Scenario Supporting Document

PACTA FOR INVESTORS

October 2024

PACTA
Paris Agreement Capital Transition Assessment

Table of Contents

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1. Introduction

RMI's Paris Agreement Capital Transition Assessment (PACTA) is a climate scenario analysis methodology designed to evaluate the alignment of financial portfolios with climate change scenarios, particularly those aligned with the Paris Agreement. By focusing on climate-critical sectors, PACTA aims to identify alignment and potential transition risks, ultimately driving emissions reductions in the real economy.

With RMI's free and open source PACTA for Investors (P4I) web tool, investors can analyze their portfolios using the PACTA methodology. The PACTA for investors tool assesses financial assets, including long positions in listed equities, corporate bonds, and funds. Unlike traditional carbon accounting frameworks that rely on historical data, PACTA utilizes forward-looking production values measured in economic output, providing a more relevant assessment of portfolio alignment with climate scenarios.

Measuring alignment requires well-defined scenarios that outline necessary steps for sector decarbonization. While climate scenarios do not predict the future, they offer critical insights into achieving climate goals. It's essential to compare various scenarios, as they are built on different assumptions and may propose diverse pathways for reaching climate targets. Additionally, not all scenarios encompass every sector, which may necessitate analyzing different sectors with tailored scenarios.

This guide is designed to help PACTA users understand key concepts related to climate change scenarios and considerations when interpreting results. We recommend reading this document alongside the PACTA for Investors methodology for a comprehensive understanding. Furthermore, there is a wealth of literature available on climate change scenarios, including their development and applications. We encourage you to explore these resources further. While we provide a brief overview of the scenarios included in the online tool, we advise reaching out to the scenario provider for in-depth information regarding their methodology and underlying assumptions.

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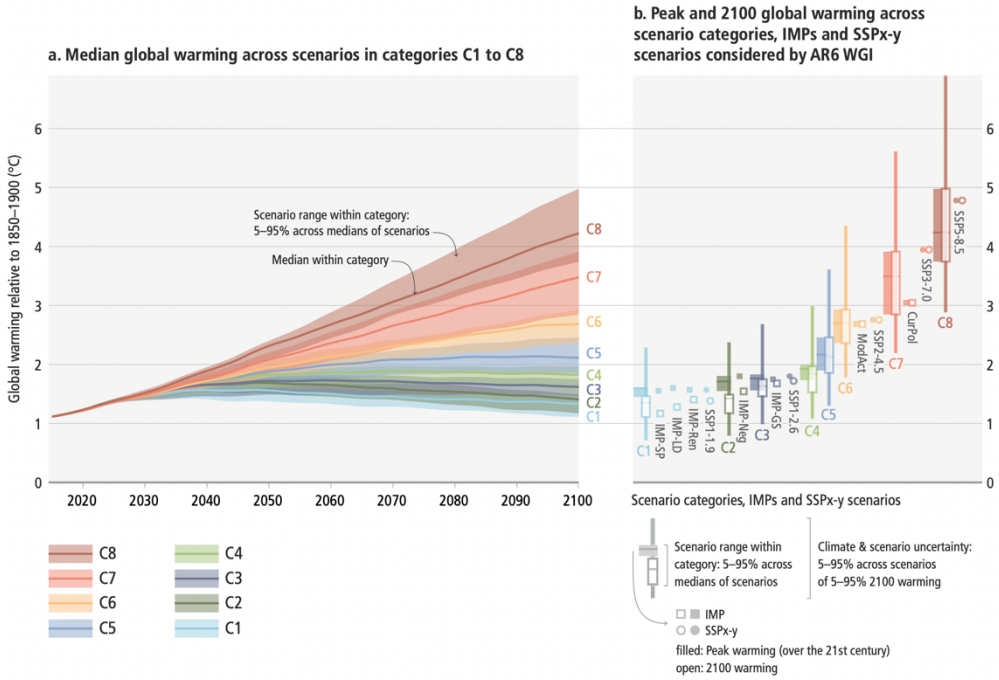
2. What are Decarbonization Scenarios?

Understanding decarbonization scenarios is essential in our efforts to combat climate change. While the future is inherently uncertain, these scenarios provide valuable foresight that helps us plan for potential outcomes. Climate change scenarios integrate scientific, technical, and socio-economic assumptions to illustrate a spectrum of possible futures. They serve as powerful tools, enabling society to grasp the challenges posed by climate change and the risks of inaction today. Essentially, scenarios are derived from research and analysis, presenting different narratives about what the future could look like.

A foundational reference for understanding these scenarios comes from the pathways developed by the United Nations' Intergovernmental Panel on Climate Change (IPCC). The IPCC regularly reviews and updates the latest climate science, forming a crucial basis for international policymaking. It maintains a comprehensive global database of models and over 2,000 scenarios, which it reviews and aggregates to create a categorized set of climate scenarios. These scenarios outline various potential pathways for average global temperature rises by 2100, including their associated probabilities and the techno-economic and social changes required to achieve them.

The IPCC defined eight broad categories of climate scenarios In its sixth review published in February 2022. From these, it developed Illustrative Mitigation Pathways (IMPs) and Shared Socio-economic Pathways (SSPs) for policymakers to consider on a global scale (see Figure 1). These frameworks guide the understanding of potential climate futures and inform strategic decision-making.

Figure 1. the IPCC's eight indicative pathways to the year 2100, published in their AR6 (2022) review

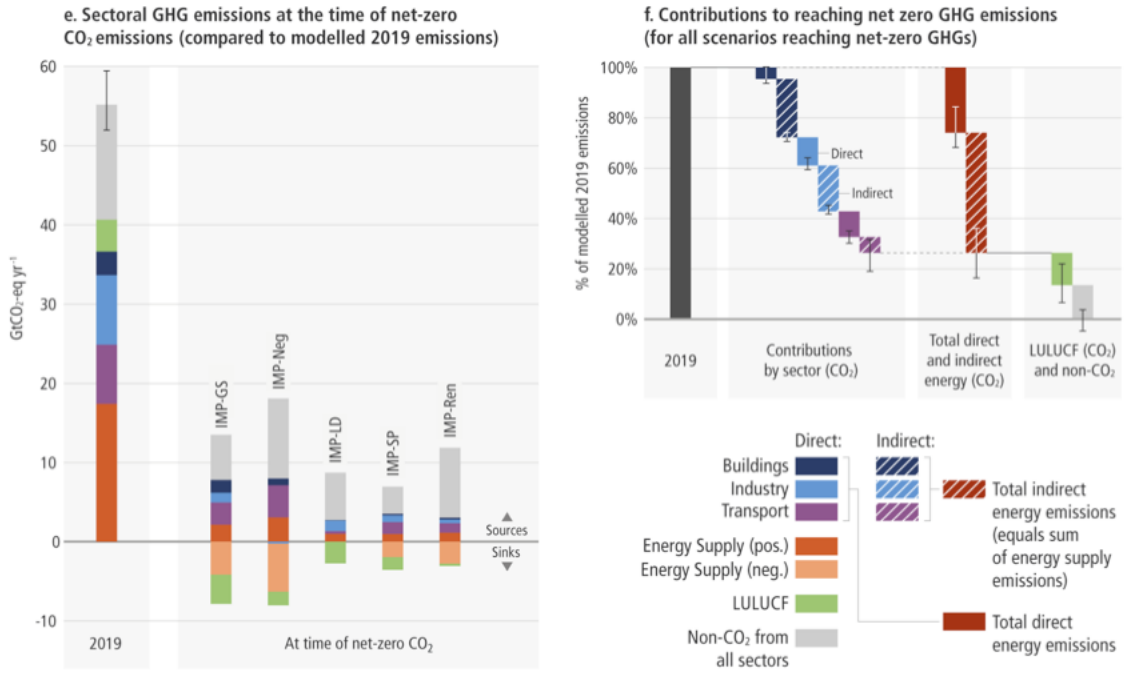


The Shared Socio-Economic Pathways (SSPs) describe different future worlds with contrasting socio-economic conditions and driving forces, including different population growth forecasts. The five pathways comprise:

- SSP1 ´Sustainability´
- SSP2 ´Middle of the road´
- SSP3 ´Regional rivalry´
- SSP4 ´Inequality´
- SSP5 ´Rapid growth / fossil fueled development´

Only SSPs 1 and 2 are modelled to achieve a below 2°C (SSP2) or below 1.5°C (SSP1) world. SSPs 3, 4 and 5 are associated with global warming of below 4°C (SSP3), below 2.5°C (SSP4) and above 4°C (SSP5). The new Illustrative Mitigation Pathways introduced in 2021 are illustrated in Figure 2. They explore different technology transitions, including renewable energy (IMP-Ren), CO_2 removal technology (IMP-Neg) and greater resource efficiency (IMP-LD), as well as a gradual strengthening of mitigation measures (IMP-GS) and sustainable development with a focus on reducing global inequality (IMP-SP).

Figure 2. the IPCC's five Illustrative Mitigation Pathways (IMPs) to the year 2100, published in their AR6 (2022) review



In the last AR6 synthesis report, published in 2023, the IPCC also flagged that limiting global warming to 1.5°C and 2°C requires rapid, deep, and immediate GHG emissions reductions across all sectors, and that under the current situation, high risks, such as extreme weather events are now assessed to occur at lower global warming levels. This report also presented some of the opportunities for scaling up climate -action, as presented in Figure 3.

While it's helpful to grasp the broad changes and investments outlined in the IPCC's SSP and IMP pathways, these frameworks often lack the granularity needed for sector-level analysis in PACTA. Among the scenarios available in the IPCC database are Integrated Assessment Models (IAM), which are more suited for PACTA as they incorporate detailed sector-specific information. These models draw on scenarios developed by organizations like the IEA, the European Commission, the Institute for Sustainable Futures (ISF), and the International Institute for Applied Systems Analysis (IIASA).

Similar to the high-level IPCC pathways, these decarbonization scenarios are typically designed to meet specific carbon budgets and climate mitigation goals. They also illustrate the potential outcomes of various political and economic actions. There are several scenarios that could be utilized in PACTA; while they may share common climate targets, it's crucial to evaluate the underlying assumptions that each scenario provider uses to achieve those targets.

Of particular interest for implementing PACTA are sets of scenarios that reflect varying levels of ambition, especially the sectoral decarbonization pathways they outline. These pathways provide insights into how different technologies may evolve within a sector and how emissions intensity might change as different measures are implemented over time. Key factors that can vary between scenarios include:

- The pace of decarbonization
- The availability, maturity, scalability, and cost of technologies
- The inclusion or exclusion of certain technologies (e.g., reduced reliance on nuclear in the OECM scenario versus a greater emphasis on CCUS in the SDS and B2DS scenarios)
- The ambition level for decarbonization, which affects the likelihood of limiting global temperature rise to below 2°C
- The degree of granularity (temporal, geographical, etc.) in the modeling.

Suggested reading on scenarios

1. Carbon Brief. (2018, April). *Explainer: How 'shared socioeconomic pathways' explore future climate change*. https://www.carbonbrief.org/explainer-how-shared-socioeconomic-pathways-explore-future-climate-change
2. I4CE. (2019, November). *Understanding transition scenarios: Eight steps for reading and interpreting these scenarios*.
3. Institut Louis Bachelier et al. (2020). *Alignment cookbook on choosing one or several scenarios and associated trajectories*.
4. Task Force on Climate-related Financial Disclosures (TCFD). (2017, June). *Technical supplement: The use of scenario analysis in disclosure of climate-related risks and opportunities*.
5. Task Force on Climate-related Financial Disclosures (TCFD). *The use of scenario analysis in disclosure of climate-related risks and opportunities*. https://www.tcfdhub.org/scenario-analysis/

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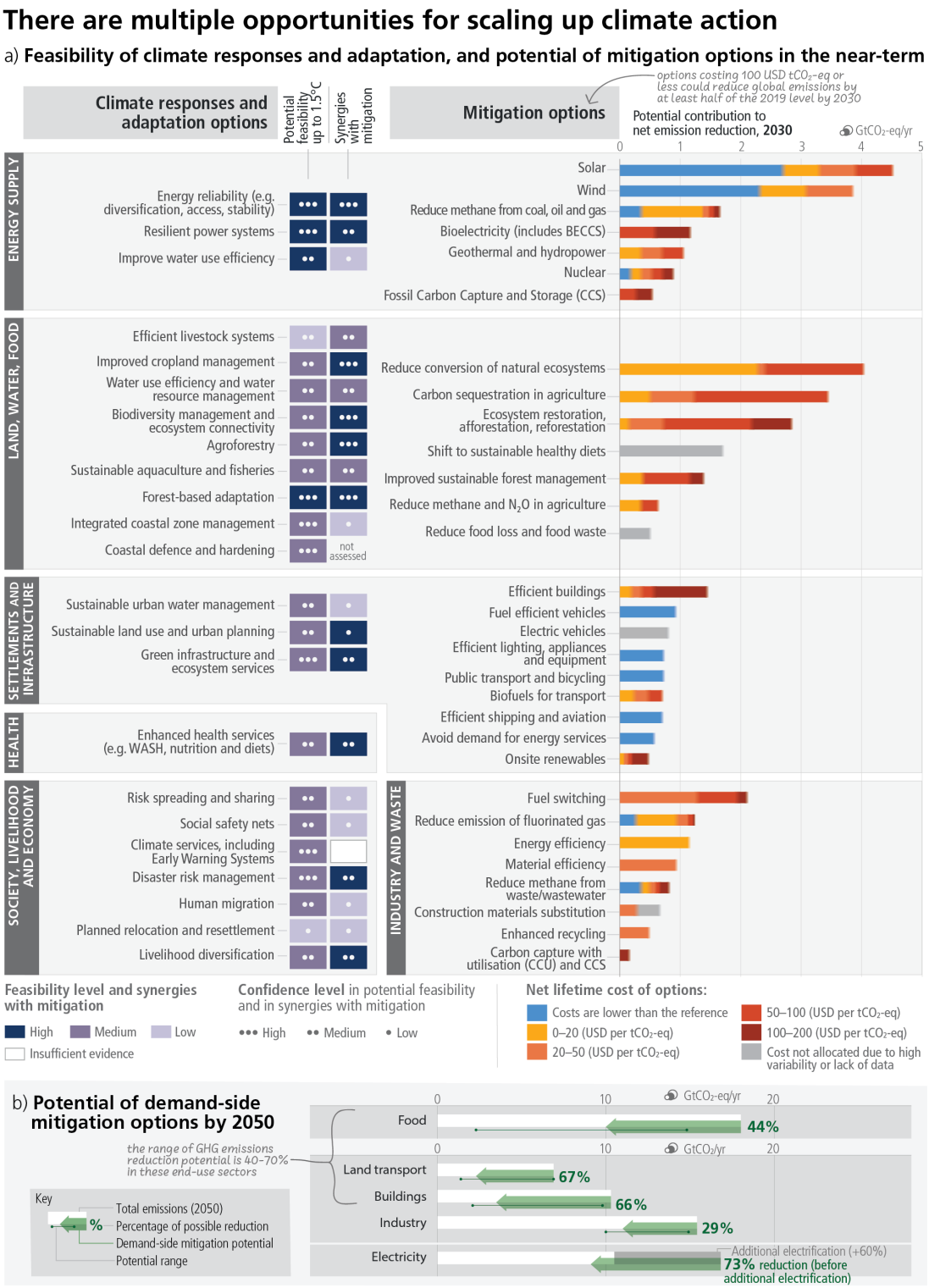
Figure 3. the IPCC's Illustration of Multiple Opportunities for scaling up climate action. AR6 WG2 (2023)



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3. Limitations and Assumptions of scenarios

As we have already emphasized, scenarios and their sectoral pathways are still only depictions and models of possible futures. When conducting scenario analysis on a portfolio it is therefore important to understand the following limitations and assumptions:

3.1 PROBABILITY OF ACHIEVING THE STATED GOALS

The estimated temperature targets associated with climate scenarios typically come with probabilities indicating the likelihood of stabilizing global warming at those levels above pre-industrial temperatures by 2100. For instance, a scenario aligned with a 2°C target might reflect only a 50% chance of achieving that goal, meaning it does not guarantee that global warming will be limited to 2°C. Table 1 compares the global warming targets and associated probabilities of four scenarios included in PACTA.

The selection of a particular scenario (NZE, APS, STEPS) does not represent any opinion by RMI that it is more likely to occur than others. Instead, the assumptions about the market maturity of various technologies within these pathways can offer insights into the overall uncertainty involved (see section 3.2). It's also important to note that the choice of integrating IEA scenarios or those from other providers should not be seen as an endorsement of their underlying assumptions by RMI.

Table 1. Comparison of the global warming goals of four scenarios included in PACTA

Scenario parameters	**IEA Net Zero by 2050 scenario**	**ISF (NZAOA) Net Zero scenario**	**JRC GECO 1.5ºC scenario**
Average global temperature target in 2100	1.4ºC	1.5ºC	1.5ºC
Probability of achieving warming goal by 2100	50%	66%	50%

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3.2 UNDERSTANDING THE ASSUMPTIONS AROUND AVAILABLE TECHNOLOGIES

Some scenarios rely on technologies which are still in the development phase and hence may not be available at the speed and scale that the scenario requires. For example, the IEA 2°C scenario relies on a significant portion of BECS (Bioenergy with Carbon Storage) after 2050, but there are still open questions regarding its technological feasibility.

On the other hand, past IEA scenarios have been quite conservative. They have underestimated both energy efficiency developments and renewable deployment rates (as a result of accelerated reductions in the cost of technologies). This means that the scenarios might not be ambitious enough (compared to what is feasible) and that there is a need for more ambitious scenarios that lead to higher probabilities to limit global warming to well below 2°C, one of the main goals of the Paris agreement.

Table 2 summarises some of the main sources of uncertainty related to technology assumptions for four scenarios included in PACTA, as identified by the scenario developers, as well their main assumptions on technological maturity of solutions.

Table 2. Comparison of the uncertainty factors and technology assumptions of four scenarios included in PACTA

Scenario parameters	**IEA** **Net Zero by 2050 scenario**	**ISF** **Net Zero scenario**	**JRC** **GECO 1.5ºC scenario**
Main identified sources of model uncertainty	Behavioral change, bioenergy, CCUS for fossil fuels	Behavioral change, large-scale deployment of renewables[4]	Carbon price and mitigation policies
Main assumptions on technology maturity	50-60% of required CO_2 reductions are from technologies currently at demonstration or prototype stage.	Only considers theoretical technologies that have demonstrated proof of concept.	A technology learning-curve approach is applied.

3.3 DIFFERENT SCENARIOS ARE UNDERPINNED BY DIFFERENT MODELING ASSUMPTIONS

Scenarios are not future projections, they are estimations and are based on numerous indicators and assumptions, which might not all hold true and will depend on the beliefs of the publishers of the scenarios. Hence, it is important to understand the underlying assumptions behind the scenarios being used. Table 3 compares some these assumptions for four scenarios included in PACTA – including energy demand, fossil fuel use, renewable energy and carbon capture.

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Table 3. Comparison of the major technology assumptions of four scenarios included in PACTA

Scenario parameters	IEA Net Zero by 2050 scenario	ISF Net Zero scenario	JRC GECO 1.5ºC scenario
Primary Energy demand reduction	15% less in 2050 compared to 2020 (Total Energy Supply)	8% less in 2050 compared to 2020	6% less in 2050 compared to 2020
Fossil fuel use and exploitation	No new development or exploitation from 2020 onwards.	Emissions from fossil fuel must decline by more than half by 2030.	Fossil fuel share in the primary energy mix falls around 70% by 2050
The role of renewable energy	Renewable energy generation is 60% of global power generation by 2030	Renewable energy generation share increases from 30% in 2019 to 75% in 2030	Renewable energy accounts for 62% of global power generation in 2030.
The role of nuclear energy	95% growth in nuclear capacity by 2040	No new nuclear power stations	11% growth in nuclear capacity by 2040.
The role of carbon capture utilization and storage	6 Gt CO_2 in 2050	No use of the technology	N/A
Use of nature-based solutions as offsets [7]	No offsets assumed	152 Gt CO_2 in 2050	Use of forest management to mitigate emissions.

3.4 SECTORAL ALIGNMENT TO A SCENARIO

Considering that scenarios are built taking into account a specific remaining carbon budget that is intended to limit global warming to a certain temperature rise, it is recommended to make the PACTA analysis using the same scenario to analyse multiple sectors. This means that in order to claim to be aligned with a specific scenario, all the technologies of the analyzed sector must be aligned with this scenario or with a stricter one from the same scenario set or publication.

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4. Scenarios in PACTA for Investors

PACTA as a methodology is scenario agnostic, however, the methodology requires data with sufficient technological and regional breakdowns; i.e. it should cover the same sectors and ideally provide pathways at a country or regional granularity. Investors can perform a free PACTA analysis of their portfolio through the PACTA for Investors. The process to upload a portfolio and execute the analysis is described in the PACTA For Investors guide. A short description of the scenarios that are currently available in the online tool is provided below.

4.1 WORLD ENERGY OUTLOOK (WEO) 2023

Stated Policies Scenario (STEPS):
The STEPS scenario considers policies that have been implemented by countries. In the STEPS energy demand rises by 1% per year until 2040. More than half of this growth in demand is met by solar photovoltaics (PV) while natural gas enabled by trade in liquefied natural gas (LNG) accounts for a third. Oil demand plateaus in 2030. Despite this, the global economic and population growth means that there is no peak in global emissions ahead of 2040 and hence globally shared sustainability goals (like that set out in the Paris Agreement) are missed.

Announced Pledges Scenario (APS):
This scenario models the new commitments and pledges to meet net-zero emissions targets made by countries in the run-up to COP26. This is equivalent to a warming of 1.7°C at the end of the century. This scenario assumes that countries will implement their plans in time and in full. The projections evidence a decrease in global CO2 emissions driven by the capacity additions of low emission power generation sources in the period to 2030, which generates a decline in coal consumption in the power sector. Announced pledges save around 20% of the gap in emissions until 2030 from the Net Zero Scenario to the Stated Policies Scenario.

Net Zero Emissions by 2050 (NZE):
This scenario extends the Sustainable Development Scenario (SDS) to target net-zero emissions. The scenario responds to the increasing number of countries and companies that have made commitments to reach net zero emissions earlier, combined with the aim of limiting the rise in global temperatures to 1.5°C by the end of the century (with a 50% probability). In particular, it explores the actions needed in the period to 2030 to be on track to achieve net zero emissions by 2050, including the need to end new fossil fuel exploitation from 2021 onwards and to avoid stranded assets across sectors.

For further information about the WEO scenarios, please visit:
IEA World Energy Outlook (2023)

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4.2 GLOBAL ENERGY AND CLIMATE OUTLOOK (GECO) 2023

This edition of GECO offers an updated perspective on the impact of global energy and climate policies on energy trends and emissions, as well as their implications for achieving the goals of the Paris Agreement. The report delivers insights into the investments and new job opportunities needed for the transition to a low-carbon economy. The time horizon extends to 2070. The focus on G20 emitters is accompanied by detailed modeling and analysis of how each country can achieve its climate goals with great granularity.

Reference scenario (Ref):
This scenario models, at the macro-economic level, the effect of enacting current policies that have already been adopted up until 2019. If there are NDC targets at national level but no policies, then these are not taken into account. Macro-economic projections for GDP and population growth are combined with the modelled effects of policies on energy prices and technology development and deployment in order to then make projections for changes in energy systems and CO2 emissions. The global temperature outcome of the scenario is to not exceed 2.7°C with a 67% probability

Nationally Determined Contributions – Long Term low GHG emission development Strategies (NDC-LTC):
This scenario includes the country and NDC pledges updated at COP26. It is based on an implied temperature rise of about 1.7°C by 2100. To achieve the target, additional policies need to be put in place, as current policies would stabilize emissions by 2035-2040. The power sector also play an important role to achieve this scenario target, especially by the reduction of coal power generation. The NDCs covered around 50% of the ambition gap to 1.5°C in 2030. (JRC, 2021)

1.5ºC:
This scenario represents an economically efficient pathway to achieving 1.5°C. The scenario assumes low overshoot by 2050 (1.6°C) with global net-zero GHG emissions reached before 2070. The 1.5°C scenario relies less on unproven technologies like Carbon Capture and Storage. In 2050, global investment is expected to represent 26.4% of global GDP, while it will represent 25.7% of GDP in the Reference scenario. If all the targets are achieved as specified by the scenario there would be at least a 50% chance of limiting global temperature rise to 1.5°C by 2100.

For further information about the GECO scenarios, please visit:
European Commission, Joint Research Centre (JRC) (2023): Global Energy and Climate Outlook 2023: Investment Needs in a Decarbonised World. European Commission, Joint Research Centre (JRC)

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4.3 INSTITUTE FOR SUSTAINABLE FUTURES (UTS-ISF) 2023

Sectoral pathways to Net Zero emissions:
This scenario was developed on the request of the Net Zero Asset Owners Alliance (NZAOA). It presents a contrasting net zero scenario to that of the IEA, with a focus on existing, mature technologies, with the exclusion of carbon capture technologies to achieve net zero and greater overall investment in renewable energy and demand-side efficiency. The scenario is an output of the One Earth Climate Model (OECM). The main scenario assumptions are documented in Table 4. If all the targets are achieved as set out by this scenario there would be at least a 66% chance of limiting global temperature rise to 1.5°C by 2100. Users of this scenario are encouraged to look at the ISF NZ scenario documentation.

For further information about the UTS-ISF scenario, please visit:
UTS - Sectoral pathways (2023)

4.4 SUMMARY OF SCENARIOS INCLUDED IN PACTA FOR INVESTORS

Table 4. Summary of scenarios included in the PACTA for Investors tool.

Scenario	Sectors Covered	Global Average Temperature rise in 2100	Probability	Publication	Abbreviation
Net Zero by 2050	Oil and Gas, Coal, Power, Automotive, Steel, Cement, Aviation	1.4°C	50%	IEA, NZE report	NZE_2050
Announced Pledges Scenario	Oil and Gas, Coal, Power, Automotive	1.7°C	50%	IEA, WEO 2023	ADS
Stated Policy Scenario	Oil and Gas, Coal, Power, Automotive	2.4°C	50%	IEA, WEO 2023	STEPS
Baseline	Power, Automotive, Oil & Gas	2.7°C	67%	JRC, GECO 2023 Baseline	
NDC LTS	Power, Automotive, Oil & Gas, Coal	1.9°C	67%	JRC GECO 2023, NDC LTS	
1.5C	Power, Automotive, Oil & Gas, Coal, Aviation, Steel	1.5°C	50%	JRC GECO 2023, 1.5C	
ISF Net Zero Scenario	Power, Coal, Oil & Gas	1.5°C	66%	ISF 2023, Sectoral Pathways to Net Zero Emissions	ISF_NZ

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