FMO

Entrepreneurial
Development
Bank

Deriving a 1.5°C Pathway for a Financial Institution

FMO Technical Paper | Version 2 | November 2019

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1 Introduction

Climate change is real and requires urgent action. The number of extreme weather events, like wild fires, hurricanes, droughts have increased dramatically. Scientists, countries and businesses agree that global warming is caused by the release of Greenhouse Gases (GHG), mainly from the burning of fossil fuels and industrial processes, as well as from agriculture, forestry and other land-use. The climate Paris Agreement calls for real impact, which if global temperature rise is to be limited to 1.5-degrees requires global CO_2 emissions to hit net zero by 2050.

The World Economic Forum (WEF) lists the *failure of climate change mitigation and adaptation* as a dominant risk in both its 2016 and 2017 global risks assessments, and the World Bank views climate change as the most significant challenge to achieving sustainable development as it threatens to drag millions of people into grinding poverty.

Global response to climate change saw a major breakthrough with the signing of the Paris Agreement in 2016. Here 195 countries committed themselves to hold the increase in the global average temperature to well below 2°C and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels by the end of the century. The agreement represents a collective recognition that limiting global warming would significantly reduce the risks and impacts of climate change.

However, pledging to stay below 2°C implies that global CO_2 emissions will be net zero by 2070. Staying within a 1.5°C temperature increase requires decisions very similar to the ones needed for a 2°C pathway, yet they need to be taken even sooner: emissions would need to hit zero twenty years earlier, in 2050. Should emissions, according to recent research[1], continue to rise after 2020, or even remain level, the goals set in Paris become almost unattainable.

A growing number of countries, businesses and financial institutions have already committed to take bold actions to meet the Paris Agreement. In the US, under “We Are Still In” a coalition has formed of now over 3,500 institutions across government, the private sector, faith communities and higher education institutions in all 50 states who have committed to the Paris Agreement and take actions accordingly. Next to this, the Science Based Targets initiative by CDP, UN Global Compact, WRI and WWF has grown to the biggest platform with over 600 companies committing to align greenhouse gas reduction targets with the Paris Agreement. Within this initiative, the largest number of commitments are put forward by the financial sector. That’s why the initiative has started to develop a harmonized framework of methods to align a financial portfolio with the Paris Agreement. A final framework with methods to set science-based targets is expected to be available early 2020.

Delivering the Paris Agreement dictates the ability to not only track and measure absolute emissions, but also to assess progress against an agreed reduction pathway.

[1] Mission 2020. 2020: the Climate Turning Point (Mission 2020, 2017) http://go.nature.com/2takuw3

Like other Development Financial Institutions (DFIs), FMO recognizes the importance of systematically integrating climate change considerations across strategies, sectors and operations to deliver better, more sustainable short-term and long-term results both developmentally and financially.

In FMO's new 2025 Strategy, climate action has been identified as one of the three top-line Sustainable Development Goals (SDGs) to which FMO can particularly contribute. In practice, this means pursuing a portfolio that delivers positive outcomes on climate mitigation and adaptation. Focussing on climate is also aligned with FMO's Sustainability Policy, published 4 January 2017, which states the aim to contribute to financing the transition to a green economy in line with the climate goal agreed in Paris. As climate change affects developing countries most, we strive to align our portfolio with 1.5°C.

Together with Navigant, we have been working on constructing a 1.5°C pathway for FMO's portfolio based on existing climate scenarios from the International Energy Agency (IEA), the Intergovernmental Panel on Climate Change (IPCC) and scientific literature. *It is important to note that this scenario was constructed prior to the existence of the IPCC 1.5*°C *scenarios. Therefore, in 2019, Navigant compared the FMO 1.5* °C *scenario against the IPCC 1.5*°C scenarios and found that the former fits within the ranges of the latter.

The methodology developed to assess our alignment with 1.5°C is the focus of this paper and marks the beginning of a journey whereby FMO seeks to not only assess its financed emissions (in absolute terms) but also to judge its performance against an externally set goal (i.e. Paris Agreement). We invite other financial institutions and well as anyone else with an interest in the topic to provide their views and feedback on the methodology and to join our pursuit for real climate impact. In a separate paper we have outlined our current thinking around an absolute GHG accounting approach. On the second paper we would also welcome any feedback.

Both papers have been developed in direct response to Article 2a of the Paris agreement which states: "*Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change ".*

2 Constructing a global 1.5°C decarbonisation scenario

This section explains how a 1.5°C decarbonisation scenario is constructed based on leading 2°C emissions scenarios and key insights from literature regarding the difference between a 1.5°C and 2°C scenario.

As no detailed and peer-reviewed emissions scenarios leading to an increase of global temperature by a maximum of 1.5°C were available at the time of creating the scenario, we decided to construct this scenario ourselves. Constructing such a scenario provides us with valuable insights into the required transition in terms of emissions reduction. Given that FMO predominantly invests in developing countries, we limited our geographical scope to non-OECD. This non-OECD 1.5°C scenario was constructed following the steps below. The construction is based on existing 2°C scenarios and scientific literature on the carbon budget available under 1.5°C and on the difference between decarbonization below 2°C and towards 1.5°C. Also the split in emissions between OECD and non-OECD stems from the existing scenarios. Carbon budget allocation between OECD and non-OECD are based on the climate scenarios modelling from IEA and IPCC, where these integrated assessment models are based on population and GDP growths per regions/country combined with the cost-efficiency of mitigation measures.

At the time of updating this report, the IPCC 1.5°C scenarios were available; therefore, we carried out a comparison to validate the accuracy of our scenario against the IPCC 1.5°C scenarios. As a result, we can confirm that the FMO 1.5°C scenario fits well within the ranges of the IPCC 1.5°C scenarios (see Annex B).

Approach followed:

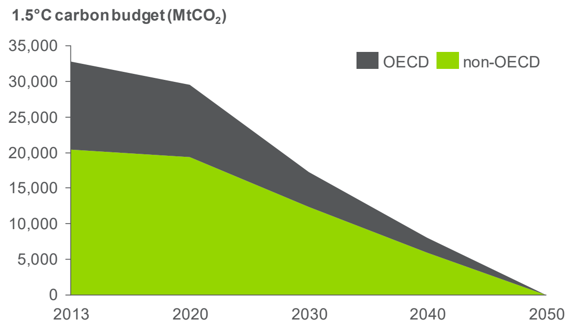
1. Assessing the carbon budget in line with 1.5°C
2. Taking existing 2°C scenarios and translating them to a 1.5°C scenario, based on scientific literature and the carbon budget available under 1.5°C
3. Splitting the 1.5°C scenario into OECD and non-OECD
4. Adding a non-OECD scenario for Agriculture, Forestry and Land-Use (AFOLU)

A detailed description of the construction of our non-OECD 1.5°C scenario including assumptions and limitations is provided in annex A.

Figure 1 and 2 show the non-OECD 1.5°C scenario resulting from these steps. Figure 1 presents the CO_2 emissions split over OECD and non-OECD, and the divisions of the CO_2 emissions in non-OECD over four sectors: power, industry, transport and buildings. In Figure 2 also non-CO_2 emissions from agriculture, forestry and land-use change are added.

Similarly, like in existing scenarios from the IPCC and the International Energy Agency, the carbon budget is split over OECD and non-OECD, recognizing that non-OECD countries have more room to emit while growing the economy.

Unfortunately, we are not able to further breakdown the 1.5°C scenario to specific countries as data in existing scenarios and scientific literature doesn’t suffice. However, as FMO invests in various non-OECD countries, we believe that aligning our portfolio with a non-OECD 1.5°C scenario is a meaningful starting point.



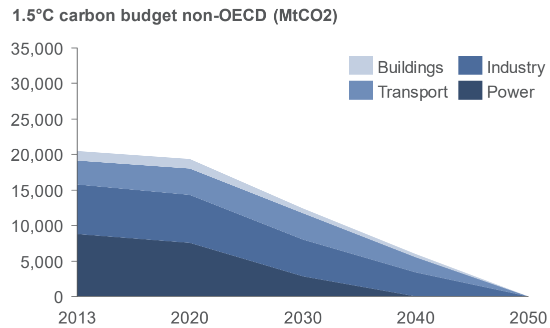


Figure 1. 1.5°C carbon budget OECD and non-OECD (left) and 1.5°C carbon budget non-OECD per sector (right).

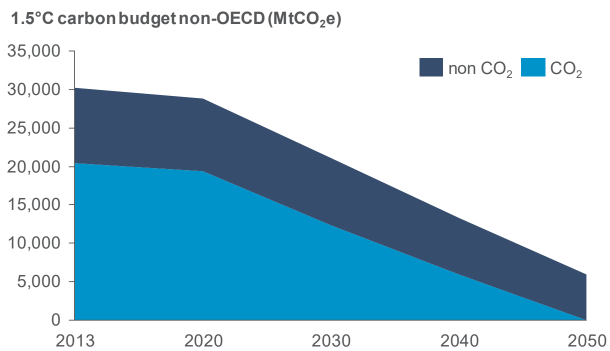


Figure 2. 1.5°C GHG emissions scenario for non-OECD including breakdown in non-CO_2 emissions from agriculture, forestry and land use change and CO_2 emissions from the power, industry, transport and buildings sectors.

3 Aligning a financial portfolio with a 1.5°C scenario

In line with the methods developed under the Science Based Targets initiative of CDP, UN Global Compact, World Resources Institute (WRI) and WWF, we have identified three emission-based methods to align a financial portfolio with a low carbon scenario. In this chapter we present these three methods together with the implications for a financial institution.

3.1 Alignment methods

3.1.1 Absolute alignment method (absolute contraction)

According to this method, a financial institution will have to reduce the absolute emissions generated by its portfolio with the same percentages as in the developed 1.5°C decarbonisation scenario. This can be done on a regional (non-OECD) or sectoral level if decarbonization scenarios exist. For example, absolute GHG emissions of a financial portfolio in non-OECD should be reduced by -17% between 2013 and 2025, according to this method.

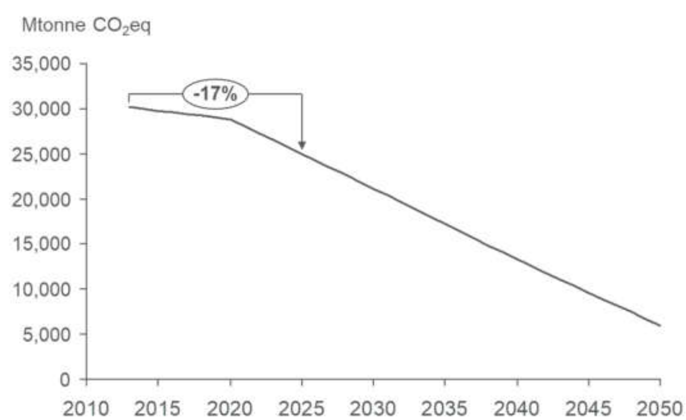


Figure 3. 1.5°C GHG emissions scenario for non-OECD (Mtonne CO_2eq)

The main advantage of using this method is that it's simple and easy to communicate. However, if the portfolio declines or increases differently than the GDP growth projection in the 1.5°C scenario (i.e. 4-5% annual GDP growth), this method doesn't correct for that growth difference and a new pathway for the financial institution will have to be established.

3.1.2 Economic alignment method

In contrast to the absolute alignment method, the economic alignment method uses an intensity approach. The absolute 1.5°C decarbonisation scenario is translated into an intensity pathway by dividing the absolute scenario with the GDP projection used in the modelling of the 1.5°C decarbonisation scenario (see figure 4). As GDP grows by 4-5% annually, the intensity pathway gets steeper.

Accordingly, a financial institution will have to reduce its economic emissions intensity per € added value with the same percentage as the reduction of the 1.5°C emissions intensity pathway (i.e. kg CO_2eq/GDP). Added value of investments can be calculated based on the gross profit data associated with each investment, or by using input-output models. For example, a financial institution providing finance in non-OECD countries must reduce its emissions intensity (kg CO_2eq/€ added value) from its portfolio by -54% between 2013 and 2025, according to this method (see figure 7).

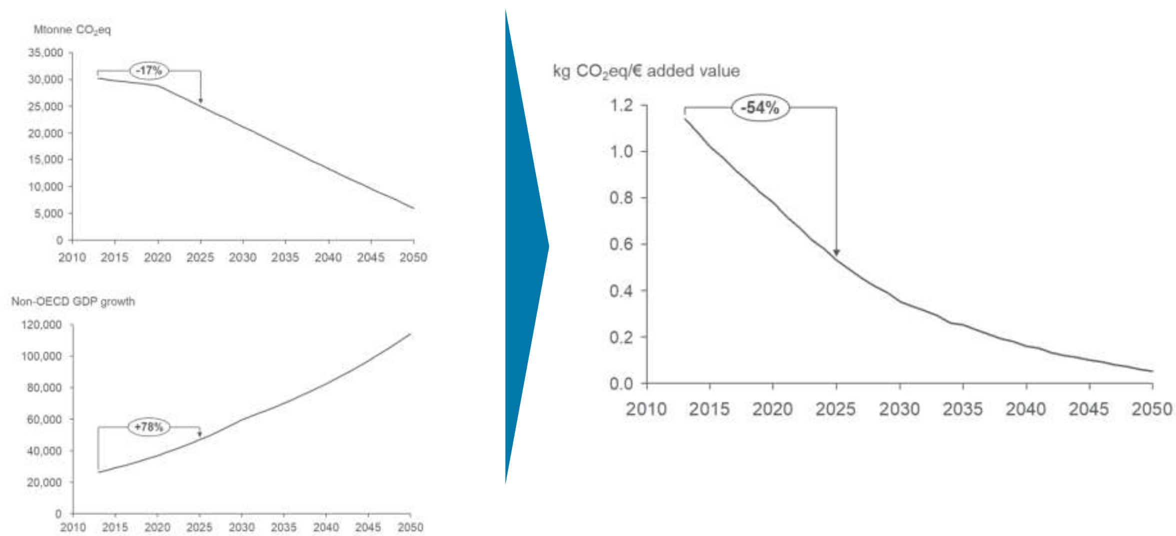


Figure 4. 1.5°C GHG emissions intensity pathway for non-OECD (kg CO_2eq/added value)

The main advantage of this method is that it takes growth of added value generated by the investments of the financial institution into account when this differs from GDP projections. However, added value calculations associated with investments depend on gross profit data of each investment and macroeconomic models and can thus differ based on the data quality and could vary over time due to financial market fluctuations. Another assumption is the correlation between GDP and the added value generated by investments. Economic growth is universally expressed as GDP, which is an established metric for global and local economies as well as sectors. This method aims to establish a measure that captures the contribution of a single investment to the GDP used to build the intensity pathways. However, this link is not straightforward. For the purpose of GDP and national accounts, gross value added (GVA) usually accounts for more than 90 percent of GDP and is calculated as:

GVA = Output at producer prices – Intermediate consumption at purchaser prices

The equivalent measure of gross value added in an organization can be calculated as:

GVA = Employee wages + Taxes net of subsidies (excluding those applied to products) + Gross profit.

3.1.3 Physical alignment method (sectoral decarbonization approach)

Third alignment method builds on a physical approach. The physical alignment method combines sectoral emissions scenarios with sectoral activity projections to construct sectoral intensity pathways. Like in the Science Based Targets initiative, the method can only be applied to investments in homogeneous sectors like the power, buildings and agricultural and forestry production (i.e. gCO2e/kWh, m2, resp. gCO2/tonne of product). Financial portfolios can align with these sectoral intensity pathways by combining emissions data with physical data associated with their investments. For example, a financial institution with a portfolio in power generation could align its average emissions intensity (kg CO_2eq/kWh) from its power generation and steer investments to reduce this intensity by -56% between 2013 and 2025 (see figure 5).

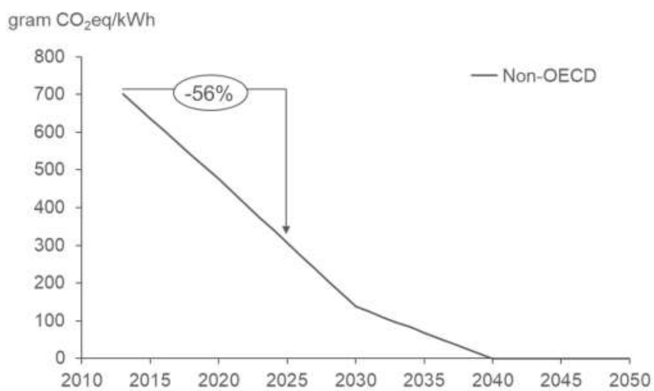


Figure 5. 1.5°C emissions intensity pathway for power generation in non-OECD (g CO_2eq/kWh)

The main advantage of using this method is that it is specific and leads to more accurate pathways with which to align. However, this method can only be applied to homogeneous sectors, and currently, a limited number of sector-specific scenarios exists. Furthermore, this method also requires information like physical data. As physical data of investment in energy production or real estate is often available at financial institutions, physical alignment is most appropriate to these types of investments.

3.2 Steps to apply these methods

To apply these methods, a financial institution can follow the steps below:

1. ***Calculate the GHG emissions associated with the portfolio for a certain year***
   A financial institution has to calculate the associated GHG emissions (carbon footprint) related to the portfolio or parts thereof which they would like to align with the Paris Agreement (i.e. according to GHG Protocol Corporate Value Chain (Scope 3) Accounting and Reporting Standard, category 15 investments). In the Netherlands, fourteen financial institutions including FMO formed the Partnership Carbon Accounting Financials (PCAF) to improve carbon accounting by increasing transparency and uniformity in carbon accounting and target setting. In December 2018 their second report was published, providing a harmonised approach on carbon accounting of eight asset classes. The PCAF report provides a useful approach to calculate emissions.
2. ***Select a low carbon scenario***
   Several published scenarios from IEA, IPCC, IRENA and specific companies (like BP, Shell etc.) are available and lay out various plausible emissions pathways to particular target outcomes (e.g., specific temperature increases or CO_2 concentration levels). These scenarios have varying assumptions about the likely timing of policy changes, technology adoption, changes in energy mix, and other factors to achieve a climate-friendly economy. The Taskforce on Climate-related Financial Disclosure (TCFD) of the Financial Stability Board (FSB)

has described these plausible scenarios in more detail in its technical supplement The Use of Scenario Analysis in Disclosure of Climate-Related Risks and Opportunities.

3. ***Select and apply an alignment method***
   Depending on the portfolio composition a selection can be made for one or more of the alignment methods.
   - For investing in asset classes related to a homogeneous sector (e.g. power generation, real estate, mortgage, production of agricultural commodities) the physical alignment is most suitable as it is the most specific and accurate.
   - For investments in a broad range of sectors reflecting global or national economies, e.g. listed equities (world indices), indirect investment via local financial institutions, the economic or absolute alignment method can be applied. If the growth projection of the portfolio is higher than the growth projections of the economy, the absolute alignment method is more conservative to ensure that the carbon budget that is attributed to the financial institutions doesn't exceed the overall global carbon budget.
   - When a portfolio is very diversified with e.g. both direct and indirect investments into a broad range of sectors, the absolute alignment method is most suitable for a full portfolio view.
   - When different methods are used to define specific pathways for certain sectors or departments, the specific emissions pathway per sector or department can be summed up in absolute terms. In order to do so, the applied intensity pathways per sector or department should be translated into an absolute pathway by taking growth of that specific sector or department into account.

3.3 Assumptions and limitations

Applying these alignment methods to a financial portfolio comes with the following assumptions and limitations:

- One clear limitation of these methods is that the financial institution has to assess the associated GHG emissions of its portfolio, before it can align its portfolio with a low carbon scenario.
- By shifting investments to lower-emitting countries and sectors, a financial institution could lower its absolute emissions and thus align its portfolio with a 1.5 scenario. However, the effects on global absolute emissions will be minimal as no real GHG reduction is taking place. A real impact could be created if significant amounts of finance were to be redirected from high emitting sectors to low emitting sectors. As this is probably not the case within the short term, we assume that a financial institution will not totally divest from sectors, i.e. sectors that are currently in the portfolio will stay in the portfolio; though, in the long run it is expected that financial institutions develop pathways for divesting from high emitting sectors. The financial institution should therefore, in the short term, focus on lowering the emissions of the sectors it invests in by fostering change within the sector. Under this assumption, steering on sectoral emission intensity (gCO_2eq per added value or kWh or tonne of product) still applies.

3.4 Recalculating of the pathways

Aligning a portfolio with a low carbon scenario should involve recalculation under certain circumstances; for example, when significant changes occur in:

- Portfolio structure (e.g. acquisition, divestiture, mergers, investing in new markets/sectors)
- Growth projections (e.g. difference between projected and actual growth of the portfolio)

- Data used in defining the pathways (e.g. discovery of significant errors or a number of cumulative errors that are collectively significant)
- The evolution of new 1.5°C or 2°C scenarios and/or more sector-specific decarbonization scenarios

Regarding these circumstances, we propose to check the validity of the pathways annually when checking the progress on the alignment of the portfolio with a low carbon scenario. At a minimum, we propose to update the pathways at least every five years.

4 Assessing FMO's portfolio and associated emissions against a 1.5°C scenario and pathway

For illustrative purposes, this chapter presents the findings of a pilot study where scope 1 and 2 emissions from FMO's investments contracted in 2015 and 2016 (accounting for 40% of current total portfolio) are presented in relation to the 1.5°C scenario. FMO's emissions allowance is calculated based on the economic alignment method reflecting FMO's added value[2] to the economy, while the specific pathway is derived from the absolute alignment method based on emission level.

4.1 FMO portfolio

FMO has invested in the private sector in developing countries and emerging markets for more than 46 years. With a committed portfolio of almost €10 billion, FMO is one of the larger bilateral private sector development banks globally. We have investments in more than 85 countries, offering our clients a variety of financial products, as well as expertise and access to our networks. Our financing is mainly focused in three key sectors: Financial Institutions, Energy, and Agriculture, Food and Water (AFW). FMO also has investments in Private Equity.

4.2 Sampled portfolio

In our pilot to assess alignment with the 1.5°C scenario, we chose to include all new investments contracted in 2015 and 2016, which accounts for approx. 40% of our total portfolio. GHG emissions associated to these investments were estimated using the FMO Impact Model (see box below).

FMO's Impact Model

In 2014 we developed a tailor-made input-output model, called Impact Model, that quantifies added value, emissions and jobs created/supported by FMO's investments. The macroeconomic data used in the Impact Model is provided by the data sets of the Global Trade Analysis Project (GTAP). The Impact Model calculates the additional economic output (revenues) of an end-beneficiary generated by our capital which can thus be attributed to FMO. This calculation is based on the capital intensity of the end-beneficiary. For direct investments, capital intensities are calculated based on direct client data (revenues, non-current and total assets) from FMO's database. For indirect clients, calculations are based on macroeconomic statistics on the capital intensities of the industries and end-beneficiary types (corporates or SMEs, formal or informal) spread over the countries/regions in FMO's portfolio. For more information on this model, see here.

[2] One could of course also have developed an emissions allowance per capita, but since FMO in optimising on its economic input (i.e. capital) a scenario and pathway using a comparable indicator (i.e. GDP/value add) made most sense.

4.3 Emissions allowance for FMO

Knowing the added value (wages + taxes + profits) generated by the sample portfolio, it was possible to determine FMO's fair share of the total carbon budget for non-OECD. We applied the economic alignment method to assess this emissions allowance for FMO based on added value as a proportion of GDP.

FMO's share of the non-OECD carbon budget was calculated by multiplying our added value with the emission intensity of non-OECD in 2016 (GHG emissions of non-OECD divided by non-OECD GDP in 2016).

Taking this initial share, we assume that our share of the non-OECD emissions follows the same reductions as the non-OECD 1.5°C climate scenario. This results in an absolute emissions allowance scenario for FMO (see figure below), based on the assumption that our portfolio and added value grow similarly to the non-OECD economy.

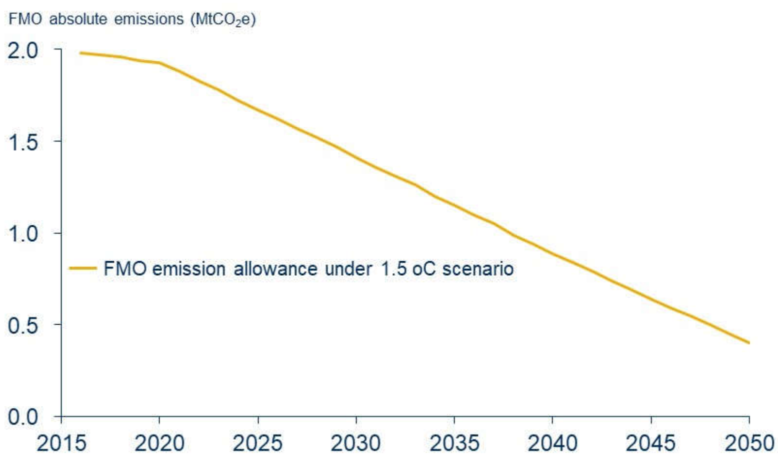


Figure 6. FMO emissions allowance

4.4 FMO's emissions from the sampled portfolio

The associated GHG emissions from our sampled portfolio was approx. 1.8 Mton CO_2eq. This is lower than our emissions allowance based on added value, which is mainly caused by our large share of renewable energy investments and our investments in low-emitting sectors.

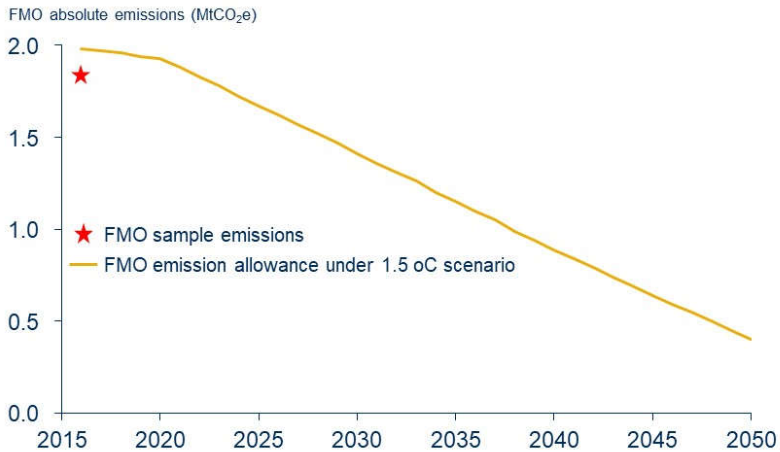


Figure 7. FMO emissions in 2016 against our allowance

4.5 FMO's specific 1.5°C pathway

Taking this starting position for the sampled part of our portfolio, the FMO specific emissions pathway was constructed based on the absolute alignment method so that the emissions associated with FMO's portfolio decrease with the same percentage over time as they would in the 1.5°C non-OECD scenario. We decided to apply this method, as we have a diversified portfolio with direct investment in Energy, Agriculture, Food and Water, and indirect investment reflecting the broad economies of our focus countries. Next to this, this method is easy to use and communicate.

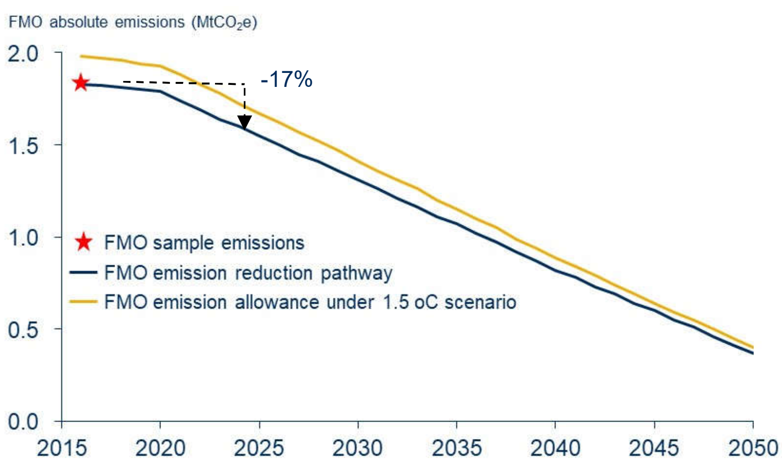


Figure 8. FMO's specific emission reduction pathway.

4.6 Assumption and limitations

- The assessment of our GHG emissions comes with a lot of challenges as we invest (direct or through local financial institutions) in various businesses in developing countries which lack the knowledge and capabilities to account for and report on their GHG emissions. Using sector data from input-out databases to quantify the associated GHG emissions of our investments comes with uncertainties. Moving to more and better data on the GHG emissions associated with our investments is essential if we are to stay focused on our goals.
- Applying these methods to non-OECD countries could favour investments in low-emitting countries, since these would more closely align with the pathway. However, investing in improvements in low-income countries with higher emission factors would create opportunities for larger emission reductions. Reflection and dialogue on this question will help further refine our approach to GHG accounting.
- Our GHG emissions are accounted as *annual* emissions generated by our new investments in 2015 and 2016. They are not the emissions released into the atmosphere over the lifetime of our investment or project (e.g., the lifetime of a technology). The advantage of annual emissions accounting is that it is possible to align our associated emissions in a certain year to our emissions allowance. Moreover, it provides the possibility to annually balance emissions between investments that cause emissions, and those that lead to reduction or sequestration of emissions. FMO could use this annual balancing to steer decisions against favouring only investments in low-emitting countries. For example, FMO could continue investing in low-income countries with higher emission factors (i.e. financing the decarbonisation of high emitting sectors) and balance the emissions caused by these investments with investments in sequestration projects. By combining these two types of investments, FMO can ensure the emissions balance aligns with the FMO reduction pathway.

We will continue to advance our understanding of the emissions we are financing by broadening our sample and gaining further experience with GHG accounting from an absolute approach. In addition, we are aware that the selection of investments at project and country/regional level requires a systematic approach to ensure a balance of investments in low-emitting countries and larger emission reductions in countries with high emission factors.

5 Steering a portfolio in line with a 1.5°C scenario

Setting the target and aligning with a 1.5°C scenario based on above presented methodologies is a very important step but steering and taking actions in line with a 1.5°C scenario is much more important. Every day our investment managers are confronted with making investment decisions and they need additional guidance to inform those decisions to steer our portfolio along the 1.5°C pathway.

Regarding this additional guidance we are exploring two options and we might need to combine both:

1. Steering on portfolio level

Taking the portfolio level view, we could annually assess the absolute emissions of our portfolio (see chapter 6) and monitor if we make progress in lowering our absolute emissions by:

- Investing in low emitting countries, sectors and technologies
- Increasing our intermediate lending of green lines (green technologies)
- Increase our investments in renewable energy
- And increase our investments in forestry to sequester GHG emissions

2. Steering on impact at project level

Next to steering on portfolio level, we could steer on impact at project level, for example:

- Energy efficiency projects in polluting countries reduce more GHG emissions than in countries with a large share of renewables
- Renewable energy projects in polluting countries avoid more GHG emissions than in countries with a large share of renewables
- GHG mitigation projects in livestock agriculture (for instance dairy farming) reduce more GHG emissions than in other agriculture activities
- Forestry projects lead to sequester emissions and thus to lower our generated emissions (see chapter 6 on our absolute GHG accounting approach)

Both options come with different metrics that we will investigated going forward on their usability and effectiveness.

6 Developing an absolute GHG accounting approach

Assessing a financial institution's performance against a 1.5°C scenario requires an appropriate GHG accounting approach. In a separate paper, we have laid out what we believe to be a fair and practical approach to account for absolute financed emissions. Below, we have included a short introduction to this general approach.

FMO's current emission metric tracks GHG avoidance from green investments, i.e. the GHG emissions avoided if the baseline technology would have been realised compared to the green investments. However, not all such investments will be aligned with a 1.5°C pathway despite them avoiding future emissions and contributing to climate change mitigation. Increased GHG avoidance of course represents an improvement, yet only by considering absolute emissions will it be possible to determine if one's climate efforts are sufficient to stay within the carbon budget.

From an absolute GHG accounting perspective, financed emissions can be categorised into two main groups:

1. Financing that generates emissions
2. Financing that sequesters emissions

In our Technical Paper 2, we present our current thinking on the accounting approach in more detail and welcome input and feedback.

For more details regarding the proposed absolute GHG accounting approach, please refer to the second technical paper or contact: **Mikkel Kallesoe (M.kallesoe@fmo.nl)**

7 Glossary

AFOLU	Agriculture, Forestry and Land-Use
FI	Financial Institution
GHG	Greenhouse Gas
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
PCAF	Platform Carbon Accounting Financials
PE	Private Equity
RCP	Representative Concentration Pathway
OECD	Organisation for Economic Cooperation and Development

ANNEX A: DETAILED DESCRIPTION OF THE CONSTRUCTION OF OUR 1.5°C SCENARIO

Our non-OECD 1.5°C scenario was constructed following the steps below:

1. Assessing the carbon budget in line with 1.5°C
2. Taking existing 2°C scenarios and translating them to a 1.5°C scenario, based on scientific literature and the carbon budget available under 1.5°C
3. Splitting the 1.5°C scenario into OECD and non-OECD
4. Adding a non-OECD scenario for Agriculture, Forestry and Land-Use (AFOLU)

Assessing carbon budget in line with 1.5°C

To construct a 1.5°C decarbonisation scenario, we must start by considering the total amount of greenhouse gas (GHG) emissions humanity can still emit before it becomes unlikely we can avoid a global temperature rise of 1.5°C. In their fifth Assessment Report (AR5), the Intergovernmental Panel on Climate Change (IPCC) has assessed this finite amount of emissions related to the temperature increase. As CO_2 from fossil fuel combustion and industrial processes have been the main drivers for anthropogenic global warming, the IPCC community has defined a carbon budget, i.e. the total net amount of CO_2 emissions only that can still be emitted (see Figure 1). This carbon budget has been determined based on various climate scenarios that model the global warming impact of all GHG emissions (i.e. CO_2 and non-CO_2), of which the Representative Concentration Pathways (RCP) have been defined as the marker scenarios. According to IPCC AR5, the carbon budget corresponding to limiting global warming to 1.5°C is 400 $GtCO_2$ from 2011 onwards with 66% probability of reaching this.

Taking existing 2°C scenarios and translating them to a 1.5°C scenario, based on scientific literature and the carbon budget available under 1.5°C

The IPCC accepted the invitation during the COP21 to provide a special report in 2018 on the impacts of global warming of 1.5°C and related global GHG emissions scenarios. At the time of constructing the 1.5°C scenario for FMO, some publications were already coming out on this perspective. However, detailed and peer-reviewed emissions scenarios leading to an increase of global mean temperature by no more than 1.5°C by 2100 were not available. Yet, a generic understanding of how a 1.5°C scenario will differ from a 2°C scenario was already developed by Rogelj et al (2015). Figure 1 shows the IEA's Energy Technology Perspectives (ETP) 2016 projected energy- and process-related CO_2 emissions consistent with a 2°C emissions scenario. Please note that non-CO_2 emissions are discussed in paragraph 2.5. The carbon budget corresponding to this scenario from 2013 until 2050 is around 275 $GtCO_2$ for the OECD and 675 $GtCO_2$ for the non-OECD to limit global warming to 2°C (with 50% probability of reaching this).

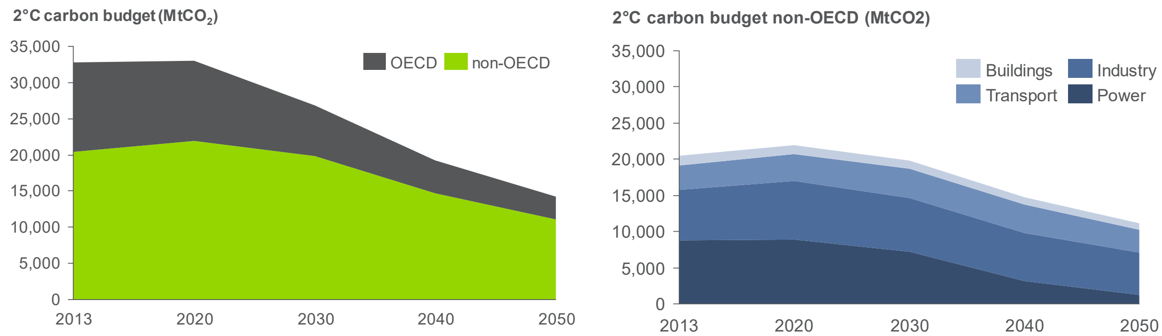


Figure 1. 2°C carbon budget OECD and non-OECD (left) and 2°C carbon budget non-OECD per sector (right) (source: ETP 2016).

Compared to OECD, emissions reductions are less strict in non-OECD countries because of growing economies and population, together with continued urbanisation.

The Nature Climate Change paper "Energy system transformation for limiting end-of-century warming to below 1.5°C" by Rogelj et al. (2015) provides global sectoral CO_2 emission projections consistent with a 1.5°C emissions scenario. The 1.5°C emissions projections cover: (a) the carbon emissions from global electricity generation; (b) the direct carbon emissions generated by the global transport sector; (c) the global direct carbon emissions from industrial processes; and (d) the direct carbon emissions from energy use by global residential and commercial buildings (see Figure 2). The box plots show the medium (red line), the 15^{th} to 85^{th} percentile range (box), and the minimum-maximum range (whiskers). Dots represent single scenarios. The scenarios calculated by Rogelj et al. (2015) show a wide range as two integrated assessment models were used and 200 scenarios were assessed.

The scenarios published by Rogelj et al. (2015) imply that compared to limiting warming to 2°C, limiting warming to 1.5°C temperature rise will require more rapid emission reductions, with net zero emissions reached by around 2050, and more negative emissions after 2050.

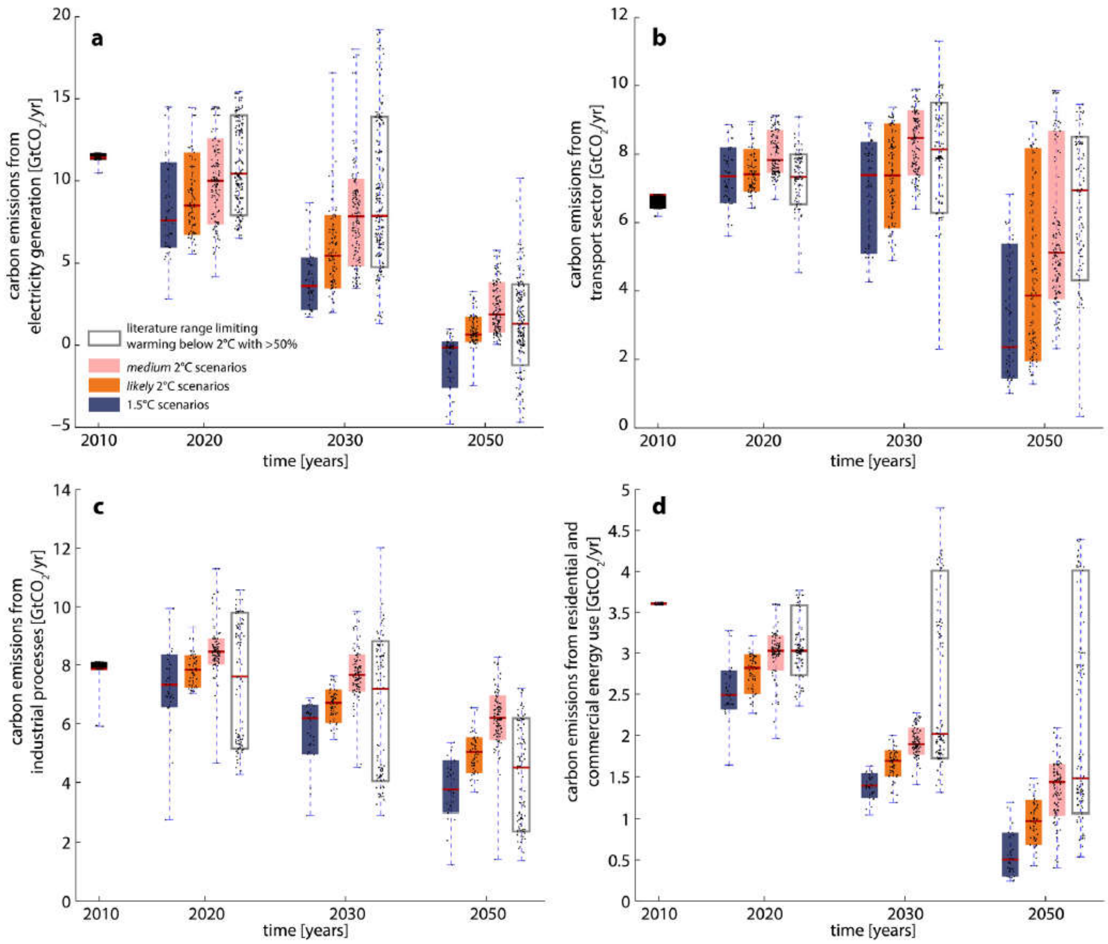


Figure 2. Global sectorial breakdown (a: power, b: transport, c: industry and d: residential and commercial buildings) of energy-related and process CO_2 emissions (source: Rogelj et al. 2015).

Splitting 1.5°C scenario into OECD and non-OECD

While the projections of Rogelj et al. (2015) are at a global level only, the sectoral breakdown is consistent with the sector breakdown used in the IEA ETP 2°C scenario, allowing indicative regional 1.5°C emissions scenarios to be constructed for each sector.

First, the share of emissions of each regional sector compared to the global emissions from that sector is calculated for the ETP 2°C scenario. Stated differently, the ETP gives 2°C emission projections for 4 sectors (i.e. power, transport, industry and buildings) in 12 different geographical regions. Within the first step, the emission contribution of each regional sector (i.e. transport in OECD, transport in non-OECD, transport in ASEAN, etc.) compared to the global emissions from that sector (i.e. transport in the entire world) is calculated.

Second, the global emissions for each sector (i.e. power, transport, industry and buildings) to limit temperature rise to 1.5°C are taken from Figure 2.

Third, the indicative regional 1.5°C emissions scenarios can be calculated for each sector and the economy as a whole. This is done by multiplying the (1) % share of regional emissions compared to the world total in year Y for sector X by (2) the global emissions in year Y for sector X from the 1.5°C emissions scenario of Rogelj et al. (2015).

As shown in Figure 2, Rogelj et al. (2015) gives a wide 1.5°C compatible emissions range. Here we developed our own scenario within this range, taking into account various considerations, given that the cumulative CO_2 emissions should be consistent with the scientific carbon budget:

- For all sectors except transport, the 85th percentile emissions for 2020 was used. This is because the base year of Rogelj et al's (2015) study is 2010, and emission reductions are therefore assumed to take place between 2010 and 2020. However, as this has not actually transpired, the 85th percentile emissions were used to produce scenarios that reflect the relatively limited emission reductions that have been achieved between 2010 and now. In this way, the resultant emissions scenario has a less dramatic decrease than if the median emissions scenario were used.
- For all sectors except transport, the median emissions for 2030 was used.
- For all sectors except the power sector, the 15th percentile emissions were used for 2040 and 2050.
- For the transport sector to 2030, Rogelj et al's (2015) study is less optimistic about electrification and efficiency improvements than the IEA ETP scenarios. For this reason, under the current scenario, the transport sector emissions were set to be 100% of the emissions in ETP 2°C scenario in 2020 and 90% of the emissions in ETP 2°C scenario in 2030.
- In the power sector, emissions in 2040 onwards are set to zero. This was to avoid negative emissions in the power sector. We assume that the negative emissions needed will be primarily realized by afforestation, soil carbon sequestration and the like.
- Additionally, the 2050 CO_2 emissions are corrected to zero, since a 1.5°C emissions scenario implies net zero CO_2 emissions at around 2050[3].

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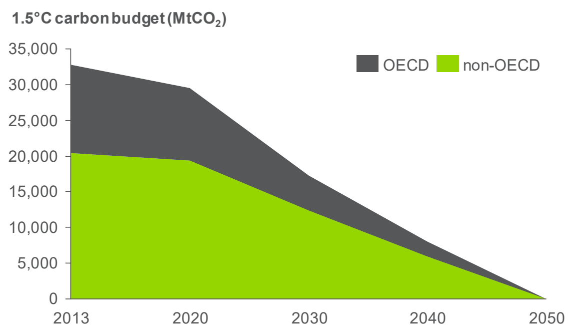
[3] Other greenhouse gases (i.e. non CO_2 gases like methane CH_4 or nitrous oxide N_2O) should be reduced to nearly zero towards 2100.



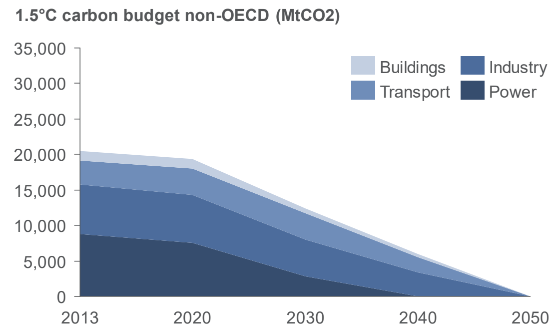


Figure 3. 1.5°C carbon budget OECD and non-OECD (left) and 1.5°C carbon budget non-OECD per sector (right).

Adding non-OECD scenario for AFOLU

Given that the climate change impacts of FMO investments (both negative and positive GHG emissions) are not all energy related, we added a 1.5°C emissions scenario on non-energy related GHG emissions, being the direct emissions from agriculture, forestry and land use change (AFOLU). The AFOLU 1.5°C emissions scenario was taken from the IPCC's Representative Concentration Pathway (RCP2.6). This scenario includes: (1) non-OECD CO_2 emissions from land use change; (2) non-OECD CH4 emissions from agricultural waste burning on fields; (3) non-OECD CH4 emissions from agriculture (animals, rice and soil); (4) non-OECD CH4 emissions from grassland burning; (5) non-OECD CH4 emissions from forest burning; and (6) non-OECD N2O emissions. Although, the RCP2.6 emissions scenario is originally a below 2°C emissions scenario, we assumed the non-CO_2 emissions scenario for agriculture, forestry and land use change to be similar to those for a 1.5°C scenario. As shown in Figure 4, these non-CO_2 emissions from agriculture, forestry and land use change in non-OECD are not zero in 2050. After 2050, these GHG emissions should be reduced to nearly zero towards 2100 by realizing negative emissions through afforestation, soil carbon sequestration and the like.

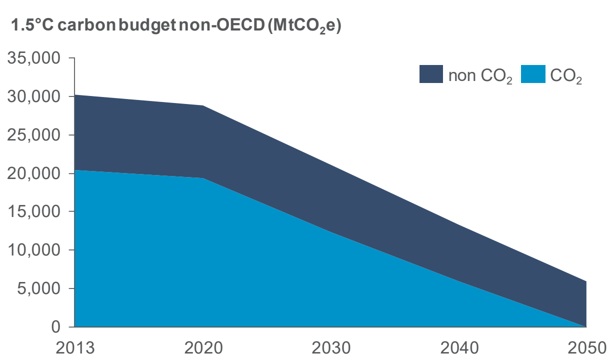


Figure 4. 1.5°C GHG emissions scenario for non-OECD including breakdown in non-CO_2 emissions from agriculture, forestry and land use change and CO_2 emissions from the power, industry, transport and buildings sectors.

Assumptions and limitations

Due to limitations in the available data, assumptions were made to be able to construct a 1.5°C decarbonisation scenario for non-OECD. The most important assumptions and limitations are listed below:

- The regional emissions trajectories are approximations of 1.5°C scenarios adapted from a 2°C emissions scenario. The actual split of the carbon budget between different regions under 1.5°C could differ.
- The scenarios calculated by Rogelj et al. (2015) show a wide range as two integrated assessment models were used and 200 scenarios were assessed. Many of the scenarios evaluated by Rogelj et al assume substantial amounts of negative emissions in the second half of the 21st century. The validity of such scenarios is subject to debate.
- It is assumed that the non-CO2 emissions scenario for agriculture and land use change are similar for the RCP2.6 emissions scenario as for a 1.5°C scenario, as cost of additional mitigation measures in agriculture are very high and the measures to reduce emissions are set at almost maximum potential in both scenarios.
- The level of negative emissions in a 1.5°C scenario is under discussion and depends on early actions. Looking at the increase of global emissions over the past years, more negative emissions are needed. We still assumed that the negative emissions needed will be primarily realized by afforestation, soil carbon sequestration and the like.

ANNEX B: COMPARISON OF FMO's 1.5°C SCENARIO TO IPCC 1.5°C SCENARIOS

Approach

As the FMO 1.5°C scenario was constructed prior to the existence of the IPCC 1.5°C scenarios, we performed a comparison against the IPCC 1.5°C scenarios to assess the consistency of the FMO 1.5°C scenario with limiting global warming to 1.5°C. The emissions in the FMO 1.5°C scenario (developed by Navigant) were compared with the range of low and no overshoot scenarios from the IPCC SR1.5 scenario database[4]. Within this full range, consisting of 52 scenarios, we distinguish a subset of 20 scenarios which we consider "1.5 compatible". This subset excludes scenarios that exceed the BECCS and AFOLU sustainability limits identified in the IPCC SR1.5. Thresholds of 5 GtCO2/yr globally and 3.6 GtCO2/yr globally, are applied for BECCS and AFOLU respectively.

The FMO 1.5°C scenario covers the non-OECD region. This grouping is not available in the IPCC SR1.5 scenario database. Therefore we approximate the grouping by using the following regional groupings: R5ASIA, R5LAM, R5MAF, and R5REF. This grouping excludes R5OECD90+EU, which also includes some non-OECD countries. As a result, the IPCC ranges used in the comparison could represent a slight underestimation of the non-OECD country grouping). The scope of emissions covered also differs between the FMO 1.5°C scenario with the IPCC 1.5°C scenarios. Whereas the IPCC 1.5°C scenarios cover all Kyoto gases, the FMO 1.5°C scenario has a slightly incomplete scope. The scenario covers energy-related emissions, CO_2-process emissions and AFOLU emissions. The scenario does not cover waste emissions, and non-CO2 emissions outside the AFOLU sector (e.g. fugitive emissions in oil and gas extraction).

To be able to compare the scenarios despite these scope differences, we have selected two metrics that are independent of the absolute level of emissions: the emission intensity of the power sector (gCO_2eq/kWh) and the reduction pathway of the total emissions covered since 2013[5], the base year of the FMO scenario. These two metrics give an indication of the alignment of the FMO scenario with the IPCC 1.5°C scenarios.

Findings

Figure 5 shows the emissions intensity of the power sector in the FMO 1.5°C scenario and the IPCC 1.5°C scenario range. FMO power sector emissions intensity falls within the low and no overshoot scenario range, as well as the 1.5 compatible range. This shows that the decarbonisation of the power sector in the FMO 1.5°C scenario is in line with what's required in a scenario limiting global warming to 1.5°C. As decarbonization of power is a major driver of the the global decarbonization, this already provides a good indication of the alignment of the FMO scenario with the IPCC 1.5°C scenarios.

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[4] https://data.ene.iiasa.ac.at/iamc-1.5c-explorer/#/workspaces

[5] To derive 2013 values for the scenarios in the IPCC 1.5°C scenario database and the AFOLU part of the FMO 1.5°C scenario, we used linear interpolation.

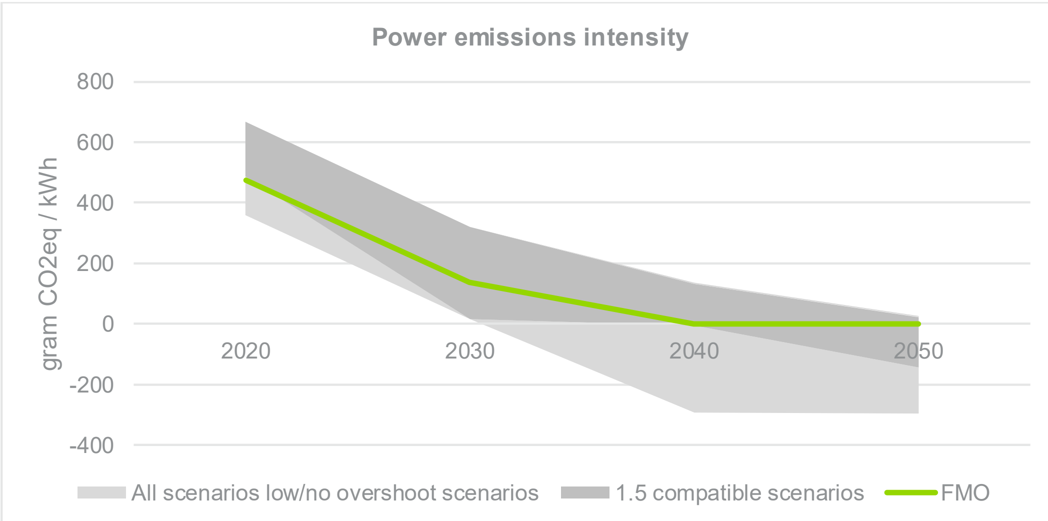

Figure 5. Power emissions intensity (2020-2050)

Figure 6 shows the percentage reduction of the total emissions within the scope since 2013 for the FMO 1.5°C scenario and the IPCC 1.5°C scenario range. The FMO scenario realizes a reduction of 68% below the 2013 level by 2050. The FMO emissions trajectory falls within the low and no overshoot scenario range, but slightly exceeds the 1.5 compatible range in 2030. Overall, this shows that the total emissions trajectory of the FMO scenario is well aligned with scenarios limiting global warming to 1.5°C.

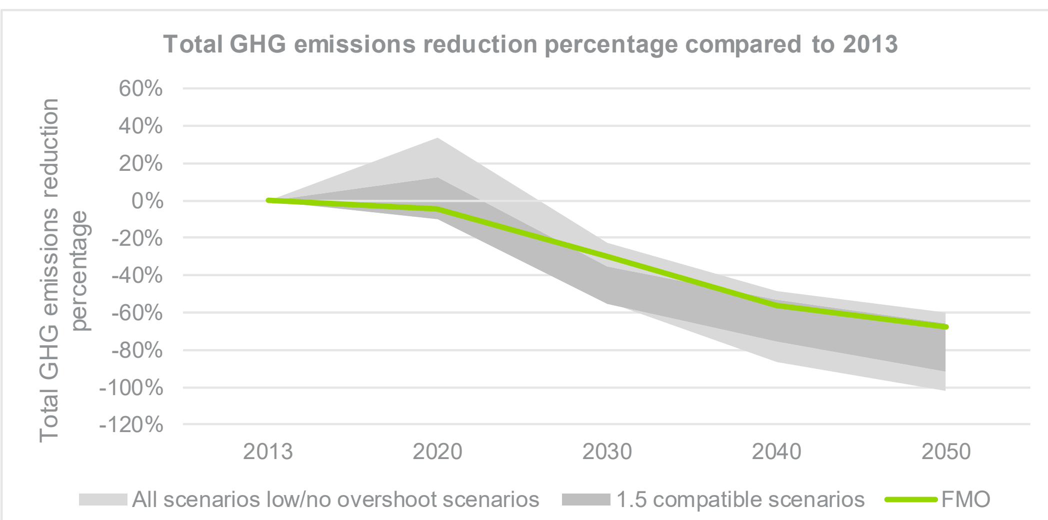

Figure 6. Total GHG emissions reduction percentage compared to 2013