQNT, and EXPQNT) by EU DEMAND 2019.
4. Estimation of the demand for the product group in 2030 and 2050 (Baseline) using the corresponding annual demand growth rates by 2030 and 2050. This involved projecting the known demand in 2019 forward in time and calculating its growth over the years (2019 to 2030) based on the provided annual growth rate. We then applied the same approach to estimate the demand for the product group in 2050.
5. Correction of the demand in 2050 (Baseline) for the 1.5TECH and 1.5LIFE LTS for the product group by applying the percentage changes in activity for the 1.5TECH and 1.5LIFE LTS to the baseline demand for 2050 (e.g., of passenger transport)
6. Estimation of the future consumption for each product within the product group for the 1.5TECH and 1.5LIFE scenarios using the the shares of relevant vehicle stock predicted for that year. The total number of personal vehicles was split between power train technologies (various types of internal combustion engines, electric), as per the selected Long-Term Scenarios.

b. *For products in other sectors different from transport, for which the LTS provide data on % annual demand growth (not activity change).*

1. Collection of data. For each product, data was collected including:

    - Data about annual demand growth rates for the periods 2015-2030 and 2030-2050 for the different scenarios (Baseline, 1.5TECH, 1.5LIFE). For instance, for renewable energy products data was mostly extracted from the power generation capacity forecast [3]

    - Trade data of 2019: Data on the volume of imports i.e. quantities (IMPQNT), exports (EXPQNT), and production (PRODQNT) for all products in the list. QNTUNIT provides the unit in which the volume data is presented. For some products, PRODCOM data is not available, and therefore, COMEXT data was used. In these cases, PRODQNT values are not available.

2. Estimation of EU demand in 2019 of each product was estimated (EU DEMAND) for products for which PRODQNT is available: . The EU demand in 2019 (EU DEMAND) for each product was estimated using apparent consumption, which is calculated by adding production and imports while subtracting exports. Note the limitations of this approach, including the possibility of negative figures, as mentioned in the PRODCOM user's manual.

    EU DEMAND 2019 = IMPQNT + PRODQNT – EXPQNT

3. Estimation of proportions of exports, imports, and production over demand in 2019 Computed the proportions of exports, imports, and production over demand in 2019 for each product by dividing the respective volume data (IMPQNT, PRODQNT, and EXPQNT) by EU DEMAND 2019.

4. Estimation of the demand for the product group in 2030 and 2050 (Baseline) for products for which PRODQNT is available, by using the corresponding annual demand growth rates by 2030 and 2050. This involved projecting the known demand in 2019 forward in time and calculating its growth over the years (2019 to 2030) based on the provided annual growth rate. We then applied the same approach to estimate the demand for the product group in 2050.

5. Estimation of the volume of imports and exports by 2030 and 2050 (Baseline) for products for which PRODQNT is NOT available, by using corresponding annual demand growth rates for products by 2030 and 2050. It was considered that the imports grow according to the demand growth rate

    This was done by first starting with the known demand in 2019 and projecting its growth over the years (2019 to 2030) based on the given annual growth rate. Following the same approach, the 2050 demand for different producs were estimated. This allowed us to estimate the future demand for the specified product by 2030 and 2050.

6. Estimation of the future consumption for each product within the product group for the 1.5TECH and 1.5LIFE scenarios If applicable, the number of functional units was converted into quantities of products using substitution factors in some specific, but important, cases:

    - The proteins and fats brought by animal-based products (beef, pork, dairy products) were converted into proteins and fats brought by legumes, oils and nuts, as per substitution factors detailed in Annex 6;

The subsequent methodological steps were followed for all products:

7. To forecast the future consumption of each product, we projected a demand growth rate from 2019 to 2050 considering the LTS scenarios. The anticipated demand growth for each product is detailed in the summary table below.

8. The future value of imports and exports was estimated based on the projected future consumption. This future consumption, expressed in physical units, was then converted into economic value by applying the expected prices per functional unit as derived from the following sources:

    - For abiotic products: the prices per functional unit from the techno-economic forecasts used in other assessments by the European Commission[4];

    - For biotic products: the prices per tonne anticipated by the *EU agricultural outlook 2022-32*[5];

9. A "Competitiveness Multiplier (CM)" was computed for imports (resp. for exports) of manufactured products, dependent upon the scenario (optimistic or pessimistic) regarding the competitiveness of EU producers for the most traded climate-relevant manufactured products, itself based on data on:

    - for imports: the current and anticipated future share of the EU internal demand covered by imports, in each of the competitiveness scenarios (Optimistic or Pessimistic);
    - for exports: the current and anticipated future share of the global demand covered by EU producers, in each of the competitiveness scenarios (Optimistic or Pessimistic);

    In both cases, the current value is based on the data available from sector associations and from external studies. Future value is estimated based on the consultants' expert view on representative figures in each of the contrasted scenarios;

10. The future value of **imports** in a given scenario was computed as per the following formula: Future value of imports = Value of imports in 2050 x Competitiveness Multiplier for imports;

11. The future value of **exports** in a given scenario was computed as per the following formula: Future value of exports = Value of exports in 2050 x Competitiveness Multiplier for exports

For abiotic products, in addition to insights from the survey and expert inputs, relevant sectorial reports were consulted that provide information on market and demand forecasts, as well as data regarding the current and anticipated future share of EU demand covered by imports and share of global demand covered by EU exports. This data served as a basis for estimating the CM for each product category of abiotic products.

The trade of biotic products under opposite scenarios of EU competitiveness was not considered and thus CM were not derived for these products. This approach was followed for two main reasons. First, the competitive positions of agricultural products, including biotic products, are primarily influenced by climatic and soil aspects., which tend to be more stable over time compared to the dynamic nature of manufacturing industries. As a result, it is reasonable to expect the current competitive position of the EU for biotic products to remain relatively stable until 2050. Secondly, the lack of sufficient data for biotic products (compared to the selected abiotic products) renders it more challenging to quantitatively assess the precise impact of climate and energy policy on biotic products' competitiveness.

A summary of the competitiveness multipliers and rationale used are presented below.

Table 1 02 Overview of main assumptions used for the estimation of trade values in an optimistic and pessimistic scenario of the competitiveness of EU producers

Product group		Anticipation of future consumption Demand growth between 2019[1]- 2050	Anticipation of competitive position: Competitiveness Multipliers (CM) Optimistic			Pessimistic		
			Imports	Exports	Assumption /Rationale	Imports	Exports	Assumption /Rationale
Personal vehicles with internal combustion engine (ICE)	Petrol vehicles, Spark-Ignition vehicles, motorcycles, diesel vehicles	Passenger transport activity (average growth rates per year) and shares in total cars stock by drivetrain technology in the 1.5TEC/1.5LIFE scenarios by 2050	1	1	Competitiveness position of the EU is assumed to remain unchanged due to limited data to quantitatively assess the precise impact of climate and energy policy on these products' competitiveness in the future	1	1	Competitiveness position of the EU is assumed to remain unchanged due to limited data to quantitatively assess the precise impact of climate and energy policy on these products' competitiveness in the future
EVs	Electric personal vehicles		0.7	1	Importers' market share decreases (from ca. 20% in 2022 to 15% in 2050). EU's share of the world market is assumed to remain unchanged due to limited data to derive another assumption.	2	0.33	Importers' market share in the EU doubles (from ca. 20% in 2022 to 40% in 2050). The EU's share of the world market shrinks at 5%

[1] *For all products the estimation of future trade values are based on 2019 value of imports and exports. The only exception for this approach is electric vehicles, for which 2022 values were used given the considerbly large increase in trade of this product between 2019 and 2022.*

Product group		Anticipation of future consumption Demand growth between 2019[1]- 2050	Anticipation of competitive position: Competitiveness Multipliers (CM) Optimistic			Pessimistic		
			Imports	Exports	Assumption /Rationale	Imports	Exports	Assumption /Rationale
								(current value of the EU's share of the world market is considered to be 15%[2])
Goods vehicles	Light and heavy commercial vehicles	Inland freight transport activity (average growth rates per year) and in the 1.5TECH and 1.5LIFE scenarios by 2050	1	1	Competitiveness position of the EU is assumed to remain unchanged due to limited data to quantitatively assess the precise impact of climate and energy policy on these products' competitiveness in the future	1	1	Competitiveness position of the EU is assumed to remain unchanged due to limited data to quantitatively assess the precise impact of climate and energy policy on these products' competitiveness in the future
Railway & tramway	Various railway and tramway vehicles,	Passenger transport activity (average growth rates per year) in the 1.5TECH and 1.5LIFE scenarios by 2050 for rail,	1	1		1	1	
Aircraft	Aeroplanes and other aircraft and turbo-jets and propellers for civil use	Passenger transport activity (average growth rates per year) in the 1.5TECH and 1.5LIFE scenarios by 2050 for aviation	1	1		1	1	
Cruise vessels	Cruise vessels	Passenger transport activity (average growth rates per year) in the 1.5TECH and 1.5LIFE scenarios by 2050 for inland navigation	1	1		1	1	
Solar power	Photosensitive semiconductor devices; solar cells, photo-diodes, photo-transistors, etc.	Based on solar power generation capacity for the baseline, 1.5TECH/1.5LIFE scenarios	0.96	1	Gains in production capacity anticipated by the current investment plans[3] in the EU for the solar PV industry are successful, however, EU manufacturers of PV cells focus their efforts on the EU internal market. The current dominance of Chinese manufacturers remains unchanged.[4] The future share of EU manufacturers increases to 4% (current market share <1%)[5]	1	0.5	Gains in production capacity anticipated by the current investment plans in the EU are unsuccessful. The current situation of domination by Chinese competitors remains. US' strategic campaign promoting PV products made in the USA[6] impacts negatively EU manufacturers.
Wind power	Generating sets, wind-powered	Growth of annual demand estimated based on power generation capacity for the baseline, 1.5TECH/1.5LIFE scenarios (average of wind onshore and wind offshore)	1	1	EU manufacturers maintain their current leading position in the world market.[7]	1.33	0.5	EU manufacturers lose their current leading position on the world market so that their share of the world reduces from the current approximate level

[2] *Based on IEA (2023), Global EV Outlook 2023, IEA, Paris https://www.iea.org/reports/global-ev-outlook-2023, License: CC BY 4.0*

[3] *Bettoli, A. et al. (2022) Building a competitive solar-PV supply chain in Europe, McKinsey & Company. Available at: https://www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/building-a-competitive-solar-pv-supply-chain-in-europe (Accessed: 10 July 2023)*

[4] *IEA (2022), Solar PV Global Supply Chains, IEA, Paris https://www.iea.org/reports/solar-pv-global-supply-chains License: CC BY 4.0. The world will almost completely rely on China for the supply of key building blocks for solar panel production through 2025. Based on manufacturing capacity under construction, China's share of global polysilicon, ingot and wafer production will soon reach almost 95%*

[5] *Based on Bettoli, A. et al. (2022) Building a competitive solar-PV supply chain in Europe, McKinsey & Company. Available at: https://www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/building-a-competitive-solar-pv-supply-chain-in-europe (Accessed: 10 July 2023).*

[6] *Groom, N. and Lawder, D. (2023) US Treasury takes Middle Road on solar panels 'made in the USA', Reuters. Available at: https://www.reuters.com/markets/us/us-treasury-takes-middle-road-solar-panels-made-usa-2023-05-12/ (Accessed: 11 July 2023).*

[7] *Based on WOOD MACKENZIE(2021) Extract: Global wind turbine OEMs 2020 market share*

Product group		Anticipation of future consumption Demand growth between 2019[1]- 2050	Anticipation of competitive position: Competitiveness Multipliers (CM) Optimistic			Pessimistic		
			Imports	Exports	Assumption /Rationale	Imports	Exports	Assumption /Rationale
								of 40%[8] to around 20%. In terms of imports, the share of the RoW increases from currently 60% of world market to 80%)[9]
Other energy & storage	Lithium-ion accumulators (excl. spent accumulators), heat exchange units, lithium primary cells and primary batteries and gas turbines (excluding turbojets and turboprops).	For lithium-ion accumulators, and for lithium cells and batteries, it was assumed that consumption grows proportionally with EVs demand. For heat exchangers and gas turbines, growth is expected to be aligned with the forecasted changes in the EU GDP.	0.2; 1[10]	1	Concerning imports of batteries, the massive investment programme for the production of EV batteries is successful so that imports are evicted from the EU market, with 90% covered by EU producers.[11] Regarding exports, it was considered that EU battery manufacturers manage to cope with the gigantic growth in domestic demand and to conquer EU market share, while keeping their current market share in the export markets, leading to a CM of 1. The competitiveness position of EU producers of heat exchangers and gas turbines remains unchanged.	1	0.7, 1[12]	The massive investment programme for the production of EV batteries is unsuccessful so that imports continue their domination of the EU market. Competitiveness position of EU producers of heat exchangers and gas turbines remains unchanged.
Electric lighting fittings	Electric lamps and lighting fittings	Evolution of the energy consumption in buildings in 2050 (compared to 2005) considering the average value between appliances and lighting for residential and services	1	1	Competitiveness position of the EU is assumed to remain unchanged due to limited data to quantitatively assess the precise impact of climate and energy policy on these products' competitiveness in the future	1	1	Competitiveness position of the EU is assumed to remain unchanged due to limited data to quantitatively assess the precise impact of climate and energy policy on these products' competitiveness in the future
Ethylene & propylene	Ethylene & propylene	Gross inland consumption of non-energy use (oils) in the baseline, 1.5TECH/1.5LIFE scenarios by 2050	1	1	Competitiveness position of the EU is assumed to remain unchanged due to limited data to quantitatively assess the precise impact of climate and energy policy on these products'	3	1	It is anticipated that the CBAM scope will be expanded to include the chemical sector.[13] Despite this, in a pessimistic scenario, this analysis considers

[8] *Ibid*

[9] *Ibid*

[10] *A competitive multiplier of 0.2 has been applied for Lithium-ion accumulators (excl. spent accumulators), and lithium primary cells and primary batteries. This multiplier has been derived under the premise of a significant increase of the participation of EU producers in the market, wherein the current import market share of approximately 50% (as gauged from the highest market import share for batteries in 2019, as indicated by PRODCOM data for 'Lithium primary cells and primary batteries') is anticipated to contract notably, ultimately reaching 10%. A CM of 1 was considered for heat exchangers and gas turbines.*

[11] *EUROBAT(2020) EU battery demand and Supply (2019-2030) in a global context - EUROBAT. Available at: https://www.eurobat.org/wp-content/uploads/2021/05/Avicenne_EU_Market_-_summary_110321.pdf (Accessed: 9 July 2023).*

[12] *A competitive multiplier of 0.7 has been applied for Lithium-ion accumulators (excl. spent accumulators), and lithium primary cells and primary batteries. This factor accounts for the assumption that ca. 30% of extra-EU exports of batteries (which are today roughly going to the US and China) could be displaced by local competitors. A CM of 1 was considered for heat exchangers and gas turbines.*

[13] *Deal reached on new carbon leakage instrument to raise global climate ambition: News: European parliament (2022) Deal reached on new carbon leakage instrument to raise global climate ambition | News | European Parliament. Available at: https://www.europarl.europa.eu/news/en/press-room/20221212IPR64509/deal-reached-on-new-carbon-leakage-instrument-to-raise-global-climate-ambition (Accessed: 8 July 2023).*

Product group		Anticipation of future consumption Demand growth between 2019[1]- 2050	Anticipation of competitive position: Competitiveness Multipliers (CM) Optimistic			Pessimistic		
			Imports	Exports	Assumption /Rationale	Imports	Exports	Assumption /Rationale
					competitiveness in the future			that imports of both ethylene and propylene will increase from an average of 10% in 2019 to 30% in 2050.
Cement & ceramics	Ceramic tiles and portland cement	Growth is expected to be alligned with the forecasted changes in the EU GDP, assuming a proportional relationship between sectorial growth and the overall EU economic performance.	1	1	Competitiveness position of EU producers assumed to remain unchanged due to limited data to derive another assumption.	5	0.3	The effectiveness of the Carbon Border Adjustment Mechanism (CBAM) in preserving the cost competitiveness of the sector is limited, resulting in a continued loss of market share for EU manufacturers.[14] The multiplier factor for imports is set at 5, indicating that imports are anticipated to cover approximately 10% of the overall demand. Currently, the share of imports in the demand for cement stands at 2%.[15] Due to the low transportability of cement and its relatively low price, imports of this product remain modest compared to other goods like steel or iron. Multiplier factor for exports is set to 0.3 assuming a gradual reduction in exports over the next decades.
Iron & steel	A range of steel and iron products, incl. hot-dipped metal coated sheets and strips,flat-rolled products, etc.	Growth is expected to be alligned with the forecasted changes in the EU GDP, assuming a proportional relationship between sectorial growth and the overall EU economic performance.	1	1	Competitiveness position of EU producers assumed to remain unchanged due to limited data to derive another assumption.	3	0.125	The effectiveness of the CBAM in preserving the cost competitiveness of the sector is limited, resulting in a continued loss of market share for EU manufacturers. Specifically, the multiplier factor for imports is 3, suggesting that imports are projected to cover the majority of the

[14] Overall for this product category, the EU has a trade surplus over the entire period (2010-2019), with both the value of exports and imports showing an increasing trend with some fluctuations. See Annex 4 for a detailed analysis of historical trade data.
15 Estimated based on quantities of imports and exports in 2019 for Portland cement from PRODCOM data. An estimation of consumption was esimated by calculating production + imports - exports.

Product group		Anticipation of future consumption Demand growth between 2019[1]- 2050	Anticipation of competitive position: Competitiveness Multipliers (CM) Optimistic			Pessimistic		
			Imports	Exports	Assumption /Rationale	Imports	Exports	Assumption /Rationale
								demand. Currently, the average share of imports in the demand for the products considered stands at 26%.[16] Conversely, the multiplier factor for exports is 0.125, consistent with the gradual reduction in exports by half every decade, following the recent trends.
Ores & concentrates	Copper, iron and lead, zinc, and tin ores & concentrates	Growth is expected to be alligned with the forecasted changes in the EU GDP, assuming a proportional relationship between sectorial growth and the overall EU economic performance.	1	1	Competitiveness position of EU producers assumed to remain unchanged due to limited data to derive another assumption.	1	1	Competitiveness position of EU producers assumed to remain unchanged due to limited data to derive another assumption.
Plastics	Plastic windows & frames, plates, bags, boxes, containers and closures	Gross inland consumption of non-energy use (oils) in the baseline, 1.5TECH/1.5LIFE scenarios by 2050	1	1	Competitiveness position of EU producers assumed to remain unchanged due to limited data to derive another assumption.	3	1	It is anticipated that the CBAM scope will be expanded to include the plastics sector.[17] Despite this, in a pessimistic scenario, this analysis considers that plastic products will increase from an average of 8% in 2019 to 20% in 2050.
Aromatics	Benzene, toluene, xylenes naphthalene, other aromatic hydrocarbon mixtures	Gross inland consumption of non-energy use (oils) in the baseline, 1.5TECH/1.5LIFE scenarios by 2050	1	1	Competitiveness position of EU producers assumed to remain unchanged due to limited data to derive another assumption.	1	1	Competitiveness position of EU producers assumed to remain unchanged due to limited data to derive another assumption.
Coals	Various types of coal and related products (incl. bituminous coal, high-temp coal tar oils, etc.)	Gross inland consumption of fossil fuels (solids) in the baseline, and 1.5TECH/1.5LIFE scenarios by 2050	1	1	Competitiveness position of EU producers assumed to remain unchanged due to limited data to derive another assumption.	1	1	Competitiveness position of EU producers assumed to remain unchanged due to limited data to derive another assumption.
Oils	Petroleum oils, and preps. containing petroleum oils	Gross inland consumption of fossil fuels (liquids) in the baseline, 1.5TECH/1.5LIFE scenarios by 2050	1	1	Competitiveness position of EU producers assumed to remain unchanged due to limited data to derive another assumption.	1	1	Competitiveness position of EU producers assumed to remain unchanged due to

16 Estimated based on quantities of imports and exports in 2019 for selected iron&steel products from PRODCOM data. An estimation of consumption was esimated by calculating production + imports - exports.

[17] Deal reached on new carbon leakage instrument to raise global climate ambition: News: European parliament (2022) Deal reached on new carbon leakage instrument to raise global climate ambition | News | European Parliament. Available at: https://www.europarl.europa.eu/news/en/press-room/20221212IPR64509/deal-reached-on-new-carbon-leakage-instrument-to-raise-global-climate-ambition (Accessed: 8 July 2023).

Product group		Anticipation of future consumption Demand growth between 2019[1]- 2050	Anticipation of competitive position: Competitiveness Multipliers (CM) Optimistic			Pessimistic		
			Imports	Exports	Assumption /Rationale	Imports	Exports	Assumption /Rationale
								limited data to derive another assumption.
Natural gas	Natural gas in gaseous state and liquefied	Consumption of natural gas in the baseline, and 1.5TECH/1.5LIFE scenarios by 2050	1	1	Competitiveness position of EU producers assumed to remain unchanged due to limited data to derive another assumption.	1	1	Competitiveness position of EU producers assumed to remain unchanged due to limited data to derive another assumption.
Hydrogen[18]	Hydrogen	Consumption of gaseous fuels hydrogen. [19]	1	1	Competitiveness position of EU producers assumed to remain unchanged due to limited data to derive another assumption.	1	1	Competitiveness position of EU producers remains unchanged
Critical Raw Materials (CRM), batteries	Graphite (articles and natural graphite), cobalt (incl. mattes, products, waste and articles, and ores, and concentrates) and lithium oxide hydroxide	Annual growth based on the estimated growth of EVs consumption	1.80(graphite) 1.51 (cobalt) 1.69 (lithium)	1	The massive investment programme for the production of EV batteries is successful Imports of raw materials rises proportionally with that of batteries produced in the EU modulated by recyclability efforts by the sector. Therefore, the expansion factor for imports was considered as the multiplier of the market share for EU manufacturers of batteries (see category above *other energy & storage)* multiplied by a factor equal to (1 - (share of recycled raw materials in batteries prescribed in the revised Batteries Regulation)[20]	1	1	Competitiveness position of EU producers remains unchanged The massive investment programme for the production of EV batteries is unsuccessful so that imports continue their domination of the EU market.
Critical Raw Materials(CRM), others		Annual growth based on the estimated growth of EVs consumption	1	1	Competitiveness position of EU producers remains unchanged	1	1	Competitiveness position of EU producers remains unchanged
Critical Raw Materials (CRM), photovoltaic		Based on solar power generation capacity for the baseline, 1.5TECH/1.5LIFE scenarios	4	1	The (ca-4 fold) gains in production capacity anticipated by the current investment plans in the EU for the solar PV industry are successful.[21]	1	0.5	Gains in production capacity anticipated by the current investment plans in the EU are unsuccessful. The current situation of domination by Chinese competitors

[18] *Our methodology takes the current value of imports and exports to estimate the future value of trade However, when it comes to hydrogen, existing trade databases do not differentiate between green hydrogen and fossil-fuel-based hydrogen. As a result, despite the significant predicted increase in hydrogen demand according to the 1.5 TECH scenario (from 0 MToe in 2030 to 68 Mtoe in 2050), trade values remain relatively low. It is important to note that this is the best data currently available. We have adjusted the current value of hydrogen consumption by incorporating the current values of green hydrogen production capacity. As per the provided source (https://energy.ec.europa.eu/system/files/2023-03/COM_2023_156_1_EN_ACT_part1_v6.pdf), approximately 0.3 million tonnes of electricity-based hydrogen are produced in the EU (approximately 0.85 Mtoe)*

[19] *In Figure assumes that hydrogen consumption in 2015-2030 is zero. This value was corrected to add current values of hydrogen production capacity. 0.3 million tonnes of electricity-based hydrogen are produced in the EU. (see https://energy.ec.europa.eu/system/files/2023-03/COM_2023_156_1_EN_ACT_part1_v6.pdf) .*

[20] *The regulation provides for mandatory minimum levels of recycled content for batteries of 16% for cobalt and 6% for lithium. See https://www.consilium.europa.eu/en/press/press-releases/2023/07/10/council-adopts-new-regulation-on-batteries-and-waste-batteries/*

[21] *Bettoli, A. et al. (2022) Building a competitive solar-PV supply chain in Europe, McKinsey & Company. Available at: https://www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/building-a-competitive-solar-pv-supply-chain-in-europe (Accessed: 10 July 2023)*

Product group		Anticipation of future consumption Demand growth between 2019[1]- 2050	Anticipation of competitive position: Competitiveness Multipliers (CM) Optimistic			Pessimistic		
			Imports	Exports	Assumption /Rationale	Imports	Exports	Assumption /Rationale
								remains. US' strategic campaign promoting PV products made in the USA impacts negatively EU manufacturers,

Table 0-3 Overview of main assumptions used for the estimation of trade values in an optimistic and pessimistic scenario of the competitiveness of EU producers

Product group		Anticipation of future consumption Demand growth between 2019 - 2050
Beef and veal products	Beef and veal cuts and carcasses	Beef consumption of beef in the diet 4 scenario.[22]
Pork products	Pig meat, carcasses, cuts and frozen	Pork consumption of beef in the diet 4 scenario.
Milk products		Milk consumption of beef in the diet 4 scenario.
Other diary products	Cheese, yoghurt, and butter	Milk consumption of beef in the diet 4 scenario.
Vegetable oils	Virgin and crude olive oil; palm oil sunflower/safflower oil; rape, colza or mustard oil	Population projections (Eurostat)[23]. For rape, colza or mustard oil, growth was considered to be proportional to the demand for liquid biofuel in the transport sector by 2050 for the 1.5 LIFE scenario. In addition, vegetable oils substituting beef, pork and milk production were considered. See details in Annex 6 (detailed methodology for the functional substitution of animal-based products with plant-based products)
Legumes	Soybeans and soybean residues; dried peas, chickpeas, kidney beans, broad beans and lentils	Population projections (Eurostat). For soybeans and soybeans residues, growth was considered to be proportional to the demand for soya used for animal feedstock based on the consumption of animal products predicted by the diet 4 scenario. In addition, legumes substituting beef, pork and milk production were considered. See details in Annex 6 (detailed methodology for the functional substitution of animal-based products with plant-based products)
Nuts	Groundnuts and nuts, shelled and sunflower seeds, peeled	Population projections (Eurostat). In addition, nuts substituting beef, pork and milk production were considered. See details in Annex 6 (detailed methodology for the functional substitution of animal-based products with plant-based products)

22 Diet 4 scenario is described in detail in section 4.6.2. of the In-depth analysis in support of the Commission Communication COM (2018)773

23 Data set available at: https://ec.europa.eu/eurostat/databrowser/product/page/TPS00002

Annex 6: Detailed methodology for the functional substitution of animal-based products with plant-based products

The identification of a list of animal products and consequent potential substitute products was the first step towards the definition of a methodology for the functional substitution of animal-based products with plant-based products. Please refer to chapter 3.2 for a more detailed description on the list of products. Three criteria have been used for the selection of animal-based products: their relevance in terms of both the EU agri-food trade balance and of their global environmental impact and their consideration in the LIFE 1.5 scenario – Diet 4. Beef and veal meat, pork meat and milk meet these criteria.

Plant products have been selected by looking at main ingredients for available plant-based alternative products to meat and dairy, following available literature, and considering their nutritional profiles. To this regard, it is important to specify that, in defining the substitution methodology, it was decided not to take any specific processed alternative to animal products as reference substitute products. The main reason behind this choice was to avoid any biased commercial approach, while focusing on complementary substitute products in terms of nutritional intake rather than truly nutritionally interchangeable products. Based on this approach, two key nutritional elements have been identified: fats and proteins.

To determine the functional substitution coefficient between the different chosen categories of animal and plant-based products, nutritional values for the fats and proteins content as well as overall kcal of each category and individual products have been investigated using the Ciqual database developed by the French Agency for Food, Environmental and Occupational Health & Safety (ANSES). Ciqual is one of the most comprehensive food composition tables in Europe and provides the nutritional composition of over 3,000 foods consumed in France: lipids, proteins, carbohydrates, sugars, fatty acids, salt, vitamins and minerals. Three categories of plant-based alternatives have been considered following the presence of these nutritional elements: legumes, nuts and oils.

A combination of the nutritional values of fats and proteins have been used to calculate the substitution coefficients for animal-based products. The nutritional values were sourced from two plant-based alternatives:

- For fats: a combination of nuts and oils was considered
- For proteins: a combination of legumes and nuts.

Maintaining at least one of the two plant-based substitutes, in this case nuts, allowed to consider the proteins already provided by the nuts in the final coefficient. To do so, a distribution of 1/3 – 2/3 between nuts and oils and nuts and legumes for fats and proteins coefficients respectively was operated. This distribution is based on the assumptions that nuts are more expensive compared to oils and legumes and that it would be more difficult to use them and source them as replacements, despite their nutritional efficiency.

Finally, it was assumed that the difference in kcal intake between the diet baseline and the diet 4 in the LIFE 1.5 scenario for the same set of animal-based products would have to be substituted by plant-based alternatives. Available data in kcal/capita/day have been converted to grams to be able to compare with trade flows.

Annex 7: Survey on the anticipated impacts of trade liberalisation on the EU sectors of climate change-mitigating goods & services

Questionnaire used in the survey of stakeholders of climate change-mitigating goods

8.7.1 Information on the respondent

To what category does your organisation belong?

- Industry association – general
- Industry association – GHG-intensive goods or services
- Industry association – climate-change mitigating goods & services
    - If yes: please specify the goods / services
- EU chamber of commerce in third country
    - If yes: please specify country
- Industrial trade union

8.7.2 Goods and services of interest

'Climate change-mitigating goods & services' already considered

For each good or service in the list below of 'Climate change-mitigating goods & services', please state if this good or service is of interest to your organisation: (max 3 answers, including additional goods / services)

1. Refrigerants alternative to hydrofluorocarbon (HFC)
2. Onshore wind power
3. Offshore wind power
4. Utility scale PV
5. Distributed solar PV
6. Concentrated solar power
7. Biomass
8. Geothermal
9. Small hydropower
10. Tidal systems
11. Biogas stoves
12. High-efficiency heat pumps
13. Waste-to-energy systems (transition solutions)
14. Solar water heaters
15. Efficient motors (rated international efficiency 3 or higher)
16. LED lighting
17. Solar cookstoves
18. High-performance glass
19. Insulation materials
20. Smart thermostats
21. Building automation systems
22. Hydrogen
23. Electric trains
24. Electric cars
25. Carbon capture and storage

Additional 'climate-change mitigating goods & services'

What additional good or service, that you believe contributes significantly to the mitigation of climate change and hence can be qualified as a 'climate change-mitigating good or service', is of interest to your organisation? Please specify as well the sectors in which these goods and services are used. (free text up to 75 characters)

- Additional 'climate change mitigating good or service' n°1
- Additional 'climate change mitigating good or service' n°2
- Additional 'climate change mitigating good or service' n°3
- Additional 'climate change mitigating good or service' n°4
- Additional 'climate change mitigating good or service' n°5

8.7.3 Competitive position of the European Union in the design and manufacture of 'Climate change-mitigating goods & services'

Current competitive position in product design

For each of the 'climate change-mitigating goods & services' of interest to your organisation and listed below (same selection of products initially selected under section 1.2.1), please state what the competitive position is of EU manufacturers compared to non-EU manufacturers, regarding the design of products. [Very weak / Weak / Equal / Strong / Very strong / No opinion]

Please explain why [Free text, maximum 500 characters]

Current competitive position in product manufacturing

For each of the 'climate change-mitigating goods & services' of interest to your organisation and listed below (same selection of products initially selected under section 1.2.1), please state what the competitive position is of EU manufacturers compared to non-EU manufacturers, regarding the manufacturing of products. [Very weak / Weak / Equal / Strong / Very strong / No opinion]

Please explain why [Free text, maximum 500 characters]

Near future competitive position in product design in the context of a transition to a net-zero economy

For each of the 'climate change-mitigating goods & services' of interest to your organisation and listed below (same selection of products initially selected under section 1.2.1), please state what the near future competitive position is of EU manufacturers compared to non-EU manufacturers, regarding the design of products in the near future. [Very weak / Weak / Equal / Strong / Very strong / No opinion]

Please explain why [Free text, maximum 500 characters]

Near future competitive position in the manufacturing of products in the context of a transition to a net-zero economy

For each of the 'climate change-mitigating goods & services' of interest to your organisation and listed below (same selection of products initially selected under section 1.2.1), please state what the near future competitive position is of EU manufacturers compared to non-EU manufacturers, regarding the manufacturing of products in the near future. [Very weak / Weak / Equal / Strong / Very strong / No opinion]

Please explain why [Free text, maximum 500 characters]

Long-term competitive position in the manufacturing of products in the context of a transition to a net-zero economy

For each of the 'climate change-mitigating goods & services' of interest to your organisation and listed below (same selection of products initially selected under section 1.2.1), please state what the long-term competitive position is of EU manufacturers compared to non-EU manufacturers, regarding the manufacturing of products in the long term. [Very weak / Weak / Equal / Strong / Very strong / No opinion]

Please explain why [Free text, maximum 500 characters]

Long-term competitive position in the design of products in the context of a transition to a net-zero economy

For each of the 'climate change-mitigating goods & services' of interest to your organisation and listed below (same selection of products initially selected under section 1.2.1), please state what the long-term competitive position is of EU manufacturers compared to non-EU manufacturers, regarding the design of products in the long term. [Very weak / Weak / Equal / Strong / Very strong / No opinion]

Please explain why [Free text, maximum 500 characters]

8.7.4 Preferences regarding the liberalisation in the trade of 'Climate change-mitigating goods & services'

Nature of the trade policy measures

For each of the 'climate change-mitigating goods & services' of interest to your organisation and listed below, please state if the following trade policy tools should be applied: [Strongly Disagree / Disagree / Neutral / Agree / Strongly Agree / No opinion]

Table with:

- List of 'climate-change mitigating goods & services' of interest to the organisation, following answers provided in § 1.2.1 and in § 1.2.2
- Trade policy tools =
    - elimination of tariffs and quotas
    - lower tariffs or higher quotas compared to conventional goods of the same category
    - elimination of non-tariff barriers (e.g., harmonization or mutual recognition of regulations, requirements, etc.)
    - reduction in non-tariff barriers (e.g., approximation of regulations, requirements, etc.)

For each of the 'climate change-mitigating good or service' for which you 'disagree' or 'strongly disagree' with a trade liberalisation, please explain why. (max 500 characters)

Conditions to be set for the liberalisation of trade

For each of the 'climate change mitigating goods & services' of interest to your organisation and listed below, please state if the following condition, bearing on the behaviour of the trading partners, should be set for a liberalisation of trade in this good or service: [Strongly Disagree / Disagree / Neutral / Agree / Strongly Agree / No opinion]

Table with:

- List of 'climate-change mitigating goods & services' of interest to the organisation, following answers provided in § 1.2.1 and in § 1.2.2
- Conditions:
    - Enforcement of Intellectual Property Rights owned by EU-based companies in the sector
    - Fair treatment of EU-based companies in the sector regarding the verification of compliance of their products with national regulations
    - Access by EU companies in the sector to public procurement by national and sub-national entities
    - Freedom of establishment by EU companies in the sector (including licences to operate, etc.)
    - Abolition of public subsidies to R&D
    - Abolition of public subsidies to investment (CAPEX)
    - Abolition of public subsidies to production (OPEX)

Annex 8: Complete results of the survey of stakeholders of climate change-mitigating goods

Competitive position of the European Union in the design and manufacture of 'Climate change-mitigating goods & services'

8.8.1 Current competitive position in product design and manufacturing

Wind power: In terms of product design and manufacturing, a majority of respondents consider onshore and offshore wind power to be strong. Respondents mentioned that there are a good number of European leaders in the market, this includes players like Vestas, Siemens Gamesa, Nordex, Enercom. As a result of advances in systems engineering, manufacturing techniques and expertise in the development of components, these factors have contributed to enabling wind power players to deliver industry leading products which can cope with a broad range of high torques and ultimately reduce the levelized cost of wind energy.

Certain respondents explained why they considered on shore wind to be weak. The company ZF, which creates products for wind turbines, said they were powering more than 80,000 wind turbines with gearboxes representing 180 GW of installed capacity. In the meantime, their largest Chinese competitor, NGC, has been benefitting from lower energy costs, labour salaries and material costs and now has a dominant position in the Chinese market. Additionally, with the recent opening of NGC's new production facilities, their total production capacity now exceeds 50 GW in total, exceeding the global gearbox production capacity of the two European wind power market leaders combined (Flender and ZF). Additionally, it was also mentioned that European manufacturers had been struggling with innovating their platforms and ensuring prices were low (which is required mostly due to competition from PV), while also raising their prices enough to cover the cost of inflation, mostly on commodities. Respondents suggest that other markets, specifically China, has been better at passing on the costs (to the consumer?) resulting in their manufacturers being in a better financial condition.

Additionally, respondents also indicate that there is an impact from former national and EU legislation and framework conditions that resulted in the bankruptcy of many existing European manufacturers.

Table 1.1 Current competitive position in product design and manufacturing for onshore and offshore wind power

Wind power	Type of services	Value	Percentage of respondents	Number of responses
On shore wind power	Product design	Strong	66.7%	2
		Weak	33.3%	1
Off shore wind power	Product design	Strong	100%	1
		Weak	-	-
On shore wind power	Product manufacturing	Strong	-	-
		Weak	50%	1
		Equal	50%	1
Off shore wind power	Product manufacturing	Strong	100%	1
		Weak	-	-
Overall total		Strong	-	4
		Weak	-	2
		Equal	-	1

Solar power: A significant number of respondents indicated that the current competitiveness of solar energy is very weak, especially for utility scale PV and distributed solar PV. In the case of utility scale PV, respondents indicated it was weak because most of the manufacturing now takes place in China. In terms of product design, there are a few European manufacturers that are well positioned, but are slower than Chinese competitors in bringing design innovations to the market at the scale required. One of the key reasons is there are small scale production capacities in Europe and huge PV import pressure, due to the large-scale production in other countries and restricted import policies in the US. In terms of product manufacturing, the entire supply chain is dominated strongly by Chinese manufacturers who have been able to scale up very fast, partly due to long lasting, local and stable incentives. In addition to this, it is increasingly more expensive to manufacture solar PV modules in Europe due to it being a non-level playing field, compared to partners in other countries who have lower electricity prices and labour costs, higher production scale, stable sustainability criteria, amongst other factors.

In the case of distributed PV, one of the respondents that indicated it was strong, said it was the case because European PV manufacturers can provide customised PV solutions for the distributed solar installations, including building integrated PV and other similar characteristics adapted to European domestic conditions. Other respondents indicated that the competitiveness conditions for distributed solar PV are a little better than the conditions for the utility scale PV, specifically due to consumers intentions to buy more expensive, but European produced PV products. However, a majority of respondents indicated that distributed PV was weak for the same reasons mentioned for utility scale PV.

In the case of concentrated solar power (CSP), respondents that indicated it was weak mentioned that despite innovative projects and leading technologies being present in this sector, there appeared to be hardly any development of CSP in the EU. Again, respondents indicated that non-EU competitors mostly from China were challenging EU leadership. There was one respondent that indicated that CSP was strong but did not provide any concrete comments that could support this claim.

Table 1.2 Current competitive position in product design and manufacturing for solar power

Solar power	Type of services	Value	Percentage of respondents	Number of responses
Utility scale PV	Product design	Strong	16.7%	1
		Weak	66.6%	4
Distributed solar PV	Product design	Strong	25%	1
		Weak	50%	2
Concentrated solar power	Product design	Strong	50%	2
		Weak	25%	1
Utility scale PV	Product manufacturing	Strong		-
		Weak	100%	4
Distributed solar PV	Product manufacturing	Strong	-	-
		Weak	100%	3
Concentrated solar power	Product manufacturing	Strong	50%	1
		Weak	-	-
		Strong		5

Overall total	Weak	14

Solar water heaters: In terms of both product design and manufacturing, only one respondent filled in the response rating the current competitiveness of solar water heaters to be strong. According to the respondent, the reasons for this included the fact that the European industry has maintained the technological leadership in this sector, being a front runner in new concepts and solutions. The respondent applies this both for products such as solar panels (e.g.: hybrid PVT solar panels, new collector technologies), and for solutions, for instance the integration of solar thermal in large scale systems such as industrial heat processes or district heating. Additionally, the respondent indicated that there are important quality assurance instruments in place in Europe (namely the third-party volunteer certification Solar KEYMARK) that play an important role in limiting the impact of cheap low quality imported products in the market.

Table 1.3 Current competitive position in product design and manufacturing for solar water heaters

Solar water heaters	Type of services	Value	Percentage of respondents	Number of responses
Solar water heaters	Product design	Strong	50%	1
		Weak	-	-
Solar water heaters	Product manufacturing	Strong	100%	1
		Weak	-	-
Overall total		Strong		2
		Weak		

High efficiency heat pumps: In terms of product design, respondents indicated that the current level of competitiveness is strong, however, in terms of manufacturing, the respondents indicated it was equally competitive, citing that the reason for this is that the European geothermal heat pump supply chain is to a large extent powered by European businesses.

Table 1.4 Current competitive position in product design and manufacturing for solar water heaters

High efficiency heat pumps	Type of services	Value	Percentage of respondents	Number of responses
High efficiency heat pumps	Product design	Strong	66.7%	2
		Weak	-	-
		Equal		
High efficiency heat pumps	Product manufacturing	Strong	-	-
		Weak	-	-
		Equal	100%	1
Overall total		Strong		2
		Weak		

Biomass: In terms of both product design and manufacturing, respondents indicated that the current level of competitiveness is strong. The reason cited for this was that there appears to be a good domestic market present in many EU countries, especially in central and eastern Europe, however further details were not mentioned in the comments.

Table 1.5 Current competitive position in product design and manufacturing for biomass

Biomass	Type of services	Value	Percentage of respondents	Number of responses

Biomass	Product design	Strong	66.6%	2
		Weak	-	-
		Equal	33.3%	1
Biomass	Product manufacturing	Strong	100%	1
		Weak	-	-
		Equal	-	-
Overall total		Strong		3
		Weak		
		Equal		1

Geothermal: In terms of both product design and manufacturing, respondents indicated that the current level of competitiveness is strong. Within the comments, respondents mentioned that one of the reasons for the strong position is that the manufacturing of equipment's and components for geothermal heating and cooling, and electricity is to a large extent European based. As a result of this, the specific requirements of materials for geothermal uses do not expose them to significant supply chain vulnerability.

Table 1.6 Current competitive position in product design and manufacturing for geothermal energy

Geothermal	Type of services	Value	Percentage of respondents	Number of responses
Geothermal	Product design	Strong	33.3%	1
		Weak	-	-
		Equal	33.3%	1
Geothermal	Product manufacturing	Strong	100%	1
		Weak	-	-
		Equal	-	-
Overall total		Strong		2
		Weak		
		Equal		1

Small hydropower: In terms of product design, there was only one response where the respondent indicated that the current level of competitiveness is strong. The respondent added a comment that there is a huge export to countries outside the EU, however there is a weak domestic market that is restricted to some EU member states, the respondent also indicates that there is a strong environmental NGO campaign at the EU level to kill the small hydropower sector but did not elaborate further. There were no responses for product manufacturing.

Table 1.7 Current competitive position in product design and manufacturing for small hydropower

Hydropower	Type of services	Value	Percentage of respondents	Number of responses
Hydropower	Product design	Strong	100%	1
		Weak	-	-
		Equal	-	-
Hydropower	Product manufacturing	Strong	-	-
		Weak	-	-
		Equal	-	-
		Strong		1

Overall total	Weak	-
	Equal	-

Tidal systems: In terms of product design, there was only one response where the respondent indicated that the current level of competitiveness is strong. Within the comments, the respondent indicated that while Europe presently holds leadership in tidal technologies, additional policy support is required to safeguard it. The respondent attributes it to the fact that besides China, competition is arising around the globe, with a massive amount of investment from the US, along with Canada and UK also paving the way for the creation of a market, with the setup of market incentives such as revenue support. There were no responses for product manufacturing.

Table 1.8 Current competitive position in product design and manufacturing for tidal systems

Tidal systems	Type of services	Value	Percentage of respondents	Number of responses
Tidal systems	Product design	Strong	50%	1
		Weak	-	-
		Equal	-	-
Tidal systems	Product manufacturing	Strong	-	-
		Weak	-	-
		Equal	-	-
Overall total		Strong		1
		Weak		-
		Equal		-

Hydrogen: In terms of product design, the respondents rated the current rate of competitiveness to be equal. According to respondents, the reasons for this was that the Chinese manufacturers have concentrated on alkaline electrolysers, whereas Europeans are mostly concentrating on PEM electrolysers. Further comments to elaborate upon this were not provided. In terms of manufacturing, the respondents indicated that the current rate of competitiveness was weak. They further elaborated that though demand through pilot projects is ramping up, there is little visibility on what future demand will look like and how governments will be able to provide support. As an example, a respondent mentioned that the US Inflation Reduction Act provided a stable framework that would support better long-term investment decisions.

Table 1.9 Current competitive position in product design and manufacturing for tidal systems

Hydrogen	Type of services	Value	Percentage of respondents	Number of responses
Hydrogen	Product design	Strong	-	-
		Weak	-	-
		Equal	100%	2
Hydrogen	Product manufacturing	Strong	-	-
		Weak	100%	1
		Equal	-	-
Overall total		Strong		
		Weak		1
		Equal		2

Electric cars: In terms of product design, all the respondents indicated that it was equal in terms of current level of competitiveness. Reasons cited focused upon the global race for the lucrative geothermal lithium market, where France and Germany are in competition with China, U.S., Canada and New Zealand to develop intellectual property rights and extraction techniques for this critical feature of batteries. Additionally, this also includes the design of products to extract lithium from geothermal energy, to treat it and supply it. In term of product manufacturing, one respondent indicated that it was equal and two other respondents indicated that it was weak. Further comments to support these views were not provided.

Table 2. Current competitive position in product design and manufacturing for tidal systems

Electric cars	Type of services	Value	Percentage of respondents	Number of responses
Electric cars	Product design	Strong	-	-
		Weak	-	-
		Equal	100%	3
Electric cars	Product manufacturing	Strong	-	-
		Weak	66.7%	2
		Equal	33.3%	1
Overall total		Strong		
		Weak		2
		Equal		3

Additional products competitiveness rate: Regarding electric trains, only one respondent filled in the survey and indicated that for electric trains the current level of competitiveness for product design is equal, however, there was no response for product manufacturing. Similarly, for refrigerants alternative to hydrofluorocarbon, two respondents indicated that the current level of competitiveness for product design was strong, and one respondent indicated that it was equal for product manufacturing. However, in both cases, no comments were provided.

Missing responses: There were no responses for products such as efficient motors, LED lighting, solar cookstoves, biogas stoves, high performance glass, insulation materials, waste to energy systems (transition solutions), smart thermostats, building automation systems, carbon capture and storage.

Respondents' comments on the current level of competitiveness for product design regarding additional climate change mitigating products and services:

Battery storage systems: According to respondents, CATL, LG Chem, Tesla and other Asian manufacturers have the lead in designing batteries and their systems. Additionally, respondents also said the design of the market throughout Europe is not homogenous and that there are few markets where battery storage systems can compete and offer solutions at the right prices.

Airborne wind energy technology: According to respondents, there are about a dozen serious Airborne Wind Energy (AWE) technology developers of which only one is in the US, all the others are from European countries (CH, DE, ES, NL, NO, UK). They are organised within the sector association Airborne Wind Europe. Moreover, respondents indicated that there are about 40-50 European research institutes, suppliers and other organisations at least partially involved in AWE. Additionally, it is also mentioned that all the key designs are developed by European companies (ground gen, fly-gen, rotary).

Solar glass: According to respondents, European solar glass has better competitive conditions due to recyclability. but are not price competitive.

Wave energy: According to respondents, Europe has a long-standing competitive advantage in wave energy due to early investments in research and development. However, this advantage is being challenged by outside competitors that wish to catch up on the development of wave energy. The US is currently investing $100 million dollars each year to boost the development of marine energy. The

latest statistics indicate that competitors outside of Europe have deployed more wave capacity over the last five years than Europe.

Respondents' comments on the current level of competitiveness for product manufacturing regarding additional climate change mitigating products and services:

Airborne wind energy technology: According to respondents, the first European AWE companies have started commercializing their systems (in the 100-200 kW range) and building up production capacity (e.g. Skysail, Kitepower, Kitemill). At this stage, there are no other AWE production activities outside of Europe.

Polysilicon industry: Most of the polysilicon produced in Europe is used not for the PV industries, but for the other sectors such as semiconductors. Polysilicon industry should see a clear business case for the future to invest in this capital and time intensive industry.

Nuclear energy: The lack of nuclear installations in Europe (with the exception of France and some Eastern countries) has moved production of many nuclear components to other countries

Solar glass: European produced solar glass is less competitive due to energy prices in Europe. In addition, the current duties for the imported glass enhances the competitiveness of the European glass industry, but at the same time duty free regime for the solar PV modules imported from Eastern Asia, including China diminishes the competitiveness conditions for the European produced PV modules.

8.8.2 Near future competitive position in product design and manufacturing in the context of a transition to a net-zero economy

Wind power: In terms of product design, respondents consider onshore wind power and offshore wind power to be strong or equal. However, in terms of product manufacturing, both on shore and offshore wind power are considered to be weak, with one respondent rating onshore wind power as being equal. The reasons cited for this are that non-European manufacturers have a stronger position in terms of product price. Respondents further stated that the focus on costs in the EU will put further pressure on EU manufacturing. Concerns were highlighted about who would pay certain costs, as well as worries regarding the prevailing threat to widen the cost gap if imported products are not included in the CBAM. Additionally, respondents mentioned that while product manufacturing in the EU will have a good position in terms of product reliability in the near future, it is still difficult to compare it to real product performance figures in China.

The prevailing threat of the Chinese market will continue to be a concern for respondents. According to respondents, the Chinese wind turbine OEMs and gearbox suppliers are targeting new markets linked to the Belt & Road initiative, which results in a growing presence in Asia, the Middle East, Africa and Latin America. With wind energy continued to be a strategic focus in China's five-year plans, their wind energy supply chain continues to adapt to meet these goals, increasing pressure on international players (such as European players) and making supply from more expensive regions increasingly difficult.

Table 2.1 Near future competitive position in product design and manufacturing for onshore and offshore wind power

Wind power	Type of services	Value	Percentage of respondents	Number of responses
On shore wind power	Product design	Strong	50%	1
		Weak	-	-
		Equal	50%	1
Off shore wind power	Product design	Strong	50%	1
		Weak	-	-
		Equal	50%	1
		Strong	-	-

On shore wind power	Product manufacturing	Weak	50%	1
		Equal	50%	1
Off shore wind power	Product manufacturing	Strong	-	-
		Weak	100%	1
Overall total		Strong -		2
		Weak -		2
		Equal	-	3

Solar power: In terms of product design, out of two respondents, one considered utility scale PV to be weak and the other considered it to be equal. However, in the case of distributed solar PV and concentrated solar PV, only one respondent indicated it was strong. The comment supporting this view on concentrated solar power indicated that despite it being strong, the sector was encountering many difficulties. These difficulties are imposed by technological (modularity and standardisation) and non-technological (tendering process) framework conditions having a direct impact on the design of products of power plants. Additionally, the number of relevant patents from China is steadily increasing (according to the JRC report), clearly indicating the increasing competition from non-EU manufactures.

In terms of product manufacturing, utility scale PV, distributed solar PV and concentrated solar PV are all considered to be weak in terms of near future competitiveness. Respondents indicated that Europe is losing competitiveness in manufacturing, facing increasingly aggressive market opponents, such as China. One respondent further added that support was needed from the EU and Member States to create something similar to the United States Inflation Reduction Act within the EU Green Deal Industry Plan.

Table 1.2 Near future competitive position in product design and manufacturing for solar power

Solar power	Type of services	Value	Percentage of respondents	Number of responses
Utility scale PV	Product design	Strong	-	-
		Weak	50%	1
		Equal	50%	1
Distributed solar PV	Product design	Strong	100%	1
		Weak	-	-
Concentrated solar power	Product design	Strong	100%	1
		Weak	-	-
Utility scale PV	Product manufacturing	Strong		
		Weak	75%	3
		Equal	25%	1
Distributed solar PV	Product manufacturing	Strong	40%	1
		Weak	60%	2
		Strong	-	-

Concentrated solar power	Product manufacturing	Weak	100%	1
Overall total		Strong		3
		Weak		7
		Equal		2

Solar water heaters: In terms of both product design and manufacturing, respondents consider solar water heaters to be strong. One comment mentioned that EU manufacturers have idle production capacity that can be quickly activated (this includes an increase in the number of work shifts, full use of production lines and machinery) to increase the supply in the EU markets.

Table 1.3 Near future competitive position in product design and manufacturing for solar water heaters

Solar water heaters	Type of services	Value	Percentage of respondents	Number of responses
Solar water heaters	Product design	Strong	100%	1
		Weak	-	-
Solar water heaters	Product manufacturing	Strong	100%	1
		Weak	-	-
Overall total		Strong		2
		Weak		

High efficiency heat pumps: In terms of product manufacturing, respondents consider high efficiency heat pumps to be strong. In terms of comments, respondents indicated that competition in this sector did not come from other countries, but from other sectors (notably natural gas which has a dominant position on the H&C market) and less efficient technologies such as air heat pump that benefit from the same support framework

Table 1.4 Near future competitive position in product design and manufacturing for solar water heaters

High efficiency heat pumps	Type of services	Value	Percentage of respondents	Number of responses
High efficiency heat pumps	Product manufacturing	Strong	100%	1
		Weak	-	-
		Equal	-	-
Overall total		Strong		1
		Weak		-

Biomass: In terms of both product design and manufacturing, respondents consider the near future competitiveness to be strong for biomass, except one respondent that did indicate it was equal for product manufacturing.

Table 1.5 Near future competitive position in product design and manufacturing for biomass

Biomass	Type of services	Value	Percentage of respondents	Number of responses
Biomass	Product design	Strong	100%	1

		Weak	-	-
		Equal	-	-
Biomass	Product manufacturing	Strong	50%	1
		Weak	-	-
		Equal	50%	1
Overall total		Strong		1
		Weak		-
		Equal		1

Geothermal: In terms of both product design and manufacturing, there were an equal number of respondents that consider the near future competitiveness to be both equal and strong. According to respondents, the European geothermal industry has a strong degree of leadership, but needs a robust internal market to consolidate, notably when it looks to export its services. Additionally, comments also mentioned that global competitors are quite active and supported by a robust network of export agencies, this includes US and Japan, and China as well is becoming an increasingly strong competitor in the global geothermal market.

Table 1.6 Near future competitive position in product design and manufacturing for geothermal energy

Geothermal	Type of services	Value	Percentage of respondents	Number of responses
Geothermal	Product design	Strong	50%	1
		Weak	-	-
		Equal	50%	1
Geothermal	Product manufacturing	Strong	50%	1
		Weak	-	-
		Equal	50%	1
Overall total		Strong		2
		Weak		
		Equal		2

Hydrogen: In terms of both product design, one respondent considered it to be weak and for product manufacturing, one respondent considered it to be equal. However, no further comments were provided.

Table 1.9 Near future competitive position in product design and manufacturing for hydrogen

Hydrogen	Type of services	Value	Percentage of respondents	Number of responses
Hydrogen	Product design	Strong	-	-
		Weak	100%	1
		Equal	-	-
Hydrogen	Product manufacturing	Strong	-	-
		Weak	50%	1
		Equal	50%	1
Overall total		Strong		-
		Weak		2
		Equal		1

Electric trains: There was only one respondent who considered product manufacturing to be equal in terms of the near future competitiveness. There was no information provided on product design or any further comments shared.

Electric cars: In terms of both product design and manufacturing, an equal number of respondents considered it to be equal and strong in the near future. However, product manufacturing did have one respondent consider it to be weak. Respondents' comments mentioned that public research and innovation support is necessary considering the magnitude of the global competition and the geopolitical implication of securing lithium and other critical raw material (e.g. in the United States, $ 8 million of public R&I funding have already been invested in geothermal rare earth production technologies).

Table 2. Near future competitive position in product design and manufacturing for electric cars

Electric cars	Type of services	Value	Percentage of respondents	Number of responses
Electric cars	Product design	Strong	50%	1
		Weak	-	-
		Equal	50%	1
Electric cars	Product manufacturing	Strong	33.3%	1
		Weak	33.3%	1
		Equal	33.3%	1
Overall total		Strong		2
		Weak		1
		Equal		1

Missing responses: There were no responses for products such as small hydropower, tidal systems, biogas stoves, waste to energy systems, efficient motors, LED lighting, solar cookstoves, high-performance glass, insulation materials, smart thermostats, build automation systems, electric trains, carbon capture and storage.

Respondents' comments on the near future level of competitiveness for product design and manufacturing regarding additional climate change mitigating products and services:

PV cells, ingots and wafers: Respondents' comments mentioned that if the competitive energy prices would be ensured not only for the short term, but also for the medium and long term, then European cells, ingots and wafers producers could have the possibilities to produce competitive production.

Solar glass: In case the competitive energy prices would be ensured not only for the short term but also for the medium and long term potential European cells, ingots and wafers producers could have the possibilities to competitively participate in the global market.

8.8.3 Long-term competitive position in the manufacturing of products in the context of a transition to a net-zero economy

Refrigerants alternative to hydrofluorocarbon: There was only one respondent who considered product manufacturing to be equal in terms of long-term competitiveness. No further comments were provided.

Wind power: In terms of product design, one respondent considered onshore wind power to be weak, while a second respondent considered it to be equal. On the other hand, for offshore wind power, one respondent considered it to be strong. In terms of product manufacturing, one respondent considered onshore wind power to be weak, while a second respondent considered it to equal. For offshore wind power, only one respondent considered it to be equal. According to respondents, in the long run, the challenge remains cost, while non-EU manufacturers will close the gap on design limits and improve reliability by learning from mistakes. Respondents further commented that the EU advantage in terms

of reliability could potentially decrease in the future and that it is important to focus on excellence, rather than product size increases. Additionally, respondents have also mentioned that the industry must focus on developing sustainable and scalable regional supply chains without sacrificing reliability or quality.

Table 2.1 Long term competitive position in product design and manufacturing for onshore and offshore wind power

Wind power	Type of services	Value	Percentage of respondents	Number of responses
On shore wind power	Product design	Strong	-	-
		Weak	50%	1
		Equal	50%	1
Off shore wind power	Product design	Strong	100%	1
		Weak	-	-
		Equal	-	-
On shore wind power	Product manufacturing	Strong	-	-
		Weak	50%	1
		Equal	50%	1
Off shore wind power	Product manufacturing	Strong	-	-
		Weak	-	-
		Equal	100%	1
Overall total		Strong		1
		Weak		2
		Equal		3

Solar power: In terms of both product design and manufacturing, a majority of the respondents across utility scale PV, distributed solar PV and concentrated solar PV consider the long-term competitiveness to be weak. According to respondents, the competitive position of EU manufacturers compared to non-EU ones, in the long-term future will be determined by their capacity to respond to the challenge of lowering electricity generation costs and increasing power plant efficiency, as well as enabling easier and faster permitting for EU manufacturers. Additionally, respondents have also said that it depends on whether the EU industry is able to lead on industrialisation of relevant innovations (e.g. efficiency tandems, recycling/circularity) and not just work in laboratories. This requires investments from industry into research and innovation and political support (similar to the US Inflation Reduction Act) to be considered.

Table 1.2 Long term competitive position in product design and manufacturing for solar power

Solar power	Type of services	Value	Percentage of respondents	Number of responses
Utility scale PV	Product design	Strong	25%	1
		Weak	75%	3
		Equal	-	-
Distributed solar PV	Product design	Strong	40%	1
		Weak	60%	2
Concentrated solar power	Product design	Strong		
		Weak	100%	1

Utility scale PV	Product manufacturing	Strong	40%	1
		Weak	60%	2
		Equal		
Distributed solar PV	Product manufacturing	Strong	40%	1
		Weak	60%	2
Concentrated solar power	Product manufacturing	Strong	-	-
		Weak	100%	1
Overall total		Strong		4
		Weak		11
		Equal		-

High efficiency heat pumps: In terms of both product design and manufacturing, respondents consider the competitive position to be strong, however, no further comments were provided.

Table 1.4 Long term competitive position in product design and manufacturing for solar water heaters

High efficiency heat pumps	Type of services	Value	Percentage of respondents	Number of responses
High efficiency heat pumps	Product manufacturing	Strong	100%	1
		Weak	-	-
		Equal	-	-
High efficiency heat pumps	Product design	Strong	100%	1
		Weak		
		Equal		
Overall total		Strong		2
		Weak		-

Biomass: In terms of product design, the response was an equal level of competitiveness expected in the long- term. However, in the case of product manufacturing, a strong level of competitiveness is expected in the long-term. Respondent comments mention that is will be essential to build an emphasis upon local manufacturing capabilities.

Table 1.5 Long term competitive position in product design and manufacturing for biomass

Biomass	Type of services	Value	Percentage of respondents	Number of responses
Biomass	Product design	Strong	-	-
		Weak	-	-
		Equal	100%	1
Biomass	Product manufacturing	Strong	100%	1
		Weak	-	-

		Equal	-	-
Overall total		Strong		1
		Weak		-
		Equal		1

Geothermal: In terms of both product design and manufacturing, there is one respondent who considers it is equal and another respondent who considers it is strong in the long-term. According to respondents' comments the European geothermal industry has a strong degree of leadership, but needs a robust internal market to consolidate it, notably when it looks to export its services. Global competitors are quite active and supported by a robust network of export agencies (US, Japan), and China is become increasingly strong.

Table 1.6 Long term competitive position in product design and manufacturing for geothermal energy

Geothermal	Type of services	Value	Percentage of respondents	Number of responses
Geothermal	Product design	Strong	50%	1
		Weak	-	-
		Equal	50%	1
Geothermal	Product manufacturing	Strong	50%	1
		Weak	-	-
		Equal	50%	1
Overall total		Strong		2
		Weak		-
		Equal		2

Hydrogen: In terms of both product design and manufacturing, there is one respondent who considers it to be weak. There is also a second respondent who considers the long-term competitiveness to be equal in terms of product design. No comments were provided.

Table 1.9 Long term competitive position in product design and manufacturing for hydrogen

Hydrogen	Type of services	Value	Percentage of respondents	Number of responses
Hydrogen	Product design	Strong	-	-
		Weak	50%	1
		Equal	50%	1
Hydrogen	Product manufacturing	Strong	-	-
		Weak	100%	1
		Equal	-	-
Overall total		Strong		
		Weak		2
		Equal		1

Electric trains: There is only one response from a respondent who considered long-term competitiveness to be equal for product design.

Electric cars: There are two respondents who consider product design and manufacturing to be strong in the long-term. There is also one respondent who considers product design to be equal in the long-term.

Table 2. Long term competitive position in product design and manufacturing for electric cars

Electric cars	Type of services	Value	Percentage of respondents	Number of responses
Electric cars	Product design	Strong	60%	2
		Weak	-	-
		Equal	40%	1
Electric cars	Product manufacturing	Strong	100%	2
		Weak	-	-
		Equal	-	-
Overall total		Strong		4
		Weak		-
		Equal		1

Solar water heaters: There were no responses, however, there was one comment that mentioned it was difficult to determine the level of competitiveness in the long-term. According to the respondent, instead of focusing only on few technologies (PV, heat pumps) that are now the centre of the debate but that are still strongly dependent on imports, there should be a push for EU and national-level policies covering different technologies, in particular those with a strong EU manufacturing base such as solar thermal systems.

Missing responses: There were no responses for products such as small hydropower, tidal systems, biogas stoves, waste to energy systems, efficient motors, LED lighting, solar cookstoves, high-performance glass, insulation materials, smart thermostats, build automation systems, electric trains, carbon capture and storage.

Respondents' comments on the long-term competitiveness for product design and manufacturing regarding additional climate change mitigating products and services:

Airborne Wind Energy (AWE): According to a respondent, European AWE companies are currently the most advanced but if Europe (i.e. European Commission and Member States) do not support the sector enough, the know-how may go to the United States, China or other countries.

PV cells, ingots and wafers: According to a respondent, in case the competitive energy prices would be ensured not only for the short-term, but also for the medium and long-term, then potential European cells, ingots and wafers producers would have the possibilities to produce competitively.

Solar thermal systems: According to respondents, this depends on too many variables, in particular, the political framework. Comments further mentioned that the focus on electrification has created an unlevelled playing field for thermal based solutions, such as thermal energy storage, which is not receiving required research and innovation investment, as well as support from policy instruments (this is compared to what is provided to other solutions, such as power storage).

Respondents' comments on the long-term competitiveness for product manufacturing regarding additional climate change mitigating products and services:

AWE: According to respondents, European AWE companies are currently the most advanced, but it must be ensured that manufacturing will also take place in Europe. Since AWE systems can be mass-produced (like automobiles), there is a risk that production goes abroad, if conditions in Europe are not favourable.

8.8.4 Nature of the trade policy measures

1) **Elimination of tariffs and quotas**

Strongly disagree/disagree: offshore windpower (2), utility scale PV (4), distributed solar PV (3), concentrated solar power (4), biomass (2), geothermal (2), high efficiency heat pumps (2), hydrogen (2), electric cars (2),

Neutral: utility scale PV (4), distributed solar PV (3)

Respondents' comments:

(1) The question is not clear. If regarded from the perspective of the European manufacturers, tariffs and quotas may serve to provide them much-needed competitiveness. From the perspective of developers, tariffs and quotas will only inflate energy prices and slower the energy transition.
(2) The cost of RNG will be always more expensive than fossil energy. If we want to reduce the CO2 emission, tariffs and quotas are necessary
(3) It is not really clear to me if this is about import or export. If both, then probably elimination of tariffs and quotas are ok as long as the countries importing to the EU are subject to the same environmental and social conditions as EU suppliers.
(4) Currently there are no tariffs and quotas for PV.
(5) The elimination of tariffs on solar glass and other components should be considered as this is an important element making EU module manufacturers less competitive than their Chinese peers.

2) Lower tariffs or higher quotas compared to conventional goods of the same category

Strongly disagree/disagree: offshore windpower (2), utility scale PV (4), distributed solar PV (2), concentrated solar power (4), biomass (2), geothermal (2), high efficiency heat pumps (2), hydrogen (2), electric cars (2),

Neutral: utility scale PV (4), distributed solar PV (1)

Agree: utility scale PV (4), distributed solar PV (3)

Respondents' comments:

(1) The question is not clear. If regarded from the perspective of the European manufacturers, tariffs and quotas may serve to provide them a much-needed competitiveness. From the perspective of developers, tariffs and quotas will only inflate energy prices and slower the energy transition.
(2) The European Union's biogas and biomethane sectors are home to major manufacturers of biogas and biomethane production technologies, with a global leading role in manufacturing, exporting, patents and R&D. It has a global competitive advantage and would thus benefit from lower tariffs or higher quotas in EU's trading partners.

3) Elimination of non-tariff barriers (e.g., harmonization or mutual recognition of regulations, requirements, etc.)

Strongly disagree/disagree: offshore windpower (2), utility scale PV (3), distributed solar PV (3), concentrated solar power (2), biomass (2), geothermal (2), high efficiency heat pumps (2), hydrogen (2), electric cars (2)

Neutral: utility scale PV (1), distributed solar PV (3), concentrated solar power (1)

Agree: utility scale PV (4), distributed solar PV (3)

Respondents' comments:

(1) For AWE systems it is important to harmonize regulation and other requirements globally. We don't see common regulation not as a barrier but as an enabler.
(2) Currently there are no non-tariff barriers for PV.

(3) Impact of complex technical and regulatory requirements on costs, as well as current and future competitive advantage of EU companies.

4) Reduction in non-tariff barriers (e.g., approximation of regulations, requirements, etc.)

Strongly disagree/disagree: offshore windpower (2), utility scale PV (3), distributed solar PV (2), concentrated solar power (2), biomass (2), geothermal (2), high efficiency heat pumps (2), hydrogen (2), electric cars (2)

Neutral: utility scale PV (1), distributed solar PV (1), concentrated solar power (2)

Agree: utility scale PV (4), distributed solar PV (3)

Respondents' comments:

(1) Harmonization to higher standard in order to compete with non-EU competitors in terms of high quality, regulations, and requirements of the products.
(2) It is important for AWE that regulations and requirements are applied globally. In Europe regulation on AWE is still in its infancy, but advanced compared to other jurisdictions. Ideally the European regulation will be applied world-wide.
(3) Currently there are no non-tariff barriers for PV.

8.8.4 Conditions to be set for the liberalisation of trade

1) Enforcement of Intellectual Property Rights owned by EU-based companies in the sector

Strongly disagree/disagree: offshore windpower (2), utility scale PV (4), distributed solar PV (3), concentrated solar power (2), biomass (2), geothermal (2), high efficiency heat pumps (2), hydrogen (2), electric cars (2),

Neutral: utility scale PV (4), distributed solar PV (3), concentrated solar power (2), biomass (2)

Agree: utility scale PV (4), distributed solar PV (3),

2) Fair treatment of EU-based companies in the sector regarding the verification of compliance of their products with national regulations

Strongly disagree/disagree: offshore windpower (2), utility scale PV (4), distributed solar PV (3), concentrated solar power (2), biomass (2), geothermal (2), high efficiency heat pumps (2), hydrogen (2), electric cars (2),

Neutral: utility scale PV (4), distributed solar PV (3), concentrated solar power (2), biomass (2)

3) Access by EU companies in the sector to public procurement by national and sub-national entities

Strongly disagree/disagree: offshore windpower (2), utility scale PV (4), distributed solar PV (3), concentrated solar power (2), biomass (2), geothermal (2), high efficiency heat pumps (2), hydrogen (2), electric cars (2),

Neutral: utility scale PV (4), distributed solar PV (3), concentrated solar power (2), biomass (2)

4) Freedom of establishment by EU companies in the sector (including licences to operate, etc.)

Strongly disagree/disagree: offshore windpower (2), utility scale PV (4), distributed solar PV (3), concentrated solar power (2), biomass (2), geothermal (2), high efficiency heat pumps (2), hydrogen (2), electric cars (2),

Neutral: utility scale PV (4), distributed solar PV (3), concentrated solar power (2), biomass (2)

5) Abolition of public subsidies to R&D

Strongly disagree/disagree: offshore windpower (2), utility scale PV (3), distributed solar PV (3), concentrated solar power (2), biomass (4), geothermal (2), high efficiency heat pumps (2), hydrogen (2), electric cars (2),

Neutral: utility scale PV (1), distributed solar PV (3), concentrated solar power (2), biomass (2)

Agree: utility scale PV (4)

6) Abolition of public subsidies to investment (CAPEX)

Strongly disagree/disagree: offshore windpower (2), utility scale PV (3), distributed solar PV (3), concentrated solar power (2), biomass (4), geothermal (2), high efficiency heat pumps (2), hydrogen (2), electric cars (2),

Neutral: utility scale PV (1), distributed solar PV (3), concentrated solar power (2)

Agree: utility scale PV (4)

7) Abolition of public subsidies to production (OPEX)

Strongly disagree/disagree: offshore windpower (2), utility scale PV (3), distributed solar PV (3), concentrated solar power (2), biomass (4), geothermal (2), high efficiency heat pumps (2), hydrogen (2), electric cars (2),

Neutral: utility scale PV (1), distributed solar PV (3), concentrated solar power (2)

Agree: utility scale PV (4)

Annex 9: Toolbox of available trade instruments and rules

This annex describes a set of trade-related policy instruments and explains in what way they can support the offensive and defensive interests caused by EU climate change mitigation policies.

The instruments have been identified based on a review of relevant literature, notifications to the WTO by members and observations of evolving political practice in the EU and main third countries such as the United States and China.

The description and assessment of each trade policy instrument covers the following elements:

- A brief description of the instrument.
- An explanation of how it can constitute a tool to promote offensive and/or defensive EU interests caused by climate action.
- Multilateral rules affecting the instrument.
- Opportunities for the EU to apply the trade policy instrument, including whether it can be pursued autonomously or requires negotiations with third countries, and
- An overall assessment of the instrument.

The discussion does not address the effectiveness of measures, as this would depend on the specificities of measures taken as well as the context.74

The presentation of trade instruments and corresponding rules is structured in line with the following classification, which has been developed based on the structure of the WTO's trade policy reviews as well as the classification used in the WTO Environmental Database (EDB).75 Some adaptations have been made in view of the study topic: Notably, the comparatively less important (with respect to climate change mitigation) areas of customs and trade facilitation, rules of origin; intellectual property rights; and competition, price controls and consumer protection; and investment measures are not addressed in detail. Conversely, a category of other trade-related measures countering carbon leakage has been added:

- Import tariffs
- Quantitative import restrictions
- Export restrictions
- Trade defence instruments
- Technical barriers to trade (technical regulations, standards, labelling rules, conformity assessment)
- Subsidies
- Public procurement
- Trade agreements
- Other trade-related measures countering carbon leakage

Import tariffs

Brief description of the instrument

Import tariffs and border taxes are classical trade policy instruments applied on goods (though not services): they are charged on imported products as they enter the EU customs territory. Whereas import tariffs are applied, by definition, only on imports, some (but not all) border taxes, such as excise taxes, are simply domestic taxes that are collected at the border, but that are also applicable on domestically produced goods. For example, in the EU, excise duty rules cover all energy products used for heating and transport, as well as electricity. The EU's Energy Taxation Directive (ETD) is currently

under review as part of the EU Green Deal package of July 2021, in order to align it with the EU's climate policy objectives. Although this will undoubtedly also affect the EU's trade patterns in relation to energy (and other products), it is not primarily a trade policy measure. In terms of price-based measures, the present study focusses on import tariffs, addressed in this section.

Explanation of how it can constitute a tool to promote offensive and/or defensive EU interests

The four main applications of import tariffs to foster and support the EU's climate policies are:

- Low import tariffs by the EU on climate change-mitigating goods: If low or no tariffs are applied, prices for climate friendly goods in the EU are reduced (compared to a situation with higher tariffs). This leads to more demand for and broader dissemination of such products across the EU, thereby mitigating climate change. At the same time, low tariffs on climate change-mitigating goods may negatively affect EU producers of these goods by increasing competitive pressure from imports. Such a loss to EU competitiveness would occur normally in a static view. From a dynamic viewpoint, the liberalisation could also work encourage technological change and thus further enhance EU competitiveness in the longer term; this would depend on the specific situation. Nevertheless, a potential partial conflict between the EU's climate and competitiveness objectives exists with regard to this measure.
- Low import tariffs by the EU's trading partners on climate change-mitigating goods: Like the previous measure, low import tariffs on climate change-mitigating goods applied in other economies lead to the dissemination of such goods there, thus reducing GHG emissions globally. They also constitute a commercial offensive interest for the EU to the extent that the goods are produced in the EU and benefit from lower tariffs abroad.
- Low import tariffs by the EU on inputs needed to produce climate change-mitigating goods: This measure reduces the cost of EU firms for the production of such goods, thereby increasing profits and/or reducing the price of the final product. This in turn leads to higher output of climate change-mitigating goods by EU firms.
- High import tariffs by the EU on goods related to high GHG emissions: This measure is the mirror image of the first measure described above: making "climate-unfriendly" goods more expensive through increased tariffs discourages their consumption, thus contributing to lower emissions in the EU. With the EU being a large market, it is possible that lower demand from the EU leads to falling prices for such goods globally, which may lead to more demand in other markets. This trade diversion is a "crowding out" effect which reduces the effectiveness of the measure on the global scale. However, usually the crowding out is only partial, so that the net global effect of the measure remains positive. Its effectiveness will however be higher if high imports tariffs are applied by the main markets for such goods in an internationally coordinated way. Furthermore, from a climate policy perspective, this measure is only a second-best option: as tariffs are applicable on imports, increasing them also increases prices on the EU market, inducing EU producers to expand output. This is another case of crowding out. A better measure instead of increasing import tariffs would therefore be to increase domestic taxes on such products (as is being considered e.g. in the ETD revision mentioned above.

Another potential risk from the elimination of market access barriers to the import of certain climate action-mitigating goods, notably hydrogen and e-fuels, could support the creation of dependency from foreign suppliers. In this context, the European Commission's analysis for the climate-neutral transition found that "globally traded zero-carbon/carbon neutral fuels could […] be an economic opportunity but they do create a risk of new types of dependency, possibly affecting EU's energy security" (European Commission, 2018, p. 88).76 Accordingly, the EU should take measures to ensure a diversified supplier base for such products, as discussed in more detail in the context of critical raw materials below.

Multilateral rules on product likeness and general exceptions

One of the fundamental principles of multilateral trade rules is the non-discrimination principle with its two expressions, the most-favoured nation (MFN; GATT Art. I) and national treatment rules (GAT Art. III). Under the WTO's non-discrimination principle, "like goods" must be treated alike. And under current WTO rules, differences in the processes and production methods (PPMs) that are not reflected in different characteristics of the resulting products, so called non-product related PPMs (NPR-PPMs), do not result in products that are "unlike".77

In line with the WTO jurisprudence on NPR-PPMs, in principle a product that has been produced using production processes with low GHG emission intensity must not receive a more favourable treatment than the same product produced with higher GHG emissions. Stricter EU requirements on the GHG emission intensity of production processes that are associated with higher production costs in the EU therefore cannot be countered by setting higher market access thresholds (e.g., tariffs) for the imported like products that can be produced in third countries with lower standards and costs. This risks crowding out the measure's effectiveness, with a shift of production to third countries and higher net GHG emissions, harming both EU industry and EU (and global) climate change mitigation objectives.

Several dispute bodies under the General Agreement on Tariffs and Trade (GATT) and later the WTO have prohibited discrimination on grounds of NPR PPMs.78 Although more recently the limited use of NPR-PPMs has been permitted under the general exceptions of GATT Article XX,79 this to date has been limited only to cases where PPMs affecting the conservation of species have been involved (shrimp/turtles, tuna), not with regard to climate change considerations. This can be explained by the list of General Exceptions in GATT Article XX, where Article XX(g) specifically refers to measures "relating to the conservation of exhaustible natural resources if such measures are made effective in conjunction with restrictions on domestic production or consumption."80

In sum, current WTO rules and jurisprudence regarding NPR PPMs constitute a significant risk for EU climate change mitigation policies. Accordingly, measures for the mitigation of this risk, through negotiations at the WTO, should be considered.

Opportunities for the EU to use the trade policy instrument

The EU can implement some of the measures mentioned unilaterally, whereas others require international negotiation or coordination:

- EU tariffs on climate change-mitigating goods and inputs needed for their production can be reduced unilaterally. The EU would simply need to determine which goods are to be covered by this measure, and reduce or eliminate the MFN tariffs on them. This would also apply to imports from FTA partner countries to the extent that these have not already eliminated tariffs on these goods.
- Similarly, the EU could increase tariffs on climate-damaging products unilaterally. Nevertheless, the scope for this is likely limited, as the EU is bound by the WTO rules and its own commitments: tariffs for any product cannot be increased above the bound rate – which is typically close to the applied rate81 – without compensation (i.e. reducing other bound rates) or under exceptional circumstances. Both of these measures would require negotiations with WTO members and/or likely face legal challenges. Also, increasing tariffs on imports from FTA partners is usually not possible under the terms of the agreements.
- Import tariff changes by third countries can only be achieved through coordination or negotiations: Here, the EU could negotiate with individual countries or groups of countries new FTAs or the expansion of FTAs to cover climate change-mitigating goods. Alternatively, global coordination through the WTO aimed at reducing tariffs on climate change-mitigating goods and facilitating their production and trade could be sought. Whereas a global solution is preferable in principle, as it provides a global response to a global problem and is thus most effective, it is also more difficult to be negotiated. Therefore, reducing import tariffs in bilateral

or regional agreements might be a faster and easier option. Certain limits are however imposed by the WTO rules, specifically the requirement that trade agreements, which diverge from the MFN principle by allowing that the parties reduce tariffs only among themselves but not for other suppliers, must cover substantially all trade (see section on trade agreements below). Therefore, trade agreements liberalizing tariffs only for climate change-mitigating goods are not possible.

The application of any of these opportunities for action requires, however, clarification on a crucial practical matter: Which products should be considered as climate change-mitigating goods, and how can they be identified? Lists of environmental goods have been developed by various organisations over the years without an international agreement having been reached (e.g., Steenblik, 2005; Bellmann and Sugathan, 2022; WEF, 2022). Some of the EU's more recent EU FTAs, e.g. with New Zealand, also include lists of "green goods" (and services) covering those related to energy efficiency, renewable energy generation.

Another key issue that would remain to be addressed is that, depending on the production techniques and processes used, the same product can be climate change-mitigating or not. Accordingly, products with the same characteristics but different impact on climate would need to be distinguished and treated differently. This raises the issue of the conditions that must be met for two products to be considered "like products", as such products must also be treated alike under WTO rules (see above). Here, the EU could pursue international negotiations on amendments to the WTO rules, for example:

- Amending the concept of product likeness that would help to distinguish products depending on the carbon footprint during production, i.e. broadening the legality of NPR-PPMs on grounds of climate change. In this context, UNCTAD has also recently found that: "In the future, proving that the carbon footprint of a production process significantly impacts the demand could be an important argument to justify a possible difference of treatment between two similar goods" (UNCTAD, 2022).
- A partial substitute to the previous course of action would be, as suggested by the WEF (2022), to separate climate change-mitigating goods in customs classifications, guided by the Harmonised System (HS). This would require corresponding negotiations within the World Customs Organisation in the context of the next update of the HS. The 2022 version already established codes for some climate change-mitigating goods, such as LED lights, but this could certainly be expanded (although falling short of distinguishing products based on NPR-PPMs).
- Including climate action among the general exceptions (public policy justifications for trade restrictions, GATT Art. XX, GATS Art. XIV).
- Going one step further, the EU could push for a "climate waiver" that would permit to "impose trade-restrictive climate policy response measures that are in line with Paris Agreement obligations" (EIU, 2019, p. 6). This course of action is based on the argument that comprising climate action under the general exceptions does not provide the needed legal certainty. Such a climate waiver under Article IX:3 and Article IX:4 of the WTO Agreement would suspend any obligation of WTO law for climate actions, "thus limiting the reach of WTO law. The legality of measures for which a waiver is in effect cannot be assessed against the suspended WTO norm" (Feichtner, 2016, p. 75f).[82]

These courses of action (except changes in the HS) would require negotiations on rules at the WTO, possibly initially in the context of the TESSD.

Summary assessment of the instrument, importance and priority

Tariffs constitute the main classical trade policy instrument. Originally having been developed as a means to both protect domestic producers and generate revenues, these objectives have lost much of their importance in recent years. But tariffs can nevertheless be used to pursue other policy objectives, including climate change mitigation. Some of the identified measures – low tariffs on inputs for the production of climate change-mitigating goods, global reduction of tariffs on such goods, and

high tariffs on climate-damaging goods both contribute to the EU's climate goals and also foster EU competitiveness.

However, the overall importance of tariffs in the EU's trade policy toolbox for climate action is small: with most tariffs being low already,83 scope for further reduction is limited, as is the scope for increasing tariffs on damaging products due to the bound tariffs to which the EU has committed under the WTO. The impact of such measures would therefore be rather small – and would be further limited by the fact that, unless WTO rules on product likeness are changed to also capture differences in production techniques and processes, only a small share of goods, namely those non-controversially seen as climate-action mitigating goods, could be covered by tariff measures.

Subsidies

Brief description of the instrument

Subsidies aimed at mitigating climate change have been used by countries across the world, including the EU and its Member States, for a quite some time, and are by far the most used trade-related policy instrument since 2009 both globally and by the EU and its Member States, according to notifications made to the WTO (see Figure 4-2 above). Their implications on global trade have, however, gained much prominence with the recent massive subsidy package contained in the US Inflation Reduction Act (IRA), which subsidises production and investment in renewable technology in the US.

From an economic point of view, subsidies – which can consist both of actual payments by a government or public entity and of foregoing revenues, e.g. through tax rebates – are justified in the presence of market failures where the market price of a product does not reflect its "true" value; climate change mitigation is one such positive "externality" which is not reflected in the price.

From a trade policy perspective, subsidies are an issue as they could affect not only domestic prices in the subsidising economy but also international trade flows. If only one country applies such subsidies, the benefitting industry becomes relatively more competitive, thereby potentially leading to reduced imports and increased exports, in such case negatively affecting foreign competitors. Accordingly, multilateral trade rules put disciplines on the use of subsidies and regulate potential responses by affected countries (see below).

Explanation of how it can constitute a tool to promote offensive and/or defensive EU interests

In principle and in theory, subsidies can be an instrument to support climate action. For example:

1. Production subsidies for climate change-mitigating goods production and more broadly decarbonisation of the economy can reduce costs of R&D or production of climate change-mitigating goods or climate services, thereby expanding current and/or future output and hence contribute to climate change mitigation.
2. Similarly, consumption subsidies can reduce the cost of climate change-mitigating goods and services for consumers, thereby increasing demand.
3. To the extent that climate-friendly production standards increase production costs, EU producers exporting to markets with lower standards are put at a competitive disadvantage. Subsidies that cover the cost differential can re-establish the level playing field for such exporters with competitors producing at lower cost under less demanding standards. This would increase global availability of climate change-mitigating goods produced in the EU.

Viewed in isolation, without considering potential policy responses by third countries, such subsidies when provided by the EU would also enhance the EU's competitiveness (both current and future) in climate change mitigation technologies. This would particularly apply to production subsidies directly benefitting EU producers, but to a smaller extent also consumption subsidies: these increase demand for the subsidised products in a non-discriminatory way, and accordingly foreign and EU producers benefit from them proportionately to their shares in the EU market.

However, a more comprehensive assessment of subsidies' effects on EU competitiveness needs to take into consideration also subsidy policies of third countries, as well as the reactions of third countries to EU subsidies mentioned above. In this context, the following measures of third countries should be noted:

- Climate action-related subsidies by third countries have a positive impact on climate but, depending on the design, may have a negative impact on EU competitiveness by distorting international competition for climate change-mitigating goods and services. This is particularly the case where such subsidies are tied to local content provisions, which is illegal under WTO rules (see below). The recent US IRA is a prime example and has already created transatlantic tensions. The negative effects on EU competitiveness from such subsidies do not, however, necessarily detract from their positive impact on climate change mitigation. As Kleimann notes, "environmental subsidies that alter cross-border competitive conditions may not be all bad. They may tackle market failures in a net-global-welfare enhancing manner and may therefore be entirely appropriate" (Kleimann, 2023, p. 2f). On the other hand, the positive effects are likely to be smaller (or even not be present at all) if access conditions attached to subsidies are too stringent. For example, local content requirements "eliminate benefits of competition and therefore frequently result in higher prices, lower quality, less variety and, overall, less availability of undersupplied clean technologies and environmental goods" (Kleimann, 2023, p. 3).
- Reactions by third countries to EU green subsidies can also neutralize positive competitiveness effects. Such reactions can take place using the instruments foreseen under WTO rules (i.e. countervailing duties; see ow) and/or by reciprocating with own subsidies that provide the same (or higher) benefits. A subsidy race may lead to higher global inefficiencies in the allocation of public spending to tackle climate change and actually lead to reduced EU competitiveness (if other countries have deeper pockets than the EU and its Member States), but they are likely to speed up climate change mitigation – as long as the competing subsidies are also aimed at this.

Subsidies can also constitute a **threat to climate action**. This, in particular, occurs where (third) countries provide subsidies for sectors, products or services that contribute to climate change, such as consumption subsidies for fossil fuels, production subsidies not linked to efficiency targets, etc. – also when such subsidies are taken in response to green subsidies offered by the EU and its Member States. This reduces prices and/or increases demand for such products and services and puts competing climate change-mitigating products, including those produced in the EU, at a competitive disadvantage. Such subsidies can therefore have a **negative impact both on climate change and EU competitiveness**.[85]

Finally, another risk of the EU's using subsidies to advance climate action stems from the fact that many developing countries do not have the resources to subsidise and may be alienated if the EU subsidises heavily.

Multilateral rules on subsidies

Under the WTO, subsidies are mainly regulated in GATT Article XVI and the Agreement on Subsidies and Countervailing Measures (SCM).86 The SCM Agreement distinguishes two types of subsidies:

- Prohibited subsidies which WTO Members are not permitted to use: these include export subsidies and import substitution subsidies, i.e. subsidies that are conditioned on a recipient's export performance or use of domestically produced inputs (local content requirements).
- Actionable (or countervailable) subsidies which Members may use but against which other Members may take countermeasures – through WTO dispute settlement or countervailing measures (see summary of trade defence instruments below) – if they are adversely affected by the subsidy.

A third type, non-actionable subsidies (which could be applied by Members without other Members having the right to apply countermeasures) originally existed but the provisions in the SCM Agreement regarding these subsidies expired in 1999.

To qualify as a subsidy in line with the SCM Agreement, a support measure has to fulfil the following two conditions: There must be a financial contribution by a government or any public body within the territory of a Member, or some form of income or price support; and a benefit must be conferred by the financial contribution or support. Furthermore, for a subsidy to be actionable or prohibited it must fulfil the condition of specificity, i.e., access to the subsidy must be limited to certain enterprises, groups of enterprises or industries.

When the SCM Agreement was drafted, the main concern was to address the international trade distorting aspects of subsidies used for domestic policy goals. Addressing subsidies aimed at a global policy goal, such as climate change mitigation, were not on the agenda at the time.

Specifically with regard to the potential for the EU to use subsidies aimed at promoting the production or consumption of climate change-mitigating goods or re-establish a level playing field for EU producers subject to more stringent and cost-increasing climate-action standards, two WTO subsidy rules act as constraints. The first one is the absence in the SCM Agreement of a general exception clause as established in GATT Art. XX (see description of multilateral rules on import tariffs above), which could be applied for subsidies aimed a climate change mitigation. Although it has not been established in the WTO jurisdiction if GATT Art. XX also applies to the SCM Agreement, "the prevalent legal opinion leans strongly towards a negative answer" (Rubini, 2012; Kleimann, 2023). Second, the prohibition of export tax rebates for direct taxes, including GHG emission charges (Low, Marceau and Reinaud, 2011) would prevent the use of subsidies to compensate exporters for higher production costs stemming from more stringent standards. Third, the actionability of climate change mitigation-oriented subsidies weakens the effectiveness of such subsidies, as explained above.

Opportunities for the EU to use the trade policy instrument

The EU can determine subsidies unilaterally, subject to the disciplines established by WTO subsidy rules, agree on coordinated subsidies with key trading partners, as well as aim to negotiate amendments to multilateral subsidy rules.

Unilateral action simply means providing the subsidies mentioned above, while respecting the conditions established in the SCM Agreement. The EU is already doing this. For example, the Commission Guidelines on State Aid for Climate, Environmental Protection and Energy 2022 (European Commission, 2022b) provide EU national authorities with a framework for permissible financing of environmental technology development and the decarbonisation of energy supply and current industrial production processes, for up to 100% of the funding gap. In addition, "the 2020 EU ETS state aid guidelines […] enable a budget of more than €60 billion to compensate for ETS-induced energy costs of energy-intensive, trade-exposed sectors such as steel, aluminium and certain chemicals, to prevent companies in these sectors from relocating carbon-intensive production to 'polluter havens' outside of the EU" (Kleimann, 2023, p. 8). Also, several Member States provide consumption subsidies for the purchase of electric vehicles. Finally, the Commission plans to review the possibility of a WTO-compatible modus operandi for the adoption of export refunds for domestic carbon costs.

Nevertheless, considering the risks of a wasteful subsidies race and – if other countries' responses entail subsidies not linked to climate goals – climate damaging consequences, such unilateral action is not considered as a preferable policy. It might be considered as a reactive measure to subsidies provided by third countries (i.e., entering into the subsidies race), but even then it is preferable to negotiate a coordinated approach.

Considering that climate change is a global problem, a globally coordinated approach is most appropriate. Accordingly, at the multilateral level, the EU could aim at clarifying or amending relevant

subsidy rules so that they better facilitate global decarbonisation efforts. Specific elements that should be addressed include the following ones:

- A clarification (e.g., in SCM Agreement Art. 8) that subsidies aimed at addressing climate change are deemed non-actionable, along with the necessary guidelines to determine which subsidies are to be included in this category. This would require also the re-activation of the non-actionable category of subsidies in the SCM Agreement;
- Amendment of the SCM Agreement to clarify the legality of certain environmental subsidies, such as export tax rebates for indirect taxes related to climate change mitigation;
- Following the example of the agreement among OECD members to end support for unabated coal-fired power plants (cf. IMF et al., 2022), further international agreements on abolishing subsidies for products that are main contributors to climate change ('harmful subsidies'). This objective can also be pursued in bilateral agreements. For example, the EU-Singapore FTA already recognises the need for the parties to take proper account of the need to reduce GHG emissions when designing subsidy systems (see EIU, 2019).

Such negotiations will require action in various forums, including the WTO (SCM Committee, Trade and Environment Committee, TESSD Working Group on Subsidies, FFSR), as well as the OECD, and other forums.

As multilateral negotiations on such changes to global subsidy disciplines are difficult and likely to take some time, coordination with fewer main providers of subsidies, such as the United States and China, is a second-best option.

Summary assessment of the instrument, importance and priority

Given the widespread use and scope of subsidies being taken globally, their potential contribution to the transition to net-zero can be tremendous, but likewise subsidies can constitute a major risk for the achievement of climate policy goals, if spent on climate-damaging sectors or disregarding climate policy goals. Therefore, a prudent use of subsidies for climate change mitigation must be considered as a high priority not only by the EU but by governments globally.

As the above analysis has shown, international coordination is of prime importance to ensure an effective and efficient use of subsidies (also see Kleimann, 2023). This, however, is not an easy path given existing unilateral approaches and corresponding countermeasures, as well as the inadequacy of the multilateral regulatory subsidy regime as embodies in the WTO SCM Agreement. Negotiations towards an internationally more coordinated approach to climate action-oriented subsidies will therefore require considerable preparatory work and research.[87]

Technical barriers to trade

Brief description of the instrument

Technical barriers to trade (TBTs) comprise a vast range of different tools. At the regulatory level they cover mandatory technical requirements and voluntary standards on product characteristics or production methods.88 At the implementation level, they comprise a range of conformity assessment procedures. The Multi-Agency Support Team on NTMs provides the following definitions for technical regulations and conformity assessment procedures:

"A technical regulation is a document that sets out product characteristics or related processes and production methods, including the applicable administrative provisions, with which compliance is mandatory. It may also include or deal exclusively with terminology, symbols, packaging, marking or labelling requirements as they apply to a product, process or production method. A conformity-assessment procedure is any procedure used, directly or indirectly, to determine whether relevant requirements in technical regulations or standards have been fulfilled; it may include, inter alia, procedures for sampling, testing and inspection; evaluation, verification and assurance of conformity; registration, accreditation and approval, as well as a combination thereof" (UNCTAD, 2019, p. 10).

According to UNCTAD, "TBTs account for a large majority of all identified climate change related NTMs. […] Among TBT measures, performance requirements (emission limits, energy efficiency requirements), labelling requirements, and conformity assessments (tests and certification requirements) appear as the most common" (UNCTAD, 2022, p. 13). In addition, De Melo and Solleder estimated that "the average uniform protection from NTBs when combined with tariffs is 4 (APEC list) to 10 times (WTO list) greater than the average uniform protection from tariffs alone" (de Melo and Solleder, 2019, p. 16) – although this estimate refers to all NTBs (not only TBTs) and environmental goods (note climate change-mitigating goods), it indicates the magnitude of TBT effects.

Explanation of how it can constitute a tool to promote offensive and/or defensive EU interests

TBTs can contribute to climate change mitigation through the following causal mechanisms:

1. By setting climate change mitigation-related minimum or maximum thresholds for products and production processes, such as emission ceilings or minimum efficiency standards, technical regulations and standards promote the production of climate change-mitigating goods.
2. Similarly, labelling requirements, e.g. on energy efficiency standards, promote the diffusion of climate change-mitigating products by informing consumers about a products' impact on climate change.
3. Conformity assessment procedures ensure that the requirements established in technical regulations or standards are met and thus are an essential element for their enforcement.

An internationally harmonised approach to these measures further supports the global supply of climate change-mitigating goods by removing barriers to their trade.

The effect of such measures on EU competitiveness will depend on how they are implemented. Generally, being an early mover in the setting of new regulations in key industries has a positive effect, especially if these regulations are then taken up internationally. Conversely, setting regulations that are too demanding can negatively the EU industry by driving up compliance costs more than those for producers in third countries not subject to similarly strict rules.

TBTs can however also constitute risks for climate action. This would occur in particular where in the absence of internationally coordinated approaches climate action-oriented technical regulations, labelling requirements and/or conformity assessment procedures become nationally fragmented, resulting in higher compliance costs and thus more limited trade in and higher prices of climate change-mitigating goods. To the extent that third countries resort to such measures – for example through cumbersome licensing or verification procedures for imported goods – they also have negative effects for EU competitiveness.

Multilateral rules on technical barriers to trade

In addition to the WTO MFN and national treatment rules, the key WTO agreement governing TBTs is the Agreement on Technical Barriers to Trade (TBT Agreement). This aims to ensure that technical regulations do not create unnecessary obstacles to trade. It governs the preparation, adoption and application of technical regulations, standards, and conformity assessment procedures.

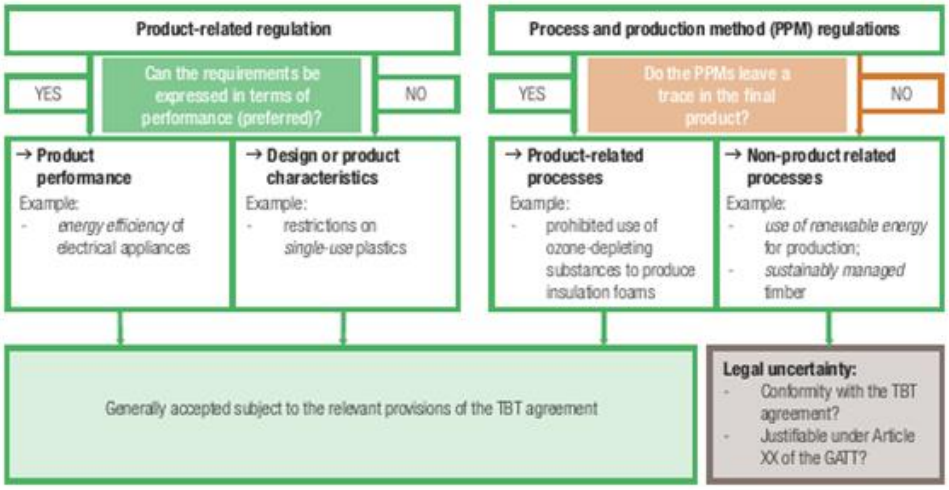
Provided that technical regulations respect the non-discrimination principle, the TBT Agreement does not prohibit the use of technical regulations for climate action purposes. Article 2.2 of the TBT Agreement lists a number of possible legitimate objectives which are, "inter alia: national security requirements; the prevention of deceptive practices; protection of human health or safety, animal or plant life or health, or the environment." On the basis of this formulation and the relevant case law, UNCTAD concludes that "there is hardly any doubt that a technical regulation adopted for climate change mitigation purposes would be considered as pursuing a legitimate objective" (UNCTAD, 2022, p. 24).

There are however a number of elements which condition the WTO-compliant use of TBT for climate change mitigation purposes (also see Low, Marceau and Reinaud, 2011; UNCTAD, 2022). First, technical

regulation should be not more trade-restrictive than is necessary to fulfil their legitimate objective. This entails that impact assessments ("necessity tests") should be made in order to determine if there are less trade-restrictive policy options available. Second, where possible, performance-based regulations should be preferred of regulations based on product design or descriptive characteristics. Third, where possible, technical regulations should be based on international standards.

In its recent analysis of the linkage between technical regulations and climate change, UNCTAD has also developed a taxonomy of the compliance of different types of technical regulations with WTO rules (Figure). This shows the important role of NPR-PPMs: process- production method-related technical regulations (right hand in the figure) are the only category of technical regulations for which the current WTO jurisprudence implies uncertainty over the legality under multilateral trade rules (also see Low, Marceau and Reinaud, 2011).

Figure 4-3: Types of technical regulations and WTO compliance



Source: UNCTAD (2022, p. 23).

Opportunities for the EU to use the trade policy instrument

Based on the foregoing discussion, the EU can use a variety of TBTs to support its climate policy goals. Examples of unilateral measures include the following ones:

- Further developing climate change mitigation-related technical regulations in the EU, e.g. through expansion of the scope and/or the tightening of minimum efficiency performance standards or GHG emission standards.
- Further development and expansion of carbon labelling requirements.

Probably as important are measures that could be taken in cooperation with third countries, be it in the framework of bilateral or (from a climate action perspective preferable) multilateral agreements. Examples of such negotiations and agreements would include:

- The reduction of technical barriers in third countries, e.g. through the harmonisation of technical regulations or establishment of international standards both for climate change-mitigating goods and climate change-mitigating production processes (including NPR-PPMs).
- The streamlining of procedures to certify energy efficiency and emission standards.

Summary assessment of the instrument, importance and priority

Due to their widespread use, including in important sectors both for EU competitiveness and climate change and their effects on emerging sectors, technical regulations, standards, labelling requirements and the associated conformity assessment are key trade-related instruments that might contribute to the achievement of the EU's climate action goals.

What also makes TBTs interesting from a policy perspective is that "Climate change-related technical regulations are generally seen as facing less political constraints when compared with other measures such as carbon taxes" (UNCTAD, 2022). They are thus less controversial and more amenable to international dialogue and harmonisation.

Quantitative import restrictions

Brief description of the instrument

Quantitative restrictions on imports include prohibitions (bans) and quotas.89 Unlike price-based measures such as import tariffs, quantitative restrictions and import bans set fixed ceilings on the level of imports and thus eliminate the price mechanism for the affected products. They thus constitute a stricter control instrument than price-based measures.

Explanation of how it can constitute a tool to promote offensive and/or defensive EU interests

Import prohibitions of climate-damaging goods in the EU or any third country would support climate mitigation efforts by reducing the demand for such goods, first of all in the jurisdiction applying the ban but also globally; the latter especially where the applying jurisdiction is a large market. If individual countries apply the measure, its effectiveness on climate change mitigation may be limited by trade diversion, i.e. the sales of the covered products in other markets will increase. Therefore, an internationally coordinated approach, such as the one taken for ozone-depleting substances (ODS) under the Montreal Protocol, is preferable.

The effects on EU competitiveness will depend on the specific condition of the measure. Normally, an EU import restriction for a climate-damaging good would be associated also with restrictions on the Union production. This would naturally have negative a negative impact on the producers of the concerned goods, and they might relocate to third countries – especially if the EU is the only jurisdiction imposing the measure without an indication that others would follow. EU users of the products covered by the restriction would also be negatively affected if no alternatives are available or are available only at higher cost. On the other hand, the competitiveness of EU producers of competing products – e.g., producers of LED lamps after an import ban of incandescent lamps – would benefit from the measure.

Multilateral rules on import restrictions

As quantitative restrictions generally have more distorting effects than tariffs (which leave the price mechanism generally intact) GATT Article XI prohibits both quantitative import and export restrictions. However, WTO jurisprudence distinguishes between border measures and domestic measures enforced at the border, which has implications on the legality of a measure under the non-discrimination principle: a border measure is subject to the MFN requirement (i.e. imports from anywhere must be treated alike but can be treated differently from domestic production), whereas a domestic measure enforced at the border is subject to national treatment (i.e. imports must not be treated differently from domestic products). For example, an import ban on incandescent lamps could be a border measure (if domestic production of such lamps is permitted) or a domestic measure enforced at the border (if there is a general sales ban on such lamps). Unfortunately, there is no simple rule to distinguish the two types of measures as they will depend on the specific design and conditions of the policy instrument. As Low and colleagues have noted: "The distinction between a border measure covered by an Article XI prohibition on quantitative restrictions and an internal or domestic regulation enforced at the border is not always simple and the complexity and sophistication of the climate change policy design will not help this fundamental legal distinction" (Low, Marceau and Reinaud, 2011, p. 14).

Opportunities for the EU to use the trade policy instrument

The EU could consider the imposition of import bans for climate-damaging goods. These are already used by the EU, e.g. with respect to ozone-depleting substances (ODS) whose imports have been prohibited since 2014. However, WTO rules set tight limits for such measures, and the justification for such a strict measure (when compared to tariffs or taxes) would have to be strong. For example, the

ban on imports of ODS could be justified by the legal obligation under the Montreal Protocol. Also, tight controls on trade in ODS are almost universally applied, and there is thus a global common approach which prevents disputes of the measure. Another option would be a justification under the general exceptions of GATT Art. XX. In any case, the use of an import ban without a general sales ban on the EU market would hardly be justifiable both from a climate change mitigation perspective and from a policy coherence perspective.

Generally, import bans can be applied unilaterally, but a preferable approach would be through international coordination – both for economic and legal reasons. This could be in the framework of the WTO rules or separate agreements.

Summary assessment of the instrument, importance and priority

Import prohibitions as a stand-alone border measure are not considered as an important or recommended trade policy measure to mitigate climate change. Their role mostly consists in enforcing a domestic measure, such as a general sales ban, at the border. In other words, they mostly constitute an administrative tool needed for the effective enforcement of a domestic climate policy instrument.

Export restrictions

Brief description of the instrument

Export restrictions as grouped here comprise all policy measures that aim at limiting the volume of exports, such as export tariffs, quantitative export restrictions including bans, non-automatic licensing requirements and export permits, etc.

Explanation of how it can constitute a tool to promote offensive and/or defensive EU interests

The impact of export restrictions for climate action is almost a mirror image to the impact of import restrictions. Their role to promote climate action internationally may be rather limited in practice: By setting restrictions to the export of climate-damaging goods the availability of such products on foreign markets is reduced – however, this is notable only if the country applying the restrictions is a major exporter. For example, Greenpeace has called for a US export ban of crude oil, urging that the "United States must not only phase out producing and burning fossil fuels at home but also stop exporting them to be burned elsewhere" (Laxman, 2022). On the other hand, unless the export restriction is not accompanied by measures aimed at curbing domestic use, prices for the goods concerned will decrease on the domestic market of the country that applies the measure, and accordingly sales with increase, thus limiting the effectiveness of the measure with respect to mitigating climate change.

More important are the potential negative effects for climate action stemming from export restrictions. Here, the main issue is that restrictions to the export of raw materials and other inputs needed for the production of climate change-mitigating products in the EU limit the supply of such products and therefore slow down decarbonisation. At the same time, these measures also negatively affect EU competitiveness in relation to producers not dependent on imports of the concerned goods.

Export restrictions of critical raw materials used for the production of climate goods have been applied in several cases. For example, Indonesia banned exports of nickel, an important input for batteries, in January 2020 – a move found to be in violation of WTO rules by the WTO panel upon a complaint made by the EU (European Commission, 2022d). Also, in December 2022 Zimbabwe banned the export of raw lithium (Marawanyika and Ndlovu, 2022).

Multilateral rules on export restrictions

WTO rules on export restrictions are equivalent to those on import restrictions and have been discussed above.

Opportunities for the EU to use the trade policy instrument

Where the EU is a large exporter globally, it could take measures aimed at mitigating climate change, although as noted above these might come at a cost for EU producers and traders. One such measure would be to require that exported products meet EU emissions and efficiency standards. More radically, exports of certain products could be prohibited. Some calls have been made to ban the export of older used cars, mirroring the import bans of such cars imposed by a number of countries (Skibell, 2021) – although less draconian (and WTO compliant) measures such as export taxes could also be considered.

With respect to export restrictions imposed by third countries – having negative effects on climate change mitigation and EU competitiveness – EU actions would primarily aim at mitigating these negative effects. Various types of such mitigating measures are available, including the following ones:

- Negotiating agreements, including investment agreements, facilitating access to critical raw materials from alternative suppliers so as to diversify supply;
- Challenging export restrictions that violate WTO rules under the WTO dispute settlement mechanism;
- Multilateral negotiations aimed at strengthening disciplines on export restrictions and ensuring the availability of critical raw materials for climate change-mitigating goods and their production.

The EU has already used, or foresees the use of these and other, including domestic, measures, inter alia within the framework of the recently proposed European Critical Raw Materials Regulation.[90]

Summary assessment of the instrument, importance and priority

From a climate change mitigation point of view, the importance of export restrictions mostly consists in the potential negative impacts for decarbonisation in the EU by limiting the availability of important raw materials and inputs such as nickel, lithium or cobalt used for energy storage.

This highlights the importance for the EU to take "defensive" measures in order to ensure continued availability of such critical raw materials needed for its climate action goals.

Trade defence instruments

Brief description of the instrument

Trade defence instruments, and in particular countervailing (or anti-subsidy) duties, are a response mechanism to the use of subsidies (see above).91 According to the SCM Agreement, in the presence of subsidies (whether prohibited or actionable), WTO Members have the choice of taking the case to the dispute settlement procedure of the WTO or imposing, following the required procedures, countervailing duties; both routes can in principle also be pursued simultaneously, although no double remedy can be imposed for the same situation at the same time.

Explanation of how it can constitute a tool to promote offensive and/or defensive EU interests

As countervailing measures are a reactive policy instrument which can only be considered in the presence of countervailable subsidies provided by another country, their potential impact on climate change depends on the impact of the subsidies being addressed. As such, countervailing measures can support climate action when used against subsidies which have a negative impact, such as subsidies for industries with high GHG emissions (unless these subsidies are linked to de-carbonisation and/or reducing polluting production processes): where such measures are applied, prices for the covered climate-damaging products increase, thereby reducing demand for them, while at the same time enhancing the competitiveness of competing products that are more climate-friendly. Also, when the EU applies such measures to restore fair competition, the result is a strengthening of EU competitiveness.

Conversely, countervailing measures can hinder climate action when applied against subsidies that are aimed at climate change mitigation. For example, the US imposes countervailing duties against certain German climate and energy-efficiency related tax breaks. Also, "transitional free emission allowances provided to energy-intensive trade-exposed sectors allocated under emissions trading systems are already subject to US countervailing duties with respect to allowances provided under the EU ETS" (Kleimann, 2023, p. 8). As Kleimann also notes, the effect of this particular measure with respect to climate change action is actually ambiguous: "While these countervailing duties offer a political side-effect of incentivising the phase-out of free allowances provided to the highest emitting industries in the EU […], they disincentivise third-country regulatory pilot projects of a nature similar to the ETS" (Kleimann, 2023, p. 8). What is an unambiguous result of such measures is the negative effect on EU competitiveness.

Multilateral rules on trade defence instruments

Multilateral rules for countervailing measures are provided by the WTO SCM Agreement (see the section on subsidies above). Environmental considerations are not a factor in the investigation, determination or level of countervailing measures.

Opportunities for the EU to use the trade policy instrument

In line with the two different potential effects of countervailing measures, the EU could pursue two strands of measures:

- In anti-subsidy investigations carried out against subsidised products from third countries, explicitly consider the effect of these subsidies on GHG emissions and other climate impacts. Such an assessment could take place as part of the union interest test. Nevertheless, the determination of the upper level of countervailing measures to be taken is determined by the SCM Agreement, which does not take environmental of climate change considerations into account.
- To mitigate the negative effects that could stem from third countries' use of countervailing measures against EU climate action mitigating products (or products benefitting from decarbonization production subsidies), bilateral negotiations with the country concerned or amendments to the WTO subsidy rules as discussed above are the only possible response.

Summary assessment of the instrument, importance and priority

The use of trade defence instruments, notably countervailing measures, for the purposes of mitigating climate change remains to be assessed as the research progresses.

Public procurement

Brief description of the instrument

Government procurement constitutes a significant share of economies globally. According to the WTO, it accounts for 10%–15% of GDP globally (WTO, no date). In the EU, its share is above 14% of GDP (European Commission, no date). Because of the specific conditions applied, including the eligibility of suppliers or service providers, public procurement also plays an important role for international trade. For example, according to several studies the "procurement of services by governments could represent as much as 30% of overall services trade" (Bellmann and Sugathan, 2022, p. 23).

Explanation of how it can constitute a tool to promote offensive and/or defensive EU interests

Because of its economic importance and its potential impact on trade, public procurement can play an important positive role for climate action: "green procurement practices can be a powerful lever to influence market demand, promote the uptake of EGS [environmental goods and services], set minimum environmental standards, and encourage the development of local EGS industries" (Bellmann and Sugathan, 2022, p. 23). Specifically, the following causal mechanisms apply:

By setting minimum standards or granting preferences related to GHG emissions or other climate change-mitigating effects, public procurement increases demand for climate change-mitigating effects.

Public entities can also create assured demand for new and climate change-mitigating goods in the first place, thereby fostering investment in the production of such goods and allowing producers to benefit from scale effects and make products commercially viable (EIU, 2019, p. 25); examples include green hydrogen or e-fuels

These measures will typically also have **positive effects on EU competitiveness**: the extent that EU businesses are active in the relevant markets they will benefit proportionately to their market share from them; also, because domestic firms tend to have larger-than-average shares in public procurement markets than in the economy overall, it is likely that they benefit more than foreign competitors from green procurement. Nevertheless, to ensure that such gains do take place in practice, public procurement conditions can also include local content requirements – although this is a more controversial measure due to the globally distorting effects and potential international repercussions – similar to the issues related to subsidies discussed above.

In line with the above considerations, green public procurement measures taken by third countries can have **negative effects on EU competitiveness** due to the fact that the benefits from such measures are likely to accrue mostly to third country companies.

Multilateral rules on public procurement

The main global regulatory instrument on public procurement and trade is the plurilateral WTO Government Procurement Agreement (GPA), revised in 2012. It has 21 parties representing 48 WTO members (the EU is a party representing its 27 members). Its rules only apply to these parties, and among those only covered procuring entities, and only listed goods, works and services above specified threshold values.

Even for covered procurement, the GPA does not establish strict conditions that would limit the EU's use of public procurement for climate change-mitigation. Within the boundaries of the non-discrimination principle, Art. III:2(b) of the GPA provides for exceptions for the protection of human, animal or plant life or health, and the 2012 revised version introduced a new provision (Art. X:6) clarifying that "a Party, including its procuring entities, may, in accordance with this Article, prepare, adopt or apply technical specifications to promote the conservation of natural resources or protect the environment."

Opportunities for the EU to use the trade policy instrument

Based on the foregoing discussion, the EU can unilaterally use green public procurement to support its climate policy goals, for example by:

- Establishing EU rules for setting minimum standards or granting preferences related to GHG emissions or other climate change-mitigating effects in EU public procurement; or
- Determining new key climate change-mitigating goods and services to be procured publicly to ensure demand and foster corresponding investment and innovation in the EU.

Constraints for such measures by global trade rules are limited, and accordingly less coordination with third countries may be required in the area of public procurement than for other trade related measures discussed in this report. Nevertheless, to address the potential negative effects on EU competitiveness caused by third countries' green public procurement, negotiations with key economies on such measures should be considered.

Summary assessment of the instrument, importance and priority

Because of its economic importance and the comparatively limited level of constraints posed by multilateral rules, EU public procurement measures can potentially play an important positive role for climate action: they can relatively easily be implemented unilaterally – assuming consensus among EU members – without the need to negotiate amendments to WTO rules.

Trade agreements

Brief description of the instrument

In 2021, the EU had 42 preferential trade agreements in place with 74 partners (European Commission, 2022a). As of March 2023, this has increased to 78 partners; negotiations with another 25 countries have been completed, and negotiations with five more countries are ongoing.92 This indicates the importance of trade agreements for the EU.

Explanation of how it can constitute a tool to promote offensive and/or defensive EU interests

Trade agreements can foster the diffusion of climate change-mitigating goods and services by making particularly ambitious commitments (i.e. full liberalisation) for these products. Such liberalisation can take implicitly, i.e. without specifically referring to green goods, or explicitly – for example as done in the recent EU-New Zealand FTA.93 Trade agreements also provide institutional frameworks for consultations and negotiations among the parties on the climate effects of various trade policy instruments and mitigating measures to be taken. For example, the Commission's 2022 Report on the Implementation and Enforcement of Trade Agreements states: "At the TSD Committees, the EU and its trading partners also monitored the implementation of Multilateral Environmental Agreements (MEAs) and discussed how to jointly tackle environmental challenges, notably on climate change, circular economy and resource efficiency (e.g. plastics, waste and residues), exchanging views on national climate and biodiversity action plans" (European Commission, 2022a, p. 11). The EU's trade agreements are therefore a potential arena through which the EU could aim at pursuing trade-related measures to foster its climate action, as discussed in the other sections on trade policy instruments.

However, through their trade and economic effects, trade agreements also promote or hinder the pursuit of climate policy goals. On the positive side, FTAs can reduce global GHG emissions through relocating production from high-intensity GHG emitters to lower-intensity emitters. On the negative side, they can also increase GHG emissions through more trade. Which of the impacts prevails, and whether the net climate effect of trade agreements is positive or negative, is an empirical question. A priori, the climate effects of trade agreements are ambiguous – as are effects on EU competitiveness at the sectoral level, as these vary across sectors and agreements. At the economy-wide level, however, EU trade agreements have positive effects on EU competitiveness.

Effects on climate change and EU competitiveness are already being assessed by the Commission, at the time of negotiations through trade sustainability impact assessments (SIAs), as well as through ex post evaluations of trade agreements carried out after a few years of agreement implementation.94 Generally, these tend to find limited impacts on global GHG emissions.

Multilateral rules on regional trade agreements

Trade agreements typically constitute an exception of the WTO's non-discrimination principle, because they provide for lower market access barriers among the parties than those applied on non-parties to the agreement. On the other hand, trade agreements are allowed under WTO rules as they are considered as a steppingstone towards broader, multilateral trade liberalisation – but to ensure this role, trade agreements are subjected to certain conditions to be considered WTO-compatible. In particular, trade agreements must cover "substantially all trade" between the parties to the agreement. This means that trade agreements covering only e.g. climate change-mitigating goods would not comply with WTO rules.

Opportunities for the EU to use the trade policy instrument

As mentioned, in addition to reducing or removing market access barriers for climate change-mitigating goods and services, trade agreements are important vehicles to discuss climate change mitigation with partner countries. However, the degree to which EU agreements institutionalise such provisions varies considerably. Especially older agreements tend not to have trade and sustainable development (TSD) chapters and related dedicated committees. Also, the scope and depth with which climate change issues are addressed in the agreements varies, with a trend towards broader scope

and deeper commitments by the parties over time.95 Accordingly, measures which the EU could take are:

- In the negotiation of new agreements, continue to strive for ambitious and binding liberalisation of climate change-mitigating goods and services and other measures, including the establishment of corresponding joint institutions, monitoring mechanisms and dispute and sanctions regimes;
- For existing agreements, expand the scope for discussions of climate issues to the maximum degree possible foreseen under the agreement. For example, not all EU trade agreements have comprehensive TSD chapters that would specifically foresee discussions on climate policy issues; however, in the joint institutions established under the agreement, such climate issues could nevertheless be raised. In addition, the modernisation of agreements could be considered where these are no longer aligned with the EU's climate policy objectives and policies.

In addition, considering the ambiguous impact of trade agreements on GHG emissions stemming from the changes in trade flows and production patterns, for each trade agreement the potential effects on climate change should be assessed ex ante, be monitored and regularly evaluated. This is already the standing practice of the Commission and should be continued.

Summary assessment of the instrument, importance and priority

Trade agreements provide an important forum to discuss climate action-related trade measures with partner countries, especially if the agreements institutionalise such discussions. The impact of trade agreements on climate change stemming from the changes in trade and production patterns are typically ambiguous and therefore need to be assessed and monitored individually for each agreement. Overall, the importance of trade agreements with regard to climate impacts and policies is considered are moderate: the impact of most agreements on climate change may be limited, but their role as discussion forums is important and should be strengthened, where required.

Other trade-related measures countering carbon leakage

Brief description of the instrument

Many of the instruments described in the preceding sections can be used, and are used, to address carbon leakage, i.e. the negative effects on climate change mitigation (and also EU competitiveness) resulting from more demanding and hence costlier rules in the EU, which prompt the increase in production (including through the possible relocation of producers from the EU) in third countries with weaker, and less costly, regulations. However, some specific instruments aimed at countering carbon leakage by eliminating the cost advantage provided in lesser regulated countries that have been developed defy an easy classification under international trade law. These notably include different types of carbon border adjustments such as taxes levied on imports of products or mandatory carbon offset purchases by importers of carbon-intensive products. The EU's CBAM is based on this concept and would apply it to the import of products covered by the ETS. In theory and if correctly applied different carbon border adjustment measures have equivalent results.

Explanation of how it can constitute a tool to promote offensive and/or defensive EU interests

Carbon border adjustments are not a self-standing instrument to mitigate climate change but rather a tool to safeguard the effectiveness of other climate action measures. Regardless of the specific type of adjustment measure, by definition they support climate action by protecting the expected benefits of these other measures for climate change mitigation. At the same time, when taken by the EU they also address the negative EU competitiveness effects that certain climate change-mitigating measures such as stringent regulations may have for the EU industry.

A risk of carbon border adjustments both for climate change mitigation and EU competitiveness stems from their potential abuse as a protectionist instrument. This risk is particularly high because of

the complexity of implementation, which requires the correct calculation and valuation of differences in carbon intensity between domestic and imported products, while incorporating the effect of other climate change mitigation measures to which these products have already been subjected (Bellora and Fontagné, 2022). In sum, as noted by Brenton and Chemutai: "Carbon border adjustments can be politically controversial, challenging to reconcile with international trade law, and administratively demanding to implement. [A]ny new program will be carefully examined for its consistency with World Trade Organization (WTO) rules and is very likely to be challenged in the WTO dispute settlement system" (Brenton and Chemutai, 2021, p. 68).

Relevant multilateral trade rules

No specific multilateral trade rules on carbon border adjustment measures exist, as such measures are not explicitly addressed in any of the WTO agreements. Some relevant WTO case law exists but provides only limited indications on the compatibility of such measures with WTO rules (e.g., Low, Marceau and Reinaud, 2011; Pauwelyn and Kleimann, 2020; Brenton and Chemutai, 2021; Sapir, 2021), although there appears to be an agreement among legal scholars "that WTO rules in principle allow WTO members to adjust their ETS systems for imports" (Sapir, 2021) – but complex issues regarding the nature of a measure, and its compliance with key WTO principles and specific rules need to be assessed on a case-by-case basis.

Opportunities for the EU to use the trade policy instrument

The EU has already decided that the mandatory purchase of certificates by importers is the preferred option for carbon border adjustment. The use of an import carbon tax was studied in the process but ultimately rejected (European Commission, 2021a). There would thus seem to be no need for further unilateral measures to be taken until lessons from the CBAM can be drawn.

However, further work at the multilateral level – not necessarily in the WTO context - could contribute first, to greater legal certainty over carbon border adjustment and, secondly, higher effectiveness of measures globally:

- A first-best climate policy measure would be the establishment of global carbon markets or similar global coordination effort, e.g. under Article 6 of the Paris Agreement. Such a global approach would eliminate or reduce the need for the EU and other countries to resort to carbon border adjustment measures by eliminating carbon leakage (and distortions to competitiveness across jurisdictions stemming from carbon pricing). The need for global cooperation on carbon pricing has also been highlighted by the WTO (2022b, chap. D)
- A second-best option would be an agreement or clarification, within the WTO regulatory framework, on the principles and features that carbon border adjustment measures would need to comply with to be considered as WTO-compliant.

Summary assessment of the instrument, importance and priority

Carbon border adjustment measures are an important trade policy instrument needed to address carbon leakage, which inevitably occurs in a world where jurisdiction apply uncoordinated GHG emissions policies aimed at climate change mitigation with different levels of strictness and costs imposed on emitters. At the same time, given the lack of clarity of multilateral trade rules and the complexity of determining the right level of border adjustment, the risk which carbon border adjustment measures constitute for protectionist abuse is also considered high.

A coordinated global approach to carbon pricing would constitute the optimum policy measure, as this would remove the need for border adjustment measures in the first place. A second-best option would be to agree on the main principles and characteristics of border adjustment measures.

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