Limit global warming to 1.5°c

Sectoral pathways & Key Performance Indicators

05 . 2022

Report prepared by the University of Technology Sydney for the UN-convened Net Zero Asset Owners Alliance.

Aluminium | Chemical | Cement | Steel | Textile & Leather industry | Power Utilities | Gas Utilities | Agriculture | Forestry | Aviation & Shipping industry | Road Transport | Real Estate & Building industry

UTS Institute for Sustainable Futures

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About the authors
The Institute for Sustainable Futures (ISF) is an interdisciplinary research and consulting organisation at the University of Technology Sydney. ISF has been setting global benchmarks since 1997 in helping governments, organisations, businesses, and communities to achieve change to support sustainable futures.

ISF acknowledges and respects the Aboriginal and Torres Strait Islander custodians of Australia and the Gadigal people, custodians of the land upon which the UTS City Campus now stands. We continue to value the generations of knowledge that Aboriginal and Torres Strait Islander peoples embed within our university, and we pay our respect to their elders past, present and emerging.

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Recognitions

"The OECM model provides very granular sector specific net zero pathways based on currently available technologies and with the highest ambition regarding renewable deployment, both well in line with the latest IPCC report. Next to the IEA Net Zero scenario it is the best available source to understand the enormous speed which is needed in all sectors to achieve a net zero world in 2050. For asset owners committed to net zero portfolio alignment sector pathway information is of utmost importance for investment portfolio steering. Asset owners' investee companies are assessed against these pathways. Furthermore the OECM pathways need to be the basis for discussions with policy makers on the development of industry sectors."

Günther Thallinger, Member of the Board of Allianz and Chair of the UN-convened Net-Zero Asset Owner Alliance

"As a leading provider of scenario alignment tools and methodologies to investors, 2DII welcomes the further update of the 1.5 °C, Net Zero pathways based on UTS's OECM. Sectoral carbon budgets and pathways are essential to understand the scale and pace of change and the associated investment that is needed to limit global warming and in seeking, like the NZAOA, to measure the climate alignment of investments being made with the intention of achieving real world emissions reductions. We look forward to making the updated scenario and its ambitious, science-based pathways available to PACTA users so that they can make use of them for forward looking alignment measurements."

Jakob Thomae, CEO and co-founder of 2° Investing Initiative Deutschland e.V.

"To enable a rapid climate transition, and to be aligned with a 1.5-degree world in a longer term, investors need detailed information about the emission reductions needed for high emitting sectors in the short term. We welcome the second version of the One Earth Climate Model (OECM), outlining detailed data for 12 high emitting sectors with a geographic split and comparison to the IEA 1.5-degree scenario for relevant sectors. We hope this data and other sector pathways will be used by both investors and high emitting companies to track progress in the years to come."

Marcus Bruns, Nordic Head of Sustainability in Storebrand and Sector Lead in the UN-convened Net Zero Asset Owner Alliance

"We welcome the release of the One Earth Climate Model (OECM) as it is an essential component for robust sector target-setting methodologies, decarbonisation strategies and guiding dialogues with investee companies. The OECM not only aligns with the needed 1.5°C trajectory but also provides the necessary granularity and sectoral breakdowns directly applicable to the sector classifications used by the financial sector."

Peter Sandahl, Head of Sustainability, Nordea Life & Pensions

"The One Earth Climate Model provides asset owners and managers with urgently needed quantitative detail to align their portfolio holdings with science. In particular, it provides scenarios beyond the IEA scenario, which should help increase resilience in capital allocation strategies. Investors beyond those who are members of the UN-convened Net Zero Asset Owner Alliance should apply this new model widely. For regulators, this is a critical opportunity to ensure reporting requirements align with these science-based scenarios, and provide forward looking data aligned with global ambition to limit warming to 1.5C, for instance through the EFRAG and ISSB reporting standards."

Margaret Kuhlow, Global Finance Practice Leader, WWF

Contents

How to limit global warming to 1.5 °C: Research identifies the remaining global carbon budget for 12 main industries

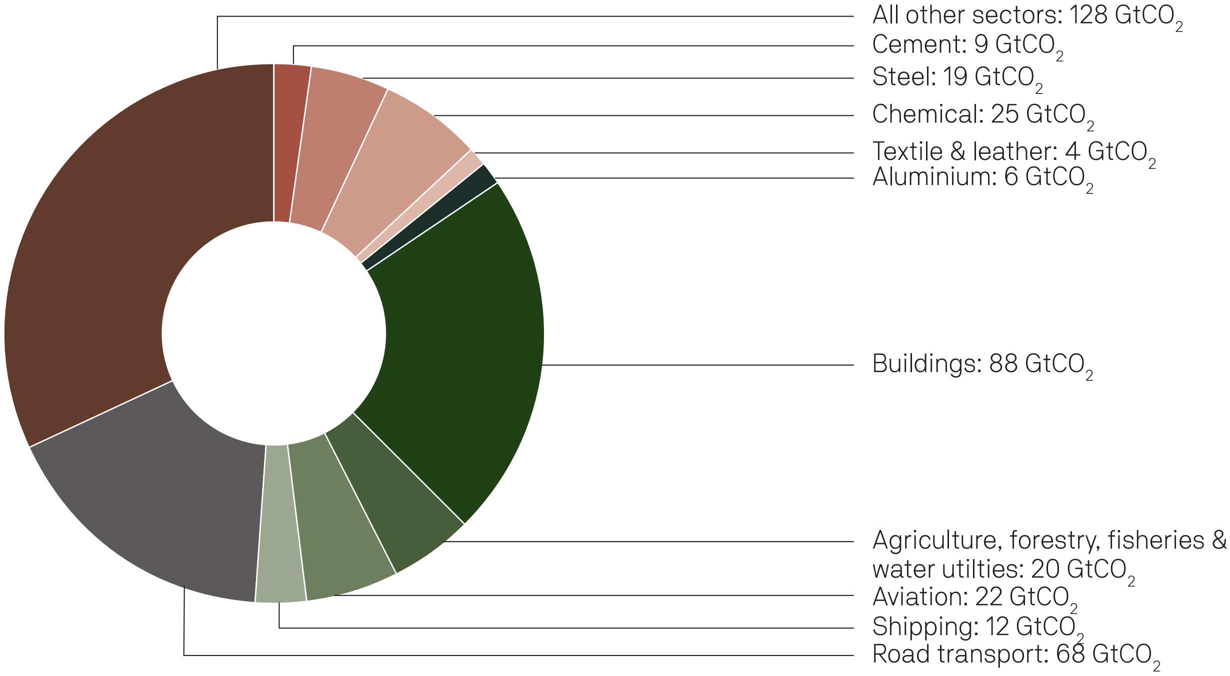
The remaining **global carbon budgets** required to limit global warming to 1.5 °C **for the 12 main industry sectors have been defined. Scientists at the University of Technology Sydney** (UTS) have developed energy-related carbon budgets for 12 main industry and service sectors: *aluminium, chemical, cement, steel, textile & leather industry, power utilities, gas utilities, agriculture, forestry, the aviation and shipping industry, road transport, and the real estate & building industry. The full data sets are now available for OECD Europe, OECD North America, and the world.*

The specific industry emission budgets were further **subdivided into so-called Scope 1, 2, and 3 emissions, which define the industries responsible for those emissions.** So far, this system has only been applied to companies, but not as yet to an entire industry sector or region. The researchers used and streamlined **three financial industry classifications (BICS, GICS, and NACE) for energy and climate scenarios for the first time.** The **interconnections across the 12 industry sectors in terms of scope 1, 2, and 3 emissions are reported with a Sankey diagram.**

The UTS research shows that **it is still possible to limit global warming to 1.5 °C** and implement the Paris Climate Agreement. However, this will require **timely climate action by key stakeholders:** policy makers, industry sectors, and financiers. With the help of these new UTS findings and data, operationalising the global 1.5 °C objective is now feasible, including tracking progress toward this objective in the short term.

For instance, financial actors and corporations increasingly set strict and ambitious climate neutrality targets—often called 'net-zero targets'. Climate target setting and implementation require sector decarbonisation models, such as the *UTS One Earth Climate Model (OECM)*, to be used as benchmarks and guidance when making decisions about investment portfolios and when engaging with various

FIGURE 1 GLOBAL CARBON BUDGET BY SUBSECTOR IN [$GTCO_2$] - 2020 - 2050



stakeholders (e.g., corporations, sector associations, and governments). An emission pathway is required for each specific industry classification, which is then captured in one consistent model that is in line with the net-zero ambition. **Global and sectoral interconnections mean that silo approaches will not work.** Members of the UN-convened Net Zero Asset Owner Alliance ('the Alliance') have already started using this model to set targets and steer investment portfolios.

The *UTS OECM* is an integrated energy assessment model with which net-zero targets can be developed, based on science, for all major industries **in a granularity and with the key performance indicators (KPI) required to make short-, mid-, and long-term investment decisions. The 1.5 ˚C-directed emissions pathways developed by UTS are no- or low-overshoot scenarios (Shared Socioeconomic Pathway 1, SSP1)**, as defined by the Intergovernmental Panel on Climate Change (IPCC). This means that a carbon budget overshoot is avoided and that the CO_2 already released is not assumed to be 'removed' by unproven technologies still under development, such as **carbon capture and storage** (CCS). The OECM **does take negative emissions into account, but only natural carbon sinks**, such as forests, mangroves, or seaweed, are considered to compensate for process emissions that are currently unavoidable, such as those from cement production.

The OECM remains within an energy-related carbon budget of 400 $GtCO_2$, whereas the recently released Net Zero scenario of the International Energy Agency (IEA NZ) leads to "(…) cumulative energy-related and industrial process CO_2 emissions between 2020 and 2050 of 460 $GtCO_2$." In August 2021, the IPCC, the United Nations body that assesses the science related to climate change, identified the global carbon budget required to achieve 1.5 ˚C between 2020 and 2050 with 67% likelihood as 400 $GtCO_2$, or with 50% likelihood as 500 $GtCO_2$. Another key difference between OECM and IEA NZ is that because IEA NZ uses technical measures to remove CO_2 after its emission, it is classified as an IPCC SSP2 scenario. The IEA NZ does not provide disaggregated Scope 1, 2, and 3 emissions and does not specify all industry sub-sectors. According to the UTS scientists, the most important measures required to limit global warming to a maximum of 1.5 °C are the rapid phase-out of coal and internal combustion engines for cars. Power utilities and electricity suppliers will play a central role, and must be able to provide electricity from renewable sources in sufficient quantities for energy-intensive industries and for electric cars.

The OECM has been developed under the leadership of the Institute for Sustainable Futures (ISF) at UTS to calculate 1.5 ˚C-compatible climate and energy pathways for countries, regions, or the world. **A number of climate modelling organizations**, including the Energy Transition Commission, the Potsdam Institute for Climate Impact Research, the Science Based Targets initiative, and the Carbon Risk Real Estate Monitor (CRREM) **have been invited to peer-review the OECM-derived net-zero pathways.** The initial work by UTS and the University of Melbourne, Australia, together with the German Aerospace Centre (DLR), led to the publication of the first joint OECM in February 2019 as an open access book with Springer Nature.

The first phase of the research, from 2017 to 2019, was financed by the Leonardo DiCaprio Foundation. Since 2019, the OECM has been developed further to calculate no/low-overshoot sectoral pathways for 12 industry sectors. This research has been supported and financed, in part, by the UN-convened Net-Zero Asset Owner Alliance and the European Climate Foundation (ECF).[1] The latest OECM research methodology has been published in the scientific literature in April 2022.[2] The **full datasets are now made available as open data for use by the public**, especially academics and researchers, civil society organizations, the financial industry, companies, and policy makers.

The UN-convened Net-Zero Asset Owner Alliance is an international group of (currently) 71 institutional investors committed to transitioning their investment portfolios of about 10.4 trillion USD *Assets under Management (AuM)* to net-zero emissions by 2050 on a low/no overshoot path. **In the first major application of the OECM, the Net-Zero Asset Owner Alliance endorsed its further development and** is offering to

1 Responsibility for the information and views set out in this research is the authors. None of the founders can be held responsible for any use that may be made of the information contained or expressed therein.

2 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

Teske, Sven and Guerrero, Jaysson, One Earth Climate Model - Integrated Energy Assessment Model to Develop Industry-Specific 1.5 °C Pathways with High Technical Resolution for the Finance Sector, *Energies*, 15, 2022, 9, 3289, https://www.mdpi.com/1996-1073/15/9/3289, ISSN 1996-1073.

the financial sector **to apply the latest UTS findings and data** to inform the investor group's protocol to set net-zero targets and make decisions about investment portfolio decisions, **sending a strong signal to the United Nations Framework Convention on Climate Change Conference of Parties (UNFCCC COP) negotiations.**

The following recommendations derive from this new UTS research:

Industry:

1. A climate strategy consistent with a 1.5 °C no/low-overshoot sector model should be set, disclosed, and implemented.
2. Immediate cessation of investments in new oil, coal, and gas projects.
3. Utilities must rapidly upscale renewable electricity to provide logistical support to reduce Scope 2 emissions for all industries and services. This is a huge market opportunity for utilities.
4. Efficient technologies must be developed to implement electric mobility.
5. There must be transparent mandatory forward-looking and historic disclosure of the most relevant key performance indicators (KPIs), e.g., carbon emissions, energy demand, carbon intensities per production unit.

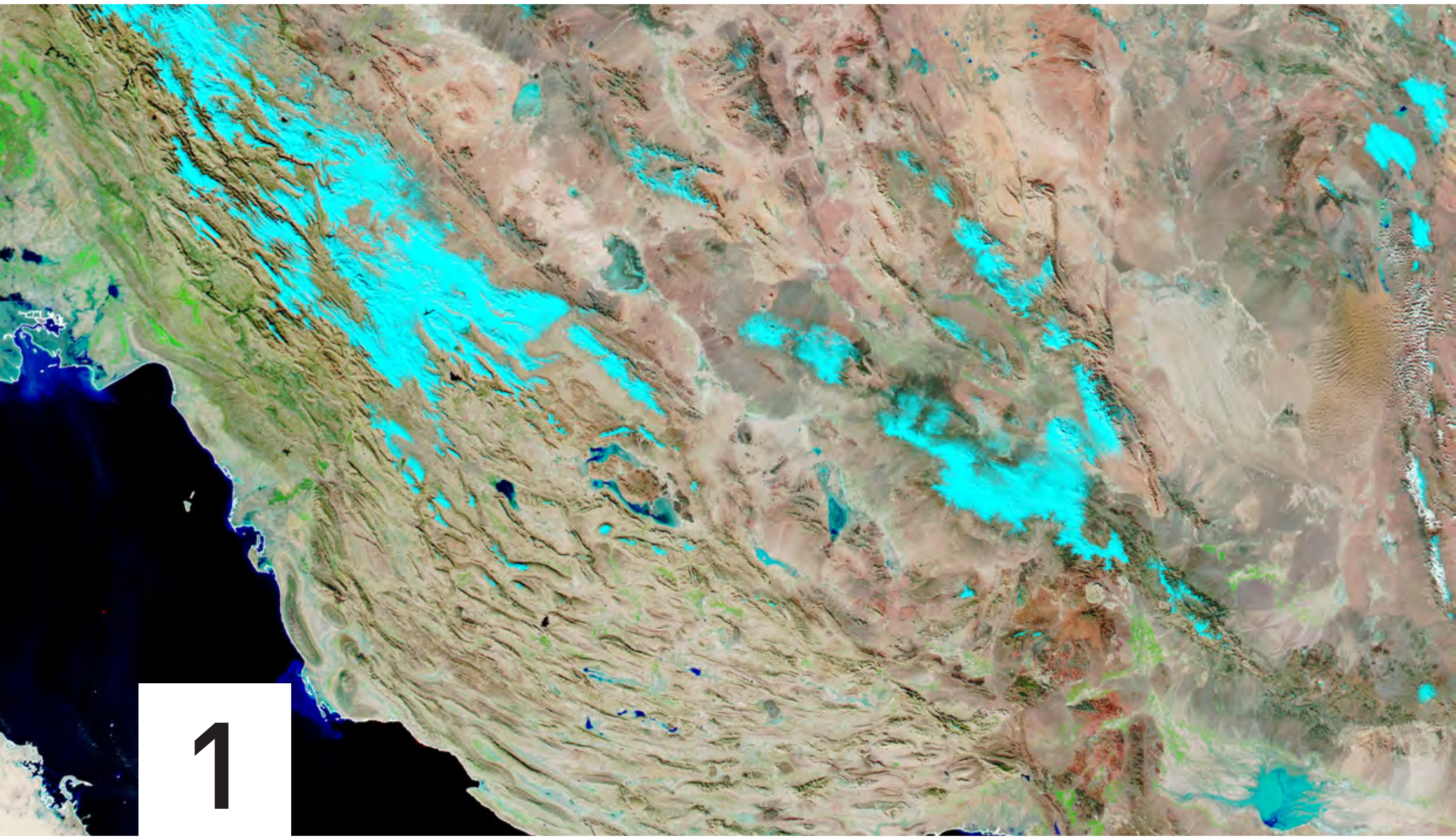
Financial Institutions:

1. Decarbonisation targets for investment, lending, and underwriting portfolio sectors consistent with 1.5 °C no/low-overshoot sector models should be set, disclosed, and implemented.
2. Investment in new oil, coal, and gas projects must cease.
3. Coal must be phased-out by 2030 in OECD countries, and in all regions by 2040.
4. Climate solution investments must be scaled, especially in emerging economies.
5. Disclosure of
    - Climate mitigation strategies;
    - Short- and mid-term target setting;
    - Target achievements;
    - Climate solution investments;
    - Progress of engagement outcomes.

Government Policies:

1. Immediate cessation of public and private investments in new oil, coal, and gas projects.
2. Implementation of carbon pricing with a reliable minimum CO_2 price, with the underlying OECM emissions caps.
3. All OECD countries must phase-out coal by 2030.
4. Automobile industry must phase-out internal combustion engines for passenger cars by 2030.
5. Legally binding efficiency standards for all electrical application, vehicles, and buildings.
6. Renewable energy targets based on the IPCC's carbon-budget-based 1.5 °C no/low-overshoot scenarios, outlined and detailed in each country's master plan.
7. Mandatory transparent forward-looking and historic disclosure of the most relevant KPIs: energy intensity, share of renewable energy supply, energy demand, carbon emissions, and carbon intensities per unit production.

Flash Floods Swamp Iran. NASA Earth Observatory



1

The OECM Defines the Global Industry Sector Carbon Budget

The global carbon budget identifies the total amount of energy-related CO_2 emissions that can be emitted while limiting global warming to a maximum 1.5 °C with no/low overshoot. The IPCC is the United Nations body that assesses the science related to climate change. In August 2021, the IPCC published a new report that identified the global carbon budget required to restrict climate warming between 2020 and 2050 to 1.5 °C with 67% likelihood as 400 $GtCO_2$ (IPCC AR6, 2021).[3]

The OECM uses this as the overall remaining budget and has developed energy scenarios and emission pathways across all major industry sectors, buildings, and transport, and sub-divides those large sectors further for specific industries. Figure 1 shows the industry shares of the total budget in percentages, and Table 1 shows the remaining cumulative CO_2 emissions (in gigatonnes, Gt) for various industries.

3 IPCC, 2021: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, Masson-Delmotte V, Zhai P, Pirani A., Connors SL, Péan C, Berger S, Caud N, Chen Y, Goldfarb L, Gomis MI, Huang M, Leitzell K, Lonnoy E, Matthew JBRs, Maycock TK, Waterfield T, Yelekçi O, Yu R, and Zhou B (eds). Cambridge University Press.

FIGURE 1 GLOBAL CARBON BUDGET BY SUBSECTOR IN [GTCO$_2$] - 2020 - 2050 (%)

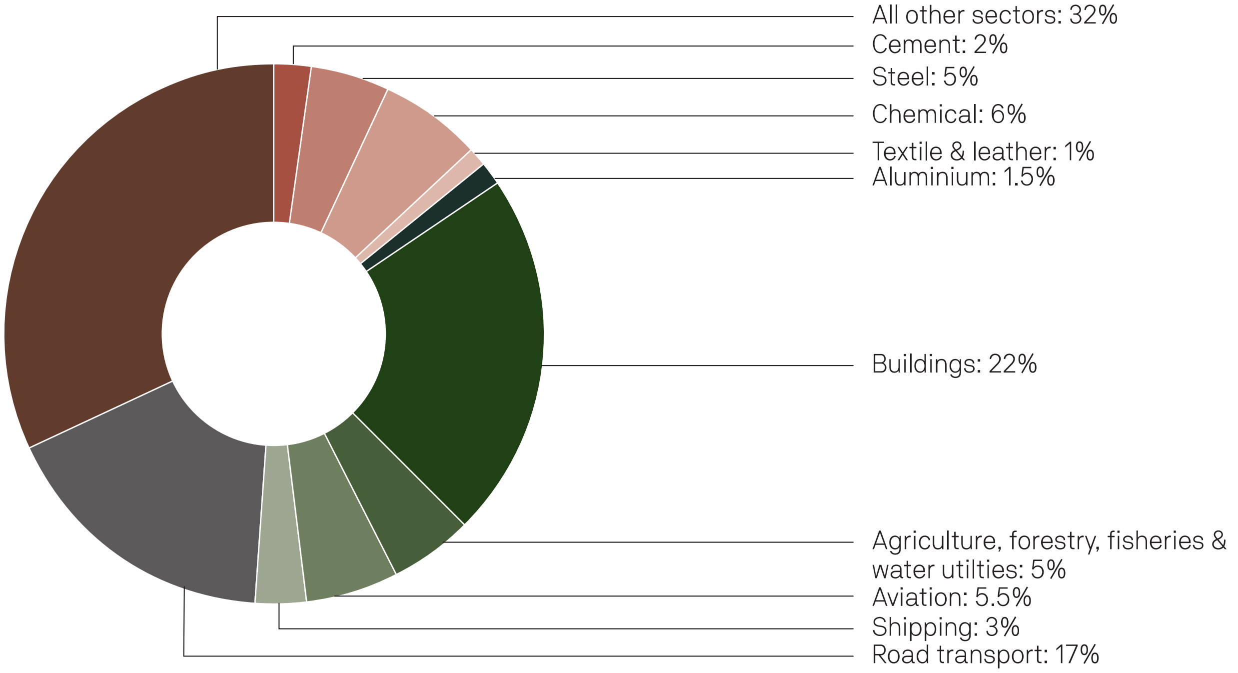
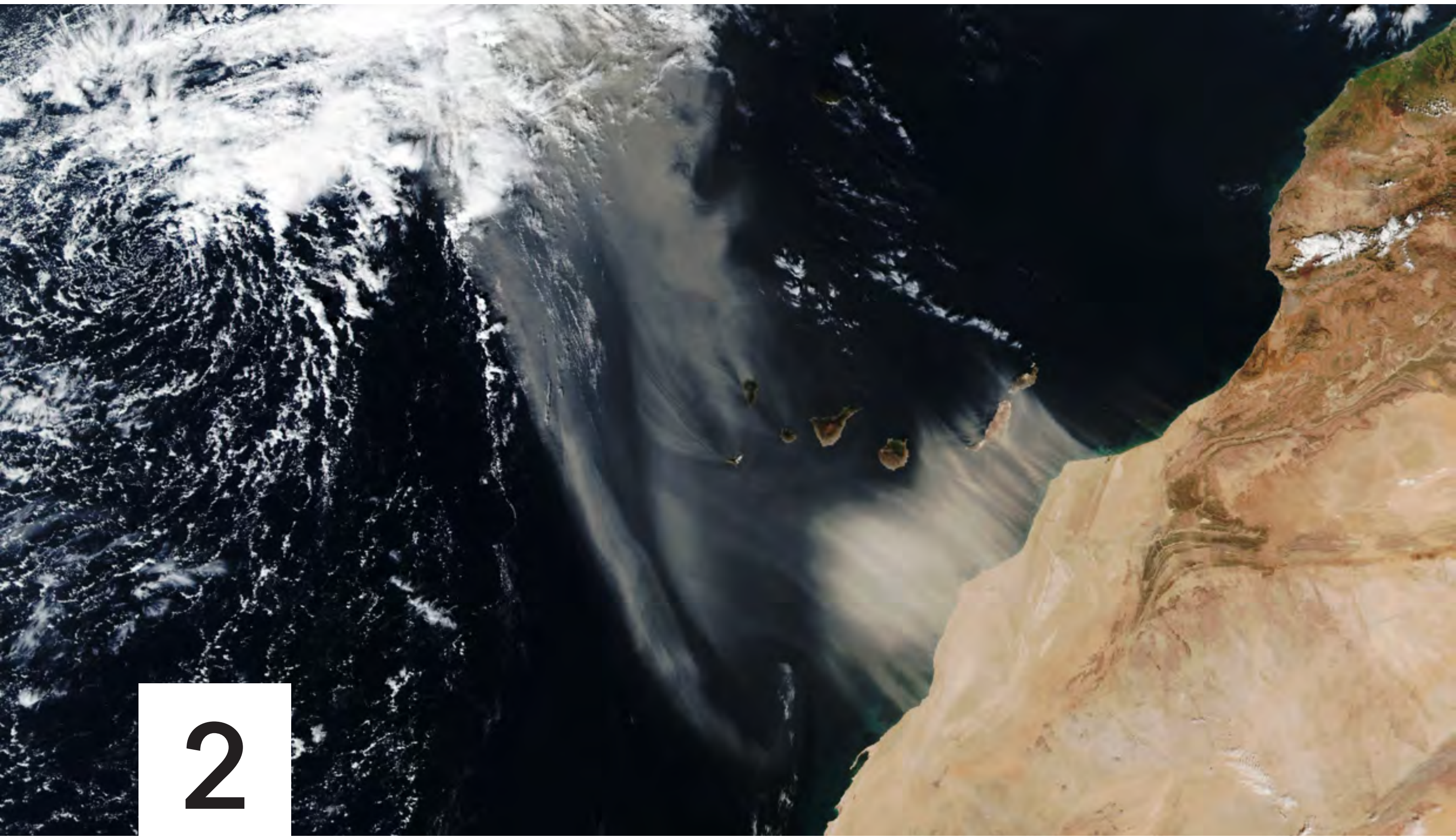


TABLE 1 GLOBAL CARBON BUDGETS—CUMULATIVE ENERGY-RELATED CO$_2$ EMISSIONS BY INDUSTRY SECTOR

Global carbon budget for energy-related CO$_2$ emissions by subsector (2020–2050) **Total 400 GtCO$_2$—1.5 °C (67% likelihood)**	**2020–2030**	**2020–2050**
Primary energy		
Energy Industry—Production from fossil fuels	4	5
Remaining Energy Services (Fossil Fuels)	57	96
Secondary energy		
Utilities (Power & Gas)—Distribution	1	1
Remaining Electricity Services	11	17
Other conversions & losses	7	9
Final energy		
Cement (process heat, fuels, & electricity)	6	9
Steel (process heat, fuels, & electricity)	14	19
Chemical Industry (process heat, fuels, & electricity)	17	25
Textile & Leather (process heat, fuels, & electricity)	3	4
Aluminium (process heat, fuels, & electricity)	5	6
Buildings—commercial, residential incl. construction—(heat, fuels, & electricity)	69	88
Fisheries (fuels & electricity)	0	1
Agriculture & Food Processing (heat, fuels, & electricity)	10	14
Forestry & Wood (heat, fuels, & electricity)	4	5
Water Utilities (heat, fuels, & electricity)	1	1
Aviation	17	22
Navigation	8	12
Road Transport	54	68
Total Cumulative Energy-related CO$_2$ Emissions	286	401

Dust Storm Engulfs Canary Islands. NASA Earth Observatory



2

Scopes 1, 2, and 3—Global Cross-sector Responsibility for Greenhouse Gas Emissions

Reporting corporate greenhouse gas (GHG) emissions is important, and the focus is no longer on direct energy-related CO_2 emissions but includes other GHGs emitted by industries. These increasingly include the indirect emissions that occur in supply chains. The Greenhouse Gas Protocol, a global corporate GHG accounting and reporting standard (WRI 2021),[4] distinguishes between three 'scopes':

- *Scope 1*—emissions are direct emissions from owned or controlled sources;
- *Scope 2*—emissions are indirect emissions from the generation of purchased energy;
- *Scope 3*—emissions are all the indirect emissions (not included in Scope 2) that occur in the value chain of the reporting company, including both upstream and downstream emissions.

The United States Environmental Protection Agency (US EPA) defines *Scope 3* emissions as 'the result of activities from assets not owned or controlled by the reporting organization, but that the organization indirectly impacts in its value chain. They include upstream and downstream of the organization's activities' (EPA ND).[5] According to the EPA, *Scope 3* emissions include all sources of emissions not within an organization's *Scope 1* and *2* boundaries, and the *Scope 3* emissions of one organization are the *Scope 1* and *2* emissions of another organization. *Scope 3* emissions, also referred to as 'value chain emissions' or 'indirect emissions', often represent the majority of an organization's total GHG emissions (EPA).

4 WRI 2021; WRI & WBCSD. Greenhouse Gas Protocol. WRI & WBCSD. https://ghgprotocol.org/. Accessed 25 Oct 2021.

5 EPA ND; EPA. Scope 3 Inventory Guidance.

Whereas the methodologies for determining *Scope 1* and *Scope 2* emissions are undisputed, the method of calculating *Scope 3* emissions is an area of on-going discussion and development. The main issues discussed are data availability, reporting challenges, and the risk of double counting. MSCI, for example, tries to avoid double counting by using a de-duplication multiplier of approximately 0.205 (MSCI 2020).[6] This implies that the allocation of emissions based on actual data is not possible. Accounting methodologies for Scope 3 emissions have been developed for entity-level accounting and reporting (WRI 2013).[7]

Overall, the reporting of *Scope 3* emissions ('indirect emissions') is often incomplete and there are no reporting standards to support the comparison of companies (Ducoulombier 2021[8], Schulmann et al. 2021[9]). These authors found that over 80% of emissions in the food industry are *Scope 3* emissions, and that the data reported by the Carbon Disclose Project (CDP), a global data service for investors, companies, cities, states and regions, are incomplete and inconsistent throughout (Schulmann et al. 2021).

In 2009, Huang et al.[10] suggested that 'Protocol organizations should actively make more specific Scope 3 guidelines available for their constituents by developing sector-specific categorizations for as many sectors as they feasibly can and create broader industry-specific protocols for others'. Therefore, the accounting methodology for Scope 3 emissions requires significant improvement and has been under discussion for more than a decade.

TABLE 2 UPSTREAM AND DOWNSTREAM SCOPE 3 EMISSIONS CATEGORIES

Upstream			**Downstream**		
Greenhouse Gas Protocol Scope 3		OECM 2.0—emissions included in the following sectors	Greenhouse Gas Protocol Scope 3		OECM 2.0—emissions included in the following sectors
U1	Business travel	Part of the respective transport mode (aviation, road, rail, etc.)	D1	Use of solid products	All sector uses of solid products are included
U2	Purchased goods and services	All sector-specific goods and services are included	D2	Downstream transportation and distribution	Sector-specific transportation and distribution and end-of-life treatment are included. This includes the actual use of the product, e.g., emissions when driving a manufactured car
U3	Waste generated in operations	All waste generated in sector-specific operations are included	D3	End-of-life treatment of solid products	
U4	Fuel- and energy-related activities	All sector fuel- and energy-related activities are included	D4	Investments	Not included
U5	Employee commuting	Part of the respective transport mode (aviation, road, rail, etc.)	D5	Downstream leased assets	Not included
U6	Upstream transportation and distribution	Part of the respective transport mode (aviation, road, rail, etc.)	D6	Processing of solid products	All sector processing of solid products is included
U7	Capital goods	Not included	D7	Franchises	Not included
U8	Upstream leased assets	Not included			

6 MSCI 2020; MSCI. Global Industry Classification Standard (GICS®) Methodology Guiding Principles and Methodology for GICS. 2020.

7 WRI 2013; WRI & WBCSD. Technical Guidance for Calculating Scope 3 Emissions, Supplement to the Corporate Value Chain (Scope 3) Accounting & Reporting Standard. 2013.

8 Ducoulombier 2021; Ducoulombier F. Understanding the Importance of Scope 3 emissions and the implications of data limitations. The Journal of Impact and ESG Investing. 2021;1:63–71.

9 Schulman et al. (2021); Schulman DJ, Bateman AH, Greene S. Supply chains (Scope 3) toward sustainable food systems: An analysis of food & beverage processing corporate greenhouse gas emissions disclosure. Cleaner Production Letters. 2021;1:100002.

10 Huang et al. 2009; Huang YA, Weber CL, Matthews HS. Categorization of Scope 3 emissions for streamlined enterprise carbon footprinting. Environmental Science & Technology 2009;43(22): 8509–8515; DOI: 10.1021/es901643a.

The OECM model focuses on the development of 1.5°C net-zero pathways for industry sectors classified under the Global Industry Classification Standard (GICS), for countries or regions, or at the global level. Emissions methodologies for entity-level *Scope 3* emissions require bottom-up entity-level data to arrive at exact figures. Therefore, data availability and accounting systems for whole industry sectors on a regional or global level present significant challenges.

Therefore, the *Scope 3* calculation methodology required simplification for country-, region-, and global-level calculations and to avoid double counting. In the Greenhouse Gas Protocol, Scope 3 emissions are categorized into 15 categories, shown in Table 2.

To include all the upstream and downstream categories shown in Table 2 for an entire industry sector is not possible because first, complete data are not available (for example, how many kilometres employees commute), and second, it is impossible to avoid double counting (for example, when calculating *Scope 3* for the car industry).

Table 2 identifies how the 15 categories are handled in the proposed OECM 2.0 methodology.

The OECM methodology is based on the Technical Guidance for Calculating Scope 3 Emissions of the World Resource Institute (WRI 2013)[111], but is simplified to reflect the higher levels of industry- and country-specific pathways. The OECM defines the three emissions scopes as follows:

- *Scope 1*—All direct emissions from the activities of an organization or under its control, including fuel combustion on site (such as gas boilers), fleet vehicles, and air-conditioning leaks.

  Limitations of the OECM Scope 1 analysis: Only economic activities covered under the sector-specific GICS classification and that are counted for the sector are included. All energy demands reported by the International Energy Agency's (IEA's) Advanced World Energy Balances for the specific sector are included.

- *Scope 2*—Indirect emissions from electricity purchased and used by the organization. Emissions are created during the production of energy and are eventually used by the organization.

  Limitations of the OECM Scope 2 analysis: Because data availability is poor, the calculation of emissions focuses on the electricity demand and 'own consumption', e.g., that reported for power generation by the IEA.

- *Scope 3*—GHG emissions caused by the analysed industry that are limited to sector-specific activities and/or products classified in GICS.

  Limitations of the OECM Scope 3 analysis: Only sector-specific emissions are included. Traveling, commuting, and all other transport-related emissions are reported under '*transport*'. The lease of buildings is reported under '*buildings*'. All other financial activities, such as 'capital goods', are excluded because no data are available for the GICS industry sectors and their inclusion would lead to double counting.

The main difference between the OECM and the World Resources Institute (WRI) concepts is that the interactions between industries and/or other services are kept separate in the OECM. The OECM reports only emissions directly related to the economic activities classified by GICS. Furthermore, the industries are broken down into three categories: Primary Class, Secondary Class, and End-use Activity Class.

The OECM is limited to energy-related CO_2 and energy-related methane (CH_4) emissions. All other GHG gases are calculated outside the OECM model by Meinshausen et al. 2019.[12]

Table 3 shows a schematic representation of the OECM calculation methods for *Scopes 1, 2* and *3* emissions according to the GICS classes, used to avoid double counting. The sum of *Scopes 1, 2* and *3* emissions for each of the three classes is equal to the actual emissions. Example: total annual global energy-related CO_2 emissions are 35 Gt in a given year.

11 WRI (2013), WRI & WBCSD. Technical Guidance for Calculating Scope 3 Emissions, Supplement to the Corporate Value Chain (Scope 3) Accounting & Reporting Standard. 2013.

12 Mainshausen et. al. 2019; Meinshausen M, Dooley K. Mitigation Scenarios for Non-energy GHG. In: Teske S, editor. Achieving the Paris Climate Agreement Goals Global and Regional 100% Renewable Energy Scenarios with Non-energy GHG Pathways for +1.5°C and +2°C. SpringerOpen; 2019.

TABLE 3 SCHEMATIC REPRESENTATION OF OECM SCOPES 1, 2, AND 3 ACCORDING TO GICS CLASSES TO AVOID DOUBLE COUNTING

	Primary Class					Secondary Class				End-use Activity Class			
	GICS 10 Energy	Scope 1	Scope 2	Scope 3		**GICS 55 Utilities**	Scope 1	Scope 2	Scope 3	**All other Industries & Services**	Scope 1	Scope 2	Scope 3
CO_2		Production and conversion losses	Power	Embedded emissions—energy use	CO_2		Transport losses	Own consumption and conversion losses	Embedded emission electricity use		Production and conversion losses (heat & fuel use)	Power	Embedded emission from energy service /product use
CH_2 AFOLU					CH_2 AFOLU								
CH_4					CH_4								
N_2O					N_2O								
					CFCs								
Total GHG		Sum of *Scopes 1, 2, & 3* equals total emissions			Total GHG		Sum of *Scopes 1, 2, & 3* equals total emissions				Sum of *Scopes 1, 2, & 3* equals total emissions		

- The sum of *Scope 1, 2,* and *3* emissions for the primary class is 35 $GtCO_2$
- The sum of *Scope 1, 2,* and *3* emissions for the secondary class is 35 $GtCO_2$
- The sum of *Scope 1, 2,* and *3* emissions for end-use activities is 35 $GtCO_2$

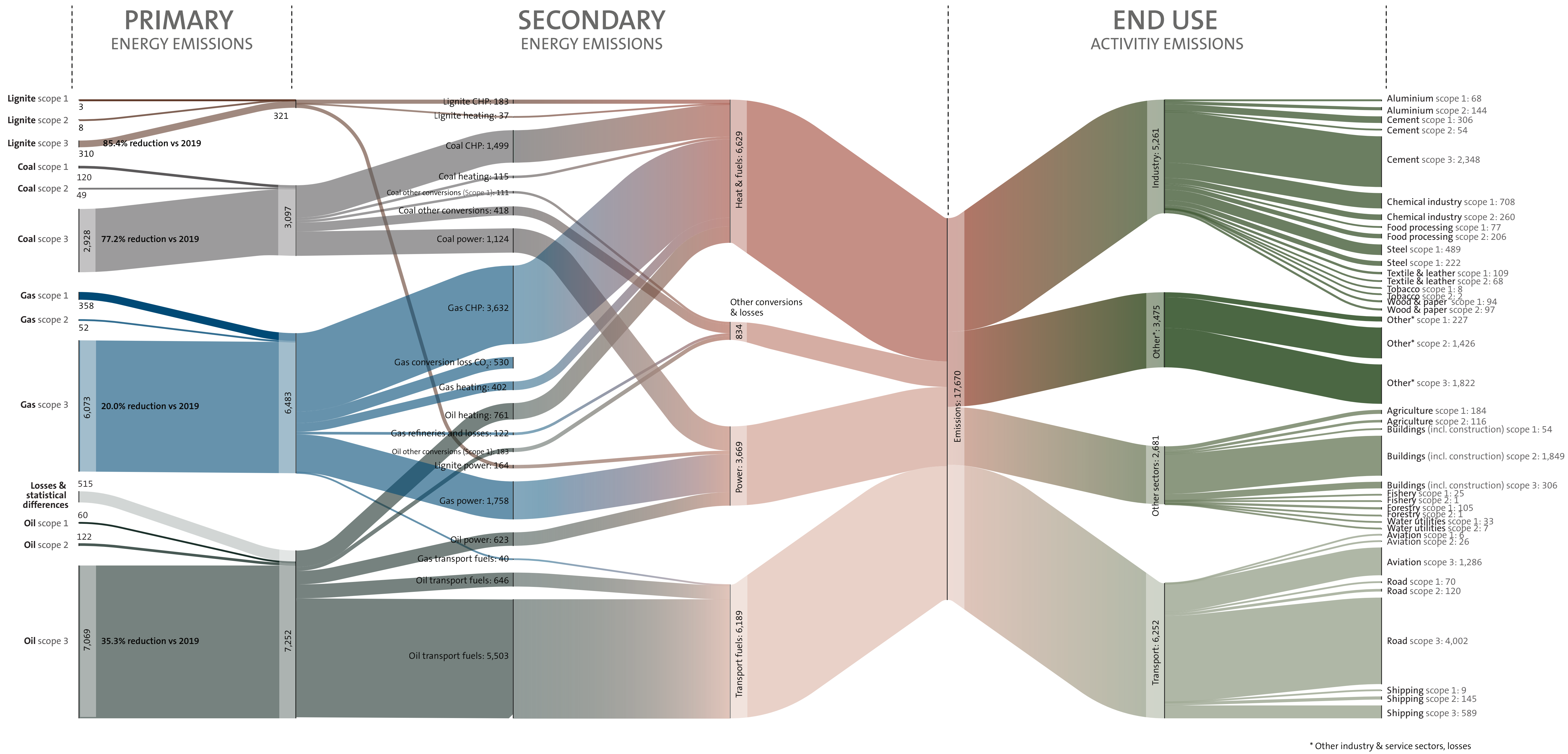
Double counting can be avoided by defining a primary class for the primary energy industry, a secondary class for the supply utilities, and an end-use class for all the economic activities that use the energy from the primary- and secondary-class companies. Furthermore, the separation of all emissions by defined industry categories—such as GICS—streamlines the accounting and reporting systems. The volume of data required is reduced and reporting is considerably simplified under the OECM methodology.

Achieving the global target of 1.5 °C and net-zero emissions by 2050 under the Paris Agreement for a specific industry sector requires that all its business activities are with other sectors that are also committed to a 1.5 °C–net-zero emissions target.

All calculated energy-related Scope 1, 2, and 3 emissions for the primary and secondary energy industries and for the analysed industry sectors are shown in Figure 2 (next page). Detailed results for the Scope 1, 2, and 3 emissions are given in section 5.

2. SCOPES 1, 2, AND 3—GLOBAL CROSS-SECTOR RESPONSIBILITY FOR GREENHOUSE GAS EMISSIONS

FIGURE 3 ENERGY-RELATED SCOPES 1, 2, AND 3 EMISSIONS FOR THE PRIMARY AND SECONDARY ENERGY INDUSTRIES AND FOR THE ANALYSED INDUSTRY SECTORS IN 2030



Legend

Scope 1: All Direct Energy-related CO_2 emissions from the activities of an organisation or under their control.
Scope 2: Indirect Energy-related CO_2 emissions from electricity / energy purchased and used by the organisation.
Scope 3: Energy-related CO_2 emissions caused by products/services of industries.

Note: This diagram only shows energy related Scope 3 CO_2 emissions. Scope 3 emissions are not displayed if they constitute other types of greenhouses gases (GHGs), other than CO_2.

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Bracing for Batsirai, Madagascar. NASA Earth Observatory

3

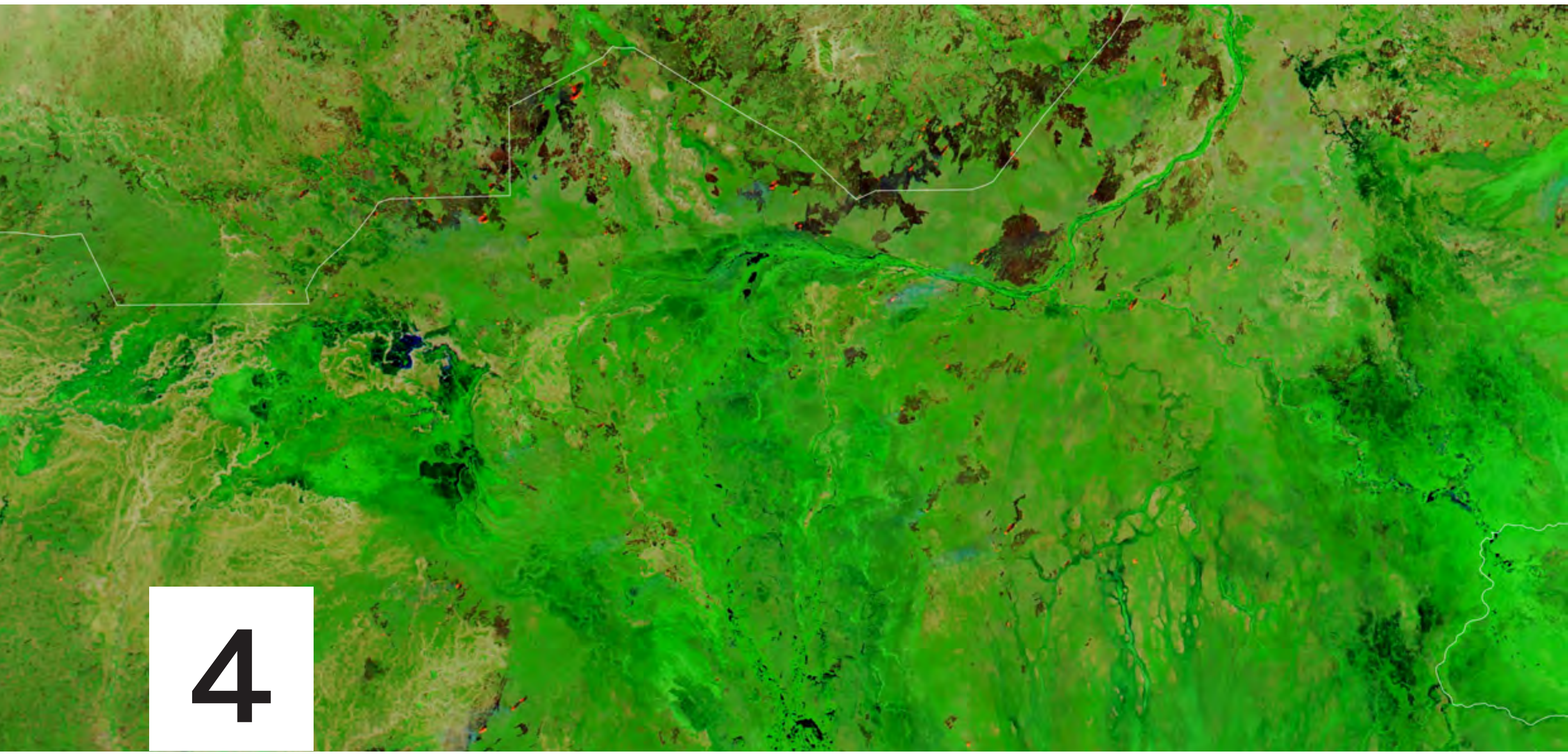
OECM Tackles the Challenge of Varying the Industry Classification Systems

Investment decisions directed toward achieving the decarbonisation of investment portfolios are highly complex processes. In November 2020, the European Central Bank published a *'Guide on climate-related and environmental risks'*, which maps out a detailed process to undertake 'climate stress tests' for investment portfolios. For the global finance industry to implement the Paris Climate Agreement, decarbonisation targets and benchmarks for the industry sectors are required. **The estimation of the carbon budget for a specific industry sector based on an industry classification system requires a holistic approach, and the interconnection of all sectors and regions must be considered.** To estimate the carbon budget for a single industry sector in an isolated 'silo approach' based on current emissions shares inevitably leads to inaccurate results because this approach does not consider possible technical developments or interactions with other industry sectors. Therefore, the total of all sub-concepts for certain industries exceeds the actual CO_2, or the responsibility for CO_2 reductions is shifted to other areas. decarbonisation pathways have so far been developed for countries, regions, or communities, but less so for cross-industry sectors.

Globally, there are three main industry classification systems. The *Nomenclature statistique des Activités économiques dans la Communauté Européenne* (NACE) is used in Europe, BICS-Bloomberg is used in the Americas, and the Global Industry Classification System (GICS) is widely used globally. The classifications vary, but the 12 main industries analysed are classified similarly—although with small variations. The **OECM is an integrated assessment model for climate and energy pathways that focus on 1.5 ˚C scenarios** (Teske et al. 2019) and has been further developed to reflect the need for these pathways. To develop energy scenarios for industry sectors classified under the GICS, the OECM had to significantly improve the technical resolution. Furthermore, **the demand and supply calculations had to be broken down into industry sectors to develop individual pathways**. The BICS, GICS, and NACE definitions must be accommodated.

13 Teske et. al. 2019, Teske S, Pregger T, Naegler T, Simon S, Pagenkopf J, van den Adel B, Deniz Ö. Energy aScenario Results. In Achieving the Paris Climate Agreement Goals: Global and Regional 100% Renewable Energy Scenarios with Non-Energy GHG Pathways for +1.5 °C and +2 °C; Teske S, (Ed.) Springer International Publishing: New York, NY, USA, 2019.

South Sudan Submerged. NASA Earth Observatory



4

How Does the OECM Net-Zero Pathway Differ from the International Energy Agency (IEA NZ) Pathway?

The OECM is a Shared Socioeconomic Pathway 1 (SSP1) scenario, as defined by the IPCC: '*A scenario in which social, business and technological innovations result in lower energy demand up to 2050 while living standards rise, especially in the global South. A downsized energy system enables rapid decarbonisation of energy supply. Afforestation is the only CDR option considered; neither fossil fuels with CCS nor BECCS are used.*' The OECM avoids a carbon budget overshoot and expands natural carbon sinks (e.g., forests, mangroves, & seaweed) to achieve negative emissions and to compensate for the process emissions that are currently unavoidable (with currently available technologies). The relevant industry sectors are cement, steel, water utilities, and fossil fuels for non-energy use from process emissions unrelated to energy use.

- Cumulative energy-related CO_2 emissions until 2050: 400 $GtCO_2$.
- Overall cumulative negative emissions via natural carbon sinks: (–) 86 $GtCO_2$.
- The OECM include 50 GHG gases—including over 30 chlorofluorocarbons (CFCs) and hydrofluorocarbons (HFCs) and black carbon.

The energy pathway of the IEA Net Zero by 2050 scenario is classified as an IPCC SSP2 scenario because it uses technical measures to remove CO_2 after its emission: 'A scenario with a broad focus on sustainability including energy intensity, human development, economic convergence and international cooperation, as well as shifts towards sustainable and healthy consumption patterns, low-carbon technology innovation, and well-managed land systems with limited societal acceptability for BECCS.'

- The IEA Net Zero states that "(…) If today's energy infrastructure was to be operated until the end of the typical lifetime in a manner similar to the past cumulative energy-related and industrial process CO_2 emissions between 2020 and 2050 of just under 650 $GtCO_2$. This is around 30% more than the remaining total CO_2 budget consistent with limiting global warming to 1.5 °C with a 50%

probability." The IEA calculates the cumulative global energy-related and industrial process CO_2 emissions between 2020 and 2050 to be just over 460 Gt in the NZE. Assuming parallel actions to address the CO_2 emissions from agriculture, forestry, and other land uses (AFOLU) over the period to 2050 will result in around 40 $GtCO_2$ from land-use emissions (AFOLU). Thus, the total CO_2 emissions from all sources will be 500 $GtCO_2$.

The IEA Net-Zero scenario requires the direct air capture of (–) 29.4 $GtCO_2$ between 2020 and 2050 and the removal of (–) 89.5 $GtCO_2$ with carbon capture, usage, and storage (CC[U]S)—including bioenergy with carbon capture and storage (BECCS).

Reporting: The OECM reports all GHG emissions separately according to:

- Scope 1, 2, and 3 emissions (IEA NZ does not provide disaggregated Scope 1, 2, and 3 emissions).
- Data for 12 industry sectors consistent with the Global Industry Classification Standard (GICS, NACE, and BICS).
- All data are broken down regionally: global, OECD North America, OECD Europe (more regions are planned).
- With key performance indicators (KPIs), such as absolute carbon emissions, energy intensity, and carbon intensity.

Colorado Faces Winter Urban Firestorm. NASA Earth Observatory

5

Key Results of the Global OECM 1.5 °C Pathway and Comparison with IEA Net-Zero by 2050

This section provides an overview of the key results for the OECM for the global 1.5 °C pathways for all the sectors analysed. Because the currently used reporting format for the financial sector deviates from those of all other sectors in terms of its allocation of emission data to Scopes 1 and 3 for 'utilities', 'aviation', 'shipping', and 'steel industry', a 'production-centric view' has been added to the results for those industries (see section 7.2.2 for further details). Finally, we compare the Global OECM 1.5 °C pathway results with those for the IEA Net-Zero by 2050 scenario for those sectors analysed in the IEA report. The OECM is calculated with the IEA statistical data base year of 2019—the latest data available at the time of writing (March 2022). The comparison shows that the 2019 emissions data differ slightly (by ±2%) across all sectors, except for the chemical industry, which has a 6% deviation. These deviations arise from the different calculation methodologies.

The reporting format for emissions in the IEA report also differs from the reporting standard under the Scope 1, 2, and 3 methodology (see 7.2.3), and the report of the OECM results has been altered accordingly to allow direct comparability.

5.1 Key Results of the Global OECM 1.5 °C Pathway: Primary and Secondary Energy Industries

Table 4 shows the Scope 1, 2, and 3 emissions of the primary and secondary energy industries. The Scope 1 emissions are those related to the exploration, extraction, and refinement of fossil fuels. The Scope 2 emissions are those from the electricity used for those services. The OECM assumes the carbon intensity arising from the average global electricity generated for each calculated year according to the OECM power scenario, which will achieve 100% renewables by 2050. Scope 3 emissions are those that arise from the use of fossil fuels by industries or consumers.

TABLE 4 GLOBAL SCOPE 1, 2, AND 3 EMISSIONS FOR THE PRIMARY ENERGY INDUSTRY

Subsector	Units		2019	2025	2030	2050
Total Energy: Gas, Oil, & Coal Sectors						
Coal Scope 1 Compared with 2019	$MtCO_2$ eq/a %	OECM GHG	2,431	1,419 –42%	584 –76%	0 –100%
Coal Scope 2: Electricity—own sector use Compared with 2019	$MtCO_2$ eq/a %		255	127 –50%	57 –78%	0 –100%
Coal Scope 3 Compared with 2019	$MtCO_2$ eq/a %		12,432	6,317 –49%	2,635 –79%	0 –100%
Coal—total CO_2 emissions	$MtCO_2$ /a		14,864	7,736	3,219	0
Coal—CO_2 trajectory under IEA Net-Zero scenario Deviation: OECM compared with IEA	$MtCO_2$ eq/a %	IEA WEO 21	14,768 1%	no data	5,915 –84%	195 –
OIl Scope 1 Compared with 2019	$MtCO_2$ eq/a %	OECM GHG	990	918 –7%	732 –26%	191 –81%
Oil Scope 2: Electricity—own sector use Compared with 2019	$MtCO_2$ eq/a %		166	154 –7%	122 –26%	32 –81%
Oil Scope 3 Compared with 2019	$MtCO_2$ eq/a %		10,416	9,580 –8%	7,163 –31%	0 –100%
Oil—total CO_2 emissions	$MtCO_2$ /a		11,476	10,554	7,924	223
OIl—CO_2 trajectory under IEA Net-Zero scenario Deviation: OECM compared with IEA	$MtCO_2$ eq/a %	IEA WEO 21	11,344 1%	no data	7,426 6%	928 –316%
Gas Scope 1 Compared with 2019	$MtCO_2$ eq/a %	OECM GHG	953	918 –4%	820 –14%	61 –94%
Gas Scope 2: Electricity—own sector use Compared with 2019	$MtCO_2$ eq/a %		61	58 –4%	52 –14%	4 –94%
Gas Scope 3 Compared with 2019	$MtCO_2$ eq/a %		8,082	7,516 –7%	6,612 –18%	478 –94%
Gas—total CO_2 emissions	$MtCO_2$ /a		7,346	7,109	6,288	35
Gas—CO_2 trajectory under IEA Net-Zero scenario Deviation: OECM compared with IEA	$MtCO_2$ eq/a %	IEA WEO 21	7,270 1%	no data	5,960 5%	566 –1536%
Energy Industry						
Energy Industry Scope 1 Compared with 2019	$MtCO_2$ eq/a %	OECM GHG	4,375	3,255 –26%	2,136 –51%	252 –94%
Energy Industry Scope 2 Compared with 2019	$MtCO_2$ eq/a %		481	339 –30%	231 –52%	36 –93%
Energy Industry Scope 3 Compared with 2019	$MtCO_2$ eq/a %		30,931	23,413 –24%	16,410 –47%	478 –98%
Total energy-related CO_2 emissions under OECM	$MtCO_2$ /a		18,821	17,662	14,212	257
Total energy-related CO_2 emissions under IEA NZ Deviation: OECM compared with IEA	$MtCO_2$ eq/a %	IEA WEO 21	18,614 1%	no data	13,386 6%	1,494 –482%

TABLE 5 GLOBAL SCOPE 1, 2, AND 3 EMISSIONS FOR THE SECONDARY ENERGY INDUSTRY

Subsector	Units		2019	2025	2030	2050
Total Utilities Sectors						
Power Utilities Scope 1 Compared with 2019	$MtCO_2$ eq/a %	OECM GHG	827	325 –61%	162 –80%	0 –100%
Power Utilities Scope 2 Compared with 2019	$MtCO_2$ eq/a %		111	86 –23%	54 –52%	0 –100%
Power Utilities Scope 3 Compared with 2019	$MtCO_2$ eq/a %		14,068	8,703 –38%	4,906 –65%	0 –100%
Power Utilities Scope 1 Compared with 2019	$MtCO_2$ eq/a %	Production Centric GHG	14,068	8,703 –38%	4,906 –65%	0 –100%
Power Utilities Scope 2 Compared with 2019	$MtCO_2$ eq/a %		111	86 –23%	54 –52%	0 –100%
Power Utilities Scope 3 Compared with 2019	$MtCO_2$ eq/a %		0	0 0%	0 0%	0 0%
Gas Utilities Scope 1 Compared with 2019	$MtCO_2$ eq/a %	OECM GHG	1,243	917 –26%	694 –44%	43 –97%
Gas Utilities Scope 2 Compared with 2019	$MtCO_2$ eq/a %		175	140 –20%	125 –29%	9 –95%
Gas Utilities Scope 3 Compared with 2019	$MtCO_2$ eq/a %		7,183	7,010 –2%	6,282 –13%	24 –100%
Utilities Scope 1 Compared with 2019	$MtCO_2$ eq/a %	OECM GHG	2,070	1,242 –40%	856 –59%	43 –98%
Utilities Scope 2 Compared with 2019	$MtCO_2$ eq/a %		286	226 –21%	179 –37%	10 –97%
Utilities Scope 3 Compared with 2019	$MtCO_2$ eq/a %		21,250	15,713 –26%	11,188 –47%	24 –100%
Utilities Scope 1 Compared with 2019	$MtCO_2$ eq/a %	Production Centric GHG	22,493	16,630 –26%	11,882 –47%	67 –100%
Utilities Scope 2 Compared with 2019	$MtCO_2$ eq/a %		286	226 –21%	179 –37%	10 –97%
Utilities Scope 3 Compared with 2019	$MtCO_2$ eq/a %		0	0 0%	0 0%	0 0%
Power Sector—total CO_2 emissions incl. process	$MtCO_2$ /a		13,639	8,690	4,978	0
Power Sector—CO_2 trajectory under IEA Net-Zero scenario (excluding BECCS & CCS) Deviation: OECM compared with IEA	$MtCO_2$ eq/a %	IEA WEO 21	13,933 –2%	no data	5,816 –17%	203 >500%

5.2. Key Results of the Global OECM 1.5 °C Pathway: Transport Sector

Table 6 provides the 'Scope emissions' for the transport sector—excluding rail, which is part of the transport industry sector under the industry classification system. Scope 1 emissions arise from vehicle manufacture and—as far as documented in the energy statistics—the operation of transport services. However, the data available are sparse on the global level. Scope 2 emissions are those from the electricity used—arising either directly or in the production of hydrogen or synthetic fuels used for operating vehicles, planes, and ships. Specific emissions from airports and single airline offices cannot be assessed on a global level, and these emissions are included under commercial buildings. Scope 3 emissions are the 'classic' emissions when a car is driven or a plane is used a by consumer. The OECM deliberately includes electricity emissions for, for example, electric cars under Scope 2 emissions because some car manufacturers today include the charging infrastructure in their value chains and are therefore responsible for it.

The 'production-centric view' includes the embedded emissions of all passenger-kilometres and freight-kilometres in the aviation and shipping sectors in Scope 1—contrary to the original WRI concept, which allocates them to Scope 3. However, the embedded emissions when cars are driven are again allocated to Scope 3 in the current report practise.

TABLE 6 GLOBAL SCOPE 1, 2, AND 3 EMISSIONS FOR THE TRANSPORT SECTOR

Subsector	Units		2019	2025	2030	2050
Total Transport Sector						
Aviation Utilities Scope 1 Compared with 2019	$MtCO_2$ eq/a %	OECM GHG (CO_2 only)	16	10 –38%	6 –100%	0 –86%
Aviation Utilities Scope 2 Compared with 2019	$MtCO_2$ eq/a %		0.4	14.7 0%	25.9 0%	0 0%
Aviation Utilities Scope 3 Compared with 2019	$MtCO_2$ eq/a %		1008.4	1550.2 54%	1285.6 –100%	0 –90%
Aviation Utilities Scope 1 Compared with 2019	$MtCO_2$ eq/a %	Production Centric GHG (CO_2 only)	1,025	1,560 52%	1,292 –100%	0 –100%
Aviation Utilities Scope 2 Compared with 2019	$MtCO_2$ eq/a %		0.4	14.7 3576%	25.9 1699%	0 -100%
Aviation Utilities Scope 3 Compared with 2019	$MtCO_2$ eq/a %		0	0 0%	0 0%	0 0%
Aviation—total CO_2 emissions	$MtCO_2$ /a		1,025	1,575	1,318	0
Aviation—CO_2 trajectory under IEA Net-Zero scenario Deviation: OECM compared with IEA	$MtCO_2$ /a %	IEA WEO 21	1,027 0%	no data	783 41%	340 >500%

TABLE 6 GLOBAL SCOPE 1, 2, AND 3 EMISSIONS FOR THE TRANSPORT SECTOR - *Continued*

Subsector	Units		2019	2025	2030	2050
Total Transport Sector						
Shipping Scope 1 Compared with 2019	$MtCO_2$ eq/a %	OECM GHG (CO_2 only)	23	14 –38%	9 –100%	0 –86%
Shipping Scope 2 Compared with 2019	$MtCO_2$ eq/a %		1.7	20.4 1119%	144.9 350%	0 -100%
Shipping Scope 3 Compared with 2019	$MtCO_2$ eq/a %		874.9	825.0 –6%	588.8 –100%	0 –87%
Shipping Scope 1 Compared with 2019	$MtCO_2$ eq/a %	Production Centric GHG (CO_2 only)	898	839 –7%	598 –100%	0 –87%
Shipping Scope 2 Compared with 2019	$MtCO_2$ eq/a %		1.7	20.4 1119%	144.9 350%	0 -100%
Shipping Scope 3 Compared with 2019	$MtCO_2$ eq/a %		0	0 0%	0 0%	0 0%
Shipping—total CO_2 emissions	$MtCO_2$ /a		877	845	734	0
Shipping—CO_2 trajectory under IEA Net-Zero scenario Deviation: OECM compared with IEA	$MtCO_2$ /a %	IEA WEO 21	866 1%	no data	705 4%	122 >500%
Road Transport Scope 1 Compared with 2019	$MtCO_2$ eq/a %	Production Centric GHG (CO_2 only)	181	111 –38%	70 –9%	0 –86%
Road Transport Scope 2 Compared with 2019	$MtCO_2$ eq/a %		34	158 363%	120 24%	0 304%
Road Transport Scope 3 Compared with 2019	$MtCO_2$ eq/a %		6,062	5,044 –17%	4,002 –100%	0 –91%
Road Transport—total CO_2 emissions	$MtCO_2$ /a		6,062	5,044	4,002	0
Road Transport—CO_2 trajectory under IEA Net-Zero scenario Deviation: OECM compared with IEA	$MtCO_2$ /a %	IEA WEO 21	6,043 0%	no data	4,077 –2%	340 >500%
Transport Scope 1 Compared with 2019	$MtCO_2$ eq/a %	OECM GHG (CO_2 only)	220	136 –38%	85 –62%	0 –100%
Transport Scope 2 Compared with 2019	$MtCO_2$ eq/a %		36	193 434%	290 704%	0 –100%
Transport Scope 3 Compared with 2019	$MtCO_2$ eq/a %		7,945	7,420 –7%	5,877 –26%	24 –100%
Transport Scope 1 Compared with 2019	$MtCO_2$ eq/a %	Production Centric GHG (CO_2 only)	8,166 0	7,555 –7%	5,961 –27%	0 –100%
Transport Scope 2 Compared with 2019	$MtCO_2$ eq/a %		36.1 0%	192.9 434%	290.4 704%	0 –100%
Transport Scope 3 Compared with 2019	$MtCO_2$ eq/a %		0 0%	0 0%	0 0%	0 0%
Transport—total CO_2 emissions incl. process	$MtCO_2$ /a		8,202	7,748	6,252	0
Transport—CO_2 trajectory under IEA Net-Zero scenario Deviation: OECM compared with IEA	$MtCO_2$ /a %	IEA WEO 21	8,211 0%	no data	5,719 9%	689 >500%

5.3. Key Results of the Global OECM 1.5 °C Pathway: Chemical Industry and Textile & Leather Industry

Table 8 provides the emissions from the chemical industry and the textile & leather industry. The OECM trajectory for the chemical industry is compared with that of the IEA NZ scenario for 'chemicals'. The system boundaries for 'chemicals' are not clearly documented and the deviation of +6% from the 2019 emissions are most likely attributable to the different system boundaries and the more detailed calculation methodology under the OECM scenario, which breaks down the chemical industry into five sub-sectors. The Scope 3 emissions of the textile & leather industry include land-use emissions from the livestock farmed for leather production.

TABLE 7 GLOBAL SCOPE 1, 2, AND 3 EMISSIONS FOR THE CHEMICAL AND TEXTILE & LEATHER INDUSTRIES

Subsector	Units		2019	2025	2030	2050
Chemical Industry						
Chemical Industry Scope 1 Compared with 2019	$MtCO_2$ eq/a %	OECM GHG	1,261	996 –21%	708 –44%	0 –100%
Chemical Industry Scope 2 Compared with 2019	$MtCO_2$ eq/a %		743	494 –34%	260 –65%	0 –100%
Chemical Industry Scope 3 Compared with 2019	$MtCO_2$ eq/a %		2,520	1,852 –27%	1,220 –52%	682 –73%
Chemical Industry—total CO2 emissions, Excluding SCOPE 2 (electricity)	$MtCO_2$ eq/a		1,261	996	708	0
Chemical Industry—CO_2 trajectory under IEA Net-Zero scenario Deviation: OECM compared with IEA	$MtCO_2$ /a %	IEA WEO 21	1,182 6%	no data	1,199 –69%	66 >500%
Textile & Leather Scope 1 Compared with 2019	$MtCO_2$ eq/a %	OECM GHG	178	151 –15%	109 –39%	0 –100%
Textile & Leather Scope 2 Compared with 2019	$MtCO_2$ eq/a %		178	127 –29%	68 –62%	0 –100%
Textile & Leather Scope 3 Compared with 2019	$MtCO_2$ /a %		38	30 –23%	24 –37%	20 –48%

5.4. Key Results of the Global OECM 1.5 °C Pathway: Water Utilities, Fisheries, Agriculture, and Forestry

Table 7 shows the emissions for services. Under the energy statistics of the International Energy Agency (IEA), water utilities, agriculture, forestry, fisheries, and buildings are placed in the category 'other sectors', whereas food processing, tobacco, and wood & wood products are in 'industry'. The sector 'agriculture, food, and tobacco' includes the sum of energy-related emissions from farms and machinery and from the energy-related emissions arising from food processing and packaging. Scope 3 emissions mainly arise from land use and from meat and dairy production. This is similar for forestry and wood products—almost all Scope 3 emissions are from land-use changes. Because re-forestation is a vital part of the OECM, to generate 'negative emissions', forestry will become carbon negative.

Fisheries emissions include those from the operation of ships, fish farming, the cooling chain, and fish product processing. The majority of water utility emissions are from water pumping, water filtering, cleaning processes, and—for saltwater—desalination. The Scope 3 emissions are the methane and nitrous oxide (N_2O) from sewers or biological wastewater treatment and sludge.

TABLE 8 GLOBAL SCOPE 1, 2, AND 3 EMISSIONS FOR THE 'OTHER SECTORS' AS DEFINED IN THE IEA STATISTICS

Subsector	Units	2019 Estimate	2025 Projection	2030 Projection	2050 Projection
Water Utilities					
Water Utilities Scope 1 Compared with 2019	$MtCO_2$ eq/a %	77	53 –32%	33 –57%	0 –100%
Water Utilities Scope 2 Compared with 2019	$MtCO_2$ eq/a %	27	14 –46%	7 –74%	0 –100%
Water Utilities Scope 3 Compared with 2019	$MtCO_2$ eq/a %	830	881 6%	925 11%	1,125 35%
Fisheries					
Fisheries Scope 1 Compared with 2019	$MtCO_2$ eq/a %	29	28 –4%	25 –15%	0 –100%
Fisheries Scope 2 Compared with 2019	$MtCO_2$ /a %	4	3 –31%	1 –63%	0 –100%
Fisheries Scope 3 Compared with 2019	$MtCO_2$ eq/a %	250	239 –4%	227 –9%	178 –29%
Agriculture, Food & Tobacco					
Agriculture, Food Processing, &Tobacco Scope 1 Compared with 2019	$MtCO_2$ eq/a %	355	272 –24%	184 –48%	0 –100%
Agriculture, Food Processing, &Tobacco Scope 2 Compared with 2019	$MtCO_2$ eq/a %	962	632 -34%	324 –66%	0 –100%
Agriculture, Food Processing, &Tobacco Scope 3 Compared with 2019	$MtCO_2$ eq/a %	6,837 0%	5,413 –21%	4,515 –34%	3,994 –42%
Forestry & Wood					
Forestry, Wood Products Scope 1 Compared with 2019	$MtCO_2$ eq/a %	196	155 –21%	105 –47%	0 –100%
Forestry, Wood Products Scope 2 Compared with 2019	$MtCO_2$ eq/a %	339	184 –46%	97 –71%	0 –100%
Forestry, Wood Products Scope 3 Compared with 2019	$MtCO_2$ /a %	2,648	1,164 –56%	–619 –123%	–1,359 –151%

5.5. Key Results of the Global OECM 1.5 °C Pathway: Aluminium, Cement, and Steel Industries

The energy-intensive cement, steel, and aluminium industries are shown in Table 9. Whereas the Scope 1 and 2 emissions are basically energy-related emissions from the fossil-fuel-based generation of electricity and process heat, the Scope 3 emissions are process emissions. For the aluminium industry, tetrafluoromethane is used for certain production processes in aluminium smelters, especially in China (Nature 2021).[14] Both the steel and cement industries have process emissions, rather than energy-related emissions. Whereas the steel industry could avoid these emissions by producing hydrogen-based steel, there is no technical option yet to avoid the process

TABLE 9 GLOBAL SCOPE 1, 2, AND 3 EMISSIONS FOR ENERGY-INTENSIVE MATERIALS INDUSTRIES

Subsector	Units		2019	2025	2030	2050
Aluminium Industry						
Aluminium Industry Scope 1 Compared with 2019	$MtCO_2$ eq/a %	OECM GHG	401	337 –16%	308 –23%	270 –33%
Aluminium Industry Scope 2 Compared with 2019	$MtCO_2$ eq/a %		515	305 –41%	144 –72%	0 –100%
Aluminium Industry Scope 3 Compared with 2019	$MtCO_2$ eq/a %		72	47 –35%	15 –79%	18 –75%
Total Materials / Steel						
Materials/Steel Scope 1 Compared with 2019	$MtCO_2$ eq/a %	OECM GHG	1,073	762 –29%	489 –54%	0 –100%
Materials/Steel Scope 2 Compared with 2019	$MtCO_2$ eq/a %		636	460 –28%	222 –65%	0 –100%
Materials/Steel Scope 3 Compared with 2019	$MtCO_2$ eq/a %		1,381	1,104 –20%	740 –46%	112 –92%
Materials/Steel Scope 1 Compared with 2019	$MtCO_2$ eq/a %	Production Centric GHG	2,454	1,866 –24%	1,229 –50%	112 –95%
Materials/Steel Scope 2 Compared with 2019	$MtCO_2$ eq/a %		636	460 –28%	222 –65%	0 –100%
Materials/Steel Scope 3 Compared with 2019	$MtCO_2$ eq/a %		0	0 0%	0 0%	0 0%
Iron & Steel—total CO_2 emissions (excluding electricity [Scope 2] and iron-ore mining)	$MtCO_2$ /a		2,454	1,866	1,229	112
Iron & Steel—CO_2 trajectory under IEA Net-Zero scenario Deviation: OECM compared with IEA	$MtCO_2$ /a %	IEA WEO 21	2,500 –2%	no data	1,778 –45%	220 –96%
Total Materials /Cement						
Materials/Cement Scope 1 Compared with 2019	$MtCO_2$ eq/a %	OECM GHG	2,476	2,011 –19%	1,717 –31%	734 –70%
Materials/Cement Scope 2 Compared with 2019	$MtCO_2$ eq/a %		245	116 –52%	54 –78%	0 –100%
Materials/Cement Scope 3 Compared with 2019	$MtCO_2$ eq/a %		9,598	6,086 –37%	3,039 –68%	0 –100%
Cement—total CO_2 emissions (excluding electricity and buildings emissions, but including process emissions)	$MtCO_2$ /a		2,476	2,011	1,717	734
Cement—CO_2 trajectory under IEA Net-Zero scenario Deviation: OECM compared with IEA	$MtCO_2$ /a %	IEA WEO 21	2,455 1%	no data	1,899 –11%	133 82%

14 Nature, research highlights, 18 August 2021, What's the mystery source of two potent greenhouse gases? The trail leads to Asia, https://www.nature.com/articles/d41586-021-02231-0

emissions of the cement industry. The OECM assumes that there will still be process emissions in 2050, and that nature-based carbon sinks—such as those from re-forestation (and not CCS)—will be used to compensate for them. The OECM does not factor in any emissions compensation for energy-related emissions because an energy supply based on 100% renewable energy, which will provide all energy needs by 2050, is calculated for the supply scenarios.

The IEA NZ scenario provides data for the cement and steel industries, but not for the aluminium industry.

5.6. Key Results of the Global OECM 1.5 °C Pathway: Buildings Sector

Finally, Table 10 shows the emissions from the buildings sector, which includes construction. The calculations are based on a separate research project under the leadership of the Central European University (Uerge-Vorsatz et al. 2021).[15] The results of that research were integrated into the OECM.

TABLE 10 GLOBAL SCOPE 1, 2, AND 3 EMISSIONS FOR BUILDINGS

Subsector	Units		2019	2025	2030	2050
Residential & Commercial Buildings and Construction						
Buildings Scope 1 Compared with 2019	$MtCO_2$ eq/a %	OECM GHG	127	81 –36%	54 –57%	0 –100%
Buildings Scope 2 Compared with 2019	$MtCO_2$ eq/a %		9,598	6,086 –37%	3,039 –68%	0 –100%
Buildings Scope 3 Compared with 2019	$MtCO_2$ eq/a %		2,476	2,011 –19%	1,717 –31%	734 –70%
Buildings—total CO_2 emissions (excluding electricity [Scope 2]—heating only, but excl. electric heating	$MtCO_2$ /a		2,912	1,778	1,265	0
Buildings—CO_2 trajectory under IEA Net-Zero scenario Deviation: OECM compared with IEA	$MtCO_2$ /a %	IEA WEO 21	2,941 –1%	no data	1,809 –43%	121 >500%

15 Uerge-Vorsatz et al. 2021, paper accepted in to be published, exact reference not yet available.

5.7. Key Results of the Global OECM 1.5 °C Pathway: Energy and Carbon Intensities by sector

The global and regional industry energy demands and the resulting energy-related CO_2 emissions for all analysed industry and service sectors are key for governments and policy makers. However, total annual emissions for a whole industry, such as the aluminium or steel industry on a global or regional level cannot be directly allocated to companies and with this to investment portfolios.

Therefore, the finance industry requires more detailed data. Industry specific energy demand per production unit or economic activity are among the main key performance indicators because they can be used to set benchmarks and targets for industry sectors independent from the size of the company.

Energy intensities are calculated values and indicate the amount of energy use to produce one tonne of steel, cement, or aluminium, for climatization of office buildings per square metre or to transport one tonne of freight for one kilometre. The base year is 2019, the latest available energy statistical data. Future energy intensities are either projections based on annual progress ratios or values published by the industry itself.

Emission intensities in CO_2 per product unit are calculated as a function of energy intensity and the assumed energy supply mix. The following tables provide an overview about selected industry and service sectors. The complete list is available on the UTS/ISF website.

TABLE 11 GLOBAL – ENERGY AND EMISSION INTENSITIES TRANSPORT SECTOR

Total Transport Sector		**Units**	**2019**	**2025**	**2030**	**2050**
Aviation						
Energy Intensity	Aviation Passenger Transport					
	Energy Intensity Compared to 2019	MJ/pkm %	5.81	4.83 -17%	4.51 -22%	4.18 -28%
	Aviation Freight Transport					
	Energy Intensity Compared to 2019	MJ/tkm %	32.20	29.12 -10%	27.16 -16%	25.20 -22%
Carbon Intensity	Aviation Passenger Transport					
	Emission Intensity Compared to 2019	gCO_2/pkm %	425.87	347.24 -18%	302.39 -29%	0 -100%
	Aviation Freight Transport					
	Emission Intensity Compared to 2019	gCO_2/tkm %	2360.26	2091.81 -11%	1821.61 -23%	0 -100%
Shipping						
Energy Intensity	Shipping Passenger Transport					
	Energy Intensity Compared to 2019	MJ/pkm %	0.06	0.05 -2%	0.05 -3%	0.05 -7%
	Shipping Freight Transport					
	Energy Intensity Compared to 2019	MJ/tkm %	0.19	0.19 -2%	0.18 -4%	0.17 -10%
Carbon Intensity	Shipping Passenger Transport					
	Emission Intensity Compared to 2019	gCO_2/pkm %	4.55	4.36 -4%	2.98 -34%	0 -100%
	Shipping Freight Transport					
	Emission Intensity Compared to 2019	gCO_2/tkm %	15.43	14.76 -4%	10.01 -35%	0 -100%

TABLE 12 GLOBAL -POWER GENERATION AND CARBON INTENSITY

Total Utilities Sector		Units	2019 Estimate	2025 Projection	2030 Projection	2050 Projection
Power Generation						
Power generation	Fossil	PJ/a	58,804	40,058	25,797	0
	Nuclear	PJ/a	9,951	7,598	5,470	0
	Renewables	PJ/a	24,177	57,158	100,621	273,991
	Renewable	%	26%	55%	76%	100%
Carbon Intensity	Sector CO_2 Intensity	tCO_2/PJ	89,982	64,895	42,755	0
	Electricity Carbon intensity	g CO_2/kWh	502	291	135	0

TABLE 13 GLOBAL – ENERGY AND EMISSION INTENSITIES CHEMICAL INDUSTRY

Chemical Industries		Units	2019	2025	2030	2050
Energy Intensity	Chemical Industries - average energy intensity					
	Energy Intensity	MJ/GDP	4.36	3.64	3.56	3.29
	Compared to 2019	%		-17%	-18%	-25%
	Chemical Industries - average emission intensity					
	Energy Intensity	[g/$GDP]	0.51	0.30	0.17	0
	Compared to 2019	%		-42%	-68%	-100%

TABLE 14 GLOBAL – ENERGY AND EMISSION INTENSITIES STEEL INDUSTRY

Total Materials /Steel		Units	2019	2025	2030	2050
Energy Intensity	Average Energy Intensity in steel production	GJ/t	15.5	12.8	12.4	11.4
	Energy Intensity - PRIMARY steel	GJ/t	18.0	15.5	15.5	15.5
	Energy Intensity - SECONDARY steel	GJ/t	9.1	8.3	7.7	7.0
	Primary steel production - share on total production	%	72%	63%	61%	52%
	Secondary/scrap steel - share on total production	%	28%	37%	39%	48%
Carbon Intensity	Emission intensity - Primary Steel - Electricity	tCO_2/t steel	0.04	0.03	0.01	0
	Emission intensity - Secondary Steel - Electricity	tCO_2/t steel	1.19	0.61	0.26	0
	Emission intensity - Primary Steel - Heat	tCO_2/t steel	0	0.48	0.30	0
	Emission intensity - Secondary Steel - Heat	tCO_2/t steel	0	0.26	0.15	0
	Emission intensity - Primary Steel - energy related	tCO_2/t steel	0.04	0.51	0.32	0
	Emission intensity - Secondary Steel - energy related	tCO_2/t steel	1.19	0.87	0.41	0
	Emission intensity - Primary Steel - total	tCO_2/t steel	1.07	1.43	0.92	0.08
	Emission intensity - Secondary Steel - total	tCO_2/t steel	1.19	0.87	0.41	0

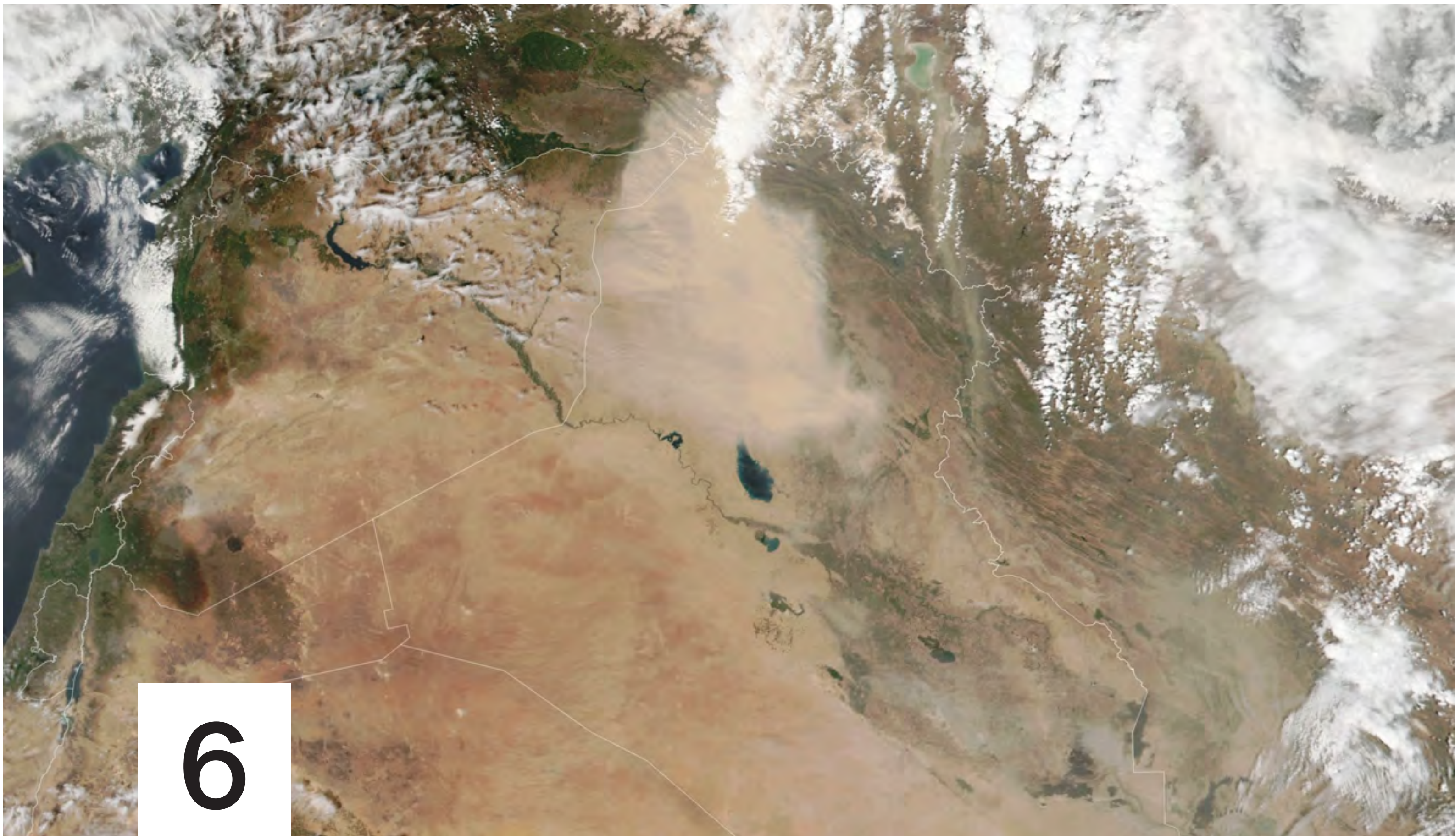
TABLE 15 GLOBAL – ENERGY AND EMISSION INTENSITIES CEMENT INDUSTRY

Total Materials /Cement		**Units**	**2019**	**2025**	**2030**	**2050**
Energy Intensity	Thermal energy intensity - per tonne of Clinker Compared to 2019	GJ/t %	3.5	3.4 -3%	3.3 -6%	3.1 -11%
	Cement production - electricity intensity Compared to 2019	kWh/t %	116	90 -22%	87 -25%	79 -32%
	Thermal energy intensity - per tonne of Cement Compared to 2019	GJ/t %	2.33	2.27 -2%	2.20 -5%	2.01 -14%
	Product Energy Intensity (thermal + electricity) Compared to 2019	GJ/t cement %	2.75	2.60 -5%	2.51 -8%	2.29 -17%
Carbon Intensity	Specific ENERGY RELATED CO_2 emissions per tonne of Clinker Compared to 2019	tCO_2/t clinker %	0.18	0.15 -16%	0.09 -49%	0 -100%
	Specific ENERGY RELATED CO_2 emissions per tonne of Cement Compared to 2019	tCO_2/t cement %	0.23	0.17 -26%	0.10 -56%	0 -100%
	Specific CO_2 emissions per tonne of Cement (including process emissions) Compared to 2019	tCO_2/t cement %	0.95	0.86 -9%	0.67 -29%	0.24 -75%

TABLE 16 GLOBAL – ENERGY AND EMISSION INTENSITIES BUILDINGS SECTOR

Residential & Commercial Buildings and Construction		**Units**	**2019**	**2025**	**2030**	**2050**
Energy Intensity	Residential Buildings: Energy Intensity Compared to 2019	kWh/m² %	81	78 -4%	74 -9%	58 -28%
	Commercial Buildings: Energy Intensity Compared to 2019	kWh/m² %	87	81 -7%	77 -11%	33 -62%
	Construction: Residential and Commercial Building - Energy Intensity Compared to 2019	MJ/$GDP %	0.70	0.57 -19%	0.56 -19%	0.54 -23%
Carbon Intensity	Residential Buildings: Total Emission Intensity (Heating & Electricity)	kg CO_2/kWh	0.60	0.35	0.17	0
	Residential Buildings: Emission Intensity - Heat per square metre	kg CO_2/m^2	7.8	5.0	2.6	0
	Residential Buildings: Emission Intensity - Heat	kg CO_2/kWh	0.097	0.064	0.036	0
	Residential Buildings: Emission Intensity - Electricity Compared to 2019	kg CO_2/kWh	0.502	0.291 -36%	0.135 -67%	0 -100%
	Commercial Buildings: Total Emission Intensity (Heating & Electricity)	kg CO_2/kWh	19.88	12.64	7.07	0
	Commercial Buildings: Emission Intensity - Heat per square metre	kg CO_2/m^2	19.6	12.5	7.0	0
	Commercial Buildings: Emission Intensity - Heat	kg CO_2/kWh	0.227	0.154	0.090	0
	Commercial Buildings: Emission Intensity - Electricity Compared to 2019	kg CO_2/kWh %	0.502	0.291 -36%	0.135 -67%	0 -100%

Dust Storm in Iraq. NASA Earth Observatory



6

Conclusion and Recommendations

The OECM is an integrated assessment tool with which to **develop truly science-based targets for all major global industries in a granularity and with the KPIs required to make informed investment decisions that credibly align with the net-zero objective in the short, medium, and long term.** The key result of the OECM 1.5 °C cross-sectoral pathway development is that **it is still possible to remain with the 1.5 °C limit if governments, industries, and the financial sector act immediately**. The technology required to decarbonize the energy supply with renewables is available, market ready, and in most cases, already cost competitive. The energy efficiency measures required to reduce the energy demand have also been known for years and can be introduced without delay. Finally, the finance industry—such as the Net-Zero Asset Owner Alliance—is committed to the implementation of carbon targets for investment portfolios. However, policies and regulations are required to implement all measures in the required rather short time frame.

Implementing short-term targets for 2025 and 2030

To implement the documented short-term targets for 2025 and 2030, **the following actions are required:**

Government Policies:

1. Immediate cessation of public and private investment in new oil, coal, and gas projects.
2. Implementation of carbon pricing, with a reliable minimum CO_2 price and the underlying OECM emissions caps.
3. All OECD countries must phase-out coal by 2030.

4. The automobile industry must phase-out internal combustion engines for passenger cars by 2030.
5. Legally binding efficiency standards are required for all electrical applications, vehicles, and buildings.
6. Renewable energy targets must be based on IPCC-carbon-budget-based 1.5 °C scenarios and detailed country master plans.
7. Mandatory transparent forward-looking and historic disclosure is required for the most relevant KPIs: energy intensity, share of renewable energy supply, energy demand, carbon emissions, and carbon intensities per unit production.

The Scope 1, 2, and 3 emissions presented identify not only the quantities of GHGs that must be avoided but also the responsibilities for avoiding them.

Scope 1 emissions are those controlled by an industry itself. They provide a red alert for industries and businesses to implement technical, financial, and logistical measures to phase-out emissions. In energy-intensive industries, the majority of energy-related emissions arise from the generation of process heat and the fuels used for machinery, and are crucial because they relate directly to the manufacturing process. The focus is on short-term actions: increasing renewable energy fuels, preparing for electrification, and the use of renewables-generated hydrogen and synthetic fuels.

Scope 2 emissions mainly arise from the energy (usually electricity) provided by utilities. Therefore, power utilities are in the very centre of the responsible industries. They must provide the quantity of renewable electricity that is required with the increased use of electricity for process heat and transport vehicles. If power utilities fail to upscale their generation of renewable electricity, almost all the industries analysed will fail to meet their targets.

Scope 3 emissions arise from the use of a product or technical equipment. Therefore, the manufacturing industry is responsible for changing the product design—so the automobile industry, for example, must stop the production of cars with internal combustion engines and provide electric vehicles instead, whereas the consumer must reduce his/her use of fossil-fuelled cars. These are only simplified examples to make this research more accessible.

Actions required by industry and financial institutions:

Industry:

1. Setting, disclosing, and implementing a climate strategy consistent with 1.5 °C no/low-overshoot sector models;
2. Immediate cessation of investments in new oil, coal, and gas projects;
3. Utilities must rapidly upscale renewable electricity to provide logistical support for the reduction of Scope 2 emissions by all industries and services. This is a huge market opportunity for utilities;
4. Development of efficient technologies to implement electric mobility;
5. Transparent forward-looking and historic disclosure of the most relevant KPIs, such as carbon emissions, energy demand, and carbon intensities per unit production.

Finance Institutions:

1. Setting and disclosing decarbonisation targets for the investment, lending, and underwriting portfolio sectors consistent with 1.5 °C no/low-overshoot sector models;
2. Cessation of investment in new oil, coal, and gas projects;
3. Ensuring the phase-out of coal by 2030 in OECD countries, and in 2030–2040 in all regions;
4. Scaling climate solution investments, especially in emerging economies;
5. Disclosure of climate mitigation strategies, short- and mid-term target setting (2025 + 2030), target achievements with respect to the decarbonisation of investment portfolios, sector decarbonisation, engagement outcomes, and progress of climate solution investments.

What's Behind California's Surge of Large Fires? NASA Earth Observatory

7

Data Format—1.5 °C Pathways for the World, OECD Europe, and OECD North Americas

The way scenario results are presented varies significantly, especially in terms of system boundaries and whether or not Scope 1, 2, and 3 emissions are reported or only total emissions are provided. Global reporting standards are not yet established and the comparability of different scenario data is therefore either negligible or at least challenging.

It is also important to assess the base year used in a scenario. The OECM uses the statistical data of the IEA Advanced World Energy Balances for the year 2019—the latest data available at the time of writing. The statistical data for 2020 and 2021 were estimated on the basis of available data to reflect the development between 2019 and 2022 (the year of publication). A scenario that uses the base year 2015 and identifies emission targets for 2025 is therefore based on a projection over 10 years, whereas the OECM projects only 4 years ahead, for a 2025 target. This ensures greater accuracy. Scenarios with a base year before 2015 are of very little practical value for investors and financial institutions because the projected development of the energy market —in terms of both the demand and supply situation and the fuel price and technology cost projections— does not reflect the major changes in the actual energy market

The COVID-19 pandemic led to significant fluctuations in energy demands, solar photovoltaic costs dropped by around 80% over the past decade, and electric vehicles had no market share in 2015, whereas the global market share is currently close to 5%. None of these developments is reflected in older scenarios, so their value for current investment decisions and target setting is extremely limited or non-existent.

This section provides an overview of the data format and the differences between methods of data reporting, with reference to a set of downloadable Excel spread sheets for three regions:

1. The Global OECM 1.5 °C pathway
2. The OECM 1.5 °C pathway for OECD Europe
3. The OECM 1.5 °C pathway for OECD North America

Sector Boundaries

Sector boundaries are based on the GICS classification

The OECM uses the IEA World Energy Statistics and Balances as one of the main input sources for the energy demand and supply data for the base year and the historical time series for model calibration. To develop energy scenarios that are based on the GICS classification, the IEA final energy demand sectors used for the statistical data had to be adapted to the GICS sectors. The GICS sectors can be simplified to accommodate the limited data available (IEA energy statistics). Two sectors in the OECM deviate slightly from the GICS to allow for a comparison with the IEA Net-Zero 2050 publication:

- ‘Water utilities’ is not included in 'utilities', but are presented as an independent sector.

- ‘Fisheries’ is not included in 'food processing', but is presented separately in the IEA statistical breakdown. Furthermore, the authors have developed a separate scenario narrative for the fishing industry in order to contribute to the debate about a possible transition towards a sustainable fishing industry.

For more details about the GICS sub-sectors, see the Appendix.

Data Format—Scopes 1, 2, and 3

The OECM 1.5 °C pathways are bottom-up energy scenarios with high technical resolution. All the sectors analysed are calculated at high resolution throughout the entire modelling period (2019–2050), in terms of both the energy demand and supply and the resulting emissions. For the primary energy sector, the energy used to extract oil, gas, or coal and the conversion losses in refineries etc. are calculated throughout the entire time series (2019–2050) and are summed only in the last step.

Therefore, the different interpretations of Scope 1—whether this includes only the production losses, as in the OECM methodology, or also includes the embedded emissions in fuel use, as in the ‘production-centric view’—can be considered. Therefore, all energy demands that are available in the energy statistics are calculated separately for the entire time series and for Scopes 1, 2, and 3.

The energy demands and supplies for all parameters of the sectors analysed (e.g., energy demand for primary steel and energy demand for secondary steel) are available for the entire time series, and the emissions are calculated separately based on the fuel-specific emission factor. This allows the scenario results to be presented for different methodologies—the parameters are ‘packaged’ according to the Scope 1, 2, and 3 definitions for the data provider and/or methodology used at a specific financial institution. The authors of the OECM selected this pragmatic approach because an extensive review process revealed that no consistent data format is currently in use.

The sector-specific data sheets provide detailed data and each user of the OECM data can ‘re-package’ them according to the company-specific methodology. Furthermore, the results of the OECM emissions pathways are presented in the same way that the International Energy Agency (IEA) presents its data (which is not consistent with the WRI Scope 1, 2, and 3 methodologies), allowing the comparison of the OECM data with the IEA Net-Zero by 2050 CO_2 emissions for the base year 2019, and ensuring the comparability of the scenarios (see section 7.2.3). All emissions are within a marginal error of ±2%, except the calculated OECM emissions for the chemical sector which are 6% higher than the emissions calculated by the IEA for 'chemicals'. The OECM calculates the chemical industry emissions within five sub-sectors, with individual energy intensities for each of the sub-sectors. A direct comparison with the IEA calculation methodology is therefore not possible. However, the results are within an acceptable range.

OECM Scope 1, 2, and 3 data presentation

The OECM Scope 1, 2, and 3 definitions are based on the WRI definitions and have been adjusted for the presentation of data pertaining to whole industries and countries, and to avoid double counting. The details are explained in section 2.

'Production-centric view' presentation of Scope 1, 2, and 3 data

The current practise of some data providers and financial institutions is to present the 'OECM Scope 3' emissions as part of the 'OECM Scope 1' emissions—and their data presentation is therefore inconsistent with the data presentation of other industry sectors. Those sectors are 'power utilities', 'aviation', 'shipping' and the steel industry. To provide comparable data, the OECM data are presented as 'production-centric' Scope 1, 2, and 3. To be consistent, all the calculated OECM sectors are presented from the 'production-centric' perspective—but the data rows are hidden for all sectors in which the common practise is consistent with the WRI/OECM definitions of Scopes 1, 2, and 3.

Comparison of OECM data with IEA Net-Zero by 2050 data

The OECM results can be compared with the IEA emissions data. The IEA presents the emissions data for each of the sectors analysed (fewer sectors than OECM) as total emissions. The emissions include all energy-related emissions—excluding emissions for power generation, which are listed separately—plus the main process emissions. For comparison, the OECM data are added up according to the IEA reporting system to make the results comparable.

See separate data sheets for all results.

The authors encourage the free use of the data for net-zero target setting and business and portfolio alignment according to the OECM. However, the authors are not responsible for any organization claiming to be OECM-aligned with net zero.

Appendix 1: Overview GICS Classification Sectors

TABLE 17 GICS SECTORS, GICS SUBSECTORS AND OECM NAMES (1)

10 Energy		OECM sector name
1010 10	*Energy, Equipment, & Services* 10101010 Oil & Gas Drilling 10101020 Oil & Gas Equipment & Services	Energy Energy Energy
1010 20	*Oil, Gas, & Consumable Fuels* 10102010 Integrated Oil & Gas 10102020 Oil & Gas Exploration & Production 10102030 Oil & Gas Refining & Marketing 10102040 Oil & Gas Storage & Transportation 10102050 Coal & Consumable Fuels	Energy Energy Energy Energy Energy Energy
55 Utilities		OECM sector name
5510 5520 5530 5540 5550	Electric Utilities Gas utilities Multi Utilities Water Utilities Independent Power and Renewable Electricity Producers	Utilities (Power & Gas only) Utilities (Power & Gas only) Utilities (Power & Gas only) Utilities (Power & Gas only) Utilities (Power & Gas only)
60 Real Estate		OECM sector name
6010 Real Estate		
601010	*Equity Real Estate Investment Trusts (REITs)* 60101010 Diversified REITs 60101020 Industrial REITs 60101030 Hotel & Resort REITs 60101040 Office REITs 60101050 Health Care REITs 60101060 Residential REITs 60101070 Retail REITs 60101080 Specialized REITs	Buildings Buildings Buildings Buildings Buildings Buildings Buildings Buildings Buildings
601020	Real Estate Management & Development 60102010 Diversified Real Estate Activities 60102020 Real Estate Operating Companies 60102030 Real Estate Development 60102040 Real Estate Services	Buildings Buildings Buildings Buildings Buildings
20 Industrials		OECM sector name
2030 Transportation		
203010	*Air Freight & Logistics* 20301010 Air Freight & Logistics	Aviation Aviation
203020	*Airlines* 20302010 Airlines	Aviation Aviation
203030	*Marine* 20303010 Marine	Shipping Shipping
203040	*Road & Rail* 20304010 Railroads 20304020 Trucking	 Not included Road
203050	*Transportation Infrastructure* 20305010 Airport Services 20305020 Highways & Rail tracks 20305030 Marine Ports & Services	 Aviation Road Shipping

TABLE 18 GICS SECTORS, GICS SUBSECTORS AND OECM NAMES (2)

1510 Materials		OECM sector name
1510 10	*Chemicals* 15101010 Commodity Chemicals 15101020 Diversified Chemicals 15101030 Fertilizers & Agricultural Chemicals 15101040 Industrial Gases 15101050 Specialty Chemicals	Chemical Industry Chemical Industry Chemical Industry Chemical Industry Chemical Industry Chemical Industry
1510 20	*Construction Materials* 15102010 Construction Materials	Not analysed separately—included in global/regional energy balance (NA)
1510 30	*Containers & Packaging* 15103010 Metal & Glass Containers 15103020 Paper Packaging	NA NA NA
1510 40	*Metals & Mining* 15104010 Aluminium 15104020 Diversified Metals & Mining 15104025 Copper 15104030 Gold 15104040 Precious Metals & Minerals 15104045 Silver 15104050 Steel	 Aluminium Industry NA NA NA NA NA Iron & Steel Industry
1510 50	*Paper & Forest Products* 15105010 Forest Products 15105020 Paper Products	Wood products Wood products Wood products
25	*Consumer Discretionary* 25203030 Textiles	Textile & Leather Industry Textile & Leather Industry
30 Consumer Staples		**OECM sector name**
3010	*Food & Staples Retailing* 30101010 Drug Retail 30101020 Food Distributors 30101030 Food Retail 30101040 Hypermarkets & Super Centres	Food Processing Food Processing Food Processing Food Processing Food Processing
3020	*Food, Beverage, & Tobacco* 30201010 Brewers 30201020 Distillers & Vintners 30201030 Soft Drinks	Food Processing Food Processing Food Processing Food Processing
302020	*Food Products* 30202010 Agricultural Products 30202030 Packaged Foods & Meats (including Fish)	Food Processing Food Processing Food Processing
302030	*Tobacco* 30203010 Tobacco	Food Processing Food Processing

Appendix 2: Overview—Differences between OECM and IEA NZ

TABLE 19 OVERVIEW—DIFFERENCES BETWEEN OECM AND IEA NZ

IEA Net-Zero Scenario	OECM—Energy Pathway
Apart from projects already committed by 2021, no new oil or gas fields, or coal mines or mine extensions should be approved for development after 2021.	Existing oil and gas fields and coal mines will be phased-out at average annual reduction rates of at least 8.5%, 3.5%, and 9.5%, respectively. New fossil fuel projects cannot go ahead.
Fossil fuel use will fall from almost 80% of global energy supply in 2021 to just over 20% in 2050. Carbon capture, utilization, and storage (CCUS) will be used after 2030 for coal-, gas-, and bio-energy-fuelled plants.	Fossil fuels will account for just under 8% of the total energy supply in 2050 (for non-energy use only).
The pathway includes the provision of electricity to around 785 million people who currently lack access, and clean cooking solutions to 2.6 billion people. This will lead to 100% access to energy services by 2050.	Likewise, the OECM provides universal access to energy services for 100% of the global population.
No new final investment decisions should be taken for new unabated coal plants; the least-efficient coal plants should be phased-out by 2030, and any remaining coal plants should be retrofitted with CCUS by 2040.	No new investment in fossil power plants after 2030, and coal power plants —including combined heat and power (CHP)—will be phased-out in Europe and North America between 2030 and 2035.
Emissions reductions through to 2030 will rely on existing technologies, but by 2050, 46% of emissions reductions will come from technologies that are currently at the demonstration or prototype stage.	Emissions reductions will be almost completely driven by the shift to existing renewable energy technologies, with some new technological development required to assist the transition to electric vehicles, biofuels, and hydrogen in the industry and transport sectors.
CCUS will capture 7,600 Mt CO_2 per year by 2050, and 5,245 Mt of this will be from fossil fuels and processes (including power, industry, and hydrogen production), 1,380 Mt from bio-energy (e.g., BECCS), and around 1,500 Mt from direct air capture and storage (DACS) technologies. IEA: Approx. –120 Gt until 2050 (cumulative); no data for 2100.	BECCS and CCUS are both excluded from the analysis because they lack commercial viability. Re-forestation begins immediately, and de-forestation ends by 2030. Nature-based carbon sinks (forests, mangroves, and seaweed) will be used instead of CCS to compensate for process emissions. **OECM: –5 Gt CO2 by 2050 / –86 Gt CO2** (cumulative until 2100).
Hydrogen production will be scaled up for use as fuel in sectors such as shipping, air travel, and heavy industry, with a total of 11 EJ/a produced by 2050.	7% of the final energy use (2 EJ/a] will be supplied by renewables-generated hydrogen, mainly for industrial process heat, by 2050.
Electricity will account for almost 50% of total energy consumption in 2050, and total electricity generation will increase by 250% from 2021. IEA: Total global power generation in 2050, 72,000 TWh.	Electricity will account for around 65% of the total energy consumption in 2050. Electricity generation will increase by 206% until 2050, based on 2020 levels. OECM: Total power generation in 2050, 53,500 TWh (2020, 26,700 TWh).
Almost 90% of global electricity generation in 2050 will come from renewable energy. Solar and wind will account for 70%. Two thirds of the total energy supply in 2050 will be from renewables, with solar accounting for one fifth of the total global energy supply.	100% of electricity generation will be from renewable energy. 100% of the total energy supply will be from renewable energy, with solar accounting for one third of the global energy supply. Any remaining fossil fuels will only be used for non-energy uses, such as the petrochemicals industry.
The solar generation capacity is expected to increase 20-fold between now and 2050, and the wind capacity 11-fold.	Solar generation is expected to increase 23-fold between 2020 and 2050, and wind 14.5-fold.
This includes annual additions of 630 GW of solar power and 290 GW of wind power by 2030.	Solar and wind power are expected to phase-up: by 500 GW per annum for solar photovoltaic in 2020–2030, and by 350 MW per annum for wind (14% of which will be offshore). This will require an increase in the current annual market volumes (in GW/a) for both technologies.
The annual rate of energy intensity will improve by around 4% per year to 2030.	Whereas the rate differs per region, this report assumes a similar global average rate of improvement in energy intensity to that of the IEA.
The total global final energy demand in 2050 will be around 17% less than in 2020.	The total global energy demand will be 29% less in 2050 than in 2020.
Bio-energy will be used for aviation, shipping, and cooking, and natural gas will be replaced with biomethane to provide heat and electricity. Bio-energy will produce 102,000 PJ/a by 2050.	Sustainable biomass will produce 85,000 PJ/a in 2050. It will be used primarily for process heat and aviation.
The biggest innovation opportunities will be in the areas of advanced battery storage, hydrogen electrolysis, and DACS.	No reliance on “break-through” technologies, such as BECCS or DACS, but a focus on technologies that are already market ready, including technologies that may still evolve and decrease in cost over time use to economies of scale.

"The OECM model provides very granular sector specific net zero pathways based on currently available technologies and with the highest ambition regarding renewable deployment, both well in line with the latest IPCC report. Next to the IEA Net Zero scenario it is the best available source to understand the enormous speed which is needed in all sectors to achieve a net zero world in 2050. For asset owners committed to net zero portfolio alignment sector pathway information is of utmost importance for investment portfolio steering. Asset owners' investee companies are assessed against these pathways. Furthermore the OECM pathways need to be the basis for discussions with policy makers on the development of industry sectors."

Günther Thallinger, Member of the Board of Allianz and Chair of the UN-convened Net-Zero Asset Owner Alliance

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