Basic Chemicals Background Paper

The Basic Chemicals Eligibility Criteria of the Climate Bonds Standard & Certification Scheme

Final for Issuance

Acknowledgements

Climate Bonds gratefully acknowledges the Technical and Industry Working Group members who supported the development of these Criteria. Members are listed in ***Appendix A***. Special thanks are given to Elias Martinez, the lead specialist and Marian Rodriguez for coordinating the development of the Criteria through the Technical Working Group.

The Industry Working Group provided critical and useability focused consultation and feedback on the Criteria, but this does not automatically reflect endorsement of the criteria by all members.

Revision	Date	Summary of Changes
Rev. 1.0	11 October 2022	Final for Issuance
Rev. 0.1	06 April 2022	Issued as draft for Consultation

List of Acronyms

A&R	Adaptation and Resilience
CBS	Climate Bonds Standard
CBSB	Climate Bonds Standard Board
CCS	Carbon Capture and Storage
CCU	Carbon Capture and Utilisation
Climate Bonds	Climate Bonds Initiative
CO2e	CO2 equivalents
EGS	Environmental, Social, and Governance
GHG	Greenhouse Gas Emissions
GWP	Global Warming Potential
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
IWG	Industrial Working Group
NGO	Non-governmental organisations
SBTi	Science-Based Targets initiative
TWG	Technical Working Group
WBSCD	World Business Council for Sustainable Development

Definitions

Absolute emissions contraction targets: It is an overall reduction in emissions by the target year, relative to the base year. (e.g., reduce annual CO2 emissions 35% by 2025, from 2018 levels)[1].

A&R Group: A group of key experts from academia, international agencies, industry and NGOs convened by Climate Bonds. The group supports the development of the Adaptation and Resilience requirements of the Sector Criteria

Activity or asset level: this refers to a specific facility carrying out the production of a basic chemical, e.g. the activity of producing ammonia, a plant or project producing ethylene. At this level emission intensity criteria will be adopted.

Allocation approach: Carbon budg*et al*location among companies with the same level of disaggregation (regional, sectoral, global)

Basic chemicals production assets and projects: Assets and projects relating to the acquisition, installation, management and/or operation of infrastructure for basic chemicals production, which include the production of the chemicals in scope for the present criteria.

Bioenergy: Energy generated from the conversion of solid, liquid and gaseous products derived from biomass.

Biomass cascading: Cascading refers to a resource-efficient and circular use of any biomass, according to European guidance on cascading use of biomass. The general idea of cascading is that resources should be re-used sequentially in the order of the specific resource quality at each stage while maximising the value of the products, for example biomass for pharmaceuticals and other chemicals are of higher value than basic chemicals or energy.

Biomass: Any organic matter, i.e. biological material, available on a renewable basis. It includes feedstock derived from animals or plants, such as wood and agricultural crops, and organic waste from municipal and industrial sources.

Carbon budget: a finite amount of carbon emitted to the atmosphere before warming will exceed specific temperature thresholds[2].

Certified Climate Bond: A climate bond that is certified by the Climate Bonds Standard Board as meeting the requirements of the Climate Bonds Standard (see below), as attested through independent verification.

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[1] SBTi (2020). SBTi manual. https://sciencebasedtargets.org/resources/legacy/2017/04/SBTi-manual.pdf

[2] IPCC (2021). 6th Assessment Report

Climate Bonds Initiative (Climate Bonds): An investor focused not-for-profit organisation, promoting large-scale investments that will deliver a global low carbon and climate resilient economy. Climate Bonds seeks to develop mechanisms to better align the interests of investors, industry and government to catalyse investments at a speed and scale sufficient to avoid dangerous climate change.

Climate Bonds Standard (CBS): A screening tool for investors and governments that allows them to identify green bonds the proceeds of which are being used to deliver climate change solutions. This may be through climate mitigation impact and/or climate adaptation or resilience. The CBS is made up of two parts: the parent standard (CBS v4.0) and a suite of sector specific eligibility Criteria. The parent standard covers the certification process and pre- and post-issuance requirements for all certified bonds, regardless of the nature of the capital projects. The Sector Criteria detail specific requirements for assets identified as falling under that specific sector. The latest version of the CBS is published on the Climate Bonds website.

Climate Bonds Standard Board (CBSB): A board of independent members that collectively represents $34 trillion of assets under management. The CBSB is responsible for approving (i) Revisions to the CBS, including the adoption of additional sector Criteria, (ii) Approved verifiers, and (iii) Applications for Certification of a bond under the CBS. The CBSB is constituted, appointed, and supported in line with the governance arrangements and processes as published on the Climate Bonds website.

Climate Bond Certification: allows the issuer to use the Climate Bond Certification Mark in relation to that bond. Climate Bond Certification is provided once the independent CBSB is satisfied the bond conforms with the CBS.

Critical interdependencies: The asset or activity's boundaries and interdependencies with surrounding infrastructure systems. Interdependencies are specific to local context but are often connected to wider systems through complex relationships that depend on factors 'outside the asset fence' that could cause cascading failures or contribute to collateral system benefits.

Contraction: All companies reduce their absolute emissions at the same rate irrespective of initial emission performance[1].

Convergence: Companies reduce their emission intensity at a standard value by a given year[1].

Emission scenario: Represent a way of distributing the available carbon budget over time[1].

Entity or company level: this refers to the specific company or organisation that is involved in the production of a basic chemical and owns certain activities or assets, or any subsidiary. At this level, absolute contraction criteria will be adopted.

Green Bond: A green bond is a bond of which the proceeds are allocated to environmental projects or expenditures. The term generally refers to bonds that have been marketed as green. In theory, green bonds proceeds could be used for a wide variety of environmental projects or expenditures, but in practice they have mostly been earmarked for climate change projects.

Industry Working Group: A group of key organisations that are potential issuers, verifiers and investors convened by Climate Bonds The IWG provides feedback on the draft sector Criteria developed by the TWG before they are released for public consultation.

Investment Period: The interval between the bond's issuance and its maturity date. Otherwise known as the bond tenor.

Technical Working Group: A group of key experts from academia, international agencies, industry and NGOs convened by Climate Bonds. The TWG develops the Sector Criteria - detailed technical criteria for the eligibility of projects and assets as well as guidance on the tracking of eligibility status during the term of the bond. Their draft recommendations are refined through engagement with finance industry experts in convened Industry Working Groups (see below) and through public consultation. Final approval of Sector Criteria is given by the CBSB.

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1 Introduction

1.1 Overview

This document serves as a reference document to the Criteria Document for Basic Chemicals. The purpose of this document is to provide an overview of the key considerations and issues that were raised during the development of the Basic Chemicals Criteria and provide the rationale for why requirements were chosen and set.

The Criteria were developed through a consultative process with TWG and IWG, and through public consultation. The TWGs comprised academic and research institutions, civil society organisations, multilateral banks and specialist consultancies whereas IWGs are represented by industry experts including potential bond issuers and investors. A 60-day period of public consultation offers the opportunity to any member of the public to comment on the Criteria. This document aims to capture these various dialogues and inputs and substantiate the reasoning behind the Basic Chemicals Criteria.

Supplementary information will be made available in addition to this document, including:

1. Basic Chemicals Criteria document: the complete Criteria requirements.
2. Basic chemicals public consultation feedback and responses summary
3. Climate Bonds Standard: the umbrella document laying out the common requirements that all Certified Climate Bonds need to meet, in addition to the sector-specific Criteria (Climate Bonds Standard V3.0 | Climate Bonds Initiative).
4. Basic Chemicals Frequently Asked Questions

For more information on the Climate Bonds Initiative and the Climate Bond Standard & Certification Scheme, see www.climatebonds.net/standards. For the documents listed above, see www.climatebonds.net/standard/Basic Chemicals

1.2 Funding the goals of the Paris Agreement

The current trajectory of climate change, expected to lead to a global warming of 2.7-3.1°C by 2100[3], poses an enormous threat to the future of the world's nations and economies. The aim of the Paris Agreement is to limit warming to a global average of no more than 2°C higher than pre-industrial levels by the end of the century, and ideally no more than 1.5°C. The effects of climate change and the risks associated even with a 2°C rise are significant: rising sea levels, increased frequency and severity of hurricanes, droughts, wildfires and typhoons, and changes in agricultural patterns and yields. Meeting the 2°C goal requires a dramatic reduction in global greenhouse gas (GHG) emissions.

At the same time, the world is entering an age of unprecedented urbanisation and related infrastructure development. Global infrastructure investment is expected to amount to USD 90 trillion by 2030, more than the entire current infrastructure stock[4].

To ensure sustainable development and avoid dangerous climate change, this infrastructure needs to be low-carbon and resilient to physical climate impacts, without compromising the economic growth needed to improve the livelihoods and wellbeing of the world's poorer citizens. Ensuring that the infrastructure built is low-carbon raises the annual investment needs by 3-4%[5]. Climate adaptation needs to add another significant amount of investment, estimated at USD 280-500 billion per annum by 2050 for a 2°C scenario[6].

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[3] According to Climate Tracker, under current policies we could expect 2.7 - 3.1°C: http://climateactiontracker.org/global.html

[4] The Global Commission on the Economy and Climate (2018), 'Unlocking the Inclusive Growth Story of the 21st Century: Accelerating Climate Action in Urgent Times': https://newclimateeconomy.report/2018

[5] The Global Commission on the Economy and Climate (2016), 'Better Growth, Better Climate': http://newclimateeconomy.report/2016/wp-content/uploads/sites/2/2014/08/BetterGrowth-BetterClimate_NCE_Synthesis-Report_web.pdf

[6] UNEP (2018), 'Adaptation Gap Report 2018': Adaptation Gap report 2018 (unep.org)

1.3 The role of bonds

Traditional sources of capital for infrastructure investment (governments and commercial banks) are insufficient to meet these capital needs; institutional investors, particularly pension and sovereign wealth funds, are increasingly looked to as viable actors to fill these financing gaps.

Capital markets enable issuers to tap into large pools of private capital from institutional investors. Bonds are appropriate investment vehicles for these investors as they are low-risk investments with long-term maturities, making them a good fit with institutional investors' liabilities (e.g., pensions to be paid out in several decades).

Bond financing works well for low-carbon and climate-resilient infrastructure projects post-construction, as bonds are often used as refinancing instruments. Labelled Green Bonds are bonds with proceeds used for green projects, mostly climate change mitigation and/or adaptation projects, and labelled accordingly. The rapid growth of the labelled green bond market has shown in practice that the bond markets can provide a promising channel to finance climate investments.

The Green Bond market can reward bond issuers and investors for sustainable investments that accelerate progress toward a low-carbon and climate-resilient economy. Commonly used as long-term debt instruments, Green Bonds are issued by governments, companies, municipalities, and commercial and development banks to finance or re-finance assets or activities with environmental benefits. Green Bonds are regular bonds with one distinguishing feature: proceeds are earmarked for projects with environmental benefits. Green Bonds are in high demand and can help issuers attract new types of investors.

A green label is a discovery mechanism for investors. It enables the identification of climate-aligned investments even with limited resources for due diligence. By doing so, a green bond label reduces friction in the markets and facilitates growth in climate-aligned investments.

Currently Green Bonds only account for less than 0.2% of a global bond market of USD 128 trillion[7]. The potential for scaling up is tremendous. The market now needs to grow much bigger, and quickly.

1.4 Introduction to the CBS

Activating the mainstream debt capital markets to finance and refinance climate friendly projects and assets is critical to achieving international climate goals, and robust labelling of green bonds is a key requirement for that mainstream participation. Confidence in the climate objectives and the use of funds intended to address climate change is fundamental to the credibility of the role that green bonds play in a low carbon and climate resilient economy. Trust in the green label and transparency to the underlying assets are essential for this market to reach scale but investor capacity to assess green credentials is limited. Therefore, Climate Bonds created the Climate Bonds Standard & Certification Scheme, which aims to provide the green bond market with the trust and assurance to achieve the required scale.

The Climate Bonds Standard & Certification Scheme is an easy-to-use tool for investors and issuers to assist them in prioritising investments that truly contribute to addressing climate change, both from a resilience and a mitigation point of view. It is made up of the overarching CBS detailing management and reporting processes, and a set of Sector Criteria detailing the requirements assets must meet to be eligible for certification. The Sector Criteria covers a range of sectors including solar energy, wind energy, marine renewable energy, geothermal power, low carbon buildings, low carbon transport, and water. The Certification Scheme requires issuers to obtain independent verification, pre- and post-issuance, to ensure the bond meets the requirements of the CBS.

Existing Sector Criteria cover solar energy, wind energy, marine renewable energy, geothermal power, buildings, transport (land and sea), bioenergy, forestry, agriculture, waste management and water infrastructure, hydropower, electricity grids and storage. In addition to Basic Chemicals, additional Sector Criteria currently under development include Cement, Steel, and Hydrogen.

[7] www.icmagroup.org/regulatory-policy-and-market-practice/secondary-markets/bond-market-size

1.5 Process for Sector Criteria Development

The CBS has been developed based on public consultation, road testing, and review by the Assurance Roundtable (a group of verifiers) and expert support from experienced green bond market participants.

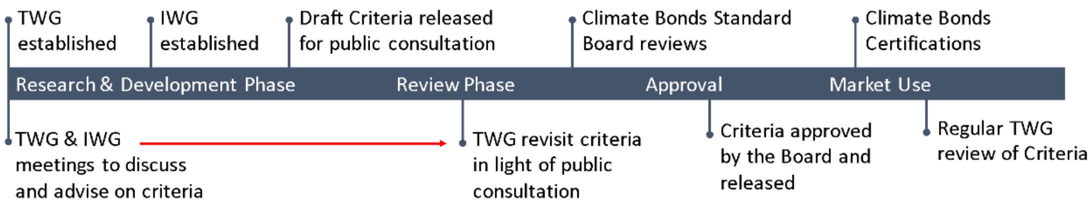


Figure 1: Criteria Development Process

The Standard is revisited and amended on an annual basis in response to the growing climate aligned finance market. Sector specific Criteria are developed by TWG made up of scientists, engineers, and technical specialists. Draft Criteria are presented to IWG before being released for public comment. Finally, Criteria are presented to the CBSB for approval (see diagram below).

Sector Criteria for many sectors are available and include wind, solar, geothermal, marine renewables, hydropower, road transport, marine transport, electrical grids, water management and buildings. Criteria are available at Sector Criteria | Climate Bonds Initiative.

1.6 Structure of this document

This document supports the Basic Chemicals Criteria. It captures the issues raised and discussed by the TWG, as well as the arguments and evidence in support of the Criteria. It is structured as follows:

- Section 2 provides a brief overview of the sector: its current status, trends and role in mitigating and adapting to climate change.
- Section 3 outlines the objectives, principles and overarching considerations for setting the criteria and provides an overview of the criteria.
- Section 4 describes the rationale behind the mitigation requirements
- Section 5 describes the adaptation and resilience requirements

2 Sector Overview

2.1 What are Basic Chemicals?

The chemical industry can be as diverse as the number of processes and products involved in their productive activities. Yet, only a few molecules (including ammonia, ethylene, propylene, methanol and benzene, toluene and xylene, among others) dominate the production volume and, consequently, the investments and carbon emissions. Their production enables the majority of chemical value chains that provide the inputs for products we use and consume in our daily life from water, food and pharmaceuticals to computers, cars and buildings. For example, ammonia is necessary for production of fertilisers used to grow our food. They are so essential to modern society that these chemical products are commonly known as basic chemicals. The basic chemicals category accounts for around 60% of the chemical industry´s energy consumption[8] and 75% of scope 1 and 2 GHG emissions from the

[8] IEA (2020). IEA Energy Technology Perspectives 2020. www.iea.org/reports/energy-technology-perspectives-2020

chemical industry[9]. The main reason for this is that their production relies on the use of fossil resources such as coal, crude oil and natural gas not only as a fuel but also as a feedstock.

Because of the variety and number of chemical products, setting standards for all of them is not feasible; thus, it requires a categorisation that allows addressing the highest emitters and most energy-intensive production processes. Various approaches exist to classify chemical assets and processes, depending on the intended goal. Some approaches are related to products, processes, activities, or the market. The EU taxonomy[10] criteria for chemicals focus on basic chemicals but are divided into four categories: Organic chemicals, ammonia, some inorganic chemicals, and plastics. The IEA focuses on two categories, basic chemicals and "the rest," in its recent Energy technology perspectives[11]. A study published by the Joint Research Centre (JRC) and the European Commission assesses 26 essential chemical compounds, covering 75 % of the total energy use and above 90 % GHG emissions of the chemical sector in 2013[12]. A report from the Inter-American Development Bank (IDB) includes chemicals such as ammonia, olefins, and methanol, and some intermediates such as styrene and plastics (polyethylene and polypropylene) as basic chemicals.

Although categorisation and the products included in the basic chemicals sector varies with jurisdiction, geographies, organisations or entities, a preselection of basic chemicals are included in scope for the criteria based on a value chain categorisation to tackle the initial building blocks in the sector first.

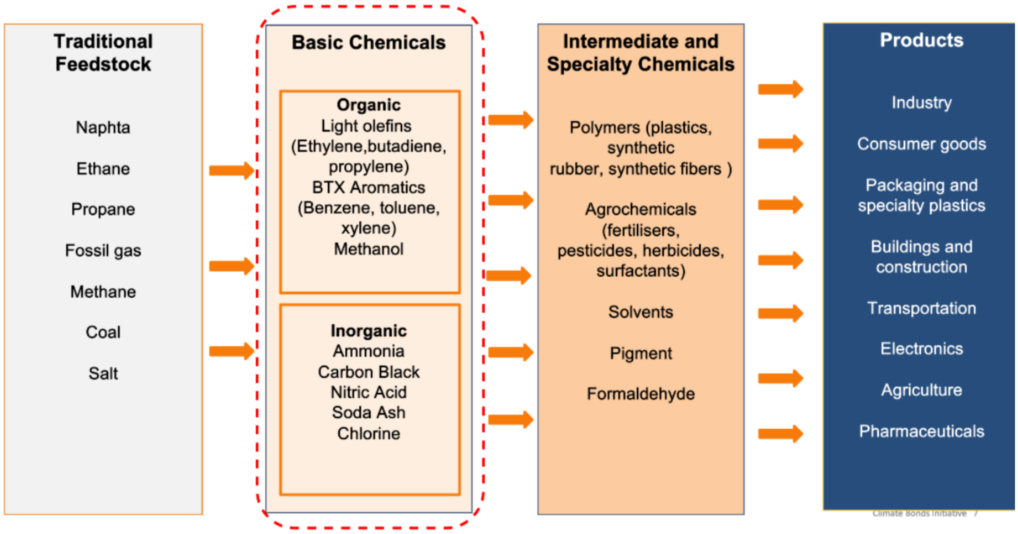


Figure 2: Chemical Industry Value Chain

As such, in this document the term basic chemicals refers to the following list of chemical products:

Table 1: Eligible Basic Chemical

Chemical Groups	Eligible Assets
Inorganic basic chemicals	• Ammonia • Chlorine • Disodium carbonate/Soda ash • Nitric acid

[9] SBTi (2020). Barriers, Challenges, and Opportunities for Chemical Companies to Set Science-Based Targets. Retrieved from https://sciencebasedtargets.org/resources/files/SBTi-Chemicals-Scoping-Document-12.2020.pdf

[10] The EU taxonomy is a classification system, establishing a list a criteria for low carbon and sustainable economic activities, aimed as a support tool to guide financial investment in different sectors. https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/eu-taxonomy-sustainable-activities_en

[11] IEA (2020). IEA Energy Technology Perspectives 2020. www.iea.org/reports/energy-technology-perspectives-2020

[12] Boulamanti, A. & Moya J.A. (2017). Energy efficiency and GHG emissions: Prospective scenarios for the chemical and petrochemical industry, EUR 28471 EN, doi:10.2760/20486

Chemical Groups	Eligible Assets
	• Carbon black
Organic basic chemicals	• High value chemicals (acetylene, ethylene, propylene, butadiene) • Aromatics (Benzene, Toluene and Xylene (BTX)) • Methanol

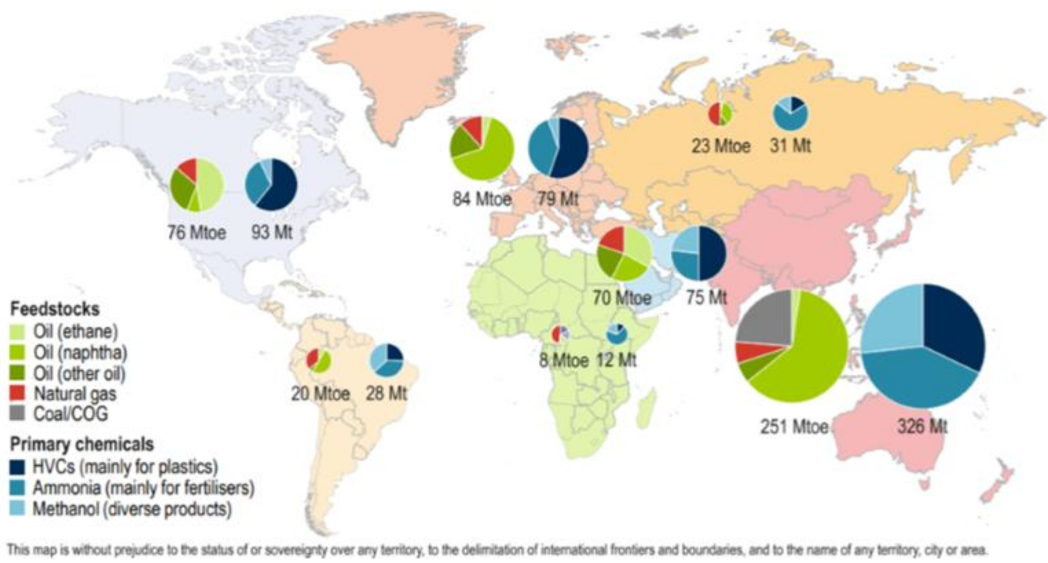
Table 2: Basic chemical products and their main applications

ASIC chemical product	Description	Main applications
Ammonia	Ammonia (NH3) is one of the main compounds used to produce fertilisers. The main technology requires steam reforming of fossil feedstocks to generate the hydrogen required.	About 90 percent of ammonia is used in fertiliser, however it is a building block to produce many other products, such as pesticides, plastics, and explosives. It is also used in the water and waste- water treatment, and as a refrigerant.
Chlorine	It is produced in the Chlor-alkali process wherein chlorine (Cl2) and caustic soda (NaOH) are produced simultaneously by electrolytic decomposition of salt, generating hydrogen as a byproduct.	Pulp, paper, textiles, bleach, water treatment, soaps, and detergents, pharmaceutical, aluminium.
Disodium carbonate/Soda ash	Soda ash is the common name for disodium carbonate (Na2CO3). The main production technology is the Solvay process from brine and limestone.	Cleansing products, water softening and glass manufacturing.
Nitric acid	Nitric acid is a strong oxidant and is mainly produced from catalytic oxidation of ammonia.	Used to synthesise fertilisers, as a strong oxidant and precursor to nitrogen compounds, and in the manufacturing of explosives.
Carbon black	Partial combustion of natural gas or crude oil heavy fractions.	Mainly used as a pigment, coatings and in automobile tires.
Acetylene Ethylene Propylene Butadiene	These are grouped here as high value chemicals (HVC). These chemicals are also known as olefins (hydrocarbons with double carbon-carbon bonds, except for acetylene which contains a triple carbon-carbon double bond). These products are usually produced together from the steam cracking of fossil feedstocks (natural gas and naphtha mainly), and also from coal. Ethylene and propylene are the major HVC products, and specific processes from ethane and propane exist.	Polymers such as polyethylene and polypropylene (Plastics for packaging, pipes, automobile parts, toys, clothing and textile, outdoor furniture, food containers, among others)
Benzene Toluene Xylene	These products are aromatics extracted from petroleum derivatives from refining and also produced from the processing of several refinery streams.	They are used as starting materials to produce several industrial products, solvents, and chemical intermediates. Additives in gasoline, paints, solvents, among others.
Methanol	Methanol is an important commercial chemical. It is the simplest alcohol and the starting material for hundreds of consumer products. The main technology requires steam reforming of fossil	Methanol can be used as a solvent, fuel additive, antifreeze, in home heating oil and to make many different chemicals. It can be used as an alternative fuel source.

ASIC chemical product	Description	Main applications
	feedstocks to generate the hydrogen and CO required.	

Ammonia and the organic basic chemicals included in the list can be produced using different feedstocks and types of energy, which implies various processes and technologies with diverse levels of GHG emissions intensity. Chemicals derived from oil & gas are petrochemicals, which represent around 90% of all feedstocks. The other 10% comes from coal and biomass. Around 50% of the energy consumption from the petrochemical industry is related to feedstocks .

The diversity of feedstocks is related to geographic availability and, thus, energy prices. Figure 3 contains a map showing the different feedstocks (ethane, naphtha, natural gas, and coal) used and the primary chemicals produced in different geographical regions and their respective market size.



Note: (CEFIC, 2021)[13]Mtoe: million tonnes of oil equivalent.
HVC in this map includes both olefins and aromatics.

Figure 3: Chemical production volumes for high value chemicals and main feedstocks by region

2.2 Future of Basic Chemicals

The chemical sector is a global market dominated by large multinational chemical corporations, such as BASF, The Dow chemical company, Sinopec, Sabic, and LyondellBasell. Chemical industry sales were valued at around €3,669 billion in 2019, with China ranking in the top with 40.6%, followed by EU27 with 14.8% and the USA with 13.8%. The size of the global chemical industry is expected to double by 2030 from that of 2017, driven by global megatrends of increasing world population and urbanisation, and the growth of industries like agriculture, transport, construction, and electronics[14]. The chemical sector has been affected by the COVID-19, in general by slowing down the growth rate. However, the growth of basic chemicals such as ethylene was stable, since basic chemical participate in the manufacturing of plastics and detergents which are used to manufacture health care and cleansing

[13] CEFIC (2021). The European Chemical Industry. A vital part of Europe´s future. Facts & Figures 2021. Retrieved from Profile (www.cefic.org)

[14] United Nations Environmental Program (2019). Global Chemicals Outlook II – From Legacies to Innovative Solutions: Implementing the 2030 Agenda for Sustainable Development - Synthesis Report (unep.org)

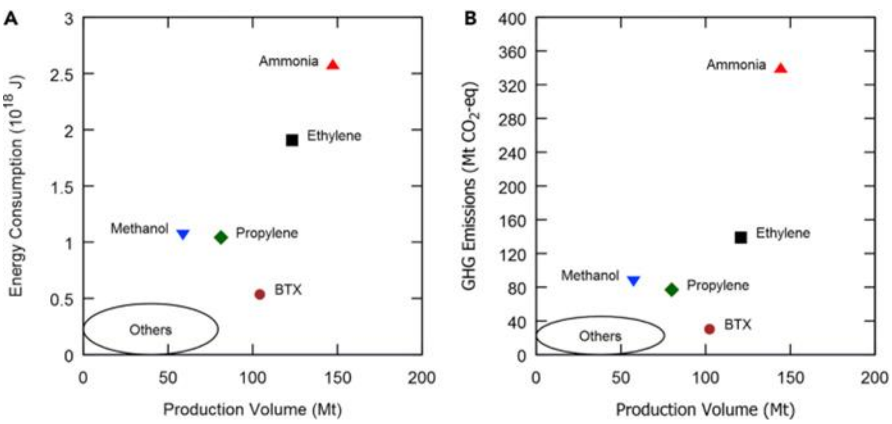
products[15]. The actual growth in the basic chemicals sector will go hand in hand with the after COVID-19 recovery of the global economies.

The global competition in the chemical industry will increase, determined by feedstock supply dynamics. Middle East countries are the lowest-cost regions to produce petrochemicals and have many future investment projects. Because of the shale gas revolution, the US is again a low-cost region for ethane-based chemical production. China and Europe have, each one, a quarter of the capacity of the naphtha-based chemical, but their availability of lighter feedstocks is very limited. China is constantly developing technologies for its growing coal-based chemical industry. India's production capacity will grow forcefully to satisfy its local demand. Due to the growth perspectives and the relatively higher margins of the chemical industry, and the slower growth in gasoline demand, oil companies seek to integrate along the chemical value chain. Oil companies are increasing their links with petrochemical markets, developing projects to produce chemicals directly from crude oil as an alternative to refining operations. Furthermore, industrial parks/clusters around the world were built around products and by-products from chemicals and petrochemical industry. This implies the existing parks for the energy intensive industry are centred around the basic chemical/ petrochemical industry, again highlighting the importance of this sector.

Another key challenge lying ahead for the basic chemicals industry is the urgent call for decarbonisation in all sectors to meet the Paris Agreement and the recent COP26 goals. This is discussed in the following section.

2.3 Climate change and main decarbonisation challenges

Decarbonisation is an increasingly important issue for the chemicals industry, especially for basic chemicals which rely on fossil energy and feedstock and contribute to climate change. Figure 4 shows ammonia and the organic basic chemicals included in scope for these criteria are the chemicals with the largest production volume and the largest contribution to the carbon emissions from the chemical industry[16] [17]. Thus, decarbonisation pathways and policies of the chemical industry have focused on these chemicals since their production has the highest potential for climate change mitigation, both within their own production processes and their downstream value chains. As an example, the EU taxonomy has already included the production of these chemicals and presented emissions benchmarks or qualitative criteria (except for methanol) to be eligible as environmentally sustainable activities.



Note: Ammonia, ethylene, propylene, methanol and BTX (benzene, toluene and xylene) are the major contributors to the sector. Source: Schiffer & Manthiram (2017)[18]

Figure 4: Energy consumption and B) GHG emissions of chemicals.

[15] Bettenhausen (2021). C&EN's World Chemical Outlook 2021. C&EN magazine. https://cen.acs.org/business/CENs-World-Chemical-Outlook-2021/99/i2

[16] IEA(2020). IEA Energy Technology Perspectives 2020. www.iea.org/reports/energy-technology-perspectives-2020

[17] Saygin,D., Gielen,D.(2021). Zero-Emission Pathway for the Global Chemical and Petrochemical Sector. Energies,14(13):3772. www.mdpi.com/1996-1073/14/13/3772

[18] Schiffer, Z. J., & Manthiram, K. (2017). Electrification and decarbonization of the chemical industry. Joule, 1(1), 10-14. https://doi.org/10.1016/j.joule.2017.07.008

As a response to the demands for a lower carbon future in the sector, several chemical companies have announced their targets for reducing GHG emissions, with wide ranging ambitions (from maintaining certain reference levels up to carbon neutrality by 2050) and decarbonisation options. Decarbonisation measures include carbon capture and utilisation (CCU), for which pending government proposals could allocate additional funding and focus. However, the measures being prioritised include improving resource and energy efficiency. Other prominent measures include the adoption of new low-carbon process technologies, increased use of renewable energy and carbon capture and storage (CCS). Due to the nature of the basic chemicals production processes, the sector requires both incremental and disruptive innovations.

The chemical industry is difficult to decarbonise mainly due to technical requirements for the production processes related to the high temperatures needed or direct process emissions produced by the chemical reactions. Table 3 presents the conventional or business as usual technologies, along with the main technical challenges for decarbonisation of the basic chemical production processes, and examples of decarbonisation options.

Table 3: Main technical challenges for decarbonisation of the basic chemical production processes

Basic chemical product	Conventional or business as usual (BAU) production process	Main technical challenges for decarbonisation	Examples of decarbonisation alternatives
Ammonia	Haber-Bosch process reacting hydrogen and nitrogen.	The need for hydrogen, produced mainly from steam reforming of fossil feedstocks (natural gas, crude oil streams) which generates most of the CO2 process emissions.	Hydrogen production from alternative process technology such as methane pyrolysis, biomass gasification or from electrolysis of water using renewable energy
Chlorine	Produced by electrolysis of salt	The electricity needed for electrolysis is the major driver for CO2 emissions	Switch from energy intensive mercury cell process to membrane processes Use of renewable power.
Disodium carbonate/Soda ash	The Solvay process from brine and limestone.	High temperature for calcination of limestone and steam required to concentrate the product are the drivers for CO2 emission, mainly due to fuel combustion and electricity.	Fuel switching, bioenergy, use of renewable power.
Nitric acid	Nitric acid is mainly produced from catalytic oxidation of ammonia.	The direct emissions of N2O are the main challenge.	N_2O abatement technologies exist
Carbon black	Partial combustion of fossil feedstock such as natural gas or crude oil heavy fractions.	High temperatures needed and direct process CO2 emissions.	Fuel switching, bioenergy, use of renewable power. Carbon capture and storage
High value chemicals: Ethylene Propylene Acetylene Butadiene	Steam cracking of fossil feedstocks (natural gas and naphtha mainly), propane or ethane dehydrogenations, and also from coal-based methanol via methanol-to-olefins process.	The need for a carbon source such as natural gas or naphtha. High temperatures needed and direct process CO2 emissions.	Fuel switching, bioenergy Electrification using renewable power Feedstock substitution (e.g. bioethanol for ethylene, recycled olefins)
Aromatics: Benzene Toluene Xylene	Produced from catalytic reforming of naphtha and the processing of other oil refinery streams. It can also be a by-product from the steam cracking process which produces olefins.	High temperatures needed and direct process CO2 emissions.	Fuel switching, bioenergy Electrification using renewable power Feedstock substitution (e.g., biomethanol, recycled olefins)

Basic chemical product	Conventional or business as usual (BAU) production process	Main technical challenges for decarbonisation	Examples of decarbonisation alternatives
Methanol	Methanol is produced mainly from carbon monoxide and hydrogen by catalytic synthesis.	The need of hydrogen and CO, produced mainly from steam reforming of fossil feedstocks (natural gas, crude oil streams, coal) which generates most of the CO2 process emissions.	Hydrogen production from alternative process technology such as methane pyrolysis, biomass gasification or from electrolysis of water using renewable energy.

Companies such as BASF recently presented its roadmap to net zero CO2 emissions by 2050[19]. The key technologies target the replacement of fossil fuels such as natural gas with renewable sources and using electrical heat pumps to produce steam from waste heat. One of the most important new technologies is electrically heated steam crackers to produce basic chemicals such as ethylene, propylene and butadiene. For hydrogen, it is developing technologies such as water electrolysis and methane pyrolysis. CCS is also another common decarbonisation technology considered in the roadmaps.

All decarbonisation efforts and activities to decarbonise the sector will require investment. Prior to releasing funds, the financial sector needs to be able to see that scientifically grounded approaches and effective strategies for decarbonisation are in place to effectively manage the risk of new investments. Analytical frameworks and certification tools are needed to identify decarbonisation pathways to enable the financial sector to prioritise projects according to their alignment to the goals of the Paris Agreement and to minimise the risk of assets being stranded. In addition, investors need to see that both transition and physical risks of the assets being financed have been considered. Transition risks include depressed asset values, stranded assets and changing market demand, as well as an eventual phase out of fossil fuels; while physical risks include direct and indirect impacts of severe weather on infrastructure, worker safety and losses of productivity[20].

2.4 Investment need

Large investments in industrial equipment for retrofitting existing facilities or building new low-carbon infrastructure will be required to decarbonise industrial sectors. Climate aligned finance will be a key driver for actual implementation of decarbonisation measures in the sector. Most of the chemical industry investment comes from the private sector, investment portfolios are managed mainly by the International Finance Corporation (IFC) and other Multilateral Financing Institutions (MFIs)[21]. The chemical sector projects are part of MFIs GHG accounting and reporting. MFIs encourage their clients to include resource and energy efficiency performance; nevertheless, there is still a lack of criteria or standards related to GHG emissions for chemical plants. That would be critical to determine whether a project can be financed or not. China dominates world chemicals investment, while Europe is the second-largest R&I investor in the world[22].

Globally, it is estimated that decarbonisation of the chemical and petrochemical industry will require 63 billion euros[17] from today up to 2050. In the EU, a stimulus package will provide more than 750 billion euros to invest in sustainable technologies, some of them will be for the chemical sector, including green hydrogen production and storage, biorefining and plastics recycling. At entity level, companies such as BASF plans to invest up to 1 billion euros by 2025 to reach its climate target presented in 2021 and a further 2- 3 billion euros by 2030[23].

[19] Nonnast T. (2021). BASF presents roadmap to climate neutrality. BASF Business & Financial News. www.basf.com/global/en/media/news-releases/2021/03/p-21-166.html

[20] Deloitte (2020). The 2030 decarbonization challenge. Chemicals. www2.deloitte.com/content/dam/Deloitte/uk/Documents/energy-resources/deloitte-uk-chemicals-decarbonization.pdf

[21] Suding, P.H. (2013). Chemical plant GHG emissions: reconciling the financing of chemical plants with climate change objectives. (Inter-American Development Bank Technical Note ; 618)

[22] CEFIC (2021). The European Chemical Industry. A vital part of Europe´s future. Facts & Figures 2021

[23] Nonnast T. (2021). BASF presents roadmap to climate neutrality. BASF Business & Financial News. www.basf.com/global/en/media/news-releases/2021/03/p-21-166.html

2.5 Deals already seen in the sector

Recently, some chemical companies started to establish green finance frameworks to issue green finance instruments for sustainable projects that benefit the environment and society. Kaneka corporation, a Japanese chemical manufacturer issued a green bond in 2019 to finance the construction and research and development investment costs of new biodegradable polymer production facilities. BASF, the largest chemical corporation from Germany, issued in 2020 a green bond with a volume of €1.0 billion and a term of seven years. In France, Arkema issued its first green bond to finance a new production facility to produce bio-based polyamide. Table 4 summarises the green bonds issued in the chemical industry so far.

Table 4: Green bonds issued in the chemical industry (Climate Bonds, 2021)

Date	Issuer Name	Amount (USD)	Maturity	Country	Second Party Opinion (SPO)	Use of Proceeds Description
2021	Arkema	333 MM	2026	France	Vigeo Eiris	Construction (CAPEX) of a plant that produces bioplastics made from castor beans.
2020	LG Chem	592 MM	2025	South Korea		The green loan will help LG Chem finance the expansion of its electric vehicle battery plant in Poland.
2019	LG Chem	565 MM	2029	South Korea	Sustainalytics	EV batteries, green buildings, and water treatment, with the objective of producing energy storage solutions for transport. Includes R&D
2019	LG Chem	500 MM	2024	South Korea	Sustainalytics	EV batteries, green buildings, and water treatment, with the objective of producing energy storage solutions for transport. Includes R&D
2019	LG Chem	500 MM	2029	South Korea	Sustainalytics	EV batteries, green buildings, and water treatment, with the objective of producing energy storage solutions for transport. Includes R&D
2020	Shaanxi Coal and Chemical Industry Group	432 MM	2025	China		
2021	BASF	1,111 MM	2027	Germany	ISS ESG	New production facility to produce biobased polyamide.
2020	Kaneka Corporation	46 MM	2024	Japan		New biodegradable polymer production facilities.

According to Bloomberg, the chemicals industry has issued almost $14 billion in loans (2018-2020), linked mainly to carbon reduction targets. However, less than 2% of the $555 billion in sustainable debt was issued to chemical companies in 2020 (examples include Air Liquide and Solvay)[24].

[24] Kane, E. (2021). Many global chemicals companies trail on carbon-transition goals. Sustainable Finance. Bloomberg Intelligence. www.bloomberg.com/professional/blog/many-global-chemicals-companies-trail-on-carbon-transition-goals/

3 Principles and Boundaries of the Criteria

3.1 Guiding principles

The objective of CBI has been to develop Basic Chemicals sector criteria that can maximize viable bond issuances with verifiable environmental and social outcomes. This means the Criteria need to balance the following objectives:

- They form a set of scientifically robust, ambitious and verifiable targets and metrics; and
- They are usable by the market, which means they must be understandable for non-scientific audiences, implementable at scale, and affordable in terms of assessment burden.

The Criteria should:

- Enable the identification of eligible assets and projects (or use of proceeds) or entities or companies (general corporate purposes) related to cement investments that can potentially be included in a Certified Climate Bond.
- Deploy appropriate eligibility Criteria under which the assets and projects or entity can be assessed for their suitability for inclusion in a Certified Climate Bond.
- Identify associated metrics, methodologies and tools to enable the effective measurement and monitoring of compliance with the eligibility Criteria.

Subject to meeting the eligibility criteria in the following sectors, the following can be certified under these criteria:

- Use-of-Proceed (UoP)[25] bonds financing decarbonisation measures (e.g., retrofits).
- Use-of-Proceed (UoP) bonds financing cement production facilities (i.e., assets and activities).

The following can be certified following the update of the Overarching Climate Bonds Standard to v4.0[26]:

- Assets not linked to any specific financing instrument (basic chemicals production facilities).
- Entities (cement production companies) and Sustainability Linked Bonds (SLBs) issued by those entities.

Each subset of criteria may share common requirements, pathways or metrics but require different demonstrations of compliance. The following sections will make distinction between the guiding principles for certifying assets and activities (***section 3.1.1***), and the hallmarks for transition for entities and companies (described in ***section 3.1.2***).

3.1.1 Guiding Principles- assets and activity certification

The Basic Chemicals Criteria are made up of two components, both of which need to be satisfied for assets to be eligible for inclusion in a Certified Climate Bond. These are as follows:

1. Climate Change Mitigation Component – addressing whether the asset or project is sufficiently ‘low GHG’ to be compliant with rapid decarbonisation needs across the sector.

2. Climate Change Adaptation and Resilience Component – addressing whether the facility is itself resilient to climate change and furthermore not adversely impacting the resilience of the surrounding system. This encompasses a broad set of environmental and social topics.

[25] Use-of-Proceed (UoP) is used as shorthand throughout this document for a variety of targeted finance instruments, including green loans, repos, and asset-backed securities. Annex 1 of the Standard v3.0 details the full list of instruments that can be certified.

[26] Expected in Q1 2023.

Table 5: Key principles for the design of Climate Bond Standard Sector Criteria

Principle	Requirement for the Criteria
Ambitious	Compatible with meeting the objective of limiting global average warming to 1.5°C temperature rise above pre-industrial levels set by the Paris Agreement.
Material	Criteria should address all material sources of emissions over the lifecycle. Scope 1 & 2 emissions should be addressed directly and scope 3 considered.
No offsets	Offsets should not be counted towards emissions reduction performance.
Resilient	To ensure that the activities being financed are adapted to physical climate change and do not harm the resilience of the system them are in
Scientifically Robust	Based on science not industry objectives
Granular	Criteria should be sufficiently granular for the assessment of a specific project, asset or activity. Every asset or project to be financed must comply.
Globally consistent	Criteria should be globally applicable. National legislation or NDC's are not sufficient.
Aligned	Leverage existing robust tools, methodologies, standards
Technology neutral	Criteria should describe the result to be achieved.
Avoid lock in	Avoid supporting development that may result in long term commitments to high emission activities

3.1.2 Guiding principles – entity and SLB certification

The nature of certifying whole entities, companies and Sustainability Linked Bonds requires a thorough ruleset and set of principles that go beyond those for assets and activities. This is to ensure that the entity truly merits certification having taken a view of its KPIs, transition plan, and planned action.

To this end, the Climate Bonds Initiative proposed 5 Hallmarks for Transition. These are discussed in greater detail in the paper 'Transition Finance for Transforming Companies[27] and illustrated in ***Figure 4***. They build on and incorporate the transition principles proposed in the paper 'Financing Credible Transitions[28]. Those transition principles are as follows:

- In line with 1.5-degree trajectory
- In line with establish science
- Offsets don't count
- Technological viability trumps economic competitiveness
- Action, not pledges

[27] www.climatebonds.net/transition-finance-transforming-companies

[28] www.climatebonds.net/transition-finance/fin-credible-transitions

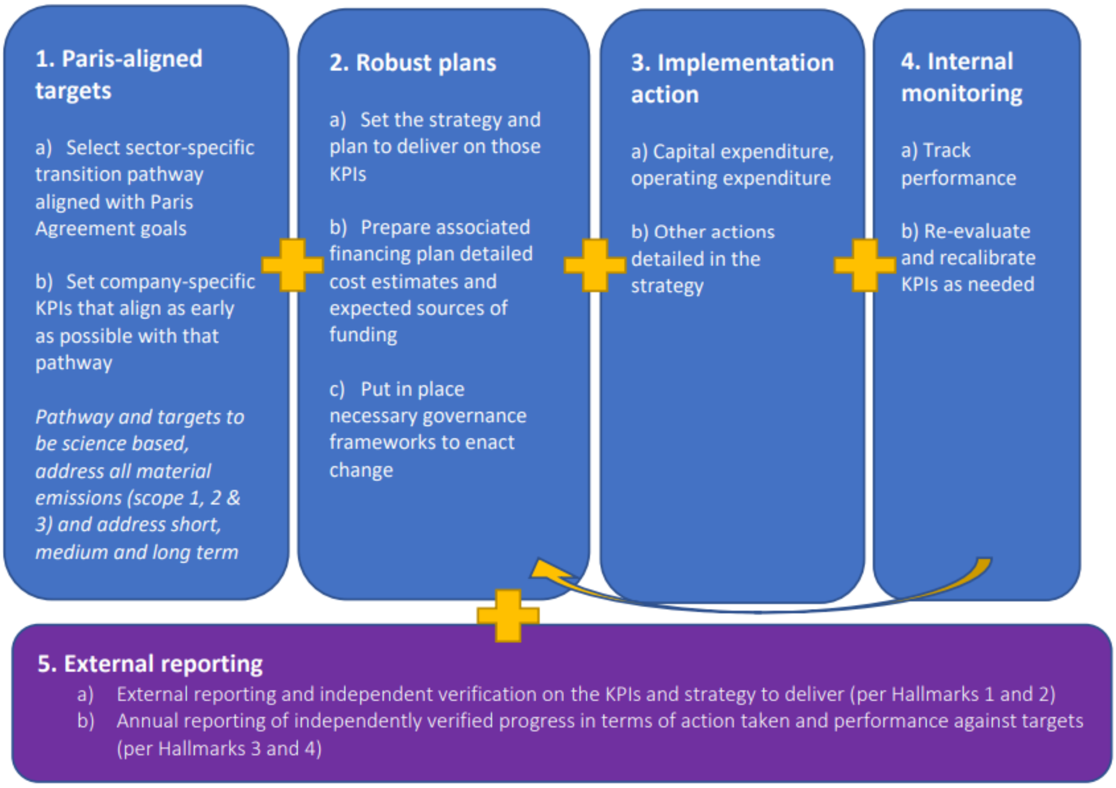


Figure 5: The hallmarks of a credibly transitioning company

3.2 Overarching considerations

In setting the criteria, the emissions to be included were discussed, along with the scope of emissions and what criteria would test that the sector is decarbonising and give assurance to investors that financial instruments issued by companies are of satisfactory quality. The key considerations are summarised in this section.

3.2.1 Emissions criteria

The type of criteria for the mitigation component was discussed and the two options explored were emissions intensity and emissions contraction.

- **Emissions intensity for assets**: The emissions intensity is a measure of the amount of GHG emitted per tonne of product, while the emissions contraction is a measure of the reduction of emissions in respect to a base line. Emissions intensity allows for a more practical metric as it is relatively easy to calculate by just dividing the amount of GHG emitted by the amount of product delivered by an asset or facility in a given period of time (e.g., annually). Furthermore, it allows an objective comparison between different assets, or against a given threshold without the need to look at the type of feedstock, process technology, and country or company size. For these reasons, emissions intensity has been selected as the key criteria for screening potential assets in respect to mitigation.
- **Emissions contraction (absolute emissions):** It is recognised that because of the normalisation with the product output, an emissions intensity may lead to cases where an asset increases production capacity and emissions intensity decreases but because of the increase of energy and raw material input to support higher capacity, the absolute emissions have increased. Emission contraction provides a clearer sense on how well entities are reducing total emissions and it can be a more direct way to track progress in overall mitigation. The absolute contraction approach is therefore more applicable at entity or company level. In setting the criteria, an emissions contraction was not considered on the basis of a lack of a clear method applicable for the chemicals sector and that the scope of the criteria was set at the lower level of facility or project. However, it is highly recommended to consider this type of criteria in subsequent updates.

Thus, emissions intensity is adopted at the asset or project level as the main indicator of the criteria for low carbon basic chemicals production. However, the values of emissions intensity were projected with different time horizons (2030, 2040 and 2050) using a decarbonisation pathway for the chemical industry. This is explained in more detail in section 4.

3.2.2 GHG emissions that are covered

Although the major GHG emitted from chemical processes is CO2, there are other GHG such as methane (CH4), fluorinated gases (SF6, HFC), and nitrous oxide (N2O) which can be important. These gases are emitted in lower quantities but have a higher global warming potential. Most of the current decarbonisation initiatives do not include these gases as they are frequently considered to be addressed by other emission reduction initiatives, for example N2O and F-gases being covered by the Montreal Protocol and Clean Development Mechanisms (CDM). Discussions concluded that all relevant greenhouse gases and not just CO2 should be included in the assessment of emissions and that the most up-to-date IPCC 100-year global warming potential factors should be adopted.

3.2.3 Scope 1, 2 and 3 emissions

The scope of emissions was another important aspect to address. It influences the focus of the analysis and sets the boundaries for the calculation of emissions intensity. Scope 1 emissions are direct emissions, scope 2 are indirect emissions from purchased electricity, heat and power; and scope 3 emissions are indirect emissions from extraction and manufacture of raw materials and fuels that are not included in scope 2 (all these also known as scope 3 upstream emission) and include waste disposal and product end use (these also known as scope 3 downstream emissions) and many others.

Scope 1 and scope 2 are the emissions that are within direct control for all types of companies. Furthermore, the references for emissions intensity thresholds for the products in scope generally cover Scope 1 and in some cases Scope 2. In the case where the scope 2 emissions are not included in the thresholds, it was considered that issuers should demonstrate the procurement for low carbon electricity to prevent carbon leakage and moving emissions from one part of the value chain to another. Thus, the criteria included the requirement for renewable-based captive power generation, renewable-abed power purchase agreement or demand side management flexibility measures. Renewable energy includes energy produced from renewable sources such as wind, solar, and small hydropower generation.

Given that the Scope 3 emissions can be significant in an industry based on fossil feedstocks and fuels; these cannot be left out. However, at this time quantitative metrics are not considered appropriate and instead the requirement is for issuers to demonstrate a strategy to address and reduce scope 3 upstream emissions. Upstream emissions are not directly controlled by the assets or companies producing the basic chemicals but there are actions that can be adopted to reduce scope 3 upstream emissions.

3.2.4 Considering regional differences

As discussed in Section 2, the chemical industry varies also with regions mainly due to the availability of certain types of feedstocks. For example, chemical production from coal is more common in China and South Africa, while natural gas is becoming more common in the US due to increased availability of shale gas. In addition, there are huge differences in technological advancement of facilities across different regions. Regulations and requirements for the installation and operation of chemical production plants have different degrees of stringency across countries, and government policies may favour certain feedstocks or types of investments in some countries more than others. However, the financial sector is global in reach and requires standardised requirements to be applied. For this reason, Climate Bonds criteria are developed with the principle that requirements should be globally applicable wherever possible. Given that many companies operate at several locations worldwide this ensures consistency across assets. Although there are concerns around the challenges that developing countries could face meeting low-carbon targets, setting ambitious and stringent criteria could help raise the bar in these geographies regarding efficiencies and low-carbon technologies.

The criteria document includes regional differences for recycled content to promote recycling processes even in regions without regulations or policies for recycling. See more details in Box 1 below.

3.2.5 Considering coal and other fossil resources

- Coal for power: Coal-based production systems are among the highest emitters of GHG emissions. Although progress has been made in reducing coal use globally, it still produced around 37% of the world's electricity in 2019[29]. According, to the IPCC special report on global warming of 1.5°C, global coal use in electricity generation must fall by 80% below 2010 levels by 2030 and phase-out before 2040[30]. In addition, one of the main outcomes of the latest COP26 at Glasgow was the pledge of several countries to phase out coal use in power generation by ending investments in new facilities; and a separate commitment was made to end public financing of unabated fossil fuel projects by the end of 2022[31]. This provided a strong basis to reject the use of coal and coal-based fuels for the power demands of the basic chemicals sector.
- Coal as a feedstock: Coal is also used as a raw material for producing the basic chemicals in scope such as methanol and HVC (through the methanol-to-olefins process). Similar to its use as a fuel in power generation, coal use for chemical production generates higher direct emissions than production with other fossil feedstocks[32]. This is mainly due to the more complex process to go from coal to chemicals, which requires gasification and water-gas-shift reaction steps. Both steps generate CO2 emissions from the reactions to generate the right composition of hydrogen and CO for further chemical synthesis. Furthermore, these are energy intensive operations due to the high reaction temperatures required, so the energy is usually supplied by coal or other fossil fuels. For example, it is estimated that the production of methanol from coal emits up to three times more emissions than methanol produced from natural gas[33] [34] [35]. Thus, it is expected that in a future where coal has been phased out from power generation, coal-based chemicals production will be the new hot spot in industrial emissions if coal is still accepted as a feedstock. Alternative feedstocks and technologies can be used to produce methanol including processes based on biomass feedstock and CO2. For these reasons assets or projects using coal and coal-derived feedstock as a raw material for basic chemicals are not eligible for certification. However, coal is still a key raw material for other chemicals (acetic acid, formaldehyde, dimethyl ether, not included in the scope of this criteria) especially in China and South Africa. These products are out of the scope of this criteria and will be addressed in future work that will address criteria for intermediate chemicals.
- Fossil resources: At this stage the criteria allow for fossil resources in existing facilities which are or will be in transition only if emissions are abated, this means in combination with CCS or CCU. It has also been highlighted that emissions from fossil gas extraction, processing and transportation may mean that gas-based systems (both energy and chemical generation) have a higher life cycle impact than coal-based systems. This is mainly due to fugitive losses and leakage of the product which is largely made up of the greenhouse gas methane which has a more potent impact on global warming[36]. Because the majority of these emissions happen upstream (i.e., they are scope 3 emissions), they are not within control of the chemical production facilities. According to studies done by CEFIC for the European Industry, it has been estimated that the GHG emissions from methane (in CO2 equivalents) from oil refining units, boilers, furnaces and steam crackers is only about 0.2 %[37]. As such, fossil gas can be considered a suitable transition feedstock for existing facilities if CCS or CCU measure are implemented. In addition, the criteria

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[29] IEA (2020) World Energy Balances: Overview. www.iea.org/reports/world-energy-balances-overview/world

[30] IPCC (2018) Global Warming of 1.5°C.An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_Full_Report_High_Res.pdf

[31] End of Coal in Sight at COP26. https://ukcop26.org/end-of-coal-in-sight-at-cop26/

[32] Lee, R. P. (2019). Alternative carbon feedstock for the chemical industry. Assessing the challenges posed by the human dimension in the carbon transition. Journal of Cleaner Production, 219, 786-796.

[33] Carbon Recycling International (2019). Curbing Carbon Emissions with Green Methanol. The Chemical Engineer 942/943. www.thechemicalengineer.com/features/curbing-carbon-emissions-with-green-methanol/

[34] Qin, Z., Zhai, G., Wu, X., Yu, Y., & Zhang, Z. (2016). Carbon footprint evaluation of coal-to-methanol chain with the hierarchical attribution management and life cycle assessment. Energy Conversion and Management, 124, 168-179. https://doi.org/10.1016/j.enconman.2016.07.005

[35] Gao, D., Qiu, X., Zhang, Y., & Liu, P. (2018). Life cycle analysis of coal based methanol-to-olefins processes in China. Computers & Chemical Engineering, 109, 112-118. https://doi.org/10.1016/j.compchemeng.2017.11.001

[36] ShareAction (2020) Slow Reactions. https://shareaction.org/reports/slow-reactions-chemical-companies-must-transform-in-a-low-carbon-world

[37] CEFIC (2021). Methane emissions in the chemical industry. www.petrochemistry.eu/wp-content/uploads/2021/03/Cefic_Paper_Methane-.pdf

document specifies the need for methane leakage prevention, monitoring and mitigation measures to be implemented. Issuers are referred to existing guidance on these matter[38].

3.2.6 Other environmental impacts

Other environmental impacts that may be necessary to be considered in tandem with climate change mitigation in order to prevent undesirable side effects on other environmental objectives were discussed. The "do not significant harm" (DNSH) principle from the EU taxonomy was presented and discussed in detail. The DNSH principle states that the activities in scope should not make a significant harm to any of the following six environmental objectives: climate change mitigation, climate change adaptation, sustainable use and protection of water and marine resources, transition to a circular economy, protections and restoration of biodiversity and ecosystems; and pollution prevention and control. The group questioned the practical application of these principles and the implications for issuers to comply with several requirements for the various environmental objectives. Given that ways to address this overarching aspect of the criteria was not achievable in a way that it complies with simple, low time and cost demand for issuers, it was agreed to focus on climate change criteria. However, it was also emphasised the need to include a thorough environmental impact assessment as a component for issuers, to identify and report any potential risks, and relevant plans or measures to address them. This suggestion was thus adopted as it is a reasonable requirement, and many facilities will already have to comply with similar local regulations which enables straightforward reporting.

3.3 Eligible assets and projects

The Basic Chemicals criteria have set out criteria for specific decarbonisation measures, entire production facilities, as well as parts of a company producing basic chemicals in scope.

The starting point for eligibility is to consider assets and projects where the production rate of the basic chemicals in scope are at least 50% of the total amount of products produced in a year by the relevant asset or project. This is a minimum set as it is understood that a facility producing more than 50% of other coproducts is not viewed as a facility dedicated to chemicals in scope, and the investment may be going into the production of uncertified products with high carbon intensities. This also mitigates the risk of greenwashing due to artificially making basic chemicals products low carbon by allocating more carbon emissions to other products not in scope of this Criteria.

Table 6 shows the type of production assets in the Basic Chemicals sector eligible for inclusion in a Certified Climate Bond, subject to meeting the eligibility Criteria discussed in this document and summarised in the associated Basic Chemicals Criteria document.

[38] UNECE (2019) Best practice guidance for effective methane management in the oil and gas sectors. Monitoring, Reporting and Verification (MRV) and Mitigation. United Nations 2019.
https://unece.org/fileadmin/DAM/energy/images/CMM/CMM_CE/Best_Practice_Guidance_for_Effective_Methane_Management_in_the_Oil_and_Gas_Sector__Monitoring__Reporting_and_Verification__MRV__and_Mitigation-_FINAL__with_covers_.pdf

Table 6: Assets covered by Basic Chemicals Criteria

Assets Covered
Facilities producing Ammonia
Facilities producing Chlorine
Facilities producing Disodium carbonate/Soda ash
Facilities producing Nitric Acid
Facilities producing Carbon black
Facilities producing high value chemicals (ethylene, propylene, acetylene and butadiene)
Facilities producing aromatics (benzene, xylene and toluene)
Facilities producing methanol

3.3.1 Scope of entities – what about companies?

The chemical sector's complexity makes it difficult to set a unique set of criteria for such diverse companies with different business and product mixes and levels of integration. A single chemical entity can produce basic, intermediates, and specialty chemicals, and even has oil and gas operations. Because these criteria only cover a group of basic chemicals, currently, certifying an entire chemical company is not possible.

Companies with parts or business segments producing basic chemicals can apply for certification for the specific part or subsidiary producing the chemicals under the scope of these criteria.

Once criteria are available for other chemical products, such as intermediates and specialties, certification of chemical companies will be expanded.

3.4 Criteria overview

Taking as basis the overarching considerations explained in the previous sections, the mitigation criteria include:

- Criteria for decarbonisation measures or retrofitting activities in facilities producing basic chemicals.
- Criteria for facilities producing basic chemicals. These criteria apply to the certification of the whole facility for production of chemicals in scope and includes carbon or energy intensity thresholds and additional criteria depending on age of facilities, feedstock and energy usage and upstream scope 3 emissions
- Cross-cutting criteria for climate adaptation and resilience. These include A&R checklist, requirements for addressing other environmental impacts and a disclosure component.
- Criteria for entities producing basic chemicals and Sustainability Linked Bonds (SLBs) for a company sustainability projects relating to the basic chemicals in scope.

4 Mitigation Criteria

4.1 Criteria for decarbonisation measures within facilities producing basic chemicals

The use of proceeds may be specifically dedicated to specific decarbonisation measures within facilities producing basic chemicals. Specific constraints to provide consistency and coherence with the decarbonisation goals have been set out. The requirements for specific mitigation measures are provided in section 3 of the Criteria document.

Several mitigation measures relevant to the basic chemical sectors have been identified in the literature[19] and reports from relevant organisations (IEA[11], IRENA[39], DECHEMA[40], ShareAction[34], BASF [19]). Various measures were discussed and are summarised in Table 6. It was considered pertinent to set specific criteria for the most promising mitigations measures. The guiding principles in setting these specific criteria were:

i. Consistency with the level of ambitions required for a low carbon future, including the need for transitioning from fossil to alternative sources of energy and feedstock,
ii. Identifying measures that need to be used in combination
iii. Consistency with existing CLIMATE BONDS criteria for directly related sectors. This means that when implementing any of these measures, care should be taken to not jeopardise the main goal of reducing emissions and the mitigation objectives of other sectors. For example, the generation of low carbon hydrogen feedstock cannot be at the expense of using high carbon electricity for its production via an electrolytic process. Similarly, the CO2 captured as a way to mitigate climate impact of burning fossil fuels cannot be then used to propagate further the extraction of more fossil fuels through enhanced oil recovery.

The most common measures, with the higher estimated potential for reductions, and under control within the battery limits of a production process facility were selected. In addition, these measures have been proposed by chemical companies in their own decarbonisation plans, international organisations and the scientific community[19-22,25]. The most frequent measures were identified and reviewed to select the following representative but not limitative list of eligible measures. The measures were classified in the Criteria document into “Relating to feedstock used”, “Relating to energy used”, and “Various”. Box 1 provides further definitions and explanation of these measures as considered in these criteria.

[39] IRENA (2020). Reaching zero with renewables: Eliminating CO2 emissions from industry and transport in line with the 1.5 o C climate goal. International Renewable Energy Agency, Abu Dhabi

[40] DECHEMA (2017). Low carbon energy and feedstock for the European Chemical Industry. Technology Study.

Table 7: Summary of mitigation measures considered in various reports and literature for basic chemicals

Technology/Activity	IRENA 2020	Saygin & Gielen, 2021	IEA 2020	DECHEMA 2017	ShareAction 2021	BASF 2021
Energy efficiency	✓	✓	✓	✓		✓
Energy recovery with CCS		✓				
Clean electricity, low carbon power	✓			✓		
Solar process heat, renewable heat	✓	✓				
Bioenergy	✓	✓	✓			
Renewable power, other than bioenergy	✓	✓	✓	✓		✓
Fuel shifting			✓			
Biomass as feedstock		✓		✓		
Fuels and feedstocks from hydrogen	✓	✓	✓			✓
CO2 capture and storage (CCS)	✓	✓	✓	✓		✓
CO2 as feedstock (CCU)			✓			
Electrification of processes			✓		✓	✓
Recycled feedstock		✓	✓			
Green hydrogen and green methanol					✓	
Methane pyrolysis						✓
Electrical heat pumps						✓
Demand reduction	✓	✓				
Industry relocation		✓				

Box 1: Eligible capital investments for mitigation measures

Several decarbonisation or mitigation measures have been proposed by IEA, IRENA and the scientific literature, with some common technologies and activities but with a rather varying terminology. Without being a harmonisation exercise, the aim of this box is to describe and define each of the mitigation measures that are provided as examples for eligibility within the Climate Bonds Basic Chemicals criteria.

- Using hydrogen as an energy source. This measure mainly applies to existing facilities and refers to using hydrogen for on-site energy generation and supply to the basic chemical production processes. Hydrogen can provide the high temperatures required in the production processes of basic chemicals especially ammonia, HVC and aromatics. This measure may require investment for the adaptation of existing equipment such as furnaces and boilers, or even the full replacement of equipment by more efficient ones with technology enhancement or new designs.
- Using fossil gas combined with CO2 capture technologies. The switching to fossil gas is considered in conjunction within the carbon capture and storage measure. However, the "lower footprint" aspect of fossil gas has recently been questioned mainly due to the likely occurrence of leakages along its supply chain which may then lead to a detrimental climate change impact (as it has higher potential for global

warming than CO2[41]) rather than a mitigation benefit[42]. Note that this measure may be revised and potentially ruled out in the next version of the criteria, due to the need to decrease the use of fossil fuels or the advancement of alternative technologies such as electrification of process heating.

- Using biomass or biomass derived feedstocks. This measure includes the direct use of biomass or its derivatives in the production of basic chemicals in scope. For example, biomass can be converted into ethanol and ethanol then converted into ethylene by dehydration. Another indirect way of using biomass is through biomass gasification processes which generate synthesis gas (a mixture of CO and H2 known as syngas) which can then be converted into methanol and then methanol converted into olefins. Recent research is also focused on directly converting syngas into mixed olefins and aromatics[43 44]. The use of biomass as a feedstock for chemical production rather than for energy purposes is advocated though biomass cascading use and biorefineries[45].
- Using biomass as an energy source. Eligibility for biomass as an energy source is restricted to secondary organic streams, (i.e., materials usually discarded or classified as wastes from another primary use, e.g. residues from agriculture, organic matter from agro-industrial processing). Primary biomass such as wood and dedicated crops can be more valuable as a feedstock rather than an energy source. Furthermore, the use of biomass as a measure for low carbon heat and power supply may lead to increased demand for wood and dedicated energy crops. This can lead to unintended consequences such as an increase in emissions due to increased deforestation, direct and indirect land use change[46]. This is also needed to promote a cascading use approach and processing in integrated biorefineries.
- Using CO2 as a feedstock. This measure is also known as carbon capture and utilisation (CCU) and includes the use of captured CO2 as a raw material. The major sources of CO2 considered in this measure include flue gases, industrial off-gases, which requires concentration and purification of CO2 using carbon capture processes. CO2 can then be converted into basic chemicals through electrochemical or catalytic synthesis. The electrochemical and thermocatalytic routes rely on the generation of a syngas, similar to biomass gasification, and this requires a hydrogen source. Alternatively, CO2 can also be converted biochemically using bacteria or yeast, as well as algae to generate a biomass source. In any case, using CO2 as a feedstock needs to be accompanied by other measures such as carbon capture, low carbon energy and hydrogen to be consistently aligned to a low carbon pathway especially when the CO2 comes from fossil carbon. The technologies required for this measure are somehow in early stages of development, but it is expected to make progress towards commercialisation. In addition, care should be taken in regard to the end use of the product generated from CO2. This is mainly because if the CO2 is immediately released into the atmosphere during end product use, the mitigation is ephemeral. This means, additional restrictions are included for the end product, which should be a long-lasting or recyclable product so as to keep CO2 in a loop.
- Use of recycled material as a feedstock. This measure is as a response to the need to decrease the environmental impact of plastics in the water and land ecosystems and circular economy approaches. This measure mainly applies to olefin and BTX production from chemical recycling of plastic feedstocks. For example, pyrolysis of plastics recovers an oily liquid which can then be processed in existing naphtha steam cracker infrastructure. As part of the feedback from public consultation it was decided to include different recycled content percentages depending on local regulations and available infrastructure for recycling. The 30% requirement is aligned to several initiatives and mandates in different geographies[47]. The 20% requirement aims to promote recycling projects in regions without local regulations for recycling or with lower recycled content requirements.

[41] 29.8 CO2-eq for methane from fossil sources as per AR6. Latest IPCC report version available from www.ipcc.ch/report/ar6/wg1/#TS

[42] Hmiel, B., Petrenko, V.V., Dyonisius, M.N. et al. (2020) Preindustrial 14CH4 indicates greater anthropogenic fossil CH4 emissions. Nature 578, 409–412. https://doi.org/10.1038/s41586-020-1991-8

[43] Jiao, F., Li, J., Pan, X., Xiao, J., Li, H., Ma, H., ... & Bao, X. (2016). Selective conversion of syngas to light olefins. Science, 351(6277), 1065-1068.

[44] Yang, J., Pan, X., Jiao, F., Li, J., & Bao, X. (2017). Direct conversion of syngas to aromatics. Chemical communications, 53(81), 11146-11149.

[45] A biorefinery is a highly integrated facility for the conversion of biomass feedstock into value added products, including materials, chemicals, food ingredients, fuels and energy by combining various chemical, thermochemical and biochemical processes. See: Sadhukhan, J., Ng, K. S., & Hernandez, E. M. (2014). Biorefineries and chemical processes: design, integration and sustainability analysis. John Wiley & Sons.

[46] Jan P.M. Ros, Jelle G. van Minnen, Eric J.M.M. Arets (2013). Climate effects of wood used for bioenergy. PBL Netherlands Environmental Assessment Agency. PBL publication number: 1182 www.pbl.nl/sites/default/files/downloads/PBL-2013-climate-effects-of-wood-used-for-bioenergy-1182_0.pdf

[47] https://resource-recycling.com/plastics/2021/07/14/acc-calls-for-30-recycled-content-mandate-in-packaging/; https://www.bloomberg.com/netzeropathfinders/best-practices/recycled-content-mandates/#example-2

- **Electrification of processes**. This measure implies a shift from providing process heat by fossil fuel combustion and using electrified equipment instead. Examples include innovations in steam crackers where the conventional thermally driven pyrolytic furnaces, are replaced with reactors powered by low-carbon electricity[20] [48]. Companies such as BASF are already developing electrical steam crackers with a potential for 90% reduction in CO2 emissions if green electricity is used[19]. A rather more advanced and accessible technology applicable in low to medium temperature processes is the use of electric heat pumps to recover and provide process heat. With this measure, up to 67% reduction in process emissions can be achieved and the use of fossil fuels is avoided[49]. This reduction can be increased when renewable power is used to run the heat pump. This measure in the future is expected to converge with other measures such as the use of renewable power, using CO2 and hydrogen as feedstocks via electrochemistry for the production of ammonia, ethylene and methanol, while also supporting higher efficiencies and reducing transport and other scope 3 emissions due to the increased feasibility for modularisation and relocation of chemical production processes[19].
- **Carbon capture and storage**. This is the process of capturing (concentrating from diluted sources), transporting and storing CO2 in order to prevent its release into the atmosphere. Carbon storage can be in open, closed or cycling systems[50]. Open systems include natural systems such as in biomass growth and soil. Closed systems include the geological storage in lithosphere or deep oceans and mineral formations. Cyclic systems include the conversion of CO2 into fuels or chemicals, this form is also known as carbon capture and utilisation (CCU). For the purposes of this criteria document, CCS refers specifically to closed systems as in geological storage since this is the one with the largest storage life span[51]. Biomass and CCU are defined and addressed separately under the measures of using biomass or biomass derived feedstock and using CO2 as feedstock, respectively. Projects using fossil gas combined with CCS should demonstrate MRV (monitoring, reporting and verification), and mitigation measures for methane leaks[52]. Methane emissions must be of maximum 0.2%. In regions where storage is not technically feasible or there is no available infrastructure, CCU can be implemented instead. Fuel and feedstock substitution are also an option for fossil-based processes where CCS is not feasible.
- **Energy efficiency**. Energy efficiency measures include process integration and reconfiguration of processes for heat recovery from streams, replacement of equipment for higher efficiency technology or design, and process intensification of the equipment. Examples of these measures are the replacement or revamping of boilers, furnaces, compressors or pumps for more efficient ones, reconfiguration of distillation columns to incorporate mechanical vapour recompression, or intensification of heat exchange equipment, reactors, and separation systems. A minimum 30% improvement in energy efficiency considers the global potential reductions in the chemical and petrochemical processes estimated by IEA[53].
- **Switching to low carbon technologies**. The switching to alternative low carbon technologies implies the adoption of technologies that reduce the emissions from the process such as membrane electrolysis technology to produce chlorine, methane pyrolysis for production of hydrogen used as feedstock, or switching from producing aromatics from thermal cracking to catalytic cracking.

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[48] Delikonstantis, E., Igos, E., Augustinus, M., Benetto, E., & Stefanidis, G. D. (2020). Life cycle assessment of plasma-assisted ethylene production from rich-in-methane gas streams. Sustainable Energy & Fuels, 4(3), 1351-1362.

[49] De Boer, R., Marina, A., B. (2020) Zühlsdorf Strengthening Industrial Heat Pump Innovation. Decarbonizing Industrial Heat. www.sintef.no/globalassets/sintef-energi/industrial-heat-pump-whitepaper/2020-07-10-whitepaper-ihp-a4.pdf

[50] Hepburn, C, Adlen, E, Beddington, J *et al*. (2019) The technological and economic prospects for CO2 utilisation and removal. Nature, 575 (7781). pp. 87-97. ISSN 0028-0836

[51] According to the IPCC, well-selected, well-designed and well-managed geological storage sites can maintain CO2 trapped for millions of years, retaining over 99 per cent of the injected CO2 over 1000 years. IPCC Special Report on Carbon Dioxide Capture and Storage, www.ipcc.ch/site/assets/uploads/2018/03/srccs_wholereport-1.pdf

[52] Additional guidance can be found in the report Best Practice Guidance for Effective Methane Management in the Oil and Gas Sector. Monitoring, Reporting and Verification (MRV) and Mitigation. United Nations Economic Commission for Europe. 2019 https://unece.org/fileadmin/DAM/energy/images/CMM/CMM_CE/Best_Practice_Guidance_for_Effective_Methane_Management_in_the_Oil_and_Gas_Sector__Monitoring__Reporting_and_Verification__MRV__and_Mitigation-_FINAL__with_covers_.pdf

[53] Saygin,D., Gielen,D.(2021). Zero-Emission Pathway for the Global Chemical and Petrochemical Sector. Energies,14(13):3772. https://www.mdpi.com/1996-1073/14/13/3772

4.2 Criteria for facilities producing basic chemicals

These criteria are set at the facility level, this means for certifying whole facilities producing basic chemicals which may also include the implementation of mitigation measures. The criteria are made up of: mitigation criteria specific to each of the chemicals in scope and cross-cutting criteria for all facilities producing any of the chemicals in scope. The first one involves carbon and energy thresholds mainly and the second one involves more general aspects of a facility.

4.2.1 Basic chemical-specific criteria

For facilities producing basic chemicals in scope, products need to meet specific carbon or energy intensity thresholds provided in the main Basic Chemicals Criteria document. The approach followed in setting criteria for this requirement is to have one threshold per product without distinguishing technology, feedstock, location or asset size. Information specific to each chemical product in scope is scarce for setting thresholds. The two main sources of reference for benchmarks or threshold data were those developed by the Interamerican Development Bank (IDB)[54] and the EU taxonomy Technical Expert Group on Sustainable Finance[55]. IDB reports benchmarks for emission intensity for ten basic chemicals, which include mainly scope 1 emissions and electricity emissions, with a distinction among feedstock or technologies. However, IDB data makes a distinction among several technologies and is a rather outdated source of benchmarks and no updates have been found to be used. This made its adoption difficult as one threshold per product was required from a source of validated and most-up-to date data with subsequent regular updates. The EU taxonomy developed specific thresholds for chemical products which are included in the scope of this criteria. The EU taxonomy approach in setting such thresholds is based on the 10% best performing facilities in Europe during a given period. This approach is taken as a basis for the development of similar taxonomies in other countries such as Australia and New Zealand[56]. In this sense, it is expected that criteria based on the existing EU thresholds would be recognised in other geographies as a high degree of alignment among the various taxonomies is anticipated. Furthermore, the EU taxonomy values were developed by a group of experts, and they are revised regularly to consider improvements in technologies. This is in line with Climate Bonds' guiding principle of building on existing material to leverage existing robust, credible and widely accepted tools, methodologies and data. Thus, these criteria adopt the EU taxonomy threshold values. However, after consultation it was recognised that these thresholds vary in scope of emissions and may include scope 1 and scope 2 emissions. The specific scope that applies to each of the chemicals in scope are indicated in the main Basic Criteria document. In addition to the thresholds adopted from the EU Taxonomy there are additional aspects that must be addressed. The rationale for the revision to the high value chemicals threshold, and the criteria for methanol are discussed as follows.

- Criteria for Production of methanol: this product is not included within the scope of the EU taxonomy[57]. The primary raw material is hydrogen (which is mostly derived from the gasification of fossil feedstocks, though it can also be derived from biomass and water electrolysis) and in this, it has similarities to the way ammonia is produced. Taking as reference the requirements for ammonia, a similar requirement for production of methanol was adopted to require the use of low-carbon hydrogen. While a threshold value could be adopted or derived from reports such as the one from IDB, there was insufficient evidence that the values mirrored the scope of emissions and whether the manner in which they were developed was as robust as the ones referenced for the rest of the chemicals in scope.
- Setting ambitions threshold for high value chemicals (HVC): High value chemicals account for around 25% of emissions from the chemical industry. It is important to mitigate GHG emissions from the production of these basic chemicals in order to decarbonise all the products downstream in their value chains and a more ambitious threshold should be sought. Upon reviewing the differences in values in the EU taxonomy from 2019 and the updated values for 2021 for HVC it was clear that

[54] Suding, P.H. (2013). Chemical plant GHG emissions: reconciling the financing of chemical plants with climate change objectives. (Inter-American Development Bank Technical Note ; 618). https://publications.iadb.org/publications/english/document/Chemical-Plants-GHG-Emissions-Reconciling-the-Financing-of-Chemical-Plants-with-Climate-Change-Objectives.pdf

[55] European Union (2020). Taxonomy: Final report of the Technical Expert Group on Sustainable Finance. https://ec.europa.eu/info/sites/default/files/business_economy_euro/banking_and_finance/documents/200309-sustainable-finance-teg-final-report-taxonomy_en.pdf

[56] World Bank (2017). A Guide to Greenhouse Gas Benchmarking for Climate Policy Instruments. Washington, DC. https://openknowledge.worldbank.org/handle/10986/26848

[57] Not to be confused with monoethylene glycol. Methanol is an alcohol with one carbon and one oxygen atom in its formula CH3OH, while monoehylene glycol is a dialcohol with two carbon and two oxygen atoms in its formula C2H6O2.

they do not show a significant progress in decarbonisation, as the difference was only 1.3 %. In order to update the threshold value, available data for average GHG emissions from scope 1 and 2 was reviewed.

The paper from Ren *et al*. (2008) analysed energy use and CO2 emissions from steam cracking for olefins production[58]. Scope 1 and 2 emissions were lumped into emissions from petrochemicals production and separated from the emissions from feedstock production.

Figure 5 shows their results for ethane and naphtha-based production, indicated by the grey section of the bars. The values range from about 0.6 tonne CO2e/ tonne HVC corresponding to naphtha-based state-of- the-art plants, up to about 0.8 tonne CO2e/ tonne HVC corresponding to the world average for naphtha-based plants.

Another study by the IEA, ICCA and DECHEMA[59] reported average specific energy consumption and GHG emissions from various production process technologies and feedstocks for ethylene and propylene production, using industry reports and the Stanford Research Institute databases. ***Figure 6*** shows that the average of the GHG emissions across all alternatives was 0.6974 tonne CO2e/ tonne HVC. This result is close to the threshold in the EU taxonomy showing that the value may have scope for higher ambition. The same study estimates the reduction on the specific energy consumption which has been taken as a proxy for GHG emissions, and the resulting average potential reduction was estimated at 27%. A new threshold has been calculated by applying such a percentage to the average GHG emission value, resulting in a threshold value of 0.51 tonne CO2e/ tonne HVC. This value is selected as being appropriate considering that this study was from 2013 and that significant improvements through energy and catalytic efficiencies of the processes are achievable today. However, it is recognised that there are major differences in the type of process and feedstocks, but the main principle applied throughout the criteria development is to have one threshold per product. The main objective is to set a level playing field for all alternative systems and promote decarbonisation. It was also important to note that the average includes processes using propane and ethane as feedstock, however selectivity is not 100% towards the corresponding olefins and these processes also produce a mix of olefins and thus the common unit of tonne HVC is appropriate. Furthermore, the proposed threshold would promote the use of lighter refinery streams as feedstock which also promote lower process emissions.

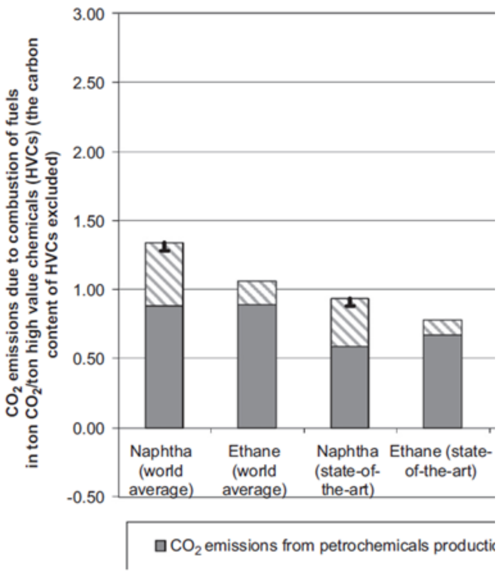
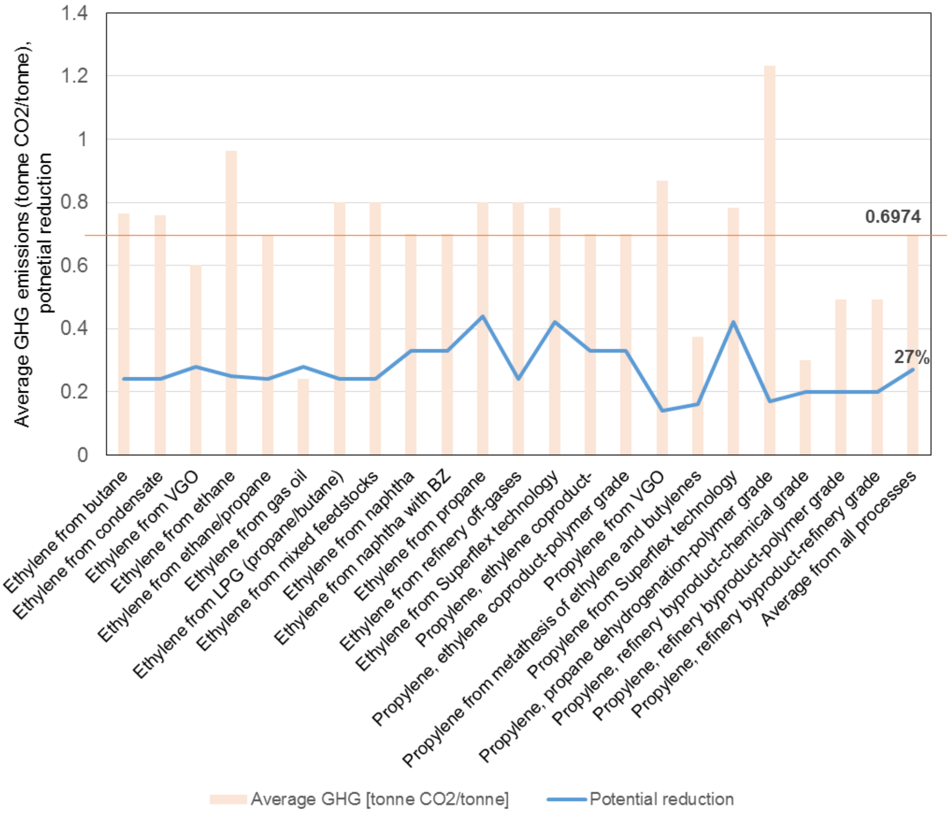


Figure 5: Extract from the CO2 emissions estimated for high value chemicals production by Ren *et al*. (2008) [56]

[58] Ren, T., Patel, M. K., & Blok, K. (2008). Steam cracking and methane to olefins: Energy use, CO2 emissions and production costs. Energy, 33(5), 817-833.

[59] DECHEMA/IEA/ICCA 2013. Technology Roadmap - Energy and GHG Reductions in the Chemical Industry via Catalytic Processes. See also Annexes. https://dechema.de/en/industrialcatalysis.html



Note: using best available techniques as estimated by DECHEMA/IEA/ICCA (2013) 57. The shaded lines in part a) are emissions from feedstock production which are scope 3 emissions not considered in the thresholds.

Figure 6: Average GHG emissions and potential for reduction

To demonstrate they meet the GHG thresholds, issuers are required to carry out a GHG emissions assessment. Additional concepts and explanations, supporting the methodological note provided in the main Criteria document are given in ***Box 2***.

Box 2: GHG Assessment

Scope 1 and 2 definitions:

- Scope 1 emissions: all direct emissions from the production processes including emissions generated during the reactions, emissions from fuel combustion for on-site energy generation
- Scope 2 emissions: indirect emissions from the energy sources: emissions embedded in the electricity or heat imported from off-site. Note that not all thresholds include scope 2, and thus a requirement for renewable electricity is set as an additional criterion for chemicals with energy thresholds or carbon thresholds that do not cover scope 2 emissions.

The figure below illustrates the scope of emissions. Note that Scope 1 emissions are those under control of the facility, i.e. on site. Scope 2 emissions are from imported energy, and they are considered indirect as they are releases off-site. There are cases where the hydrogen is produced inside the basic chemical facility, thus under its control and the emissions from hydrogen production should be accounted for. In the case of hydrogen being purchased from off-site, then they are considered as Scope 2, as in the case of purchased electricity. Also, note that the case of CCS the emissions from the capture, transportation and storage activities should be accounted for, while the amount of CO2 captured are subtracted to calculate the final carbon intensity of a product. Similarly, if the venting and off-gases released into the atmosphere contain any GHG they should be accounted for in the GHG accounting.

Scope 2
Emissions from purchased energy off-site

- **Examples**
  - Emissions from the generation of the electricity purchased form the grid
  - Emissions From the generation of the heat supplied externally

Scope 1
Direct emissions under control of the basic chemical production facility on-site

- **Examples**
  - Emissions generated from reactions (e.g. steam reforming, gasification)
  - Emissions from natural gas combustion in furnace and boilers
  - Emissions from the migration technologies that are released to the atmosphere
  - Other gas venting and off-gasses released to the atmosphere

When multiple products are generated from the same facilities, issuers must follow the ISO standards for allocation[60]. Further guidance and examples of allocation approaches specific for the chemical sector can be found in the guidelines developed by the WBCSD with the European Chemical Industry Council[61]. Only the basic chemicals in scope of these criteria need to meet the GHG emissions thresholds. However, users of these Criteria are reminded that if the amount of basic chemical production accounts for less than 50% of total annual production rate then the facility is not certifiable under these Criteria.

The issuer may use design specification for assessment of the GHG in the following cases:

i. The new equipment is part of the project and is to be integrated into existing facilities;
ii. The asset in question is a brand-new facility. For operating equipment in existing facilities, actual emissions data should be used.

4.2.2 Pathway followed for projection of the thresholds

Climate transition action plans are essential to guide investors to define whether plans are credible and ambitious enough. A key component in selecting a pathway is that it must show the way to the 1.5°C target over time. Mitigation pathways are a guide to estimate the rate of emissions reductions, and carbon intensity reductions, that are needed for achieving a certain target global average temperature rise by a certain year. Thus, the projection of decreasing threshold values was performed to ensure that assets and activities included in the use of proceeds at entity are aligned to a transition pathway that contributes to the 1.5°C target. Due to the lack of data on a pathway for each of the chemicals in scope and the fact that not even a sector level pathway has been available at the time of development of this criteria, alternative pathways were reviewed. When available, as in the case of hydrogen, the pathway specific for the feedstock or product in question was followed, otherwise the sector level pathway was adopted as a basis to estimate the threshold values in 2030, 2040 and 2050. This is further explained as follows.

- Hydrogen

The basic chemicals criteria include carbon intensity benchmarks, criteria for low-carbon hydrogen production, and a decarbonisation pathway to reduce emissions over time. Hydrogen that meets these criteria can be used for basic chemicals

[60] When production systems have more than one product, the ISO standards on LCA recommends avoiding allocation by instead "expanding the product system to include the additional functions related to the co-products" (ISO 14044, clause 4.3.4.2). In the expansion the impact from the alternative system is subtracted from the impact of the system under study. But this is not always practical in the multiple product plants in basic chemicals production, such as high value chemicals and aromatics.

[61] WBCSD Chemicals (2014). Life Cycle Metrics for Chemical Products. Available at: www.wbcsd.org/Projects/Chemicals/Resources/Life-Cycle-Metrics-for-Chemical-Products

(mainly ammonia and methanol) production projects to be certified. For the 2030 threshold, the projection using a reference pathway was used, as explained below for other chemicals. Afterwards, the life cycle GHG emission values for hydrogen produced from renewable energy and feedstock alternatives (biomass) projected by the Hydrogen Council[62] were taken as reference to set out the thresholds for 2040 and 2050. This projection reveals that achieving the thresholds adopted in these criteria is feasible.

The Climate Bonds Initiative is currently developing criteria for hydrogen. Once the hydrogen criteria are published, it shall supersede the requirements set in ***section 4.1., table 3*** of the criteria document.

- Chlorine

  In this case, there is an energy threshold whose reduction is limited by the minimum theoretical electrical energy required to perform the electrochemical process that produces chlorine. For the 2030 threshold an updated value proposed in a European Union study was used[63]. For the 2040- and 2050-time horizons, a rather qualitative requirement was set out to ensure the process delivers low carbon chlorine by using renewable power. This is because the main source of emissions in the Chlorine process come from indirect emissions due to the electricity usage.

- All other chemical products

  Existing pathways proposed by different authors and organisations specific for the chemicals sector were evaluated. The mitigation pathways consist of a combination of measures or activities with potential to decrease emissions which are assumed to be adopted in each time horizon. This provides a reference to determine the quantity of emissions that need to be mitigated and translates into a reduction rate over the time horizon established. This means, pathways then serve as a guideline to establish whether a decarbonisation plan or roadmap and their resulting reduction target is aligned with the rate of emissions reduction required.

  The feasibility of the thresholds for other products was indirectly checked against references in the literature. For nitric acid, the US EPA reported measures leading to a 98% reduction for average facilities[64], resulting in emissions as low as 0.0033 t CO2-e/t. The threshold for carbon black is also feasible as the idea is to replace fossil feedstocks by biomass or other low carbon feedstocks. The value of HVC and aromatics are feasible, for example it has been shown that combining biomass and CCS or CCUS the carbon intensity of these chemicals can be drastically reduced[65].

Table 8 summarises the main pathways and their estimated reductions resulting from scenarios for adoption of a combination of technologies and measures. It should be clarified however that the aim of considering these pathways is to set a level of ambition and have a reference for the level of emissions according to a trajectory and alignment to the 1.5°C target. This in no way aims to prescribe any specific technologies. As such, there is plenty of room to support any novel technology that may emerge in the coming years.

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[62] Hydrogen Council (2021). Hydrogen decarbonisation pathways. A life cycle assessment. Available at: https://hydrogencouncil.com/wp-content/uploads/2021/01/Hydrogen-Council-Report_Decarbonization-Pathways_Part-1-Lifecycle-Assessment.pdf

[63] EU (2021). Support study for the preparation of energy efficiency benchmarks in the context of the Revised ETS State Aid Guidelines. https://ec.europa.eu/competition-policy/system/files/2021-11/kd0121322enn_ETS_efficiency_benchmarks.pdf

[64] US EPA (2010). Available and emerging technologies for reducing greenhouse gas emissions from the nitric acid production industry. www.epa.gov/sites/default/files/2015-12/documents/nitricacid.pdf

[65] Zhao *et al*. (2018). Low-carbon roadmap of chemical production: A case study of ethylene in China. Renewable and Sustainable Energy Reviews 97, 580-591. www.sciencedirect.com/science/article/pii/S1364032118305732#bib8

Table 8: Summary of estimated reductions from pathways for chemical sector

Reference	Estimated reduction	Comments
IRENA (2020)	2.5 Gt CO2/year	Focus on using CCS and low carbon and renewable energy, net zero target.
Saygin and Gielen (2021)	4.79 Gt CO2/year	For net zero by 2050, 1.5°C pathway Adds options to IRENA report 2020 2050 PES as reference Accounts for end use emissions
IEA (2020)	0.2 Gt CO2/year by 2070 Overall sector intensity (approx.): 1.7 t CO2/t by 2020 0.7 t CO2/t by 2050 0.2 t CO2/t by 2070	SDS 2019-2070 Horizon 1.4 Gt CO2/year, 2019 baseline Net zero by 2070
DECHEMA (2017)	Maximum technical potential: 210 Mt/year Ambitious scenario: 101 Mt/year Intermediate scenario: 70 Mt/year	Focused on Europe 2050 horizon Biomass for aromatics may increase emissions Does not consider CCS, only CCU for the CO2 needed as feedstock

The IRENA report focuses on the use of renewable energy and energy related measures to achieve net zero emissions by 2050 with an important reliance on CCS. The study by Saygin and Gielen (2021) included most of the chemicals within scope of this Climate Bonds criteria (ethylene, propylene, butadiene, aromatics, ammonia, methanol, chlorine and carbon black); with an ambition for net zero emissions from global chemical and petrochemical sector by 2050. Interestingly, this pathway considers the whole life cycle emissions and this, together with a net zero ambition, may be the reason for the higher estimated reductions among the pathways included. The IEA Energy Technology Perspectives 2020 presents pathways for the chemical sector in a time horizon from 2020 and up to 2070, relying mainly on fossil-based chemical production with CCS and CCU as key mitigation measures. The study by DECHEMA also explored scenarios focused on the European chemical industry, and advocates for CO2 use as a feedstock, renewable energy and biomass (this has restrictions for certain chemical products, such as aromatics).

There is a wide range of estimated reductions across these studies mainly due to differences in mitigation measures considered, time horizons and ambitions levels (IEA's planned energy scenario, sustainable development scenario, net zero for a 1.5 oC target by 2050, etc.). There are also differences in the chemical products and technologies included in their analyses. For these reasons, it was considered that there is not a sufficiently robust basic chemicals sector pathway to adopt as reference that provides the necessary confidence regarding common levels of ambition, timelines and scope. However, robust and science-based pathways have been developed for several sectors by the Science Based Targets initiative (SBTi), including a cross-sectoral pathway that was developed through a robust process. Leading chemical companies have begun to set science-based targets (SBTs) that meet broad (SBTi) criteria. However, some barriers of this sector exist, such as the lack of scope 3 data availability, the low technological readiness of most of the carbon mitigation technologies, lack of specific sector method, and value chain cooperation initiatives, among others, making it challenging to develop target setting guidance and pathways for chemical companies.

Climate Bonds's view is to have Paris aligned pathways at the sector level and thus a common sectoral decarbonisation pathway should be identified in order to show how that sector will align with the collective goal of keeping global average temperature rise below 2 degrees and ideally 1.5 degrees[66]. The determination of the carbon emission thresholds in these criteria was done based

[66] Creed, A., Horsfield M. (2021). Transition finance for transforming companies. Avoiding greenwashing when financing company decarbonisation. Climate Bonds Initiative. www.climatebonds.net/files/files/Transition%20Finance/Transition%20Finance%20for%20Transforming%20Companies%20ENG%20-%2010%20Sept%202021%20.pdf

on the alignment to a 1.5 oC decarbonisation pathway for the entire chemical sector recently published by Teske *et al*. (2022)[67]. The pathway is compared and benchmarked with those from IEA Sustainable Development Scenario and the SBTi's cross-sectoral pathway in Figure 7. Teske's pathway practically follows the same shape and similar slope as that by SBTi's cross-sectoral pathway. The IEA only includes the direct CO2 emissions, while Teske's consider all energy related and non-energy related emissions of the chemical sector but it can be observed that they practically converge by 2050, which indicated that only unavoidable direct CO2 emissions would remain (as they are mainly forming from the reactions carried out to produce the chemical products). Thus, the selection of Teske's pathway was considered appropriate to derive the thresholds presented in the Criteria document.

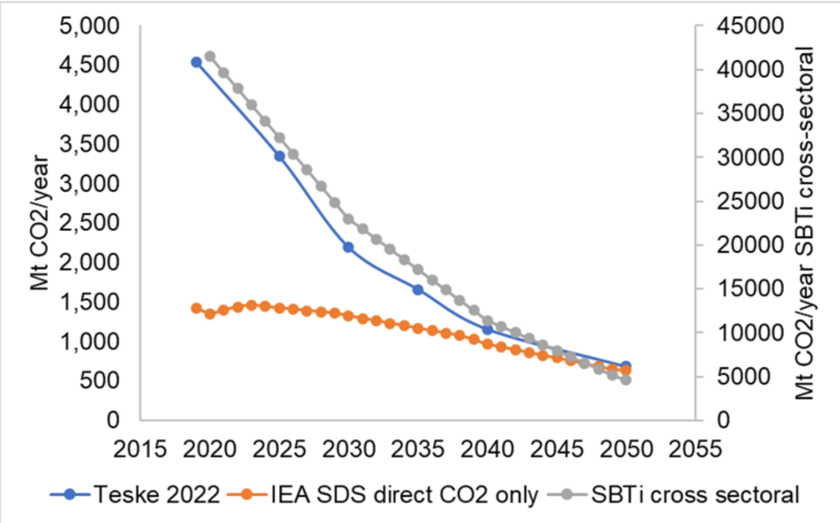


Figure 7: Comparison of decarbonisation pathways for the chemical sector and SBTI cross-sectoral pathway

In the SBTi's pathway the reduction by 2030 is estimated at 42% from the 2020 levels, resulting in a linear annual reduction of 4.2 %. After that, the total reduction should be 90% by 2050, resulting in an average linear annual reduction of 2.4 % (based on the same 2020 level). Teske's pathway is more specific to the chemical sector and estimates a lower total reduction of 85% by 2050 from 2019 level. However, the decarbonisation rates are higher. For example, from 2019 to 2030 the annual reduction rate is 4.7%, and 3.5% until 2040 and then 2.7% until 2050 based on the same levels of 2019. In order to benchmark these reduction rates with the pathways discussed above, the linear percentage reduction was estimated for the pathway from Saygin and Gielen (2021) which is the most ambitious, and the pathway from IEA which is the least ambitious. An average between 2 and 3.33% annual reduction from 2020 levels was estimated from the Saygin and Gielen (2021). These authors do not present values for intermediate time frames. The reduction rate from 2019 to 2050 from IEA report is estimated at 1.9 %, while the reduction from 2050 to 2070 is estimated at 2.14%, taking the base year of 2019. In conclusion the reduction rates being adopted from Teske *et al*. have a higher level of ambition. If we consider the average reductions of the Teske *et al*.'s pathway throughout the whole-time frame of 2019 to 2050, a similar average level of reduction rate (about 3%) estimated for the net zero case of Saygin and Gielen (2021) is achieved.

With the reduction rates from Teske *et al*.'s pathway and taking as basis the thresholds for 2022, the thresholds were extrapolated to 2019 first using the 4.7% annual reduction to have the 2019 base value, afterwards, the aforementioned reduction rates were applied to calculate the 2030, 2040 and 2050 threshold. This was performed for all carbon intensity thresholds (except for hydrogen and chlorine, as explained above).

Other specific pathways for the chemical sector are currently under research and development. These criteria may be aligned accordingly in future revisions.

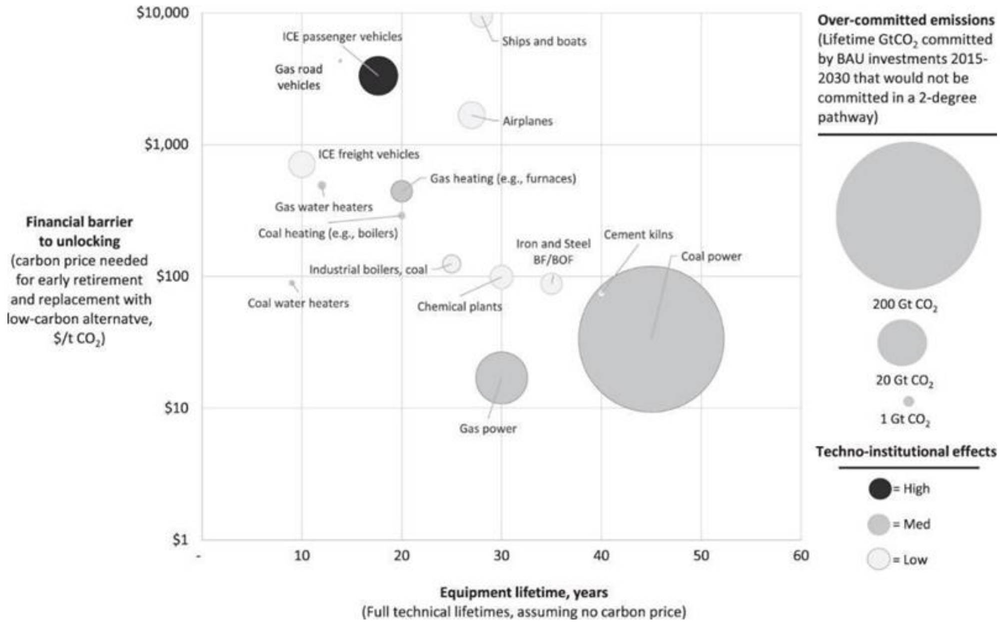
[67] Teske, S., Niklas, S., Talwar, S. *et al*. 1.5°C pathways for the Global Industry Classification (GICS) sectors chemicals, aluminium, and steel. SN Appl. Sci. 4, 125 (2022). https://doi.org/10.1007/s42452-022-05004-0

4.2.3 Cross cutting criteria for decarbonisation measures, production facilities and parts of chemical companies producing basic chemicals in scope

4.2.3.1 Additional criteria depending on the age of the facility

In setting the criteria, it was important to differentiate between existing operating assets which are transitioning towards low-carbon production processes, and those financed as brand-new assets. Brand-new assets may be standalone facilities and outside boundary limits of existing facilities, or they can be new production trains integrated into existing facilities (thus, not necessarily green field developments). Although criteria apply to both types of facilities, there are additional requirements set depending on the age of the facility, as shown in the criteria document. There are two main reasons for this: to prevent carbon lock in and ensure emissions reduction over time and prevent stranded assets.

Preventing carbon lock-in and ensuring emissions reduction over time: Chemical plants typically have an average operating life of 30 years, so if a new plant uses traditional technology, it will keep releasing the same level of emissions as today rather than the declining emissions trajectory that is required. Therefore, new facilities require the use of low carbon approaches to prevent the potential carbon lock-in that could arise from the use of traditional high emissions technologies, feedstocks and energy sources (see Table 2 for the main traditional technologies for chemicals in scope, also called conventional or business-as-usual technologies). The term 'carbon lock-in' refers to the tendency for certain carbon-intensive technological systems to persist over time because they are known and trusted, but which perpetuate the high carbon emitting processes for many decades and create the inertia that prevents the adoption of lower-carbon alternatives. Figure 8, reproduced from a study by the Stockholm Institute, shows that the potential carbon lock-in of chemical plants could be up to 5 Gt CO2[68] if new plants are designed using the same technologies and configurations of the existing ones. This is near five times the estimated emissions of the whole chemical sector in 2019[69].



Note: Erickson *et al*. (2015), which include estimated GHG emissions due to carbon lock-in of chemical plants[62].

Figure 8: Results of a global assessment of carbon lock-in risks

Preventing stranded assets: many current chemical plants use fossil carbon as the feedstock. As efforts to address climate change develop and fossil assets are kept in the ground, any chemical assets reliant on such a feedstock may find it increasingly hard to access reliable source material and ultimately become a stranded asset. Therefore, in order to align new facilities with a low carbon future and prevent assets becoming stranded, constraints for technology and feedstocks form part of the mitigation criteria and are applicable to all assets and projects in scope.

[68] Erickson, P., Kartha, S., Lazarus, M., & Tempest, K. (2015). Assessing carbon lock-in. Environmental Research Letters, 10(8), 084023.

[69] SBTi (2021). Pathway-to-Net-Zero.pdf (sciencebasedtargets.org)

Specific requirements are detailed in the criteria document. The criteria allow for promoting the use of recycled feedstocks and the adoption of alternative low carbon technologies and alternative feedstocks. The combination of low carbon technologies with fossil feedstock is not eligible for new plants; however, it is recognised that alternative feedstocks exist. For example, new plants with methane pyrolysis (which generates solid carbon as a by-product instead of CO_2) using fossil gas for hydrogen production may not be eligible for new plants but could become eligible if it uses methane derived from biomass.

4.2.3.2 Additional criteria depending on the feedstock used

These additional criteria refer to criteria set for the capital investments used for implementing mitigation measures including the use of hydrogen, biomass and CO_2 as feedstocks.

4.2.3.3 Additional criteria depending on the energy used

These additional criteria refer to criteria set for the capital investments used for implementing mitigation measures including the use of fossil gas, hydrogen, biomass and energy from alternative sources.

4.2.3.4 Additional criteria to address scope 3 upstream emissions

The scope 3 emissions can be a significant part of the total emissions of a chemical product value chain. It has been reported that up to 77% of the emissions from chemical industry value chains fall within Scope 3 emissions[70]. This is mainly due to the extraction, production, transportation and storage of fossil feedstocks and fuels, as well as other raw materials. Thus, it was necessary to set out a requirement for addressing this type of scope 3 emissions at least on the upstream side as producers can have a certain degree of control on purchasing low carbon feedstocks and energy sources. Given that most in the case of organic compounds the carbon in the feedstock remains in the products, it was also necessary to set out a life cycle GHG assessment to ensure that the use of alternative feedstock leads to true decarbonisation. The eligible elements for the strategy to address scope 3 upstream emissions are listed in the main Criteria document.

4.2.3.5 Other additional criteria

This additional criterion was set to promote the use of those technologies that do not generate direct emissions due to reactions which are then released into the atmosphere. The main examples of these include methane pyrolysis, catalytic partial oxidation of methane to methanol. These processes intrinsically do not release CO_2 emissions as the current conventional technologies (e.g., methane reforming) do.

[70] Avieco (2022). Translating Scope 3 Emissions for the Chemical Sector. https://avieco.com/news-insights/translating-scope-3-emissions-for-the-chemical-sector/

5 Criteria for adaptation & resilience

5.1 An overview of the criteria for adaptation & resilience

According to Lux Research, storms, floods, droughts, and extreme temperatures threaten the supply of chemicals as climate change impacts become more evident and frequent, leading to hundreds of millions of dollars in damage on a global scale. Potential risks associated with climate change include negative impacts on capital assets, transport and raw materials availability difficulties, productivity, and safety problems[71] . Because of the type of hazardous substances manufactured, managed, and stored, in chemical facilities, climate change risks could lead to severe consequences. Potential risks include negative impacts to capital assets, transport and raw materials availability difficulties, productivity and safety problems. This section describes the Adaptation & Resilience (A&R) Component of the eligibility Criteria for assets and projects under the Climate Bonds Standard. This component of the Criteria views the potential climate adaptation and resilience impacts/benefits of the Basic Chemicals sector as inextricably linked to a broad range of environmental and social issues and proposes to assess these in the round.

Section 5.2 below describes the scope of this component in terms of the key factors that need to be assessed to ensure that Certified Climate Bonds are delivering on key climate outcomes in line with the overall objectives of the Standard. Section 5.3 describes practical aspects of this component, to ensure that any transaction burden for issuers is minimised, while maintaining rigour and robustness in assessment. Section 5.4 describes existing tools. The Adaptation and Resilience Component of the Basic Chemicals Criteria balances the needs for assessments while leveraging existing tools where appropriate.

5.2 Key aspects to be assessed

Climate adaptation and resilience mitigation criteria are designed to ensure that a project itself is resilient to climate change and that it does not affect the resilience of other sectors. The development of the requirements for the A&R component was based on Climate Bonds' "Climate resilience principles" document[72]. ***Figure 9*** gives an overview of the six principles for resilience.

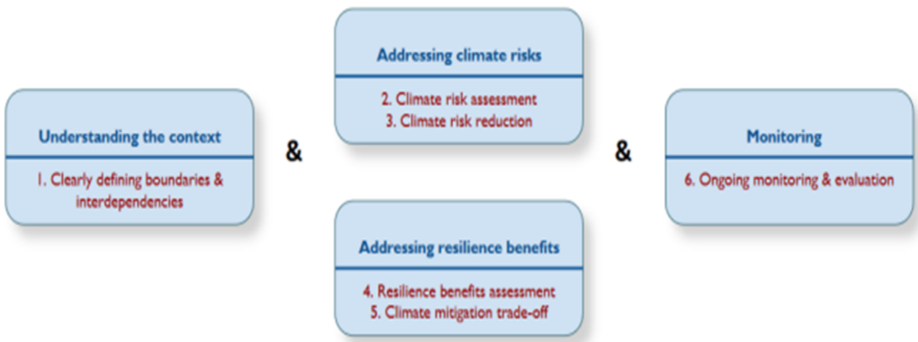


Figure 9: The Climate Bonds' principles for Resilience

Although the principles provide a framework and serve as guidance for general aspects to consider, it is also recognised the challenges and limitations to assess the adaptation and resilience aspects in general. Such limitations include the lack of awareness of climate resilience benefits and a common language, robust data on climate risks and common methodologies for climate risk assessment, lack of capacity and interdependencies with other assets or actors in the supply chains. It is also acknowledged that A&R has inherent complexities which makes it harder to quantify and it can be very context specific, depending not only on location

[71] Lux Research (2020). In the Path of Destruction: Preparing for Global Climate Change in the Chemical Industry. https://members.luxresearchinc.com/research/report/36147

[72] Climate Bonds (2019). Climate Resilience Principles. A framework for assessing climate resilience investments. www.climatebonds.net/climate-resilience-principles

but also on the type of asset, the type of risk looked at, the level of severity and frequency of the risk, and so on. The frequency and magnitude of the impacts are commonly underestimated by companies.

- Location: Appropriate geographic or other spatial boundaries for climate risk and benefits assessments for assets and activities in the sector was discussed as well as consideration of the broader system affected by those assets and activities. There are expected internal and external interdependencies between assets or activities in a given sector and between sectors (which become evident when a climate event results in a potential failure of value chains) but there can also be opportunities to maximise resilience benefit.
  When developing criteria for setting the boundaries for assessment, it was proposed to separate the analysis as follows:
  - Capital assets
  - Production
  - Logistics and supply (including raw materials, utilities and their distribution),
  - Labour.

  Key infrastructure dependencies were identified with special relevance for the chemicals sectors including water (which is as process raw material, cooling agent and in cleaning), gas, energy and other key utilities necessary to run the processes and keep the adaptation and resilience equipment and infrastructure operating during any outage arising from climate change events. All these infrastructure dependencies are to be included in the production element. Nevertheless, because the logistics and labour are out of the scope of the Climate Bonds Resilience Principles, the A&R criteria will focus on production and capital assets.

- Timeframes: Appropriate time horizons for climate resilience assessments need to be set for the assets and activities in scope. The criteria to base the time horizon for the assessments are set based on the typical lifetimes of assets in the chemicals sectors which is 30 years on average (though it is recognised that some may last for 50 years or more).
- Hazardous substances: For the special case of chemical production, it becomes critical to identify and assess the risk associated with the release of hazardous substances. It is important to understand what the facilities are doing in terms of resilience with these substances which imply a higher risk. To address this, criteria include a classification of geographies according to the level of risk. This can be determinant to certify a project or not. Risk assessments are routinely conducted by insurance companies. They include type of risk, the probability and the magnitude of the impact. In addition, a timeline of when risks could occur is required (identify zones prone to floods, storms, etc). The assessment should be preferably based on local models and data, but it can also be more regional or global. Again, the level of detail may depend on the types of risks.
- Disclosure: As part of the monitoring and evaluation principle, there are requirements for reporting and disclosing risks assessments. Currently there are a number of issued seen:
  - a lack of alignment or harmonisation as reporting is often undertaken on a voluntary basis
  - the level of completeness can be low which leads to accusations of greenwashing
  - the frequency for reporting and updating the assessment varies (recognising that the time horizons for revisiting the assessments will likely depend on the level of risk of a facility: low risk facilities can have long time horizons, and high-risk facilities short time horizons). Depending on the severity of the risk the time horizon can be set.

  Other aspects to consider when setting the A&R requirements are listed as follows:

- Identification of the key climate risks - including hazards, exposures and vulnerabilities - likely to be experienced by assets and activities in that sector The U.S. Chemical Safety and Hazard Investigation Board document is an example of guidance to reference when assessing risks. Some insurance companies, such as FM global, can also be a useful source of data for risk assessments.
- Models, methodologies and data sets that would be most appropriate for determining likely physical climate risks to be faced in context for activities and assets in that sector.
- Climate change risk measures and metrics for assets and activities in that sector - e.g., how should assets and activities deal with these risks? How this could be evaluated?.
  Based on the discussions presented above, the assessment methodology includes a verification list that the verifier should complete when assessing an asset or project. It is recognised that this may not be complete, but is presented as the most robust available, given the complexities and several angles of the topic, and the lack of robust and more quantitative methodologies

and tools. In setting such verification lists, documentation from Lux Research and guidelines from the UK Chemical Industry Association[73], and Dale (2021)[74] were taken as key references. More information on this is given in Section 5.4 below.

- Wider environmental and social risks. These risks are complex and interconnected and should be assessed under these Criteria, however the following points are noted:
  - The Climate Bonds Standard is focused on climate impacts - including low GHG-compatibility (mitigation) and also climate adaptation and resilience. Defining resilience can be challenging. However, it is clear that many topics which have been a part of environmental and social assessments for a number of years overlap significantly with the resilience of affected populations and ecosystems and their ability to adapt to climate change.
  - The most obvious example is the potential impact of climate change on hydrological conditions, and consequently water supply and local livelihoods. Another is climate change exacerbating ecological problems such as impaired species migration and algal blooms. Environmental and social impacts such as these, already complex and interconnected, become more so when climate change impacts and risks are taken into account, and there is a logic to addressing all key environmental factors, rather than trying to separate them out
  - The Climate Bonds Standard does not usually address primarily social impact issues, these were discussed but not considered within scope.

5.3 Practical requirements for this Component

- Leverage existing tools

  The knowledge and literature on adaptation and resilience impacts of the basic chemicals facilities, and the chemicals sector in general, is limited as this area is in its infancy. The A&R Component will require consideration of a highly complex and varied set of issues across the environmental and social spectrum for which data, methodologies and metrics may not be available. Qualitative methods based on verification lists or questionnaires have been proposed which can however be leveraged. It is not appropriate for Climate Bonds to commit resources to address these issues, and the guiding principle of simplicity shall be applied at this time. More robust criteria can be developed over time as more information is generated and integrated in the subsequent revisions of the Criteria.

  However, it should be noted that existing methods do not always fully or explicitly cover the additional, often interrelated impacts connected to climate adaptation and resilience. Many of the risk assessments and management processes specified by existing ES guidelines will be a prerequisite for identifying A&R risks, but more may be needed to fully address them given that this is an emerging topic.

- Minimise the assessment burden

  In addition, there needs to be a balance between rigour and practicality. Any Criteria with a prohibitively expensive assessment burden will discourage certification. Any methodology adopted therefore need to avoid this.

- A binary 'pass'/'fail' outcome rather than scores or grades

  Certification decisions under the Climate Bonds Standard are binary - applicants are either certified or not. Therefore, the A&R Component needs to be framed in terms of pass/fail thresholds. Where an assessment tool provides scores or grades for a facility, consideration has been given to what threshold 'score' or result should represent a pass for the purposes of Climate Bonds Certification.

- Retrospective application

[73] Chemical Industries Association (2015). Safeguarding chemical businesses in a changing climate. How to prepare a. Climate Change Adaptation Plan. www.cia.org.uk/LinkClick.aspx?fileticket=KW8WF8CBZG0%3D&portalid=0

[74] Dale, S.(2021). Disaster Planning: Improve Your Plant's Resilience. Become more proactive in dealing with acute and chronic natural disasters. www.chemicalprocessing.com. https://www.chemicalprocessing.com/articles/2021/disaster-planning-improve-your-plants-resilience/

Finance raised in this sector may be for new, greenfield facilities, for retrofits or upgrades to existing facilities, or they may be a straight refinancing of an existing facility. Therefore, any proposal and associated approved assessment tool under this Component needs to be usable for both new and existing facilities.

This is not a straightforward issue; as in the case of refinancing, the facility may have been operating for a number of years. It may have been compliant with best practices in place at the time of its implementation, but may not meet current best practice requirements. The selected methodology and tool will therefore need to be able to address and resolve any 'legacy issues' that may be identified.

5.4 Existing tools and guidelines considered

A range of existing tools and guidelines with the most potential to be leveraged for the Basic Chemicals Criteria are listed below, with a brief indication of whether they were taken forward for further consideration or not.

Risk Assessment and Climate Scenarios

- The ISO 14091:2021 Adaptation to climate change - Guidelines on vulnerability, impacts and risk assessment standard offers guidelines for assessing the risks related to the potential impacts of climate change.[75]
- Risks can be characterised by the associated annual probability of failure or annual costs of loss or damage
- For risk assessment, the TCFD The Use of Scenario Analysis in Disclosure of Climate Related Risks and Opportunities is recommended.
- A broad range of models can be used to generate climate scenarios. Users should apply climate scenarios based on representative concentration pathway (RCP) 4.5 and 8.5 or similar / equivalent to ensure consideration for the worst-case scenario. (The IPCC 'Shared Socioeconomic Pathways' to develop potential temperature scenarios. SSP5-8.5 is the highest warming pathway, SSP3-7.0 the second highest and so on).
- The IPCC Sixth Assessment report also provides an indication as to how different temperatures impact the likelihood and severity of different climate impacts
- A framework for risk management for climate security. https://www.c2es.org/document/degrees-of-risk-defining-a-risk-management-framework-for-climate-security/
- Climate Change Risk Assessment Guidelines. www.ctc-n.org/system/files/dossier/3b/D4.2%20Climate%20change%20risk%20assessment%20guidelines.pd

Chemicals Hazard Assessment

UCLID (International Uniform Chemical Information Database) software is a recommended source of data on intrinsic and hazard properties of chemical substances. https://iuclid6.echa.europa.eu/project-iuclid-6

The following link contains a list of regulated substances that require a Risk management plan (RMP).

www.epa.gov/rmp/list-regulated-substances-under-risk-management-plan-rmp-program

[75] www.iso.org/standard/68508.html

Appendix A: TWG and IWG members

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Robert Adamczyk Associate Director, Senior Environmental Adviser	EBRD. European Bank of Research and Development. UK	
Thomas Rehm Inaugural Chair	The Climate Solutions Community- American Institute of Chemical Engineers- Institute for Sustainability. USA.	
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Dr Fahim Tonmoy, Associate Principal Engineer	BMT Adjunct Research Fellow Griffith University. Australia.	
Kristin Marshall, Lux Research Analyst	Associate Research Director at Lux Research. Expertise assessing climate risk, adaptation and resilience in the chemical industry. USA	
Rita Ferreira Sustainable finance Associate	S&P Global Research analyst with experience in extreme weather impacts in the chemical industry. Portugal	

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