Impact Analysis of E-kerosene on Aviation CO_2 Emissions up to 2100

Guilherme da Silva Nheu Quaresma

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Orientador: Prof. Doutor André Resende Rodrigues da Silva
Co-orientador: Prof. Doutora Ana Filipa da Silva Ferreira
Co-orientador: Prof. Doutor Leandro Barbosa Magalhães

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Resumo

No âmbito da busca global por uma aviação sustentável, impulsionada por iniciativas como a Waypoint 2050 apresentada pelo Grupo de Ação do Transporte Aéreo (ATAG), esta dissertação analisa o potencial que os e-combustíveis, especificamente o e-querosene, podem ter na mitigação das emissões de CO_2 no setor da aviação até 2100. Alinhado com os objetivos ambiciosos delineados no Acordo de Paris e nos objetivos sustentáveis da Organização da Aviação Civil Internacional (OACI), este estudo utiliza o Modelo do Sistema Dinâmico de Frota (FSDM) e uma abordagem baseada na fórmula do Comité de Proteção Ambiental da Aviação (CAEP) para projetar a necessidade de combustível e as emissões de CO_2. À medida que o setor aeronáutico recupera dos efeitos do COVID-19, o estudo destaca a necessidade urgente de soluções sustentáveis e enfatiza o papel indispensável dos e-combustíveis na promoção de um futuro neutro em carbono. Os resultados realçam o papel crítico dos e-combustíveis na execução dos objetivos estabelecidos pelas organizações a longo prazo, com foco na capacidade de produção, sugerindo que uma taxa anual de produção de e-querosene de 15% poderia atingir um crescimento neutro de carbono em 2046 e reduzir as emissões em metade por volta de 2061 em comparação com os níveis de 2005, sublinhando a necessidade de ajustes na indústria para garantir um futuro sustentável. O estudo destaca a importância dos e-combustíveis, juntamente com avanços tecnológicos, no cumprimento de metas ambiciosas de combate às alterações climáticas, ao mesmo tempo que se adapta à expansão contínua do setor da aviação.

Palavras-chave

E-combustíveis, Aviação, Emissões de CO_2, E-querosene, Modelação, Impactos ambientais

Abstract

Amidst the global pursuit for sustainable aviation, catalyzed by initiatives such as Waypoint 2050 set forth by the Air Transport Action Group (ATAG), this dissertation scrutinizes the transformative potential of e-fuels, specifically e-kerosene, in mitigating CO_2 emissions within the aviation sector until 2100. Aligned with the ambitious objectives outlined in the Paris Agreement and the International Civil Aviation Organization (ICAO) sustainable goals, the study employs the Fleet System Dynamics Model (FSDM) and an approach based on the formula from the Committee on Aviation Environmental Protection (CAEP) to forecast fuel demand and CO_2 emissions. As the aviation industry charts a course towards recovery from effects of the COVID-19 pandemic, this research highlights the imperative for sustainable solutions and underscores the indispensable role of e-fuels in fostering a carbon-neutral future. The findings emphasize the critical role of e-fuels in achieving long-term sustainability goals, with a focus on production capacity and transition timelines, suggesting that a 15% annual e-kerosene production rate could lead to carbon-neutral growth by 2046 and cut emissions by half around 2061 concerning 2005 levels, emphasizing the need for industry adjustments to ensure a sustainable future. The study underscores the importance of e-fuels, alongside technological advancements, in meeting ambitious climate targets while accommodating the aviation sector's continued expansion.

Keywords

E-fuels, Aviation, CO_2 Emissions, E-kerosene, Modeling, Environmental Impacts

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List of Acronyms

AIM	Aviation Integrated Model
ATAG	Air Transport Action Group
ATM	Air Traffic Management
ASTM	American Society for Testing and Materials
ATJ	Alcohol to Jet
ATR	Auto-thermal Reforming
ASK	Available Seat Kilometer
ATK	Available Tonne Kilometer
APF	Airline Procedures File
BADA	Base of Aircraft Data
BAU	Business As Usual
CAEP	Committee on Aviation Environmental Protection
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CHJ	Catalytic Hydrothermolysis Jet
CC	Carbon Capture
CLC	Chemical Looping Combustion
CAPEX	Capital Expenditure
CMO	Commercial Market Outlook
COVID-19	Coronavirus Disease 2019
DFSTJ	Direct Fermentation of Sugar to Jet
DAC	Direct Air Capture
DME	Dimethyl Ether
DTI	Department of Trade and Industry
EU	European Union
FT	Fischer-Tropsch
FSDM	Fleet System Dynamics Model
FAP	Fleet Assignment Problem
FCECT	Fuel Consumption and Emissions Calculation Tool
GFMC	Global Fleet Mission Calculator
GDP	Gross Domestic Product
HEFA	Hydroprocessed Esters and Fatty Acids
HC	Hydrocarbon
ICAO	International Civil Aviation Organization
IATA	International Air Transport Association
IPCC	Intergovernmental Panel on Climate Change
IE	Income Elasticity
LCA	Life Cycle Analysis
OAG	Official Airline Guide
OPF	Operational Performance File

PtL	Power-to-Liquid
PtG	Power-to-Gas
POX	Partial Oxidation
PSA	Pressure Swing Adsorption
PEM	Polymer Electrolyte Membranes
PTF	Performance Table File
PDT	Performance Data Table
RWGS	Reverse Water Gas Shift
RPK	Revenue Passenger Kilometer
RTK	Revenue Tonne Kilometer
RCPs	Representative Concentration Pathways
SAF	Sustainable Aviation Fuel
SIP	Synthesized Iso-Paraffins
SKA	Synthesized Kerosene with Aromatics
SPK	Synthetic Paraffinic Kerosene
Syngas	Synthetic gas
SR	Steam Reforming
SOE	Solid Oxide Electrolyzer
SSPs	Shared Socioeconomic Pathways
SPC	Single production Capacity
SA	Single-Aisle
SMC	Single Mission Calculator
SPAs	Shared climate Policy Assumptions
TRL	Technology Readiness Level
TPC	Total Production Capacity
TA	Twin-Aisle
TUM	Technical University of Munich
UNDP	United Nations Development Programme

bpd	barrels per day
tpa	tonnes per annum
tpd	tonnes per day

Nomenclature

Symbols in Italic script

ASK	Transport supply (passengers)	$seat \cdot km$
ATK	Transport supply (freight)	$ton \cdot km$
BH	Block Hours	h
MH	Maintenance hours	h
POS	Percentage of survival	%
RPK	Transport demand (passengers)	$seat \cdot km$
RTK	Transport demand (freight)	$ton \cdot km$
TH	Turn-around hours	h
UH	Utilization hours	h
a	Age of aircraft	$year$
d	Great circle distance between an O-D pair	km
f	Number of flight frequencies	-
flf	Freight load factor	%
n	Number of aircraft units	-
p	Number of passenger transported	-
s	Number of seats	$seat$
slf	Seat load factor	%
t	Tons of freight capacity	ton

Symbols in Greek script

α	$MH/BH - ratio$	-
β	Retirement coefficient	-

Subscripts

k	One particular flight
t	Year of simulation
i	One particular route of the airline's routes network
j	One particular aircraft unit of the airline's fleet
I	First retirement coefficient
II	Second retirement coefficient
max	Maximum value

Chapter 1

Introduction

This chapter outlines the increase of aviation emissions linked with the remarkable growth observed in the sector, despite the direct effects caused by the COVID-19 pandemic, emphasizing the urgency and relevance of the issue at hand, which support the need for the proposed work. Following this, strategic measures proposed by prominent organizations are presented with the aim of promoting the decarbonization of the aviation sector by the year 2050. Lastly, in this chapter are presented the objectives of the present work and the structure of the dissertation.

1.1 Background and Motivation

Aviation is widely recognized as a necessary mode of transportation that ensures global connectivity, despite its historical dependence on economic and political factors. The amount of air travel has doubled every fifteen to twenty years since the dawn of the jet era, making it the fastest-growing mode of transportation [1]. However, due to the COVID-19 pandemic, the aviation industry was one of the economic sectors severely impacted by the pandemic outbreak [2]. According to the International Civil Aviation Organization (ICAO) [3], in 2020, aviation passenger affluence decreased by 60% compared to the year before, causing a loss of USD 372 billion in gross passenger operating revenue of airlines. By the end of 2022, ICAO estimated this decrease to be around 30%, compared to 2019, noticing an incredible recovery from 2020, as shown in Figure 1.1. By 2025, passenger affluence is expected to rise to 111% compared with pre-pandemic values [4].

The task of achieving net-zero of CO_2 emissions by 2050 of the global economy across all sectors is necessary to keep global mean temperature at 1.5° C. Many nations and businesses have already set net-zero emissions targets by increasing energy efficiency and transitioning to non-emitting electrical sources. Aviation sector stands out as one of the main contributors to CO2 emissions. Though, since aircraft rely on energy-dense liquid hydrocarbons and flights also involves non-CO_2 radiative forcing, the aviation sector is difficult to be decarbonized [5]. To date, there are no working examples of long-distance, zero-carbon commercial airplanes and, besides the fact that aviation emissions only represent less than 3% of the world's greenhouse gas emissions, they are increasing quickly [6]. The aviation industry is under more pressure than ever before to minimize its carbon impact as the movement toward carbon-neutral transportation continues. Also, as mentioned, it is anticipated that commercial aviation traffic will resume the steady growth it had before the pandemic, underscoring the necessity for lower emissions [7].

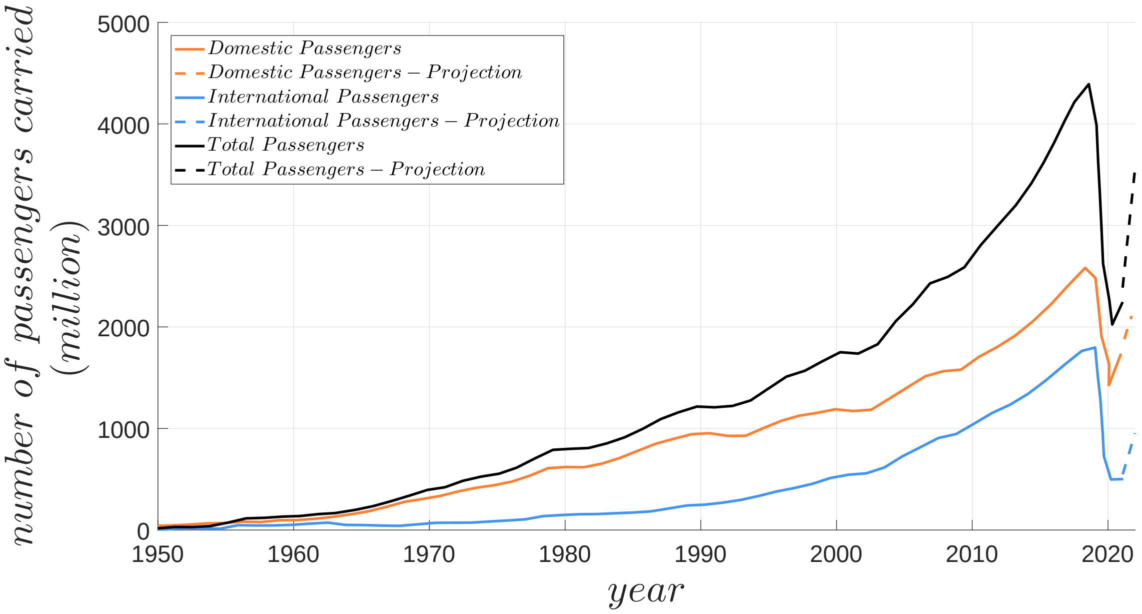


Figure 1.1: Global passengers carried from 1945 until 2022 projections [7].

According to the International Air Transport Association (IATA) [8], it is expected that the demand for air travel will increase significantly until 2050, reaching over 10 billion individual air passenger journeys. So, following this data, carbon dioxide emissions are predicted to continue growing, duplicating their value in 2050, in comparison to the year 2020, as shown in Figure 1.2. Therefore, the Paris Agreement's (2009) climate change goals put aviation and other industries under a lot of strain and environmental scrutiny, where the aviation industry is committed to achieve a 50% reduction in CO_2 emissions by 2050 compared to levels of 2005 [9]. However, more recently, the Air Transport Action Group (ATAG), composed of the main aviation industry stakeholders, came up with Waypoint 2050, where the main purpose is to reach net-zero carbon emissions by the year 2050, mitigating 21.2Gt of CO_2 [8]. There are four primary pillars to achieve this goal [10]:

- Sustainable aviation fuels (SAF);
- Investment in new aircraft technologies;
- Improvement in air traffic management and infrastructure;
- Offsetting or out-of-sector carbon reductions.

The escalating demand for aviation fuel (jet fuel) is a direct consequence of the increasing requirements of air traffic, contributing significantly to the surge in aviation emissions. According to [9], the annual global production of jet fuel stands at approximately 80 billion gallons. Acknowledging this, the potential of alternative fuels to curtail carbon

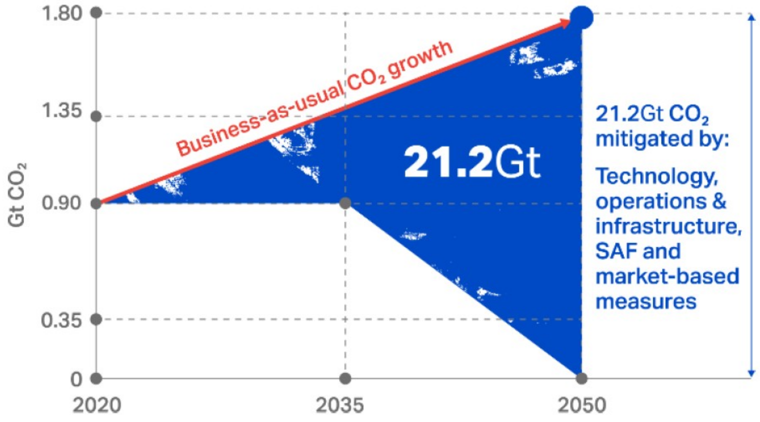


Figure 1.2: Estimated projections of CO_2 emissions until 2050 [8].

emissions has been widely recognized and e-fuels could compose a sustainable solution [11]. For instance, [12] asserts that sustainable aviation fuels represent a key pathway towards achieving climate change goals, given their ability to reduce greenhouse gas emissions throughout their life cycle. Nevertheless, it is imperative to recognize the limitations inherent in relying solely on Sustainable Aviation Fuels (SAF) to attain net-zero carbon emissions, as highlighted by [13]. Consequently, a holistic approach is essential, necessitating a focus on promising solutions across various domains, including aerodynamics, propulsion, structures, operations, and materials [14]. This comprehensive strategy, as illustrated in the flowchart in Figure 1.3 [15], aims to address the multifaceted challenges associated with achieving sustainability in the aviation sector.

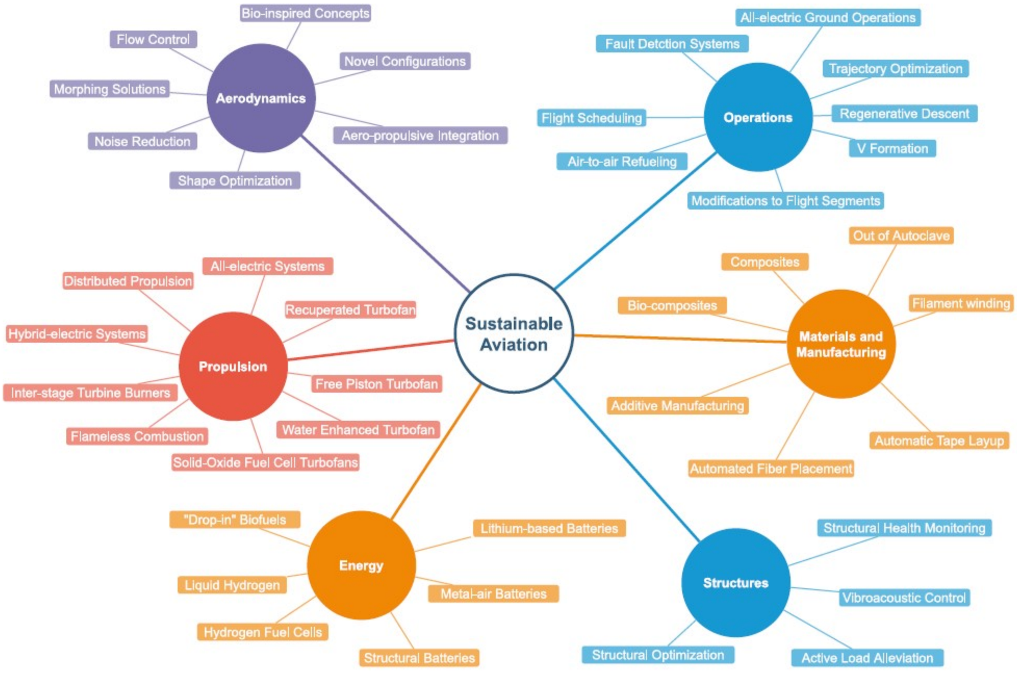


Figure 1.3: Principal disciplines in the aviation industry to achieve sustainable aviation [15].

If industry tactics are not adjusted, CO_2 emissions will rise with the reported expansion of the aviation sector. Hence, it will be required to assess which long-term measures are appropriate to reduce the damage caused by aviation and whether the suggested climate targets can be achieved, leading to the motivation for this work.

1.2 Objectives

The main objective of this dissertation is to evaluate the impact of e-fuels (e-kerosene) in aviation CO_2 emissions until 2100 and verify if is possible to achieve the environmental goals established by the aeronautical sector organizations. Considering that, the following objectives are set:

1. Find the primary factors to decarbonize the aeronautical sector;
2. literature review of e-fuels as an alternative aviation fuel and approaches to obtain aviation CO_2 emissions;
3. Apply the air transport system model to predict fuel demand and CO_2 emissions until 2100;
4. Model the impact of e-kerosene as a sustainable aviation fuel on global aviation emissions.

1.3 Dissertation Structure

The remaining of this dissertation is divided into six chapters. **Chapter 2** details the main factors and implements measures to reduce carbon emissions in the aeronautical industry. This chapter also reviews some models and approaches that evaluate the development in mitigating the CO_2 emissions of the aeronautical sector. In **Chapter 3** the method used to obtain the fuel demand and CO_2 emissions until 2100 is described. The Fleet System Dynamics Model is employed along with the concept of Shared Socioeconomic Pathways to obtain the Business-as-Usual prediction of aviation emissions and fuel demand. **Chapter 4** presents the e-fuels as a recent alternative for aviation fuel and describes the approach to obtain the impact analysis on aviation CO_2 emissions. **Chapter 5** details the major results of this work. Lastly, **Chapter 6** presents the conclusions, connecting with the objectives of this dissertation. To wrap up, there are recommendations for future works.

Chapter 2

State-of-the-Art

This chapter depicts the principal solutions to reduce aviation carbon emissions, what are the essential drivers, and options to decarbonize the aviation sector, emphasizing a detailed analysis of alternative fuels. To assess the problem of CO_2 emissions and determine the fuel demand in aviation it is necessary to select a model able to determine the performance of air transport in terms of fuel consumption and emissions, predict the future economy, and simulate up to 2100. This chapter showcases current models possessing these capabilities.

2.1 Main target solutions to decarbonize carbon emissions in the aviation industry

As mentioned in Chapter 1, concerns about increasing global warming are becoming ever more significant. Thus, it is necessary to implement measures aimed at reducing greenhouse gas levels, with a primary focus on carbon dioxide emissions. The development of new technologies, increasing aircraft efficiency, streamlining air traffic control operations, improving local infrastructure to lessen environmental impact, putting in place economic incentives for businesses to cut emissions, and eventually incorporating SAF with low carbon footprints are the main strategies for the aviation industry to meet the suggested climate objectives.

2.1.1 Entities Measures and Initiatives

With the concern to reduce carbon emissions, organizations such as IATA, ICAO, and ATAG have created measures and plans to combat the global temperature increase. Waypoint 2050 [10], a project developed by ATAG and encompassing numerous companies in the aerospace industry, aims to achieve net-zero carbon emissions by 2050. Another initiative aimed at mitigating the impact of climate change is the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) [16], established by ICAO. This project aims to restrict greenhouse gas emissions. In a broader context, the United Nations Development Programme (UNDP) established the 2030 Agenda for Sustainable Development, which includes the Sustainable Development Goals created in 2022 as a ”road map out of crisis” [17]. In line with these initiatives, the predominant pillar for reducing emissions is Sustainable Aviation Fuel (SAF), underscoring its significant impact on environmental sustainability in the aviation sector.

2.1.2 Sustainable Aviation Fuels

The development of alternative aviation fuels will be the push necessary to reach net-zero carbon in 2050. SAF are estimated to contribute around 65% in the emissions reductions. Achieving this target will require an enormous effort to increase production [18]. The two main drop-in alternatives are biofuels and synthetic fuels. The alternative fuel obtained via feedstocks or any renewable carbon-based material are biofuels. Synthetic fuels or e-fuels, in contrast to biofuels, do not need biomass to produce liquid hydrocarbons, potentially becoming the best solution short/medium-term of reaching net-zero [7].

Biofuels

Biofuels are obtained via biomass feedstocks, such as agriculture and forest residues, that went through thermochemical or biological conversion processes [15, 19]. Since 2021, there are nine pathways certified by ASTM international (American Society for Testing and Materials), Table 2.1, Fischer-Tropsch hydroprocessed synthesized paraffinic kerosene (FT), Synthesized paraffinic kerosene from hydroprocessed esters and fatty acids (HEFA), Synthesized iso-paraffins from hydroprocessed fermented sugars (SIP), Synthesized kerosene with aromatics derived by alkylation of light aromatics from non-petrole-um sources (FT-SKA), Alcohol to jet synthetic paraffinic kerosene (ATJ-SPK), Catalytic hydrothermolysis jet fuel (CHJ), Synthesized paraffinic kerosene from hydrocarbon-hydro-processed esters and fatty acids (HC-HEFA-SPK), Co-hydroprocessing of esters and fatty acids in a conventional petroleum refinery (co-processed HEFA) and Co-hydroprocessing of Fischer-Tropsch hydrocarbons in a conventional petroleum refinery (co-processed FT) [4]. From these pathways, SIP, HC-HEFA-SPK, co-processed HEFA, and co-processed FT can't be blended at a ratio of 50% with conventional jet fuels. The first two can only be mixed at a ratio by volume of 10%, and the others only with 5%.

Table 2.1: ASTM certified SAF production pathways. [4]

ASTM Reference	Production Pathway	Approved On	Feedstocks Used	Permissible Blending Ratio by Volume (%)	Commercialization Projects/Proposals
ASTM D7566-Annex 1	FT	September 2009	Carbon-based biomass	50	Fulcrum Bioenergy, Red Rock Biofuels, SG Preston, Kaidi, Sasol, Shell, Syntroleum
ASTM D7566-Annex 2	HEFA	June 2011	Oil-based feedstock	50	World Energy, Honeywell UOP,Neste Oil,Dynamic Fuels,EERC
ASTM D7566-Annex 3	SIP	June 2014	Lignocellulosic biomass	10	Amyris,Total
ASTM D7566-Annex 4	FT-SKA	November 2015	Carbon based biomass	50	Sasol
ASTM D7566-Annex 5	ATJ (Isobutanol)	April 2016	Alcohol or sugar-based feedstock	50	Gevo, Cobalt, Honeywell UOP, Lanzatech, Swedish Biofuels, Byogy
	ATJ (Ethanol)	April 2018			
ASTM D7566-Annex 6	CHJ	February 2020	Algae, waste oil, oil plant	50	Applied Research Associates (ARA)
ASTM D7566-Annex 7	HC-HEFA-SPK	May 2020	Algae	10	IHI Corporation
ASTM D1655 -Annex A1	co-processed HEFA	April 2018	Oil-based feedstock	5	
ASTM D1655-Annex A1	co-processed FT	May 2020	Carbon-based biomass	5	Fulcrum

Fischer-Tropsch

The Fischer-Tropsch synthesis is a chemical technique employed to generate liquid hydrocarbons such as gasoline, kerosene, diesel, and lubricants. The reactor type and catalyst utilized in the FT process determine the type and amount of resulting products. Coal, natural gas, or biomass are commonly used as feedstocks to produce syngas (CO and H_2), which is used in the FT synthesis. However, since coal and natural gas are non-renewable resources, they are unsuitable for sustainable aviation fuel production [2]. The FT synthesis can be separated into three different major stages, converting biomass to synthesis gas, converting synthesis gas to oil, and refining oil to SAF, as shown in Figure 2.1. The first step in the FT process involves the production of synthesis gas (comprising hydrogen and carbon monoxide), from which impurities such as CO_2 are removed. Following this, the FT synthesis generates straight-chain hydrocarbons, constituting an indirect liquefaction process. Finally, the hydrocarbon chains undergo isomerization and cracking to produce smaller units, thereby upgrading the products to liquid fuel [4]. One advantage of SAF production via Fischer-Tropsch process is that the aromatics concentration is within the permissible range, making it possible to mix with jet fuel [20].

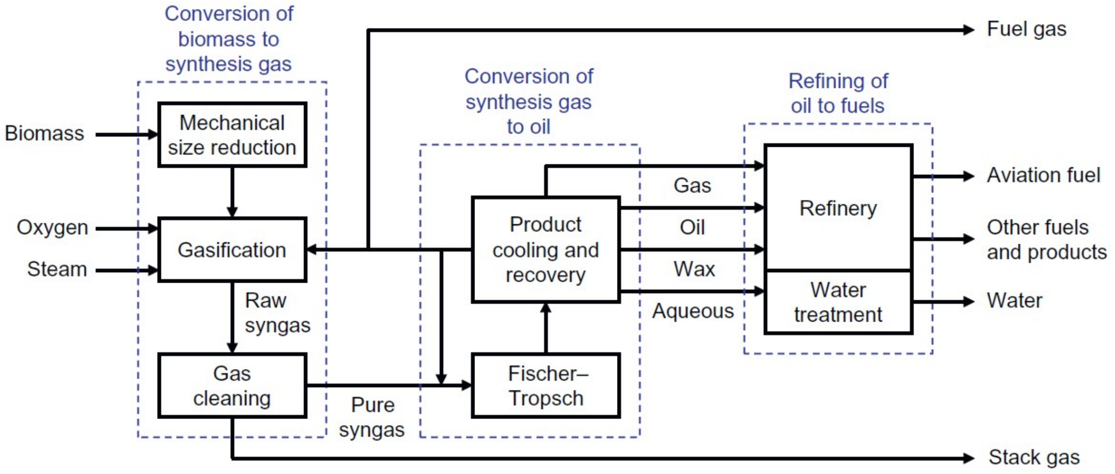


Figure 2.1: Biomass-to-liquids process based on Fischer-Tropsch synthesis to produce aviation fuels [21].

Hydroprocessed Esters and Fatty Acids

Animal fats, vegetable oils, and algae oils are all natural derivatives that are used as feedstocks in the production of hydroprocessed esters and fatty acids, or HEFA. It turns out that HEFA frequently uses leftover oils and fats, which are sources that can be considered more sustainable. It is also important to remember that the primary feedstock is triglycerides, which are the components of fats and oils. An advantage that sticks out from this process is that the first reaction is exothermic, meaning that the energy involved in the first reaction reduces the overall energy expenditures for the entire process [2]. Through a four-step process, HEFA converts oil from lipids to hydrocarbons. The purification of the biogenic material makes up the first stage. Following that, the oil undergoes a deoxygenation stage by a chemical reaction involving hydrogen and catalysts (hydrodeoxygenation). In this stage, more undesirable compounds are also eliminated. Once the chain lengths meeting the required parameters are attained, the resultant hydrocarbons are cracked and isomerized. After distillation, the final components are separated, and the jet fuel obtained is given the HEFA-SPK designation [7]. The overall process is demonstrated in Figure 2.2.

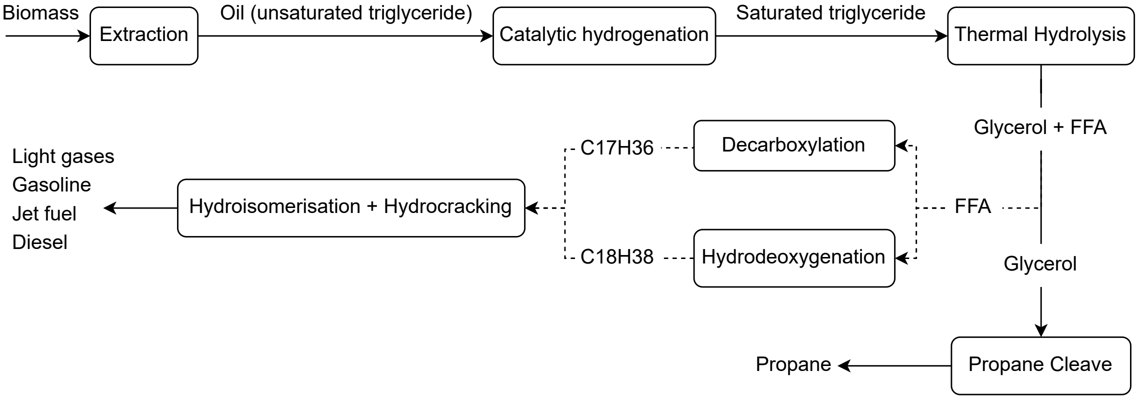


Figure 2.2: HEFA process for the production of jet fuel [22].

Synthesized Iso-Paraffins

This pathway, Figure 2.3, was incorporated into ASTM D7566 in June 2014. Synthesized Iso-Paraffins (SIP), also known as Direct Fermentation os Sugar to Jet (DFSTJ), relies in sugar cane, beet, maize, and pre-treated lignocellulosic biomass as feedstocks. The SIP synthesis depends on six steps: pretreatment and conditioning, enzymatic hydrolysis, clarification of hydrolysate, biological conversion, hydroprocessing, and final purification. Basically, enzymatic hydrolysis is used to pre-treat the biomass, and the concentrated sugars are separated from the solubilized sugars. The pre-treated material is then biologically converted to create an intermediate hydrocarbon, which is then oligomerized and hydrotreated to create gasoline. In this regard, it appears that, in order to obtain farnesane, the intermediate component must first be separated into a solid and liquid part, followed by a separation into an oily and aqueous phase by centrifugation [2, 4, 22].

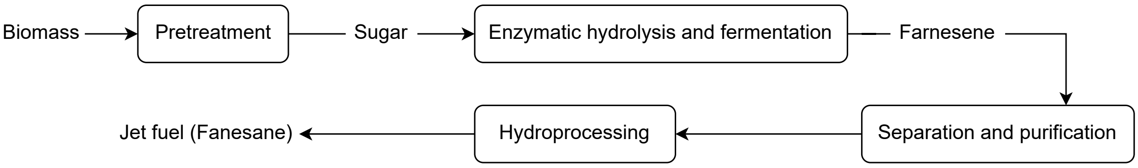


Figure 2.3: SIP process for the production of jet fuel (Farnesane) [22].

Alcohol to Jet

Alcohol to Jet (ATJ) pathway produces synthetic paraffinic kerosene (SPK) from alcohol. This route was approved in 2016 by ASTM, incorpotated into ASTM D7566. According to the literature, ATJ fuel is produced by dehydration, oligomerization and hydroprocessing of ethanol or iso-butanol, as shown in Figure 2.4. ATJ process relies on a vast range of feedstocks: sugary and starchy biomass or lignocellulosic biomass like corn grain, switchgrass, and sugarcane. At the time of approval, only iso-butanol was allowed for production. Only in 2018, ethanol was included as an ATJ feedstock. The maximum blend ratio allowed is 50% [4, 7, 23].

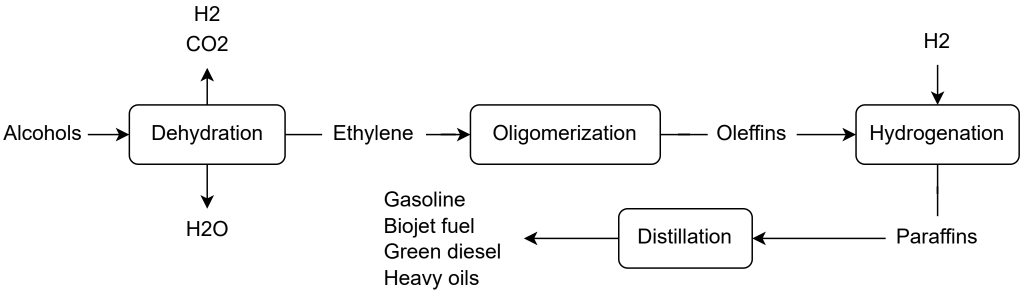


Figure 2.4: ATJ process for the production of jet fuel [23].

E-fuels

E-fuels, unlike biofuels, are not dependent on biomass to generate liquid hydrocarbons. This type of synthetic fuel is obtained by merging carbon dioxide or nitrogen with hydrogen [24]. In the process of creating e-fuel, as shown in Figure 2.5, one of the methods is using renewable electricity to split water into green hydrogen and oxygen through a process called electrolysis. The hydrogen is then combined with carbon dioxide, which can be captured from the atmosphere or industrial processes, to create a hydrocarbon molecule using a process called Fischer-Tropsch synthesis. Hydrocarbon molecules are then refined to create e-fuel that can be used in conventional combustion engines. The final product is a liquid fuel that is chemically identical to fossil fuels but with lower carbon emissions since it is created from renewable energy sources. The production of e-fuel requires a significant amount of energy and can be expensive compared to traditional fossil fuel refining processes. However, technology is constantly improving, and with the use of renewable energy sources, the carbon footprint of e-fuels can be much lower than that of fossil fuels [25].

Literature Review - E-fuels

The study conducted by Zang et al. [26] evaluated the well-to-wheel (WTW) greenhouse gas emissions from fuels produced through Fischer-Tropsch, throughout the course of

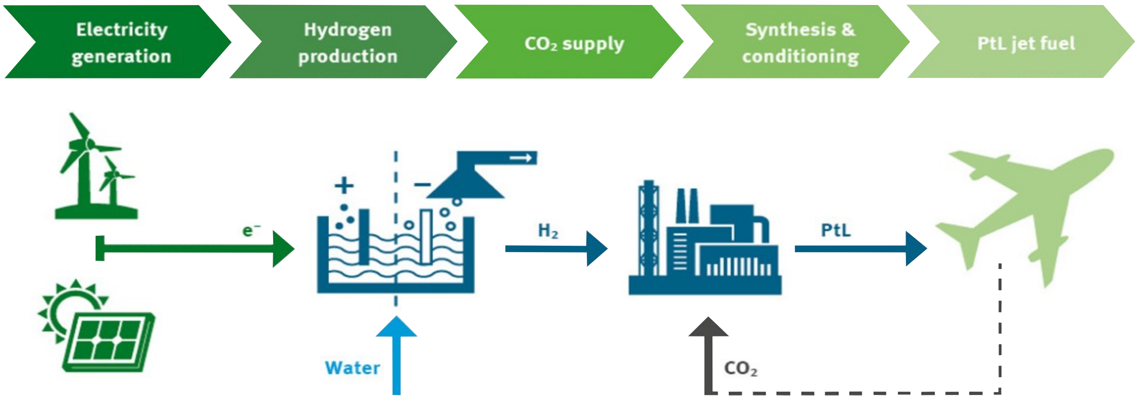


Figure 2.5: Generic Power-to-liquid production stages. [7]

their full lifespan using a variety of process designs and system boundaries. The study's main objective was to investigate several electrolytic H_2 pathways and CO_2 sources, in which, two systems were considered with different boundaries: one is a stand-alone plant, where CO_2 comes from any source, and the other is an integrated plant, which uses corn ethanol production as a supplier of CO_2. The analysis concluded that WTW greenhouse gas emissions in the first system were reduced by 90-108%, and that in the integrated system the WTW greenhouse gas emissions are 57-65% lower, both compared to traditional petroleum fuels [26].

Bicer et al. [27] performed an analysis, in 2016, with a well-to-wake approach (similar well-to-wheel), to evaluate the LCA of an aircraft using conventional fuel (kerosene) and alternative fuels (ammonia, methanol, ethanol, liquefied natural gas, and hydrogen). In this study, the life cycle analysis included three phases: the first one is production, operation and maintenance of the aircraft, the second is construction, maintenance and disposal of the airport, and, finally, the third is production, transportation and utilization of the aviation fuel. They concluded, that, besides the fact that ammonia, jet fuel and methanol have less costs, liquefied methane and hydrogen have a minor environmental impact. In terms of greenhouse gas emissions, hydropower-based ammonia is calculated to be 0.24 $kgCO_2e$/tonne-km (kilograms of carbon dioxide equivalent per traveled tonne-kilometer), significantly lower than conventional ammonia, which emits 1.08 $kgCO_2e$/tonne-km. The terminology, "$kgCO_2e$" serves as a unit to express the global warming potential of the emitted greenhouse gases, allowing for a standardized comparison based on their impact relative to carbon dioxide over a specified time period. Notably, hydropower-based hydrogen stands out as the fuel with the lowest greenhouse gas emissions, registering at 0.03 $kgCO_2e$/tonne-km [27].

Ordóñez et al. [28] assesses the environmental impact of e-fuels applying the standard LCA methodology. The results show that the two cases, one where hydrogen is produced using the PEM (Polymer Electrolyte Membrane electrolysis), and other, in which, the method used for electrolysis is SOEC (Solid Oxide Electrolyzer Cell), outperform petroleum based fuels in human health, ecosystem quality and resources. However, at the time of the study, electrofuels cost 10.4 times higher compared to petrol [28].

In a different study, Ballal et al. [29] evaluates the e-fuels impact in climate change by combining different sources of CO_2 and H_2 up to 2050 under two constrasting policy scenarios. Depending on a number of variables, in order of importance, including, the electricity mix, the source of CO_2, the method for H_2 generation, and the electrolyzer efficiency, e-fuels may or may not have a greater or lesser influence on climate change than fossil fuels. The results demonstrated that e-fuels produced from biogenic CO_2 have higher climate benefits, when compared to e-fuels produced from CO_2 from DAC or from fossil fuel consumption. They, also, concluded that in 2050 is possible to achieve considerable climate change mitigation compared to fossil jet fuel, but only if policy measures are implemented to decarbonize the electricity sector [29].

2.1.3 Operations and Infrastructures

Improving operations and infrastructure has the potential to contribute to reducing CO_2 emissions in the aviation industry. However, such measures alone may not be sufficient to meet the objectives established by ATAG. Therefore, additional measures such as reducing the weight of aircraft, improving aerodynamics, and using systems to improve efficiency during flight operations are crucial to achieve significant improvements of the short term [14]. Improvements in infrastructure, such as structural changes in air traffic management (ATM) operations and energy savings at the airport, can also contribute to reducing emissions. Limitations on the use of auxiliary power units, single-engine taxi, and reduced taxi times can significantly reduce fuel consumption and, therefore, emissions [10]. Furthermore, Afonso et al. [15] have identified some feasible solutions that require significant changes in flight operations but can result in substantial fuel savings for long-haul flights, such as flying in V formation, air-to-air refueling, and adding refueling stops. These solutions have the potential to reduce fuel consumption and, consequently, emissions, which is essential to meet the industry's targets for reducing greenhouse gas emissions. Overall, it is clear that a combination of measures is necessary to achieve significant reductions in emissions in the aviation industry. While improvements in operations and infrastructure are necessary, additional measures such as reducing the weight of aircraft and using innovative solutions are also required to meet the objectives established by ATAG.

2.1.4 Technologies

In order to address the environmental challenges facing the aviation industry, the sector is actively working to develop new technologies in various areas such as aerodynamics, propulsion, structures, and systems. These innovations include novel aircraft concepts that are currently undergoing the certification process for commercial use [14]. To evaluate the potential of these emerging technologies to reduce CO_2 emissions, a comprehensive analysis is needed to compare their impact with that of conventional aircraft. The primary technologies expected to be integrated into the air fleet include new aircraft engines, hybrid and electric propulsion systems, strut-braced wings, blended wing, canard wing bodies and hydrogen. It is important to note that these technologies are not only aimed at reducing emissions but also improving fuel efficiency and enhancing the overall performance of aircraft [1].

2.2 Aviation Emissions Calculation Models

The necessity to analyse aircraft usage, while forecasting the environmental repercussions of aviation, has driven the creation of models and tools designed to evaluate how new aircraft concepts and technologies can impact the reduction of emissions.

2.2.1 Future Aviation Scenario Tool

The Future Aviation Scenario Tool (FAST) was developed in 1990 by the UK Department of Trade and Industry (DTI), and is one of the three emissions models approved by the Committee on Aviation Environmental Protection (CAEP). FAST was used in European Union (EU) Fifth Framework Programme to calculate gobal aviation emissions for 1992 and projections for 2000. The model system is a data set of aircraft movements for one year that indicates frequency of flights for an aircraft type between O-D pairs (Origin-Destination). FAST uses a secondary software (PIANO) to obtain the aircraft performance and obtain a emissions profile [30, 31].

2.2.2 AERO

AERO was designed to assess potential strategies for reducing emissions on a global or local scale. This modeling system provides the capability to compare the costs associated with various emission reduction options. These options encompass operational, technical, and economic measures. Operational considerations involve analyzing choices such as flying at lower altitudes, utilizing alternative routes, and enhancing air traffic control. In terms of technical measures, the model allows the examination of stringent rules for NOx emissions and the implementation of CO_2 standards. Lastly, economic measures can be explored, like the assessment of taxes on kerosene and tickets at regional or global levels [32].

2.2.3 AERO2k

In the EU Fifth Framework Programme, a new global inventory of aviation fuel and emissions was created. AERO2k used the available information from civil and military flights from 2002. Through the use of aircraft performance tool (PIANO), emission levels are determined by considering factors such as flight altitude, the present weight of the aircraft, and its speed across all phases of a complete flight mission. The emissions calculated for each specific flight simulation are consolidated to generate overall quantities for the entire fleet. These aggregated quantities are subsequently assigned to one of over 3 million individual cells on a three-dimensional grid covering the global map [33].

2.2.4 Aviation Integrated Model

The Aviation Integrated Model (AIM) has been under development since 2007 and serves as a comprehensive tool for assessing global aviation policies. It facilitates in-depth analyses of the interactions among aviation, the environment, and the economy, operating on both local and global scales. AIM comprises seven interconnected modules, allowing for the modeling of the global aviation system. The AIM architecture offers several advantages, including the ability to customize temporal and spatial resolution for specific applications, independent operation of modules, and the flexibility for extensions and enhancements across different modules. The ”Aircraft Technology & Cost Module” is a crucial component for assessing technological impact. It simulates fuel burn, emissions, and operating costs for airframe and engine technologies up to 2050, categorized into three groups based on fleet size. This module’s capability extends to evaluating the feasibility of potential future technological advancements [34].

2.2.5 Fleet System Dynamics Model

A distinguishing aspect of Fleet System Dynamics Model (FSDM), in comparison to the models above, lies in how it organizes aircraft to perform simulations. Given the impracticality of simulating all existing aircraft in the aeronautical sector, this model simplifies the task by categorizing aircraft based on factors such as capacity or aircraft type (single-aisle or twin-aisle). Many of the previously mentioned models adopt the approach of grouping aircraft according to their capacity. While this method effectively captures the overall fleet’s transport capacity, it falls short in representing the fleet in terms of technological and operational performance characteristics. Other important aspect is the simulation period. FSDM has the particularity allowing modifications to increase the forecast period up 2100, besides the fact it is design for simulations until 2050. These two factors are crucial for achieving the objectives outlined in the current study.

To fulfill the purpose of this dissertation, it was necessary a model able to simulate in a time period up to 2100, that quantified the emissions globally, and consistent with the data available. So, the model chose was Fleet System Dynamics Model (FSDM) developed by Dr. Randt [35] at the Institute of Aircraft Design of Technical University of Munich (TUM).

Chapter 3

Air Traffic Emissions Calculation

This chapter presents the process used to obtain the CO_2 emissions in aviation up to 2100. To meet the objectives of the present work, an air transport system model is used to determine the long-term emissions, considering various scenarios that the society can take in the future. Firstly, the Fleet System Dynamics Model is explained, follow by the Shared Socioeconomic Pathways (SSPs) used for scenario planning.

3.1 Air Transport System Modeling

According to Mensen [36], the global air transport system has three major pillars and has the responsibility of transporting passengers, freight, and mail. These areas are:

- Airlines and other commercial aircraft operators, through aircraft operations, produce the real transport performance within the air transportation system.
- Air traffic management (ATM) authorities ensure efficient and safe execution of all aviation activities.
- Airports offer the necessary infrastructure to manage and process air passengers, freight, and mail.

The FSDM simulates the air transport capacity and air traffic market data (growth rates, payload factors, aircraft production rates, ...) into quantitative data relative to future aircraft fleet size, composition, and age distribution [37]. In this model, the air transport system is defined as a system of aircraft that operates on a determined network of air routes. While, ATM entities are only taken into consideration in light of their impact on how aircraft are typically permitted to operate, and airports are explicitly excluded. Table 3.1 details the characteristics and metrics implemented in FSDM model are presented.

Table 3.1: Characteristics and metrics of the global air transport fleet. [35]

Aircraft fleet	Air routes network
Size (number of operating aircraft)	Number of air routes
Composition (types of operating aircraft)	Length of air routes
Age distribution (age of individual aircraft units)	Geographical position of air routes
Capacity (seats, freight volume, range capabilities)	
Performance (fuel burn, emission quantities, flight speed)	

3.1.1 Fleet System Dynamics Model

For the purpose of modeling the air transport system, a fleet planning feature must be incorporated into the model, in which is the process that airlines buy and effectively manage aircraft capacity to service markets in a defined range periods of time in order to maximize the company wealth. There are two approaches to fleet planning: ”micro” or ”bottom-up” approach and ”macro” or ”top-down” approach. The method used in FSDM model is the second one. The ”macro” approach, by considering the entire network of an airline, conducts a various sensitivity analyses with little expenditure of time, to determine the ”capacity gap” from the year of interest to the next one. Capacity gap is the sole outcome of the airline’s fluctuating transport supply from year to year and a reduction in that supply as a result of the necessary retirement of in-service aircraft units, which is represented in Figure 3.1.

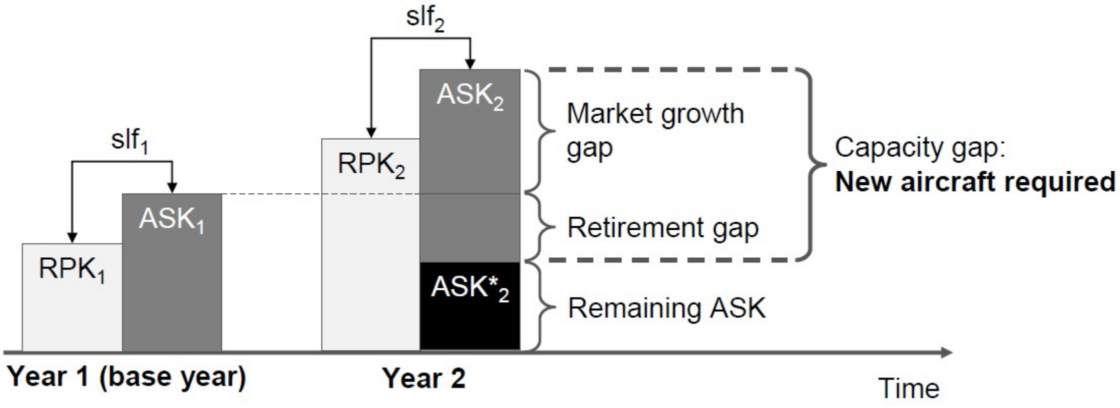


Figure 3.1: Macro approach implemented in FSDM model [35].

As illustrated in Figure 3.1, the airline assesses transport demand based on equation 3.1, with Revenue Seat Kilometers of the year of calculation (RPK_t).

$$RPK_t = \sum_k p_k \cdot d_k \quad (3.1)$$

RPK_t : Transport demand of the year t;
k : Addressing one flight performed by the airline;
p : Number of passengers transported;
d : Great circle distance between origin-destination pair of flight k.

The airline offers the market more seats in the base year than the number of passengers who could be carried, Available Seat Kilometer, ASK_t, in order to provide enough supply to meet the transport demand RPK_t and prevent an unduly high value of demand spill. The proportion of seat kilometers given to seat kilometers sold is thus known as the seat load factor, slf.

$$slf_t = \frac{RPK_t}{ASK_t} \cdot 100 \quad (3.2)$$

slf_t is the seat load factor of the year t, and ASK_t is the transport supply (passenger seats) of the year t. Equation 3.3 determines the number of new aircraft that will have to be acquired to fill the capacity gap, which defines the ASK metric.

$$ASK_{i,j} = \sum_{i,j} n_i \cdot f_{i,j} \cdot d_{i,j} \cdot s_{i,j} \quad (3.3)$$

i : Addressing one particular route of the airline's routes network;
j : Addressing one particular aircraft unit of the airline's fleet;
n_i : Number if aircraft operating on route i;
$f_{i,j}$: Number of frequencies with which aircraft j operates on route i;
$d_{i,j}$: Great circle distance flown by aircraft j on route i;
$s_{i,j}$: Number of seats transported by aircraft j on route i.

Relatively to air freight, the "macro" approach is also applicable, with the slight difference of the main metric being the freight ton, instead of number of seats transported, as demonstrated in equation 3.4. Furthermore, like the seat load factor, the freight load factor (flf_t) is used to obtain the ratio between freight demand and supply, equation 3.5.

$$ATK_{i,j} = \sum_{i,j} n_i \cdot f_{i,j} \cdot d_{i,j} \cdot t_{i,j} \quad (3.4)$$

$t_{i,j}$: Tons of freight capacity transported by aircraft j on route i.

$$flf_t = \frac{RTK_t}{ATK_t} \cdot 100 \quad (3.5)$$

RTK_t : Freight demand of the year t.

The methodological foundations of FSDM are divided in two model components: air transport fleet model and air transport network model. The first one dynamically sets the size and structure of the world fleet of commercial transport aircraft, annually. The second describes the air routes that link up local air traffic markets to create and reflect the worldwide network of air routes that the aircraft fleet operates. Since, FSDM relies on "macro" approach to fleet planning, the model has two key consequences for its basic functioning:

- For each simulation year, the model requires an amount of ASKs and ATKs, to determine the capacity gap, in which, makes it possible to obtain the amount of added new aircraft to the fleet.

- To initialize the model, the user needs to define the start year of simulation, the initial fleet, and the initial transport performance that the fleet has to deliver.

The FSDM relies on the principles of *System Dynamics* to capture the dynamic evolution of the global air transport fleet. This method is based on feedback systems and is capable of handling complex, dynamic systems' non-linearity, time delays, and multi-loop structures. The system is connected through *feedback loops*, which are a close path in a sequence consisting of a decision that controls action (stock or level of the system), resulting in flow [38]. To describe the dynamics of the evolution of the fleet in FSDM, stocks and flows are employed as a function of time, which is schematically shown in Figure 3.2. The model works with two flows: ”Add aircraft” and ”Retire aircraft”. The ”Add aircraft”, inflow, has the objective of incorporating new aircraft into the fleet, based on the growth rates of air traffic as defined by the user. The implementation is restricted by factors such as aircraft availability (specifically, whether a particular aircraft type is under construction in the simulation year) and the production capacity of aircraft manufacturers needed to create the required quantity of aircraft. The ”Retire aircraft”, outflow, is achieved by accessing survival curves of the aircraft. By applying established survival curves to the various types of aircraft, the model will use the original age distribution of the fleet as input to calculate statistically how many aircraft will need to be retired each year.

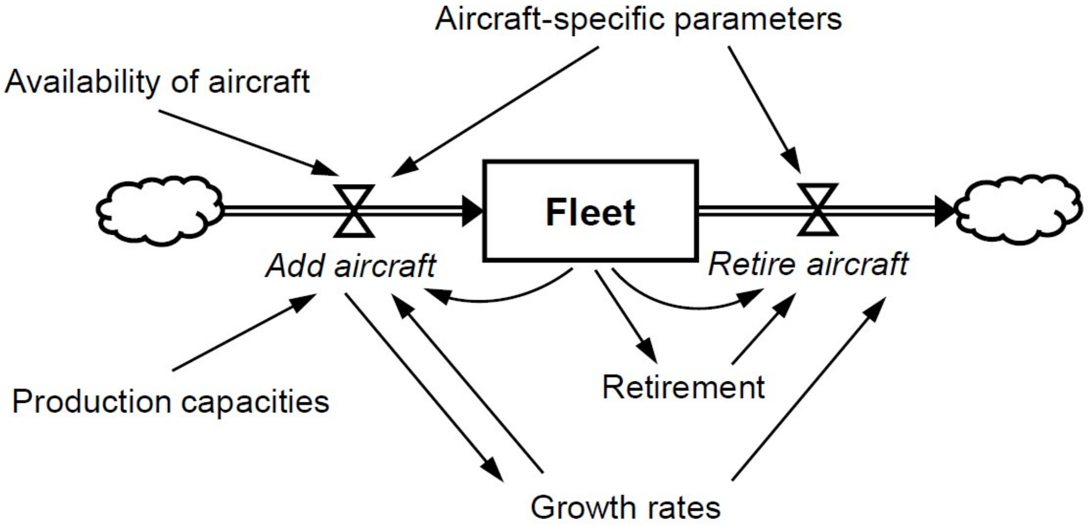


Figure 3.2: Functional scheme of the FSDM based in System Dynamics [35].

Aircraft utilization modeling

The FSDM consists of various modules, one of which is aircraft utilization modeling. Modeling the use of aircraft is one of imperative conditions for fleet planning. The amount of time that an aircraft needs to execute a flight it is called *Utilization Hours* (UH), and is composed of three sub-categories:

- *Block Hours* (BH) - amount of hours that an aircraft requires to accomplish the flight mission.

- *Turn-around Hours* (TH) - amount of hours that the aircraft requires to be prepared for the next flight.
- *Maintenance Hours* (MH) - amount of hours that the aircraft requires to maintain airworthiness.

Equations 3.6 and 3.7 demonstrate how to obtain the *Utilization Hours*:

$$UH = BH + TH + MH = \left(1 + \frac{MH}{BH}\right) \cdot BH + TH \quad (3.6)$$

$$UH = \alpha \cdot BH + TH \quad (3.7)$$

where α can be determine with Equation 3.8.

$$\alpha = 1 + \frac{\text{Daily Check} + \text{A,C,D Checks}}{\text{Taxi Time} + \text{Flight Time}} \quad (3.8)$$

In order to obtain the maximum number of flights per day an aircraft can perform, given a specific route, the Equation 3.9 is used. Here, the *Maximum Utilization Hours* (UH_{max}) represents the daily maximum an aircraft can operate. Table 3.2 shows the correlation between UH_{max} and α used in the simulations.

$$f_{i,j,max} = \frac{UH_{max}}{UH} \quad (3.9)$$

Table 3.2: Values of α and UH_{max} applied in FSDM, according to aircraft range. [35]

Aircraft range	α	UH_{max} [h]
Long-range	1.57	20
Mid-range	1.82	17.5
Short-range	2.07	15

Aircraft Retirement Modeling

Regarding fleet planning, modeling the retirement of in-service aircraft, which means that, in FSDM, the aircraft will no longer resume its long term operations, is an important assignment. Generally, the reason to retire an aircraft occurs when the costs of operating it are higher than the costs of buying and operating a new one. However, other aspects like operational performance and new regulations can influence the decision. So, the FSDM uses a module to approximate aircraft retirement through a function of aircraft age, using survival curves, reflecting the percentage of aircraft that remain in the fleet depending on their respective age, represented in equation 3.10 as POS - percentage of survival. The curves can be interpreted as a mathematical description of the degree of probability that an aircraft will remain in the fleet as it becomes older. Figure 3.3, represents an example of a typical survival curve for a mid-range aircraft.

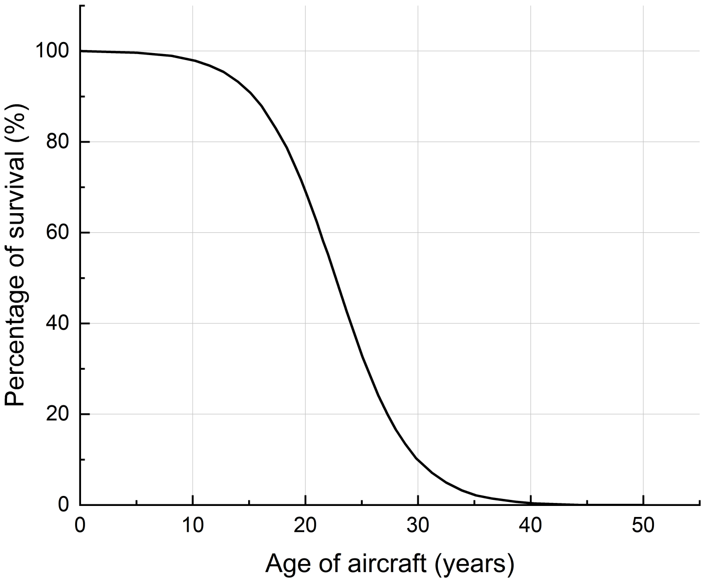


Figure 3.3: Survival curve of a mid-range transport aircraft. [35].

The spline of the survival curve is decided by two variables β_I and β_{II} from equation 3.10, which are obtain empirically depending on aircraft type or category, and can be found in Appendix B. Because of this statistical methodology, the FSDM retires aircraft in each simulation year by calculating their POS individually, without considering the present aircraft demand indicated by the capacity gap, Figure 3.1. Consequently, in scenarios of substantial growth characterized by high demand for transport capacity and a need for additional aircraft units, the FSDM retires aircraft in the same manner as it would in situations of significant contraction.

$$POS = \frac{1}{1 + e^{-\beta_I - \beta_{II} \cdot a}} \quad (3.10)$$

a : aircraft age;
β_I, β_{II} : retirement coefficients.

Aircraft Production Modeling

If an airline plans to add new aircraft to its fleet, it should consider that the aircraft won't arrive right away. The time it takes for delivery depends on the current demand for new aircraft in the market. The airline might need to wait for a specific period until the manufacturer delivers the ordered aircraft units. Once the FSDM establishes the aircraft count slated for retirement in a specific simulation year, it computes the capacity gap. This calculation sets the quantity of aircraft that should join the fleet in the subsequent year.

In every simulation year, the FSDM strategically introduces new aircraft to the fleet to minimize the overall fuel consumption across the global fleet. However, it is important to recognize that aircraft manufacturers cannot feasibly produce an unrestricted quantity of a specific aircraft type within a given timeframe, particularly when new aircraft types are introduced. As a result, guaranteeing an unlimited aircraft supply from manufacturers is not feasible, as they first need to establish the required production facilities for a new aircraft model. To enhance the authenticity of fleet simulations, the FSDM enables the control of aircraft additions in each simulation year. The model differentiates aircraft supply into two tiers, Total Production Capacity (TPC) and Single Production Capacity (SPC).

- Total production capacity (TPC): maximum aircraft units that can be supplied annually by all manufacturers. TPC is categorized into two classes: single-aisle (SA) and twin-aisle (TA). For every aircraft type integrated into the model, it is crucial that the user specify its classification, to restrict production capacity.
- Single production capacity (SPC): maximum aircraft units of a single aircraft type (not an aircraft cluster) that can be supplied annually by a specific manufacturer.

In the performed simulations in the present work, the SPC and TPC have been restricted. This approach aims to faithfully simulate real-world practices and constraints.

Aircraft Network Allocation

After an Airline has finished planning its fleet and defined the routes, it intends to operate (referred to as ”route planning”), it needs to allocate its fleet to the routes and create a detailed schedule for the planned flights, including how aircraft will be rotated. This process is known as ”schedule development” [39]. A crucial aspect of schedule development is the ”Fleet Assignment Problem (FAP),” which determines the aircraft types and their quantities from an airline’s fleet to be deployed on each flight leg in a planned route network and flight schedule. Typically, the FAP goal is to minimize the combined expenses of spill and fleet operations, or alternatively, maximize profits. The FAP is a mathematical optimization challenge that airlines often tackle using extensive mathematical network optimization methods. When aiming for the optimal fleet assignment solution, numerous factors should be considered such as maximizing aircraft utilization, ensuring adequate time for aircraft maintenance, and considering operational restrictions. The FSDM employs the MATLAB® function *fmincon* to determine the fleet’s minimum fuel consumption and solve the FAP. This function aims to find a constrained minimum of a scalar function with multiple variables, starting from an initial estimate.

Aircraft Performance Modeling

The aircraft performance model is a relevant part of the FSDM, and is primarily built upon the Base of Aircraft Data (BADA), which was developed, currently maintained, and distributed by Eurocontrol [40]. BADA is viewed as a standard tool for performance simulation in aviation, which comprises a set of data files that outline the operational and performance attributes of diverse current and past aircraft models, with a primary focus on the fleet of commercial airliners that are now in service. BADA supplies four types of files: "Operational Performance File" (OPF), "Airline Procedure File" (APF), "Performance Table File" (PTF), and "Performance Data Table" (PDT), being the first two the most important, since the BADA PTF and PDT files are generated automatically from the OPF and APF files. The OPF gives information for each aircraft type and engine designation, and characteristics parameter values like aircraft masses, engine performance, fuel burn data, and ground movements. The APF defines "standard airline procedures" for each part of the mission (climb, cruise, descend, ...).

The model was implemented in the FSDM primarily to determine the fuel consumption and emissions of the global fleet, using the algorithm as shown in Figure 3.4. The tool allow to obtain the performance characteristics of the aircraft that are being simulated in FSDM, being fuel burned and CO_2 emissions of the global fleet the most relevant. Figure 3.4 shows that, in a first instance, the Single Mission Calculation (SMC) is implemented, which simulates a given flight mission, depending on input data given by the user (mission distance, payload mass to be carried, cruise altitude, and taxi time). With these values, the tool obtains the required block hours, the vertical flight profile, and the fuel burn in this flight mission. Then, the Global Fleet Mission Calculator (GFMC) invokes the SMC. This process involves simulating all flights within the FSDM fleet and consolidating the outcomes to generate diverse fleet-level metrics, like the fuel consumption of the entire global fleet for a particular simulation year.

3.1.2 Model Assumptions and Limitations

Due to the high degree of complexity of the system, the FSDM depends on important assumptions in order to simplify the modeling efforts.

Airline competition: Commercial aviation is distinguish by airline competition. However, modeling the competition among airlines requires a great economic understanding. So, FSDM considers only one airline that meets all passenger and transport demand.

Fleet allocation: Typically, airlines optimize their fleet assignments to maximize profit, a central goal in solving the "Fleet Assignment Problem" (FAP). However, the FSDM differs from this norm by prioritizing the minimization of total fuel consumption over profit maximization. Unlike other approaches, this unique methodology eliminates the need for intricate airline business models and operating cost functions, reducing model complexity and input data requirements.

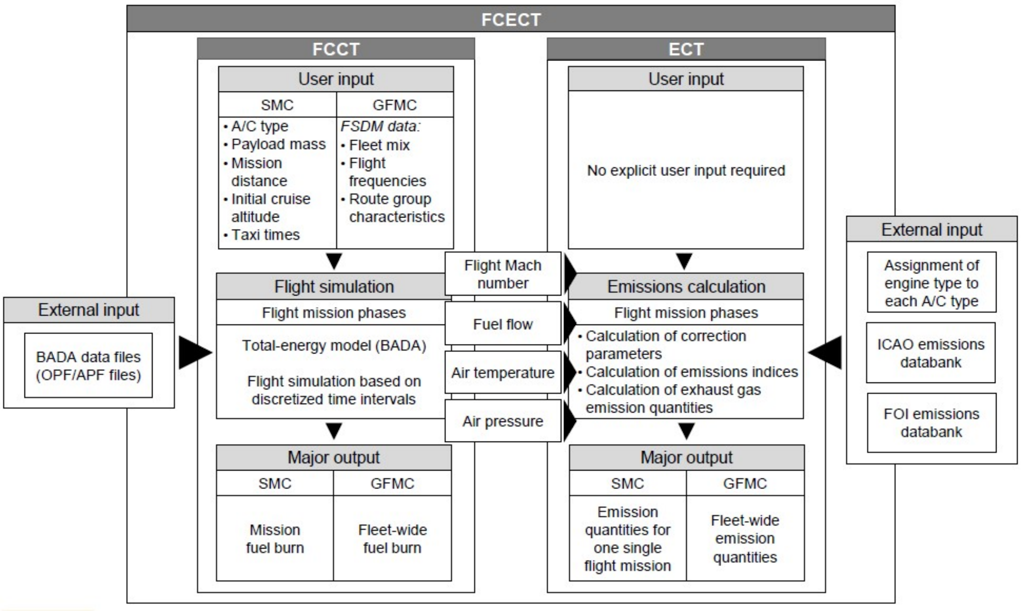


Figure 3.4: Fuel Consumption and Emissions Calculation Tool (FCECT) scheme [35].

Simulation periods: The model's minimum time interval is one year, starting from the year 2008 for any simulation. FSDM is capable of simulating periods until 2050 and beyond.

Representation of the global air transport fleet: The air transport industry relies on nearly 200 distinct aircraft types, documented in the OAG database [41]. However, incorporating all of them would overly complicate the model. To manage complexity, the FSDM narrows it down by creating specific aircraft categories that represent the global fleet, with each category embodying a specific aircraft type.

Representation of the global routes network: The characteristics of the route networks in the FSDM have been defined according to the Official Airline Guide (OAG) database [41], where it lists more than 37000 different O-D pairs (Origin-Destination) that together create the global routes network. Representing all the pairs would increase the complexity of the model. To simplify six global regions were defined (Europe, North America, Latin America, Africa, Middle East, and Asia), all connected form 21 ”routes groups”.

3.1.3 Model Initialization

As mentioned before, the FSDM relies on a macro approach to fleet planning, therefore for the model work correctly, it requires a initialization. The data needed for the initialization of the global fleet, routes network, and transport performance demand, are presented in the following sections.

Initial Fleet

The FSDM is designed to start the simulations in 2008, and by that year there were almost 200 aircraft types. Incorporating all of them would result in an high degree of complexity of the FSDM. So, to maintain an acceptable level of complexity, the model establishes a limited set of aircraft categories to represent the global fleet. Each category corresponds to a particular aircraft type. As a result, aircraft categorization is achieved through a combination of type-specific criteria including transport performance, operational, and technical metrics, using the k-medoids algorithm [42], where nine *aircraft clusters* were identified as the optimal number of groups. For the initial fleet, the FSDM has opted to depict each cluster using the aircraft with the highest ASK value for passenger aircraft and the highest ATK value for cargo aircraft. Table 3.3 displays the nine clusters along with their corresponding representative aircraft types, as well as the specific share of global ASKs/ATKs linked to each cluster.

Table 3.3: FSDM initial fleet aircraft clusters [35].

Clusters	Cluster name (SA/TA class)	Representative aircraft type (OAG name)	Approx. ASK/ATK share within cluster
1	Long-range combi (TA)	Boeing (Douglas) MD-11	43%
2	Long-range heavy (TA)	Boeing 747-400	77%
3	Mid-range freighter	Boeing 767-300F	25%
4	Jet commuter (SA)	Embraer 190	9%
5	Long-range freighter	Boeing 747-400F	47%
6	Turboprop commuter (SA)	ATR 72-500	100%
7	Mid-range (TA)	Boeing 767-300	22%
8	Long-range (TA)	Boeing 777-200	16%
9	Narrow-body (SA)	Airbus A320	23%

Routes Network

According section 3.1.2, to represent the global network, FSDM presents six gloal regions, where 21 connections defined as ”route groups”, as shown in Figure 3.5. The distances for the 21 route groups were established by utilizing the median values of the frequency-weighted average stage lengths covered by each of the nine aircraft clusters on every route group (where applicable).

Transport Performance

The distinctive seat and freight capacities offered by each aircraft cluster on their corresponding route groups were determined using the same approach mentioned in the subsection before. In addiction, the average total flight frequencies per month for each cluster and route group were computed, which is also a crucial input for initializing the FSDM. To initialize the model it is required to define an allocation of the initial aircraft fleet to the routes network, that was accomplished through a statistical approach that assigns a

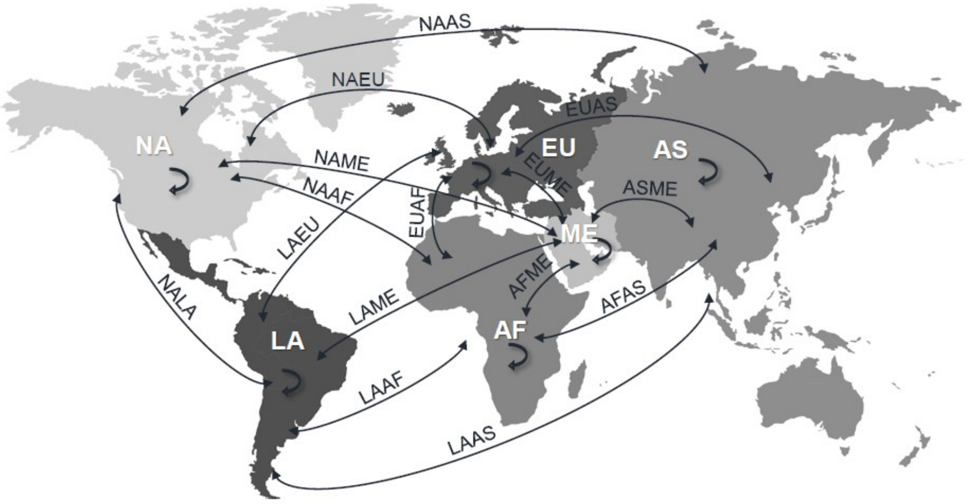


Figure 3.5: Representation of the global network used by the FSDM [35].

certain amount of aircraft units of a specific cluster to a route group as a function of this cluster's share in ASKs (or ATKs for freighter clusters) on this route group.

To ensure the accurate functioning of the simulation, the user must input a diverse set of data. The specified simulation year marks the concluding year of the fleet simulation. Current aircraft production intervals establish the timelines for producing the initial fleet's aircraft types. Data for next-generation aircraft detail the aircraft types slated to join the fleet in the future. The user is required to furnish comprehensive aircraft data, encompassing performance, utilization, and survival curve information. Next-generation aircraft production intervals delineate the timelines for producing future types. Production capacities determine both the potential total aircraft entering the fleet and the maximum units of a specific next-generation aircraft type available annually during the simulation. Regional market growth factors articulate the year-on-year changes in Revenue RPKs and RTKs within each of the 21 route groups from 2008 to the simulation's target year. Target payload factors specify the seat and freight load factors that the monopolistic airline, represented in the FSDM, aims to achieve in each of the 21 regional markets. The corresponding values can be founded in Appendix B.

3.2 Shared Socioeconomic Pathways

This section presents the concept of Shared Socioeconomic Pathways (SSPs), as well as its relevance to the work.

The development of environmental scenarios are an important part of climate change research, aiding in comprehending the enduring impacts of immediate choices, by allowing researchers to delve into diverse potential futures in the context of fundamental future uncertainties. These scenarios have played a vital role historically in fostering collaboration among diverse research communities. For instance, they establish a shared foundation for investigating aspects such as mitigation policies, impacts, adaptation possibilities, and alterations in the physical Earth system [43]. Emissions scenarios have played an important role in the Intergovernmental Panel on Climate Change's (IPCC) assessments, including the "1990 IPCC First Scientific Assessment" (SA90) [44], the "1992 IPCC Scenarios" (IS92) [44], and the "2000 Special Report on Emissions Scenarios" (SRES) [45]. Later, in 2011, van Vuuren et al. [46] developed the "Representative Concentration Pathways" (RCPs), in which are adopted by IPCC in the "IPCC Fifth Assessment Report" (AR5) [47], in 2014. More recently, in the "IPCC Sixth Assessment" (AR6) [48], that finished in 2023, is adopted a new approach, the "Shared Socioeconomic Pathways" (SSPs), that start being developed in 2014 by O'Neil et al. [49].

3.2.1 Definition

In van Vuuren et al. [50], a new framework is presented for creating integrated scenarios by combining climate models, socioeconomic factors, and climate policy assumptions. One of the main objectives of these integrated scenarios is to help research and evaluation across diverse research communities, which can effectively outline the range of uncertainty in mitigation endeavors for specific climate objectives, along with adaptation initiatives that can be executed to ready for and counteract the climate shifts and repercussions linked to those trajectories [49].

The framework's structure resembles a matrix whose dimensions are key aspects of uncertainty in outcomes for the future. The first one is climate change, as the extent of necessary mitigation actions and adaptation requirements closely hinges on the desired policy outcomes. So, one axis of the matrix describes climate outcomes, represented by the Representative Concentration Pathways or RCPs. The second source of uncertainty in outcomes is socioeconomic development, as diverse developmental trajectories can result in societies differing significantly in emission and land use drivers, as well as their abilities to mitigate emissions and implement adaptation measures. Therefore, the second axis of the matrix is defined by a group of alternative reference assumptions about future socioeconomic progress in the absence of climate policies or climate change, known as the Shared Socioeconomic Pathways (SSPs). When SSPs are joint with radiative forcing pathways or climate change outcomes in combined scenarios, policy conjectures become essential to generate emissions that would achieve the desired climate outcomes and to outline adaptation strategies. The composition of these policy assumptions constitutes the third principal determinant of outcome uncertainty, referred to as Shared climate Policy Assumptions (SPAs) as discussed in Kriegler et al. [51]. This framework is designed to help answer various questions, such as understanding what defines harmful climate change, considering its dependence on climate change and future socioeconomic factors. It also aids in assessing policies, exploring the balance between mitigation and adaptation.

As mentioned, the SSPs are key components of a novel scenario framework, set up by the climate change research community. This framework aims to streamline the comprehensive study of forthcoming climate effects, vulnerabilities, adaptation, and mitigation [43].

According to O'Neil et al. [49] the SSPs outline credible alternate trends in the development of society and natural systems, both on a global scale and within significant world regions. The pathways do not assume climate change, impacts, and policies, in order to serve a methodological purpose. In this way, SSPs differ from other global scenarios, since the uncertainty space that they aim to cover is primarily determined by the resulting outcomes rather than the inputs or components that drive these outcomes. Hence, the design process starts by identifying a specific outcome and then pinpoints the societal factors influencing it. This approach, similar to backcasting, envisions an end state during pathway creation, without assuming that all these states are desirable. While climate change scenarios have a broad scope of applications in decision-making contexts, their focus is often on choices for addressing climate change through mitigation or adaptation. So, SSPs outcomes are specific combinations of socioeconomic challenges to mitigation and adaptation, as demonstrated in Figure 3.6 [52].

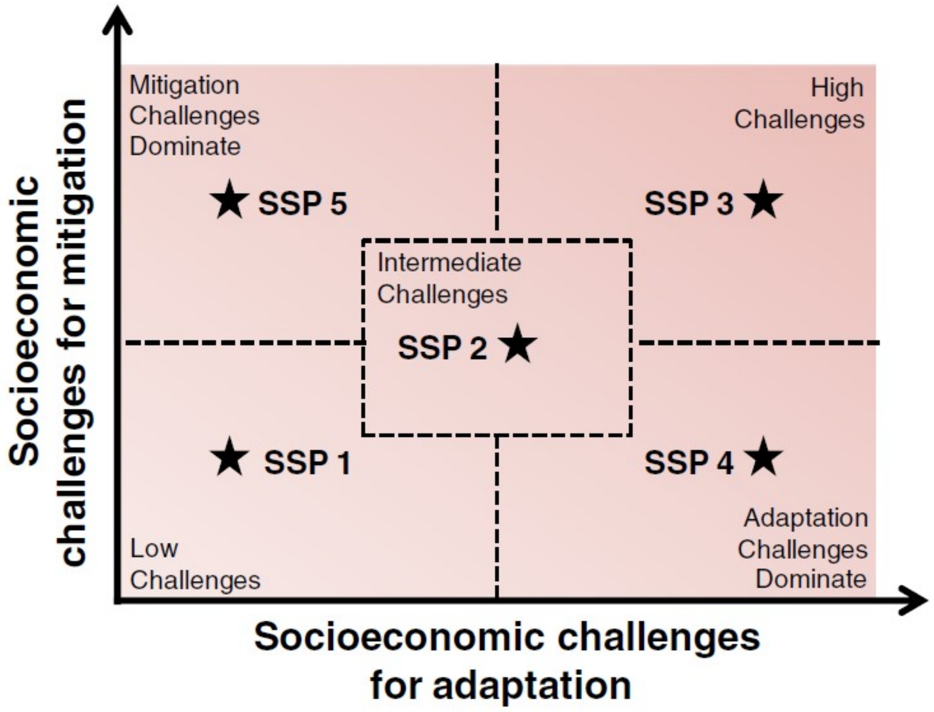


Figure 3.6: Representation of the SSPs according to their combinations of socioeconomic challenges to mitigation and adaptation [49].

3.2.2 SSPs narratives

The existing collection of SSP scenarios consists of a series of baselines. As mentioned, these baselines outline forthcoming advancements in the absence of additional climate policies beyond the current ones. Additionally, the set includes mitigation scenarios that probe the consequences of climate change mitigation policies [43]. In order to develop these narratives, three main considerations were taken into account, as outlined by O'Neill et al. [52]:

1. The primary objective of constructing narratives concerning societal development within the framework of climate change scenarios;
2. Drawing insights from past climate change and associated scenario narratives to inform the current development;
3. Recognizing the distinct role of Shared Socioeconomic Pathways (SSPs) in the present scenario framework, portraying societal futures with unique challenges in both mitigation and adaptation.

Societal development narratives in climate change scenarios serve to provide comprehensive descriptions of future conditions, which are crucial for analyzing emissions drivers, mitigation strategies, societal vulnerability to climate change, impacts, and adaptation measures. Narratives establish key storylines that guide the formulation of scenario elements, including population and economic growth patterns. Notice that, narratives maintain a level of generality, ensuring coverage of diverse potential futures, distinguishing them from more detailed storylines used in decision-making contexts to illustrate specific outcomes of actions.

Characteristics like economic growth, regional integration, and societal and environmental sustainability are key factors to define representative uncertain outcomes. They also played an important role in previous scenarios, by transmitting the overall nature of future development.

As mentioned, the current framework requires the SSPs, and consequently the narratives, to define possible worlds that differ in challenges to mitigation and adaptation. Important to notice that, these challenges are defined as characteristics of the society, and not the amount of climate change or mitigation policy.

After various iterations to produce the narratives, it was concluded that the SSPs narratives needed to be defined by six important factors: demographics, human development, economy and lifestyle, policies and institutions (excluding climate policies), technology, and environmental and natural resources [52]. As represented in Figure 3.6, five narratives were developed, where SSP1, SSP3, SSP4, SSP5 describe four arrangements of challenges to adaptation and mitigation, and the other (SSP2) represents a central case. This path, in particular, follows a the development road that is consistent with historical patterns over the past century. In O'Neil et al. [52] is presented the full description of the pathways.

SSP1: Sustainability - Taking the green road (Low challenges to mitigation and adaptation)

”The world shifts gradually, but pervasively, toward a more sustainable path, emphasizing more inclusive development that respects perceived environmental boundaries. Management of the global commons slowly improves, educational and health investments accelerate the demographic transition, and the emphasis on economic growth shifts toward a broader emphasis on human well-being. Driven by an increasing commitment to achieving development goals, inequality is reduced both across and within countries. Consumption is oriented toward low material growth and lower resource and energy intensity.”

SSP2: Middle of the Road (Medium challenges to mitigation and adaptation)

”The world follows a path in which social, economic, and technological trends do not shift markedly from historical patterns. Development and income growth proceeds unevenly, with some countries making relatively good progress while others fall short of expectations. Global and national institutions work toward but make slow progress in achieving sustainable development goals. Environmental systems experience degradation, although there are some improvements and overall the intensity of resource and energy use declines. Global population growth is moderate and levels off in the second half of the century. Income inequality persists or improves only slowly and challenges to reducing vulnerability to societal and environmental changes remain.”

SSP3: Regional Rivalry - A rocky road (High challenges to mitigation and adaptation)

”A resurgent nationalism, concerns about competitiveness and security, and regional conflicts push countries to increasingly focus on domestic or, at most, regional issues. Policies shift over time to become increasingly oriented toward national and regional security issues. Countries focus on achieving energy and food security goals within their own regions at the expense of broader-based development. Investments in education and technological development decline. Economic development is slow, consumption is material-intensive, and inequalities persist or worsen over time. Population growth is low in industrialized and high in developing countries. A low international priority for addressing environmental concerns leads to strong environmental degradation in some regions.”

SSP4: Inequality - A road divided (Low challenges to mitigation, high challenges to adaptation)

”Highly unequal investments in human capital, combined with increasing disparities in economic opportunity and political power, lead to increasing inequalities and stratification both across and within countries. Over time, a gap widens between an internationally-connected society that contributes to knowledge- and capital-intensive sectors of the

global economy, and a fragmented collection of lower-income, poorly educated societies that work in a labor intensive, low-tech economy. Social cohesion degrades and conflict and unrest become increasingly common. Technology development is high in the high-tech economy and sectors. The globally connected energy sector diversifies, with investments in both carbon-intensive fuels like coal and unconventional oil, but also low-carbon energy sources. Environmental policies focus on local issues around middle and high income areas."

SSP5: Fossil-fueled development - Taking the Highway (High challenges to mitigation, low challenges to adaptation)

"This world places increasing faith in competitive markets, innovation and participatory societies to produce rapid technological progress and development of human capital as the path to sustainable development. Global markets are increasingly integrated. There are also strong investments in health, education, and institutions to enhance human and social capital. At the same time, the push for economic and social development is coupled with the exploitation of abundant fossil fuel resources and the adoption of resource and energy intensive lifestyles around the world. All these factors lead to rapid growth of the global economy, while global population peaks and declines in the 21st century. Local environmental problems like air pollution are successfully managed. There is faith in the ability to effectively manage social and ecological systems, including by geo-engineering if necessary."

Chapter 4

E-Fuels

As mentioned in the last chapter, associations and entities like IATA, ICAO, and ATAG have invested in solutions to reach net-zero carbon. One of which is aviation alternative fuels. Their development has become one of the crucial elements in decarbonizing the aviation industry. Besides the increasing use of carbon neutral fuels, Scheelhaase et al. [53] say that there is no realistic technology option to reduce carbon emissions in a medium-to-long term. So, here appear E-fuels as new emerging alternative fuel.

This chapter will cover the production processes, from the capture of CO_2 and production of H_2 to e-fuel synthesis, and the life-cycle analysis review of E-fuels.

4.1 Production Process

Although H_2 can serve as a direct fuel, its widespread use is currently hindered by the lack of infrastructure. To address this issue, liquid electro-fuels (e-fuels) that are derived from H_2 and captured CO_2 are gaining popularity due to several advantages. These e-fuels are easier to store compared to gaseous or liquid H_2, can be transported through the existing petroleum infrastructure, and are considered safe for use in aviation without any engines or equipment changes [54].

4.1.1 Hydrogen Production

Due to its nearly ideal electrofuel qualities, hydrogen has long been thought of as the main energy carrier for developing energy systems, being the fuel with the highest gravimetric energy density. Nonetheless, due to its high diffusion coefficient and relatively low volumetric energy density, storing hydrogen is difficult [11]. There are four primary methods to produce hydrogen. One of methods is from fossil fuels by steam methane reforming (SMR), coal gasification, plasma reforming, partial oxydation, auto-thermal reforming, pyrolysis of methane, and *in situ* combustion of underground reservoirs. Hydrogen can also be produced *via* biomass and waste streams using three technologies: dark fermentation, photofermentation, and gasification. Hydrogen can be obtained through water electrolysis, which consists in splitting water into H_2 and O_2 using electricity. Water electrolysis is the technology with the least amount of emissions, where the hydrogen produced is called Green hydrogen. The last one is hydrogen production through its natural occurrence. It is considered to be the least known, but offering the best economical alternative against the other methods [54]. Table 4.1, shows a comparison of the mentioned technologies in detail, as well as their advantages and disadvantages, Technology Readiness Level (TRL), and range of cost.

4.1.2 Carbon and Nitrogen Sources

E-fuels are characterized by having a neutral carbon footprint. During the production of e-fuels, CO_2 can be captured, which in turn suffers chemical processes with hydrogen to obtain e-kerosene, e-gasoline or e-diesel. When the product is consumed, it produces carbon dioxide. The captured CO_2 can come from flue gases of concentrated sources like CO_2 waste steams from industrial processes, biogas upgrading, beer brewing, wastewater treatment plants, or biofuel production plants. It is also possible to capture carbon dioxide direct from the atmosphere - direct air capture (DAC) [9, 25]. Table 4.3, summarizes all methods and technologies used for carbon capture, discussed in the following sections. Besides the fact that e-fuels from carbon are the most researched, ammonia has also been taken into account as a hydrogen carrier or as a fuel itself. As the primary component of air, nitrogen plays a crucial part in the formation of ammonia by combining with hydrogen [55].

Carbon Capture Methods

The process of removing carbon from flue gases is crucial. There are three major methods: pre-combustion, post-combustion, and oxyfuel combustion. In the pre-combustion, as illustrated in Figure 4.1, CO_2 is separated from fossil fuel or biomass before the completion of the combustion process. Basically, in this process fuel reacts with O_2 to generate carbon monoxide, hydrogen and synthetic gas (syngas). In a catalytic reactor, CO reacts with steam to create carbon dioxide and more hydrogen. Then, CO_2 is removed by a chemical or physical absorption procedure. The post-combustion method involves separating carbon dioxide from flue gases produced after the combustion of fossil fuels. This pathway presents the most common carbon capture (CC) techniques, which are, adsorption, absorption, cryogenic fractionation, and membrane separation [56, 57, 58]. The procedure is illustrated in Figure 4.2.

Table 4.1: Summary of hydrogen production technologies. [54]

Class	Technology	Description	Advantages	Disadvantages	TRL	Cost [€ per kg H_2]
Fossil Fuels	Coal Gasification	Steam and oxygen are used for combustion and react with coal	Simpler emission control over conventional combustion	Produces CO_2 and other pollutants	9	1.21
	Steam Reforming (SR)	The steam created by combustion with air is reacted with the feedstock and catalyst. Exthermic	Mature technology and easier to scale up	Produces CO_2	9	1.87
	Plasma Reforming	Similar to SR, but uses high temperature electric heat from plasma devices instead of steam	Does not require a catalyst. Reduced reactor size and weight	High electricity requirements. Produces CO_2	5-6	1.87
	Partial Oxidation (POX)	Steam created by combustion with partial use of oxygen. No catalyst used. Exothermic	Faster start-up times and relative compactness. No catalyst required	Produces CO_2	9	1.33
	Auto-thermal Reforming (ATR)	Combination of SR and POX	Faster response times. Simpler and cheaper than SR. Compact design relative to other fossil fuel-based methods	Produces CO_2. Requires pure oxygen or air separation unit	9	1.33
	Pyrolysis of Methane	Uses a catalyst to crack methane at high temperature in absence of oxygen	No CO_2 emission. Produces solid carbon	Co-produces tar that can plug the reactor	3-5	1.43-1.53
	In situ Combustion of Hydrocarbon reservoirs	Steam/air/oxygen injection in fossil fuel-bearing reservoirs	Unwanted gases are not produced *via* downhole purification. Low-cost production	Complex in situ combustion that is difficult to control and predict	3-5	1.8
Biomass and Waste-Stream	Dark Fermentation	Wet biomass. Uses anaerobic bacteria under dark conditions	Relatively simple technology. Waste recycling. CO_2 neutral process	Low yield of H_2 relative to reactor volume	4-5	2.32
	Photo Fermentation	Wet biomass. Uses anaerobic bacteria and light	Relatively simple technology. Waste recycling. CO_2 neutral process	Low yield of H_2 relative to reactor volume	4-5	2.55
	Gasification	Dry biomass. Uses a controlled amount of oxygen and/or steam. No bacteria required	Relatively simple technology. Waste recycling. CO_2 neutral process	Pre-treatment cost. Fluctuating H_2 yields because of feedstock impurities. Co-produces tar	5-6	1.59-1.85

Table 4.2: Summary of hydrogen production technologies. [54] (Cont.)

Class	Technology	Description	Advantages	Disadvantages	TRL	Cost [€ per kg H_2]
Water-splitting	Thermochemical Process	Produces H2 by splitting water through a series of high-temperature (800°C-900°C) chemical reactions by using heat as the input energy. A single step convertion of water to H2 through direct thermolysis isl possible, but no practical as it requires extremely high temperatures (>2500°C)	Suitable for large-scale production capacity that is larger than the scale of H_2 re-fueling station. Can utilize sunlight and/or heat from nuclear waste	Requires additional H_2 distribution network due to its large-scale production capacity. Commercial viability is currently challenging	2-4	3.33
	Photoelectrochemical Process	Produces H_2 by splitting water through semiconductor immersed in water-based electrolyte that uses visible light as the input energy	Low operating temperatures and cost-effective materials (thin-film, particle semiconductor). Can utilize an unlimited source of solar light	Very low solar-to-H_2 conversion efficiency (<3%). Low current density due to reduced area of electrolysis in solar cell	2-3	5.14
	Alkaline Electrolysis	Electrolysis process converts water directly into H_2 and O_2 (without any partial reactions with other chemical/compounds) by using electricity as an input energy. Primary electrolysis components consist of an anode and a cathode separated by an electrolyte	Mature technology. The first water splitting technology to be developed. Relatively low cost	Corrosive liquid electrolyte. Perform poorly with fluctuating power sources, because of a slow response (start-up) time	9	2.07
	Solid-oxide Electrolysis		Can leverage both heat and electrical energy	Require high temperatures (>700°C-800°C). Slower start-up time	5	2.07
	Polymer Electrolyte Membrane Electrolysis		Can operate at high current densities. Perform better with fluctuating input currents. Integrate better with variable power generation, such as wind and solar. Faster response time	Expensive materials that add to the cost. Scale-up to the MW scale is a challenge	6-8	2.07
Natural Free-State Ocurrence		Naturally occuring free-state H_2 found in geological media	Can be extracted using existing oil and gas drilling technology	Its geological occurrence is not well-understood	1	Most economical

Table 4.3: Summary of carbon capture technologies. [54]

		Post-Combustion				
			Specialized Methods			
Characteristics	Pre-Combustion	Traditional Method	Cryogenic	Oxyfuel Combustion	Chemical Looping	DAC
Source of CO_2 emissions	Syngas coming from gasification units prior to combustion	Flue gas due to combustion with air and fuel	Flue gas due to combustion with air and fuel	Flue gas fue to combustion with oxygen and fuel. \ch{O2} is supplied externally from an air separation unit	Flue gas fue to combustion with oxygen and fuel. CO_2 is extracted internally from the solid-state oxygen carrier through reduction-oxidation reactions	Air. No combustion
Capture mechanism	Sorption with pressure and/or temperature swing	Sorption with pressure and/or temperature swing	Direct phase change from gas to liquid/solid	Sorption with pressure and/or temperature swing	Sorption with pressure and/or temperature swing	Membrane separation and/pr sorption
CO_2 capturing agents	Solvents and membranes	Solvents and membranes, and adsorbents	Cryogenic cooling with liquid solvents	Solvents and membranes	Solvents and membranes	Adsorbents and membranes
Outputs	CO_2 and H_2	CO_2 and N_2	CO_2, N_2, SO_x, NO_x, and Hg	CO_2 and steam	CO_2 and O_2	CO_2 and air
Advantages	High capture efficiency	Most mature technology	A high concentration of CO_2 is captured	Leads to a high concentration of CO_2 in flue stream, which is easier to capture	Cost-effective option to oxyfuel combustion, but with similar benefits	Can capture CO_2 anywhere on earth without the need for point-source emission
Disadvantages	Less mature technology	Lower capture efficiency	Relatively high CAPEX	Relatively high CAPEX	Less mature technology	Relatively high CAPEX
Major industrial sectors	Power and industrial gases	Power and cement	Power and cement	Power and steel	Power and steel	Greenhouse and carbonated beverages

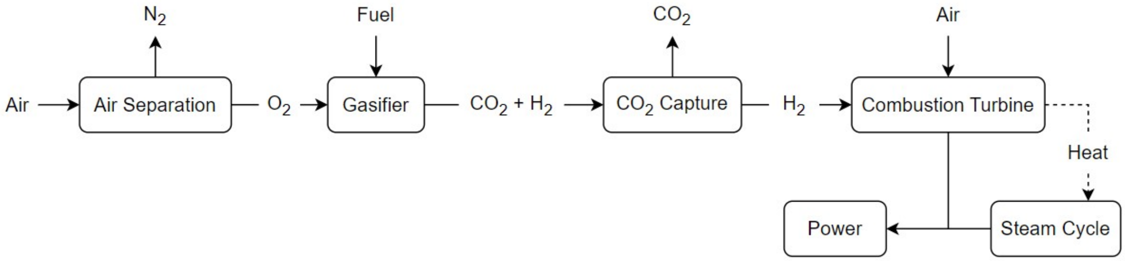


Figure 4.1: Flowchart of pre-combustion CO_2 capture [56].

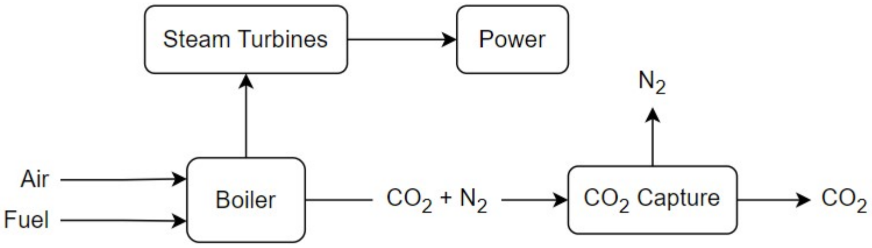


Figure 4.2: Flowchart of post-combustion CO_2 capture [56].

In oxyfuel combustion, as shown in Figure 4.3, fossil fuel is burned in pure oxygen, resulting in nitrogen-free flue gas production. The flue gas condensation results in the production of a clean carbon dioxide stream and the removal of NO_x pollutants [56, 57, 58]. Chemical Looping Combustion (CLC), currently in development phase, is an alternative to the pathways presented. CLC is an emerging technology, where fine metal particles, oxygen carrier, are used to transport oxygen between two reactors. Oxidized oxygen carrier is added to the fuel reactor to combust the fuel, reducing the oxygen carrier to metal (Me) or to a less oxidized state (MeO_{a-1}). These particles are transferred into an air reactor to oxidize to its original state (MeO_a), creating a loop. In this way, the flue gases from the fuel reactor are N_2 free, constituted by only CO_2 and steam. The process is demonstrated in Figure 4.4. The other methods previously presented require high energy levels to separate and obtain a pure stream of carbon dioxide, decreasing the system efficiency, not happening in CLC [59, 60].

Direct Air Capture

This type of technology is considered a promising and developing method. The two processes furthest along in development are liquid solvent system, and solid sorbent system. The first one is based on the absorption of CO_2 using low-toxicity solvents like water and alkaline aqueous solutions with a carbon dioxide strong affinity. A representative process flow diagram is demonstrated in Figure 4.5. This system contains two main loops: contactor loop and calciner loop. In the solid sorbent method, air is pushed through the contactor unit by fans and the CO_2 adsorbs onto the solid sorbent at ambient conditions. When the

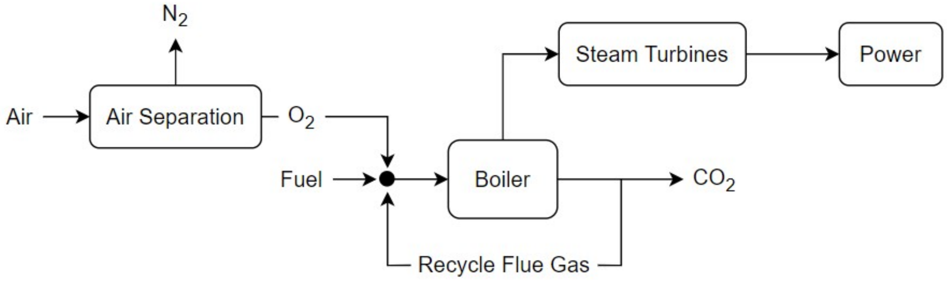


Figure 4.3: Flowchart of oxy-combustion CO_2 capture. [56]

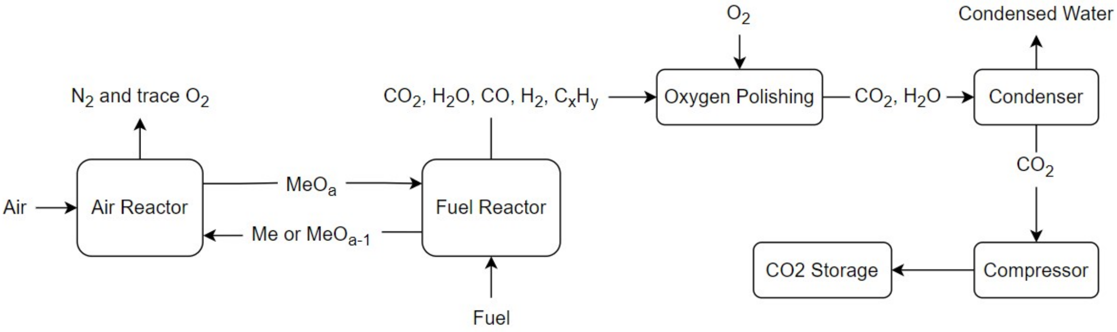


Figure 4.4: Flowchart of CLC process. [59]

solid sorbent is saturated with carbon dioxide, the device switch desorption mode. This process is illustrated in the flow diagram on Figure 4.6. Although, this approach shows higher sorption performance with better capacities and selectivity, and lower heating requirement, it also has a high operational expenditure resulting from sorbent degradation, when compared to the liquid solvent system. DAC is a new and innovative technology, but it is still in the early commercial stages and is more expensive than capturing CO_2 from flue gases [25, 61, 62].

Nitrogen Capture Methods

There are three methods to obtain nitrogen from air, cryogenic distillation, membrane separation, and pressure swing adsorption (PSA), in which, the first one is the most efficient and economical technology. The Cryogenic Air Separation method separates nitrogen from air through a high pressure and low temperature distillation. In the second method, membrane separation, the technology uses hollow-fiber membranes, to increase the surface area for a fastest permeation of nitrogen, obtaining N_2 with purity of at least 95%. The PSA method uses carbon molecular sieves to separate the nitrogen from the air. This process is the most popular approach, low-cost, environmentally friendly and frequently works well for applications that call for high nitrogen purity levels [55].

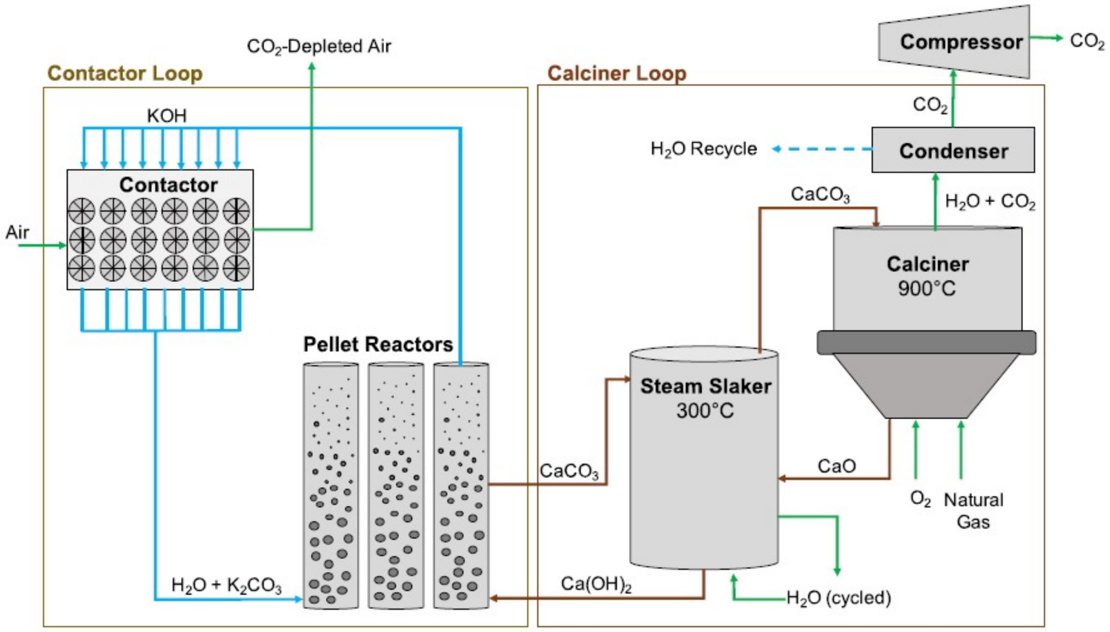


Figure 4.5: Representative process flow diagram for liquid solvent system. [62]

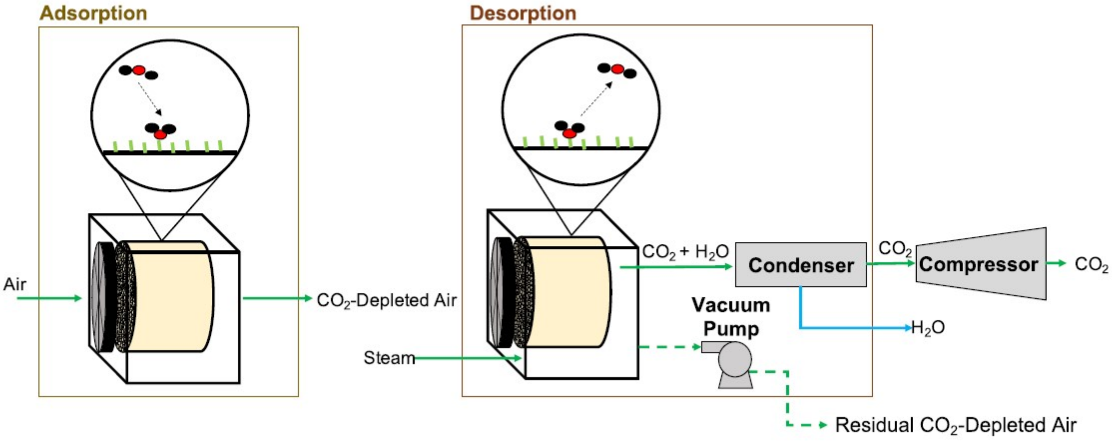


Figure 4.6: Representative process flow diagram for solid sorbent system. [62]

4.1.3 E-fuel Synthesis

An important goal in the sustainable generation of carbon-neutral fuels is catalytic CO_2 reduction. Besides the fact that hydrogen presents some barriers as a fuel, at a molecular level it can be used has chemical intermediate for the production of more manageable liquid or gaseous fuel. Therefore, reacting CO_2 with H_2, to produce syngas, it is feasible to produce a wide range of fuels, from the low-carbon fuels like methane, ethane, and propane, to the commercially high-value liquid e-fuels such as methanol and synthetic jet fuel. To convert carbon dioxide to liquid e-fuels, is necessary a one-step or two-step process, depending on the efficacy of the catalyst. While the one-step process converts directly CO_2 to liquid fuels, the two-step process, first transforms CO_2/H_2 to CO/H_2O, and then, a second reaction that integrates CO and H_2 to obtain the liquid fuel [54].

Power-to-Gas

According to Ababneh et al. [25], methane gas is already a well-established fuel that is easier to store and transport when compared to hydrogen. In a process called power-to-gas (PtG), in which involves the methanation of H_2 and CO_2, the Sabatier reaction (a slightly exothermic catalytic process) is applied, represented in the reaction 4.1. Figure 4.7, describes briefly the power-to-gas process where, in a first instance, the energy produced by renewable electricity will take part in the water electrolysis to obtain H_2, following the reaction 4.2. After that, methanation to get methane CH_4 occurs [11, 63].

$$CO_2 + 4\,H_2 \xrightarrow{\text{catalyst}} CH_4 + 2\,H_2O + 165\ kJ/mol \quad (4.1)$$

$$H_2O \rightleftharpoons H_2 + \frac{1}{2}O_2 - 282.8\ kJ/mol \quad (4.2)$$

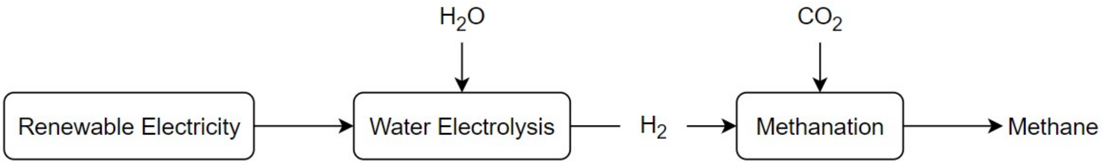


Figure 4.7: Representative flow diagram for *Power-to-gas* process. [11]

Power-to-Liquid

The synthesis for methanol and longer chained hydrocarbons is obtained through power-to-liquid (PtL) process. The process of obtaining methanol consists, normally, *via* syngas where CO and H_2 react in an exothermic reaction. However, to produce methanol through a renewable process, the synthesis can be done by direct hydrogenation, an exothermic reaction, or by reverse water gas shift (RWGS), an endothermic reaction. The methanol, or e-methanol, process by direct hydrogenation converts CO_2 directly to liquid e-methanol, reaction 4.3. Figure 4.8 presents the process to obtain methanol by traditional method (*via* syngas) and by direct hydrogenation. The other procedure, Figure 4.9, which involves two steps, first converts CO_2 and H_2 to CO and H_2O (syngas) by RWGS, and then CO reacts with H_2 to get e-methanol, reactions 4.4 and 4.5, respectively. The resulting e-methanol can further be reacted to obtain dimethyl ether (DME), gasoline, diesel and jet fuel. It is important to highlight that e-methanol can be considered a drop-in solution by blending into conventional fuels up to a concentration of 3% [54, 63, 64].

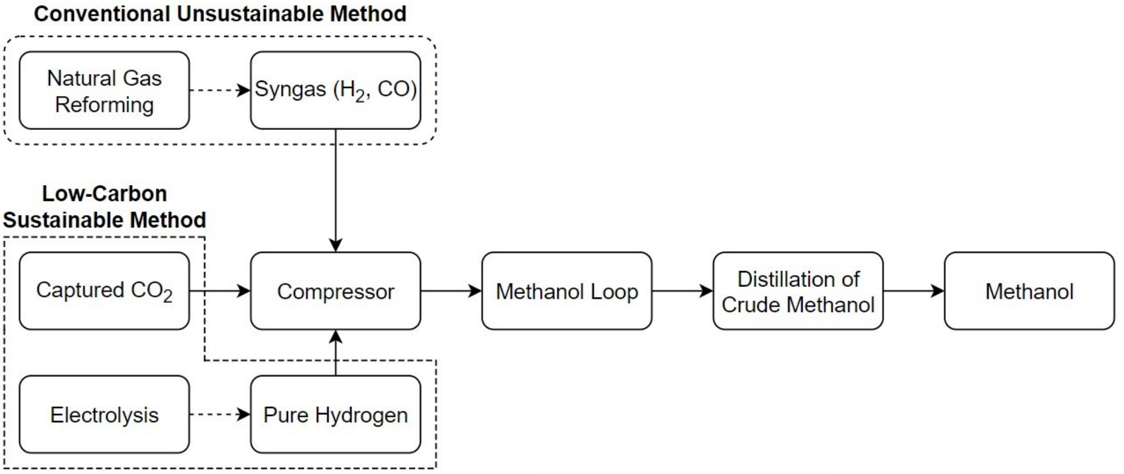


Figure 4.8: Representative flow diagram of methanol production. [54]

Direct hydrogenation process:

$$\underset{\text{captured}}{CO_2} + 3\ \underset{\text{green}}{H_2} \xrightleftharpoons{\text{catalyst}} CH_3OH + H_2O + 49.16\ kJ/mol \qquad (4.3)$$

RWGS process (at 600°C and 24.5 bar):

$$\underset{\text{captured}}{CO_2} + \underset{\text{green}}{H_2} \xrightleftharpoons{\text{catalyst}} CO + H_2O - 41.22\ kJ/mol \qquad (4.4)$$

$$\underset{\text{from RWGS}}{CO} + \underset{\text{green}}{H_2} \xrightleftharpoons{\text{catalyst}} CH_3OH + H_2O + 128\ kJ/mol \qquad (4.5)$$

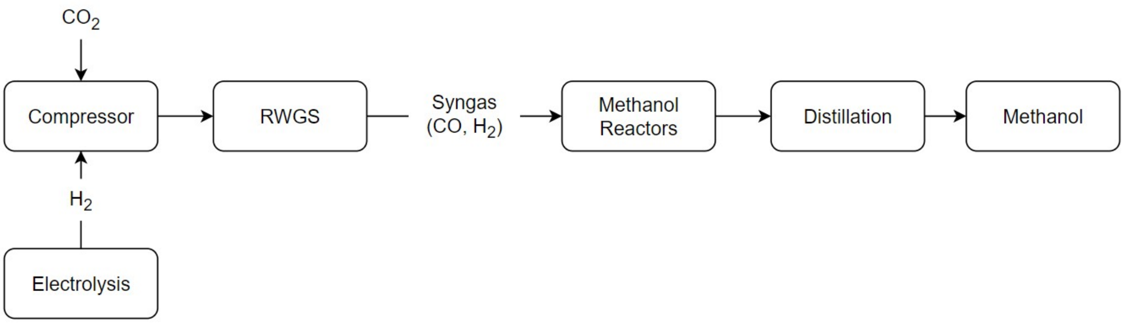


Figure 4.9: Representative flow diagram of methanol production through RWGS. Adapted from [54]

For longer chained hydrocarbons like e-kerosene, e-diesel, e-gasoline, and even SAF, the power-to-liquid process requires a different approach. This type of fuels are obtained using the Fischer-Tropsch (FT) synthesis. Here, syngas is placed in the FT reactor, which stands already at TRL 9, where it is catalytically transformed into the desired liquid hydrocarbons, depending on the operating conditions: temperature, pressure, catalyst types, and reaction rates. To produce e-fuels via power-to-liquid method includes six procedures represented in Figure 4.10. First H_2 and CO_2 are compressed to be transformed to CO in a RWGS reactor, reaction 4.4. Then CO, along with H_2, are combined in a FT synthesis reactor, reaction 4.6, and the product passes through hydro-processing and distillation to obtain the e-fuel [54, 63, 29].

$$\begin{gathered} n\mathrm{CO} + (2n+1)\underset{\text{green}}{\mathrm{H_2}} \xrightleftharpoons{\text{catalyst}} \mathrm{C}_n\mathrm{H}_{2n+2} + n\mathrm{H_2O} \\ n \in [17;32];\ \ \Delta H \overset{exo}{=} -x\ \mathrm{kJ/mol} \end{gathered} \tag{4.6}$$

As mentioned before, FT derivatives are certified by ASTM international to be mixed only up to 50%. However, due to its similar low heating value to the conventional fossil jet fuel and drop-in capability, e-fuels could be blended at higher ratios, or even completely replace conventional fuels. In Table 4.4 are summarized some current projects for commercial production of liquid e-fuels.

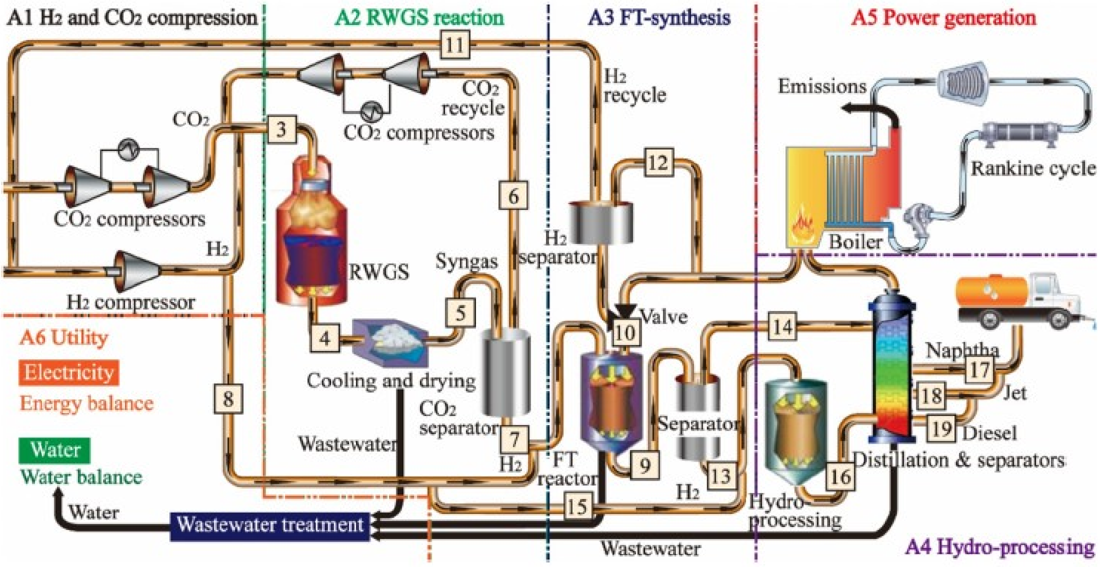


Figure 4.10: Representative flow diagram of liquid e-fuels production through FT. [54]

Table 4.4: Summary of some projects for commercial production of liquid e-fuels. [54]

					Material consumption info		
e-Fuel	Project name	Companies	Location	Date Started	H_2	CO_2	Production Capacity
e-Methanol	George Olah Plant	Carbon Recyclig International (CRI)	Svartsengi, Iceland	2012	800 tpa[a] produced using an alkaline electrolyzer powered by renewable energy	5600 tpa captured from a nearby geothermal power plant	4000 tpa
	MefCO2	Consortium of 9 partners funded by the EU	Niederaussem, Germany	2021	1.5 tpd[b] from a 600 kW PEM[c] electrolyzer from Cummins	1.5 tpd of captured \ch{CO2} from a coal (lignite)-fired power plant	1tpd (500 tpa capacity)
	e-CO2Met	TotalEnergies	Leuna, Germany	2021	1 MW electrolyzer (high--temperature SOEC[d] 80% efficiency, from Sunfire)	Captured from TotalEnergies refinery in Leuna	1.5 tpd
	FReSMe	Consortium of 13 partners funded by the EU	Lulea, Sweden	2021	100 N m3 h-1 recovered from the blast furnace in addiction to production by electrolysis	14 tpd captured from an industrial steel blast furnace	1 tpd (2.5 tpd capacity)
	Haru Oni	Siemens Energy, Porsche, HIF, Enel, ExxonMobil, Gasco and ENAP	Punta Arenas, Chile	2022	1.2 MW PEM electrolyzer (from Siemens Energy) powered by wind energy (3.4 MW Siemens Gamesa turbine)	DAC (from Global Thermostat)	750000 liters in 2022 and 1000000 tons by 2026
e-Kerosene	Synthetic diesel plant	Velocys	Oklahoma city, USA	2017			250 bpd[e]
	atmosfair FairFuel	Solarbelt FairFuel gGmbH	Werlte, Germany	2021	160 tpa using a 1.25 MW PEM electrolyzer powered by wind energy	DAC module and from waste valorization (biogas)	350 tpa of synthetic crude oil
	Haru Oni	Siemens Energy, Porsche, HIF, Enel, ExxonMobil, Gasco and ENAP	Punta Arenas, Chile	2022	1.2 MW PEM electrolyzer (from Siemens Energy) powered by wind energy (3.4 MW Siemens Gamesa turbine)	DAC (from Global Thermostat)	130000, 55 million, and 550 million liters per year by the end of 2022, 2024, and 2026 respectively
	Bayou Fuels Plant	Velocys/OLCV	Natchez, Mississipi, USA	2023			25 million gallons per year (35 million as capacity)

Acronyms: [a] tpa, tonnes per annum; [b] tpd, tonnes per day; [c] PEM, Polymer Electrolyte Membranes; [d] SOEC, Solid Oxide Electrolyzer Cell; [e] bdp, barrels per day

Power-to-Ammonia

Ammonia (NH_3) has been gaining attention lately as it is considered as an alternative fuel and an effective energy carrier, and from a fuel perspective, it has the capability to be a completely carbon-free fuel. Ammonia's principal production feedstock are fertilizers, playing, also, an important role in the synthesis of plastics, synthetic fibers, explosives and pharmaceuticals. When compared to hydrogen, ammonia also does not contain carbon in its structure. However, it can be easily stored and transported, relatively to hydrogen, due to liquefaction of ammonia being achieved at a pressure of 10.3 bar. To produce green ammonia (or e-ammonia), once again, hydrogen is necessary which is obtained through water electrolysis using renewable energy, then, H_2 and N_2 go through the Haber-Bosch process [25, 11, 63]. This reaction takes place at high temperatures and pressures, using an iron catalyst, according to the following reaction 4.7:

$$\underset{\text{captured}}{N_2} + 3\,\underset{\text{green}}{H_2} \xrightleftharpoons{\text{catalyst}} 2\,NH_3 + 91.8\,kJ/mol \tag{4.7}$$

This electrofuel has various benefits, such as not producing any carbon dioxide during combustion and being able to be kept in the wings like regular kerosene when refrigerated. However, the use of NH_3 as a fuel for aviation has only lately been given serious consideration. The majority of ammonia produced today, around 98%, is made by catalytic steam reforming natural gas, which accounts for 1.8% of the world's carbon dioxide emissions. The production cost of e-ammonia being twice the price of conventional ammonia, nitrogen oxides emissions and its high toxicity are some of the drawbacks of NH_3 [61, 55].

4.2 Life Cycle Analysis

Life cycle analysis (LCA) is a tool that, by assessing technology, processes and products, helps each individual in the decision making concerning sustainability. [65]. LCA evaluates the environmental impacts of various stages of the fuel life cycle, from the extraction and transportation of raw materials, to the production process and distribution, and to the disposal and end-of-life treatment. This type of analysis consider various environmental impact categories, such as greenhouse gas emissions, energy consumption, water usage, and other forms of environmental pollution. In the present work, it is compared the LCA of e-kerosene and conventional jet fuel, where only the CO_2 emissions were considered. Across aviation industry, where timely analysis is critical, gaining a comprehensive understanding of the entire process flow of the alternatives being assessed, along with the co-products generated, is the primary step towards conducting effective LCA. [25, 61, 29].

4.3 CO_2 Emissions Calculation

As mentioned, e-fuels have the potential to replace jet fuel in the future, but, for now, they can only be blended up to 50%. To verify if, with the e-kerosene introduction, is possible to reach net-zero by 2050, 5 possible scenarios were created. These scenarios will depend on the blend ratio of e-kerosene with jet fuel, which will vary over the years:

- **Scenario 1**: The blend ratio is 50% until 2100;
- **Scenario 2**: The blend ratio is 50% until 2050, increasing 10% in the following decades, i.e., 60% in 2051-2060, 70% in 2061-2070, 80% in 2071-2080, 90% in 2081-2090, and 100% in 2091-2100;
- **Scenario 3**: The blend ratio is 50% until 2050, increasing 10% every next 5 years, i.e., 60% in 2051-2055, 70% in 2056-2060, 80% in 2061-2065, 90% in 2065-2070, and 100% in 2071-2100;
- **Scenario 4**: The blend ratio is 50% until 2050, 75% in 2051-2060, and 100% in 2061-2100;
- **Scenario 5**: The blend ratio is 50% until 2035, 75% in 2036-2050, and 100% in 2051-2100.

The environmental impact analysis of e-kerosene, in terms of CO_2 emissions, is based on the Environmental Report by ICAO [66] that uses the quantity of SAF available and the respective life cycle to analyze the influence of SAF introduction in the emissions. Figure 4.11 depicts a flowchart of the calculation procedure, where CO_2 emissions(t) represents the total CO_2 emissions of the specific year, Jet fuel(t) the quantity of conventional jet fuel in kilograms of the specific year, E-kerosene(t) the quantity of e-kerosene in kilograms of the specific year, $LCA_{\text{E-kerosene}}$ the life cycle of e-kerosene (9.23 gCO_2e/MJ [67]), $LCA_{\text{Jet fuel}}$ the life cycle of conventional jet fuel (89 gCO_2e/MJ) and t the simulation year.

The first part of the methodology is to load the demand of jet fuel obtained with FSDM and load the production capacity of e-kerosene corresponding to each production rate case. Next, e-kerosene is introduced into aviation fuel demand, according to the required blend ratio. Lastly, CO_2 emissions are calculated, resulting from jet fuel and e-kerosene consumption.

E-kerosene Production

Finding the world production of e-kerosene was challenging, due to it being a recent technology. In Table 4.4 of Chapter 3 some projects are covered that were considered for the world production. Other projects used in this dissertation can be found in Table A.1 of

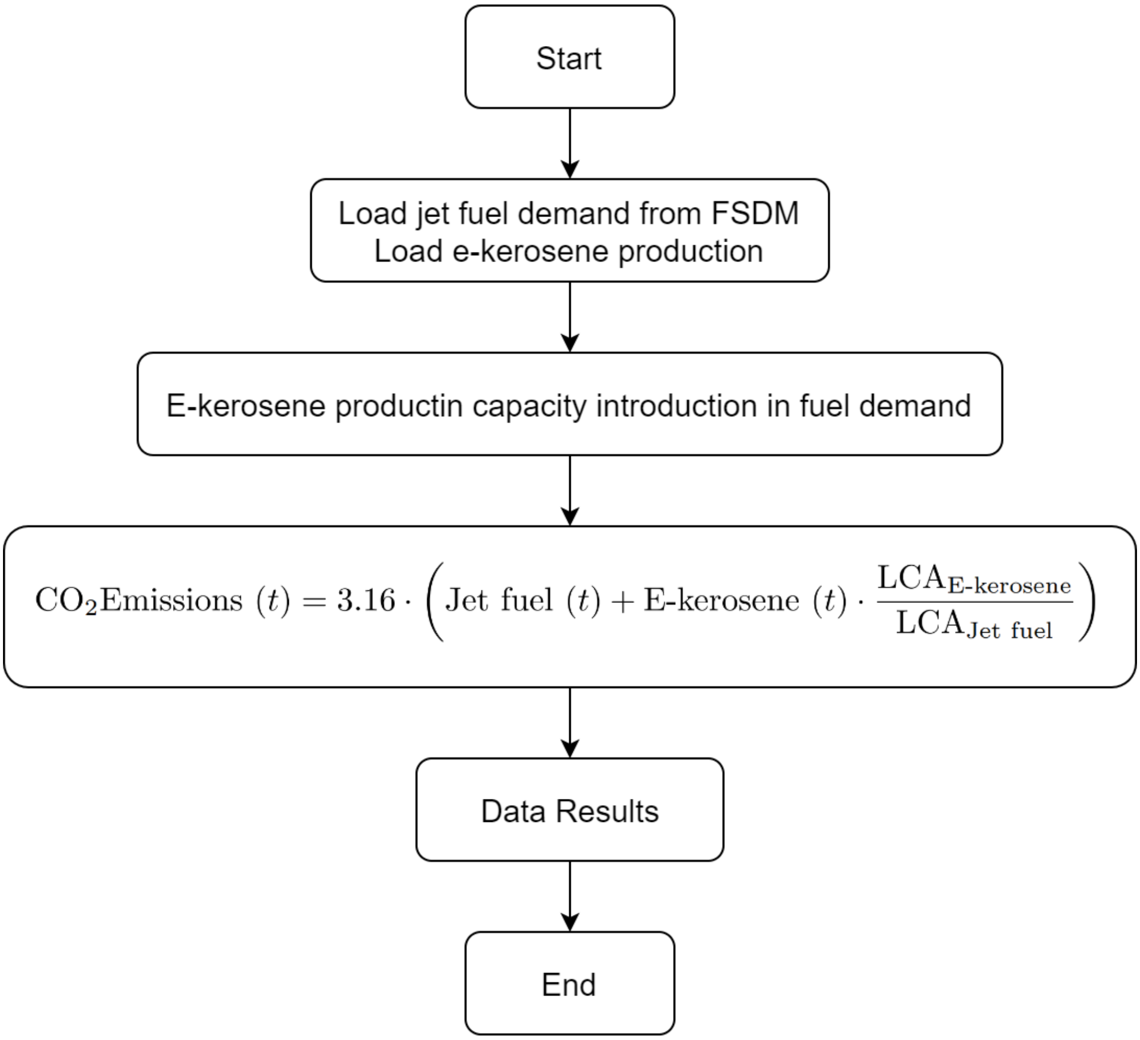


Figure 4.11: E-kerosene emissions methodology.

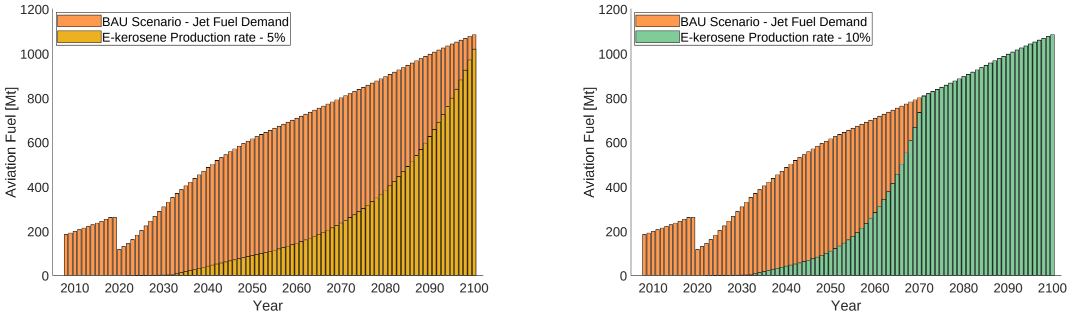
Appendix A. Most of them do not yet started the e-kerosene production, so the majority of data are projections made by the companies in charge of the projects.

Starting in 2022, the companies only project their production capacity until 2050. So, it was considered, for each scenario an annual production rate of 5% (Case A), 10% (Case B), and 15% (Case C). By 2050, the annual production rate is 5.64%. So, for the first case, Figure 4.12a, it is applied a decrease of 5% until 2100. With this production rate, e-kerosene production never reaches the necessary demand to supply the world fleet.

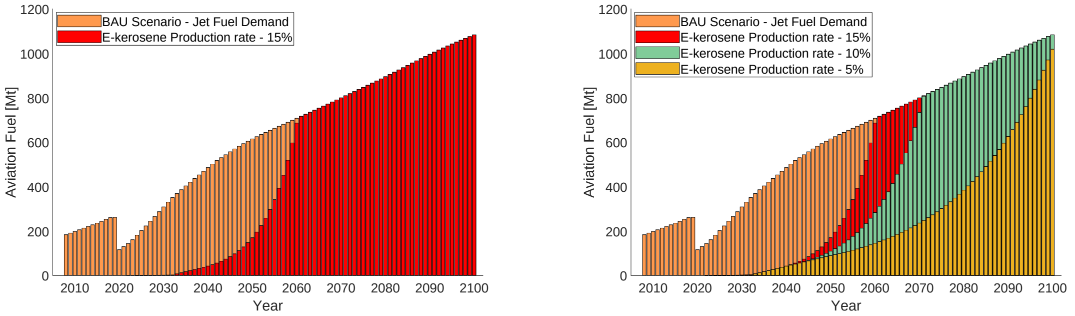
In Case B, to be able to consider a 10% production rate until 2100, it was selected the year in which that production rate is similar, like in the case before. For this Case the 10% annual production rate starts in 2043. The production capacity of e-kerosene achieves the jet fuel demand in 2072, as shown in Figure 4.12b.

In the last case, the 15% annual production rate until 2100, starts in 2040, for the same reason of the preceding case. As seen in Figure 4.12c, the necessary demand to supply the world fleet is achieved in 2061. A comparison between the 3 annual production rates is demonstrated in the final plot, Figure 4.12d.

An important note is that e-kerosene production capacity has those annual production rates until it reaches the jet fuel demand, previously obtained with FSDM model. The production capacity values, with the corresponding production rates, for the 3 cases can be found in Appendix A.



(a) Case A: E-kerosene production rate of 5%. (b) Case B: E-kerosene production rate of 10%.



(c) Case C: E-kerosene production rate of 15%. (d) Comparison with the 3 production rates.

Figure 4.12: E-kerosene production and jet fuel demand.

Chapter 5

Results and Discussion

This chapter presents the results with their respective analysis. Firstly, the fuel consumption and the CO_2 emissions are presented for the Business as usual scenario, that was obtained using FSDM for the global fleet until 2100. The selected scenario will also be used as BAU scenario for the production capacity. After that, the introduction of e-fuel is considered for different production capacities and blend ratios, in which the impact in CO_2 emissions is studied in comparison to BAU scenario.

5.1 Business as Usual

Making a projection of the emissions in aviation until 2100 was challenging, due to the lack of data. Although, using recent work about the SSPs and its impact on aviation sector, was helpful. In aviation, SSPs offer valuable insights into possible predictions of air travel demand (RPKs) and their subsequent implications for fuel consumption. For that, the work by Franz et al. [68] was used, in which the global aviation demand is forecast until the year 2100. So, this section presents results and comparison between projections made.

5.1.1 Boeing Commercial Market Outlook - Iteration 1 & 2

The first results for the Business as Usual (BAU) scenario were obtained, using only the Commercial Market Outlook (CMO), provided by Boeing, which, predicts the annual growth of RPKs, in percentage, until 2042. Using their values, in a first iteration, it was assumed that the decrease in aviation demand between 2032 and 2042, was the same between 2042 and 2100. Furthermore, in next iteration, it was assumed that the decrease was constant between 2042 and 2100, every 10 years. Table 5.1, shows the values of three routes for this two iterations. In Appendix B, the values for global routes are presented.

The prediction of fuel burned and CO_2 emissions were conducted using the FSDM, by input the RPKs values in the model, and are presented in Figures 5.1 and 5.2, respectively. As it is possible to notice, the results are very distinct. In the first iteration, the emissions will continue to growth despite the decrease in the percentage growth of RPKs. However, in the second one, as the decrease in the percentage growth of RPKs becomes more pronounced, resulting in burning less fuel, as it is demonstrated by the slope of the curve of Iteration 2. It is noteworthy to state that the values begin to diverge in 2050, as this is the year up to which Boeing supplies the data.

Table 5.1: Ratio of the RPKs growth until 2100, every 10 years, for first and second iterations.

Iter	Route	Year								
		2022	2032	2042	2052	2062	2072	2082	2092	2100
1	EUEU	1,206	0,0739	0,0362	0,0330	0,0299	0,0267	0,0235	0,0203	0,0181
	EUAS	1,311	0,4872	0,0338	0,0284	0,0229	0,0175	0,0121	0,0067	0,0029
	EUNA	2,270	0,0714	0,0328	0,0297	0,0266	0,0236	0,0205	0,0175	0,0153
2	EUEU	1,206	0,0739	0,0362	0,0178	0,0087	0,0043	0,0021	0,0010	6,08E-04
	EUAS	1,311	0,4872	0,0338	0,0023	0,0011	5,63E-04	2,76E-04	1,35E-04	8,02E-05
	EUNA	2,270	0,0714	0,0328	0,0150	0,0074	0,0036	0,0018	8,68E-04	5,14E-04

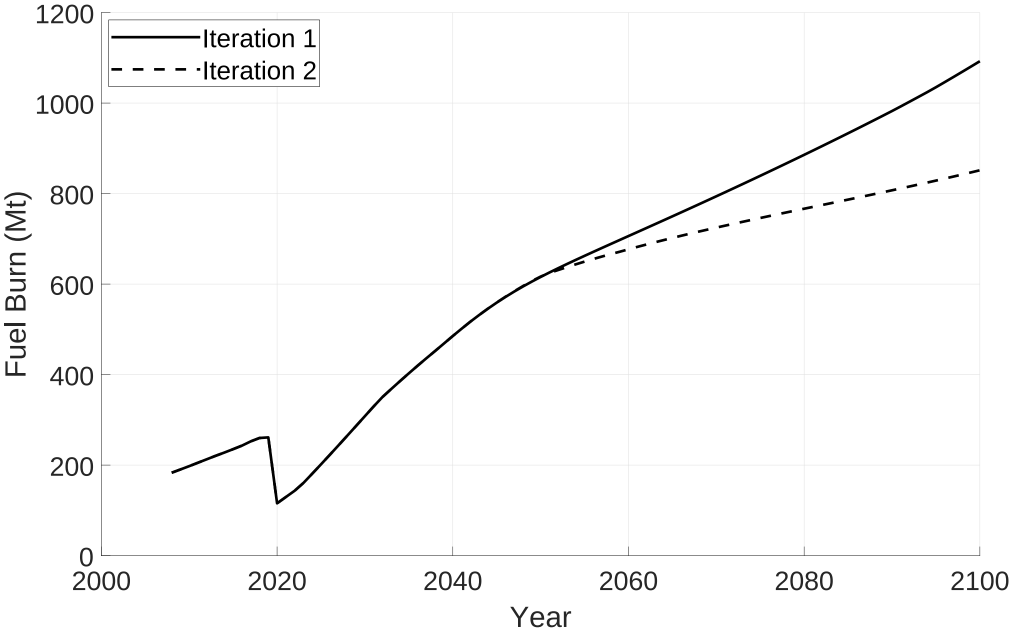


Figure 5.1: Fuel burned prediction until 2100 for first and second iteration.

An alternative approach for examining the iterations involves assessing their CO_2 performance, as outlined in Equation 5.1. This represents the amount of CO_2 produced in grams per available seat kilometer (ASK). In this way, it is also possible to consider the transport supply capacity.

$$\mathrm{CO_2}\, performance = \frac{fleet\, \mathrm{CO_2}\, emissions\ [grams]}{total\ ASK} \tag{5.1}$$

When analyzing Figure 5.3, and considering once again Figure 5.2, besides the increase of CO_2 emissions, the grams of CO_2 per ASK tend to decrease, due to the continuous grow of the demand for air travel. In 2020, due to COVID-19, the air travel was limited causing a decrease in the emissions. However, the CO_2 emissions reduction was not as much as the decrease in the air travel demand. Lastly, until 2050, CO_2 performance from both Iterations almost coincide, starting to diverge in this year. That can be explain by the big difference in the RPKs and, consecutively, in the ASKs. Despite the ratio of the RPKs are still increasing in both cases, in Iteration 2, by the year 2082, the increase is so small that the RPK values start to stabilize, contrarily to the emissions, that are still growing at considerable rate.

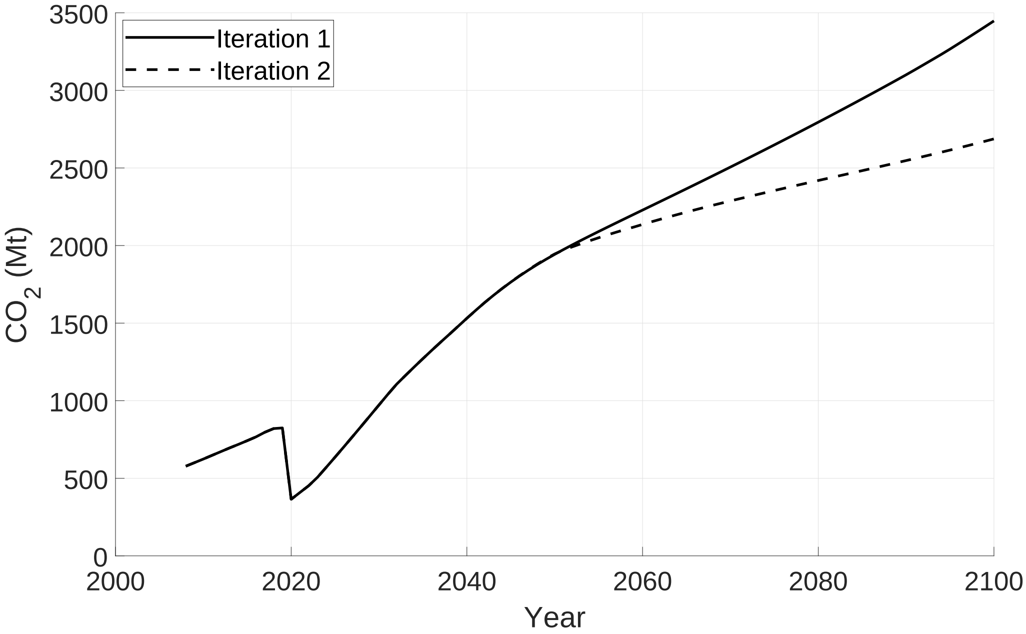


Figure 5.2: CO_2 emissions prediction until 2100 for first and second iteration.

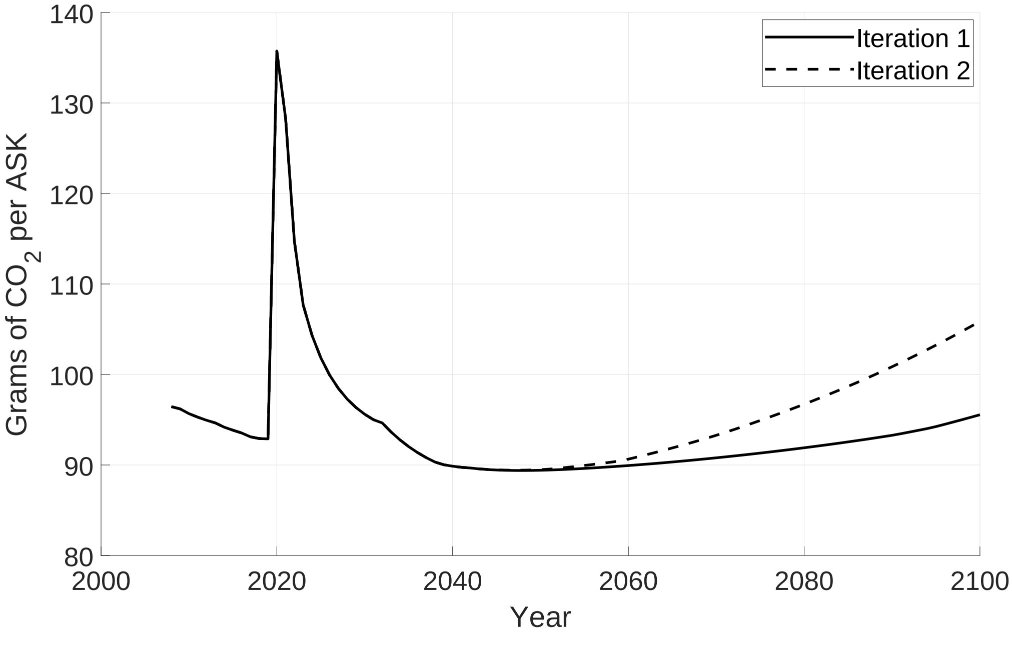


Figure 5.3: CO_2 performance for first and second iteration.

5.1.2 Shared Socioeconomic Pathways - Iteration 3 & 4

The following iterations for BAU scenario were obtained taking into account the SSPs. A study by Franz et al. [68], shows that aviation demand takes different routes depending on the pathway. The main focus is to explore various recovery scenarios for the aviation sector following the COVID-19 pandemic, considering the pandemic's long-term effects on different segments of civil aviation. They provide country-level projections for aviation demand, including international and domestic travel, as well as business and leisure travel. Furthermore, three distinct pathways are considered, SSP1, SSP2, and SSP5, each presenting unique challenges in terms of mitigation.

The studies conducted by Gössling et al. [69] and Dray et al. [70] around SSPs variation in aviation are based on single elements of SSPs, like gross domestic product (GDP) and population growth, failing to acquire, comprehensively, the narratives behind different SSPs. This research takes into account not only the GDP and population as primary influencers of aviation demand but also calculates specific behavioral effects unique to SSPs, which shape the income elasticity (IE). It is important to emphasize that income elasticities are not broadly applicable. Besides that increase income and air travel demand are in fact connected, after a certain point, having more income does not imply that people will fly more. In other words, at a certain income level, budget stops being a problem, and other constrains like, vacation time or interest in air travel, gain force, causing a decrease in he income elasticity [68]. Their results of the global average IE are presented in Figure 5.4, which were used to obtain the total aviation demand until 2100, as illustrated in Figure 5.5. The total aviation demand data is used in present work.

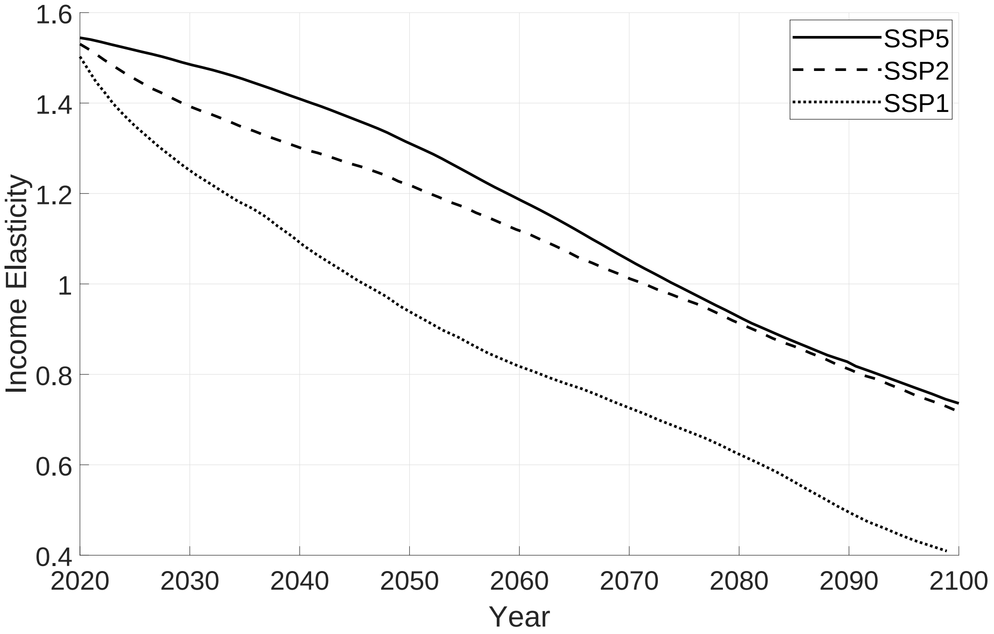


Figure 5.4: Global average income elasticity for SSP1, SSP2, and SSP5. Adapted from [68].

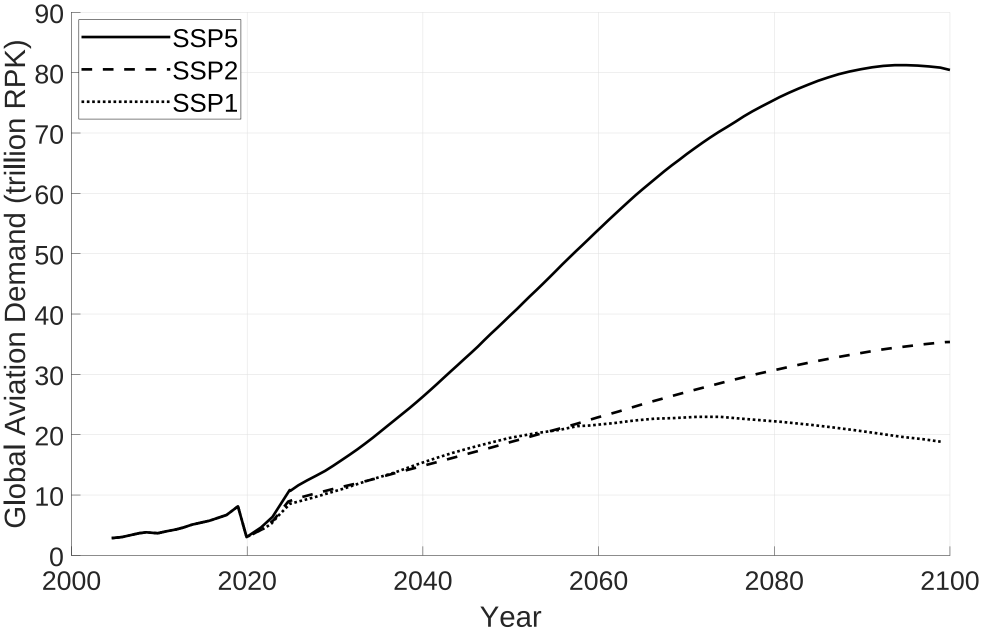


Figure 5.5: Global aviation demand for SSP1, SSP2, and SSP5. Adapted from [68].

Using the predictions for aviation demand from Franz et al. [68], it is possible to obtain other two iterations for BAU scenario. Since the work done by Franz et al.[68] only predicted the global aviation demand, for these two iterations is not possible to use the RPKs for each route, unlike what happens in the first two iterations. For Iteration 3, the simulation starts with CMO values, until 2023. In the following years prediction, the values of RPK corresponding to each pathway (SSP1, SSP2, SSP5) are used. In the case of Iteration 4, until 2042, the RPK values used were those provided by Boeing. After that, the simulation was conducted using the air travel demand values for each pathway.

Relatively to Iteration 3, Figures 5.6 and 5.7, demonstrate the fuel burn and CO_2 emissions predictions for the three SSP scenarios, respectively. From both graphs, SSP5 is the scenario that will produce more emissions, and SSP1 will burn less fuel, in the long run, in which can be explain by the difference between the scenarios. In SSP5, there is a strong focus on technological development in the field of fossil fuels, a rapid rise of the global economy and a improve in people's lifestyle, that contributes to a population growth, increasing the demand for air travel, and, consequently, cause emissions to increase. According to O'Neil et al. [52] SSP1 narrative moves toward sustainability and has a focus in human well-being, where a less material and energy consumption, accompanied by investments in people's health and education, lead to low population. The commitment to achieving development goals, environmental technological development, and resource management will improve the global environmental conditions. So, analyzing the SSP narratives and the results from Franz et al. [68], once the difference between developed and developing countries fades, and sustainable stability is achieved (year 2072 of Figure 5.5), the RPKs will decrease leading to less emissions by 2100. Lastly, the middle road narrative follows a path that does not move way from historical patterns. SSP2 is characterized by moderate population and GDP growth, some investment in renewable resources, where society still depends in fossil fuels, and a relatively weak international cooperation towards a more sustainable world. This contributes to a partially constant growth in the air travel demand, in which, leads to an expected constant emissions increase over the years.

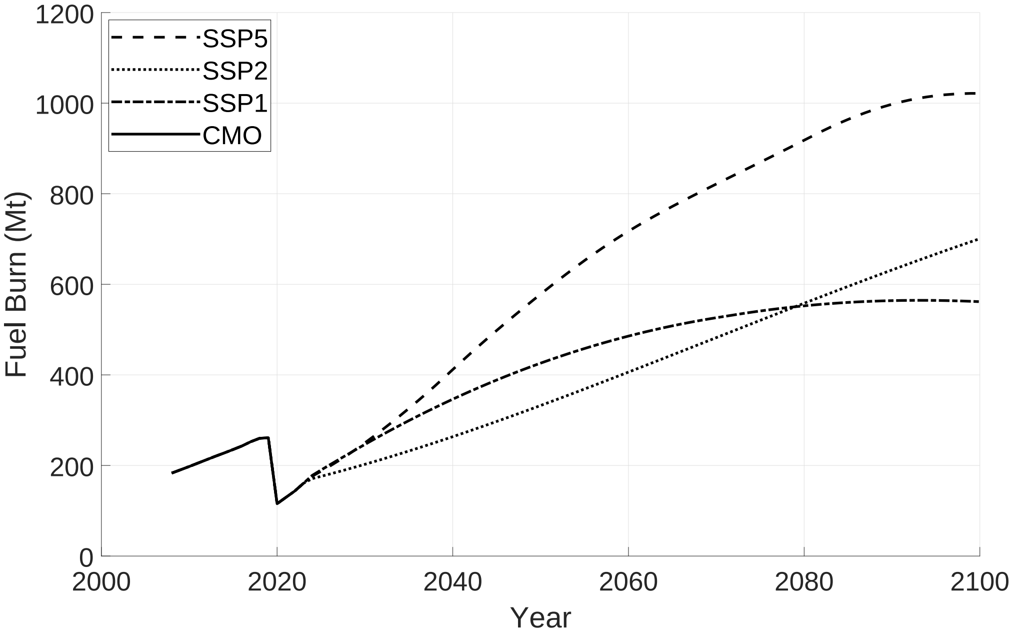


Figure 5.6: Fuel burned prediction until 2100 for Iteration 3.

When talking about CO_2 performance in Iteration 3, Figure 5.8, the results are also very distinct. In 2020, it is possible to notice COVID-19 impact in aviation, has explained before. After that, depending on the scenario, the simulation will follow different paths. Besides the fact that in the SSP5 there is more emissions production, it also has a fast population enlargement, along with bigger purchasing power, in the first half of the century, creating a smooth decrease, and nearly stabilizing in the following years. Relatively to SSP2, the CO_2 performance is bigger than the scenario before, due to the continuous increase of the CO_2 emissions, as shown in Figure 5.7. Although, the global aviation demand will also increase, it will tend to reach a stability point, creating an increment in the CO_2 performance, in the last 30 years. In SSP1, the explanation is similar to SSP2. The decrease in CO_2 emissions is lower than the decrease of the demand for air travel, due to being a less consumerist society and reaching demographic stability.

In Iteration 4, when compared to the results of SSP2 and SSP5 with those from Iteration 3, as shown in Figures 5.9 and 5.10, the predictions for fuel burn and CO_2 emissions have evolved in a similar direction. Notably, both SSP2 and SSP5 exhibit slightly larger emissions values, indicating a trajectory that is a bit more concerning, by having a bigger growth rate when compared to the previous iteration, with SSP2 emerging as the domi-

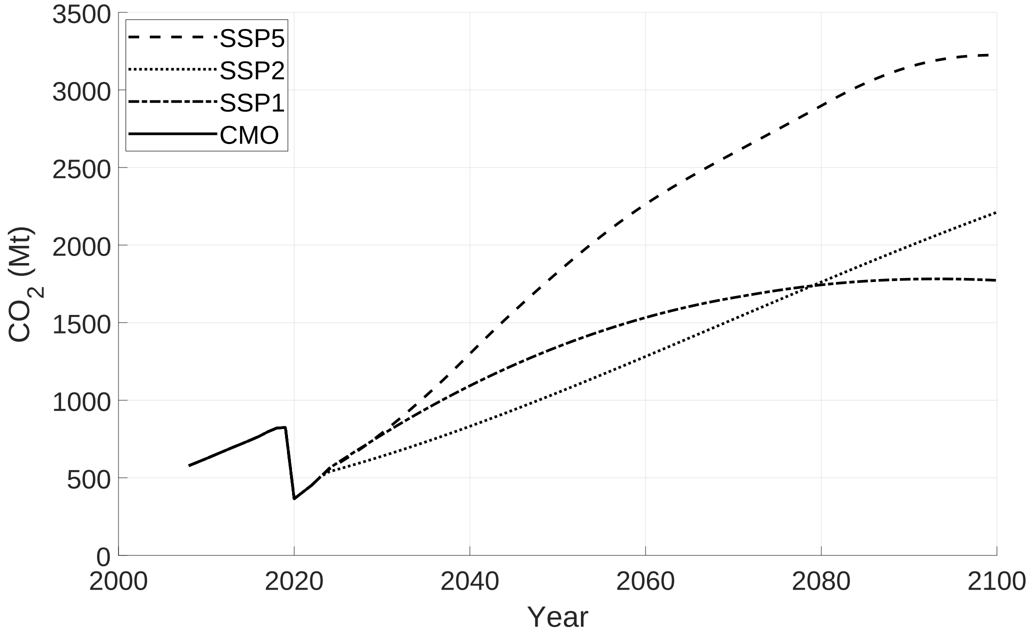


Figure 5.7: CO_2 emissions prediction until 2100 for Iteration 3.

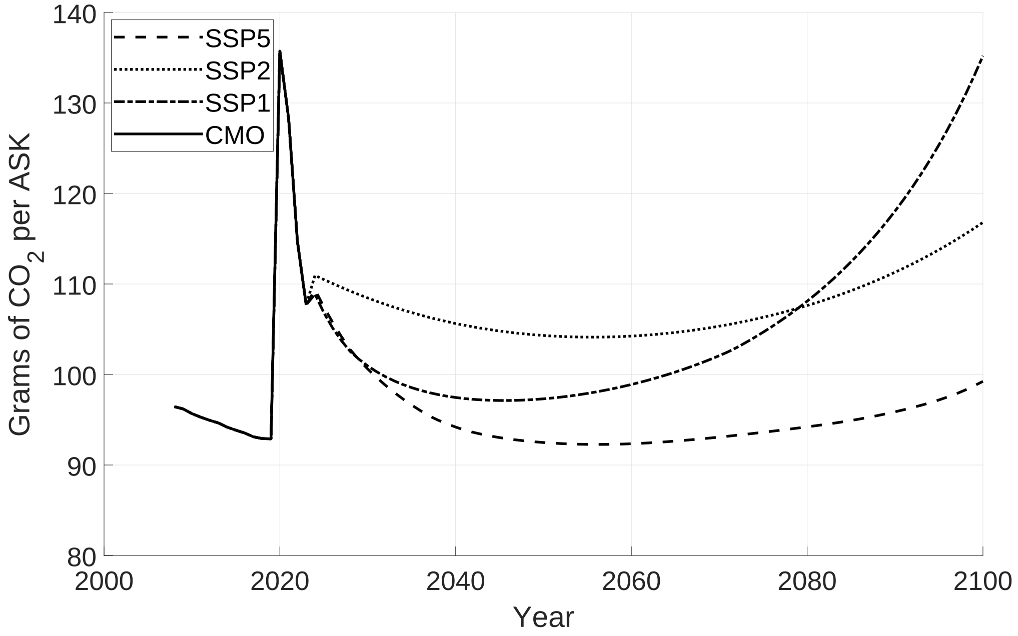


Figure 5.8: CO_2 performance for Iteration 3.

nant one. Like in Iteration 3, SSP5 remains a scenario with high emissions output, partly due to a persistent focus on technical developments within the fossil fuel industry. This strategy, together with a sharp acceleration in world economic growth and bettering lives, has resulted in a noticeable rise in population, which in turn has increased demand for air travel and, as a result, increased emissions.

On the other hand, SSP1 prioritizes sustainability and the well-being of humanity, resulting in reduced fuel burn and emissions in the long term. This achievement can be attributed to decreased material and energy consumption, as well as significant investments in healthcare and education. The commitment to achieving development goals, advancements in environmental technology, and responsible resource management all contribute to improved global environmental conditions. Contrarily to Iteration 3, here the emissions start to decrease after 2080, because, in that year, the society reaches demographic stability.

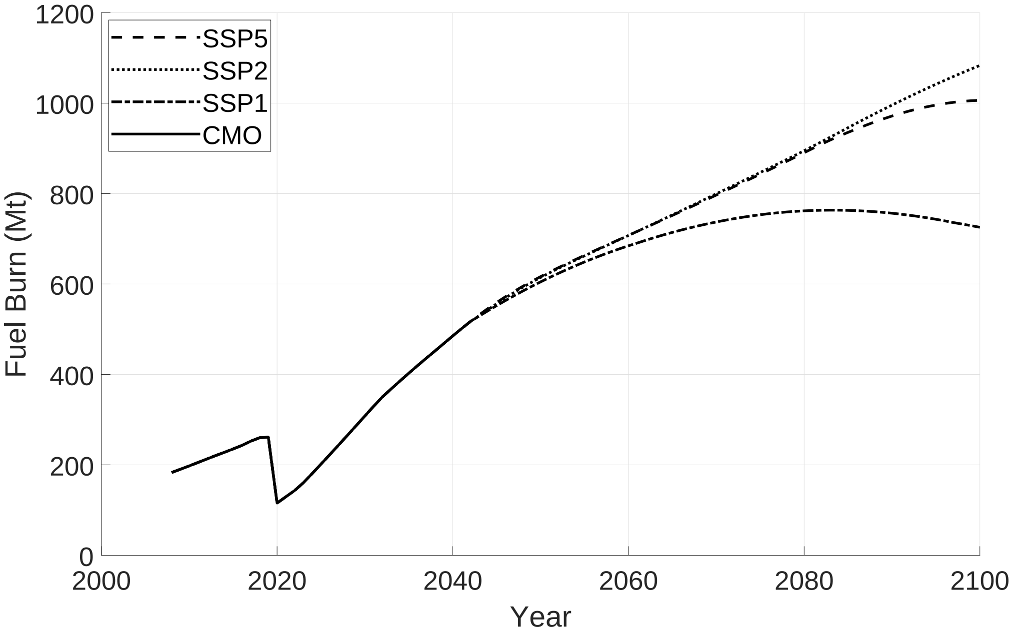


Figure 5.9: Fuel burned prediction until 2100 for Iteration 4.

The middle-road narrative embodied by SSP2 adheres closely to historical patterns. Marked by moderate population and GDP growth, as well as some investment in renewable resources, society's dependence on fossil fuels remains significant. Moreover, a relatively weak international cooperation effort towards sustainability prevails. Consequently, air travel demand experiences a consistent growth pattern, leading to a sustained increase in emissions over the years.

Finally, Iteration 4 produces more emissions, due to the impact of Boeing CMO in the RPK prediction. In Iteration 3, the RPK values have a huge decrease when the transition to SSPs RPK values occurs, as shown in Appendix B. For example, in the route EUEU, the RPK value decrease 91.1% from 2023 to 2024.

When discussing CO_2 performance in Iteration 4, as shown in Figure 5.11, the results for SSP2 and SSP5 have become more similar compared to Iteration 3, with a slight decrease in their CO2 performance values. In 2020, the impact of COVID-19 on aviation is still evident, as mentioned previously. However, post-2020, the simulation takes diverse trajectories based on the chosen scenario.

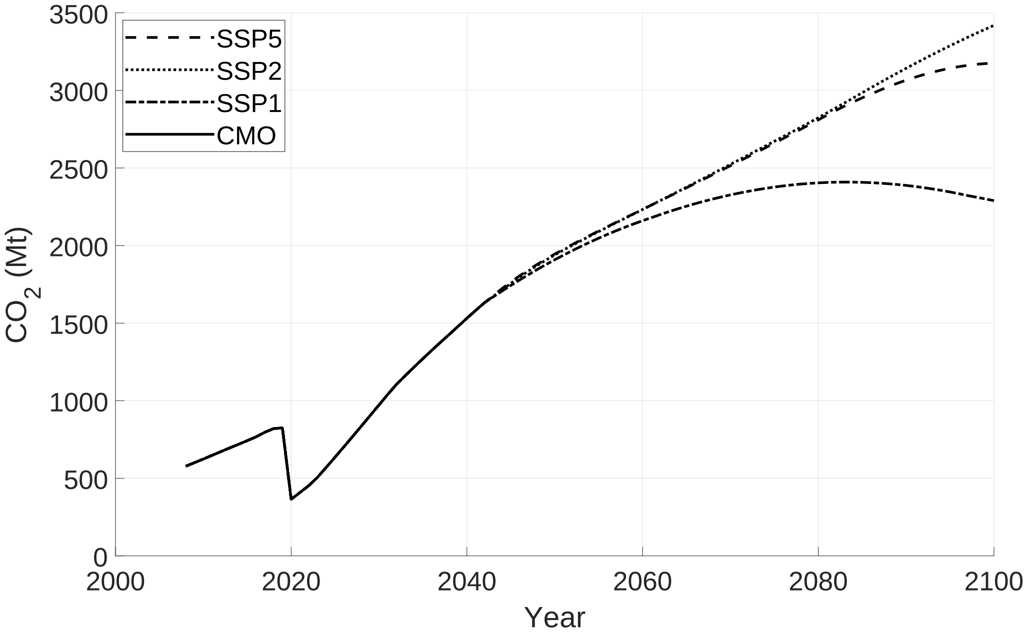


Figure 5.10: CO_2 emissions prediction until 2100 for Iteration 4.

Despite SSP5 and SSP2 having similar results, contrarily to Iteration 3, SSP2 is the one that have better results in CO_2 performance. SSP5 scenario, during the 92 years of simulation, present identical results regardless of, in this iteration, Boeing CMO is implemented until 2042. In contrast, SSP2 exhibits a much lower CO_2 performance compared to the previous iteration, primarily due to a continuous increase in CO_2 emissions, as illustrated in Figure 5.10. Nonetheless, global aviation demand, while on the rise, is tending toward stability. However, the Boeing CMO has a huge impact in the results of Iteration 4, inciting to become the scenario with better performance.

The performance results of SSP1 scenario are also lower relatively to Iteration 3, once again, due to the Boeing CMO influence. Yet, they still present the worst CO_2 performance as a result of the decrease in CO_2 emissions being lower than the decrease of the demand for air travel.

To validate the obtained results, a comparative analysis was conducted between the predictions from ATAG [10] and a study performed by Grewe et al. [71]. The ATAG forecast extends only until 2050. To align with the outcomes, a linear and logarithmic extrapolation of ATAG's data was performed, projecting it until 2100. Both extrapolations were identical, so, in Figure 5.12, is only represented the linear prediction of ATAG values.

In the analysis by Grewe et al. [71], the results exhibit that, years after COVID-19, the passenger transportation will retake the increasing tendency of the years before the pandemic, aligning with the findings in present work. However, their assessment of CO_2 emissions in the BAU scenario excludes the impact of COVID-19, as evidenced in Figure 5.12. A

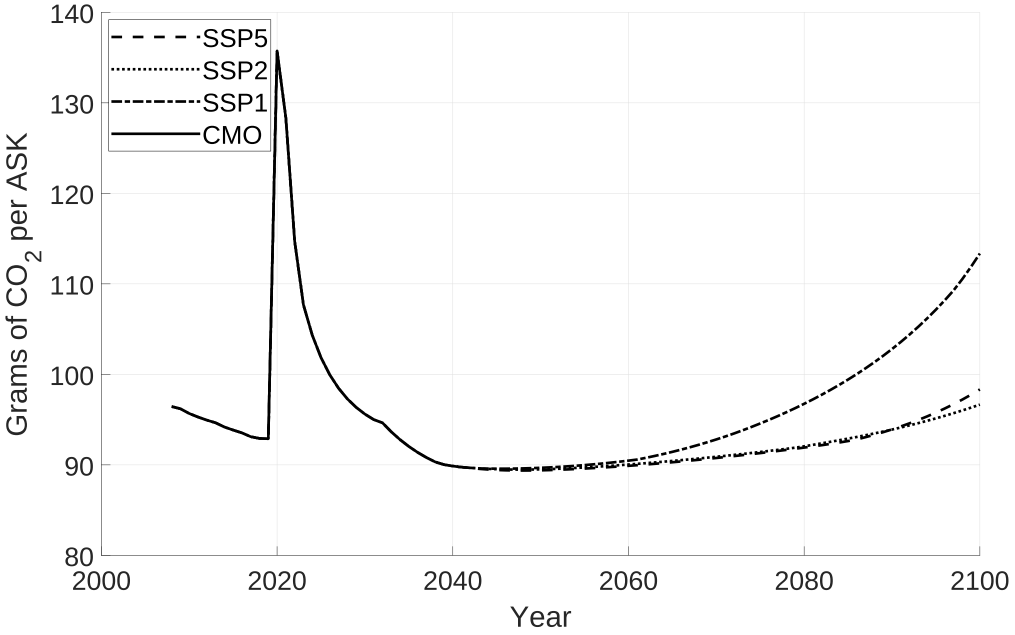


Figure 5.11: CO_2 performance for Iteration 4.

comparative evaluation reveals that while Grewe et al.'s forecast deviates from the results in the present work, plausibly due to disregarding the pandemic's influence, the outcomes converge notably around 2080. When comparing with ATAG prediction, the results are identical. Nevertheless, the linear prediction, after 2060, starts to diverge from the results in the present study, but the discrepancy is relatively small, converging towards a comparable value by 2100.

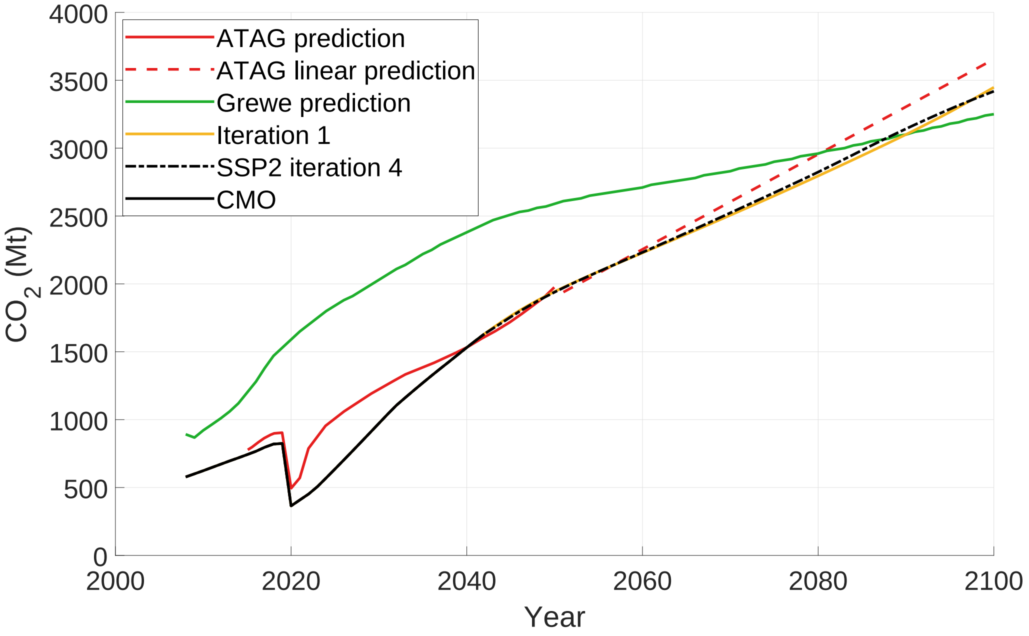


Figure 5.12: Comparison with ATAG and Grewe et al. study.

Finally, since Iteration 1 and SSP2 of Iteration 4 present similar results, either could be chosen for subsequent analyses. So, the second one was selected for the forthcoming steps.

5.2 E-fuels Scenarios Results

This section provides the findings concerning CO_2 emissions upon the introduction of an E-fuel, such as E-Kerosene. The comparison is made using the SSP2 scenario from Iteration 4, and the discussion will encompass five scenarios, differing in the blend ratio with traditional jet fuel. The evaluation includes determining when carbon-neutral growth is attained and whether net-zero is achieved. Each scenario was obtain for three distinct cases of E-Kerosene production capacity.

5.2.1 Scenario 1

In the Scenario 1, a blend ratio with jet fuel of 50% until 2100 was considered. E-kerosene is a FT derivative, so, according to ASTM international, it can be blended up to 50%, at least for now. Therefore, Scenario 1 is the most conservative. In the Figures 5.13, 5.14, and 5.15 the results for this scenario are presented. For Case A, corresponding to Figure 5.13, it is possible to notice a difference in CO_2 emissions starting around 2035, reaching carbon-neutral growth in 2067. This decrease persists until 2084, by which point, the production capacity is feasible to satisfy the demand for the global fleet, at a 50% blend ratio. In the last 16 years, CO_2 emissions start to increase again. This happens mainly because there is jet fuel in the mix. In the other 2 production rates, Figures 5.14, and 5.15, it is possible to see a faster decrease in CO_2 emissions, due to, bigger production rates. However, these e-kerosene production capacities, Case B and C, reach the world fuel demand earlier, in which emissions start to increase in 2063 and 2055, respectively. In these two productions rates carbon-neutral growth is also reached earlier. For Case B is achieved in 2051 and for Case C in 2046. The CO_2 emissions in 2100 are the same, corresponding to the value of 1889 Mt of CO_2, never reaching the net-zero. Despite the different production capacities, this decrease of almost 45% in CO_2 emissions relative to BAU scenario will be the same for the three cases, since the blend ratio is the same.

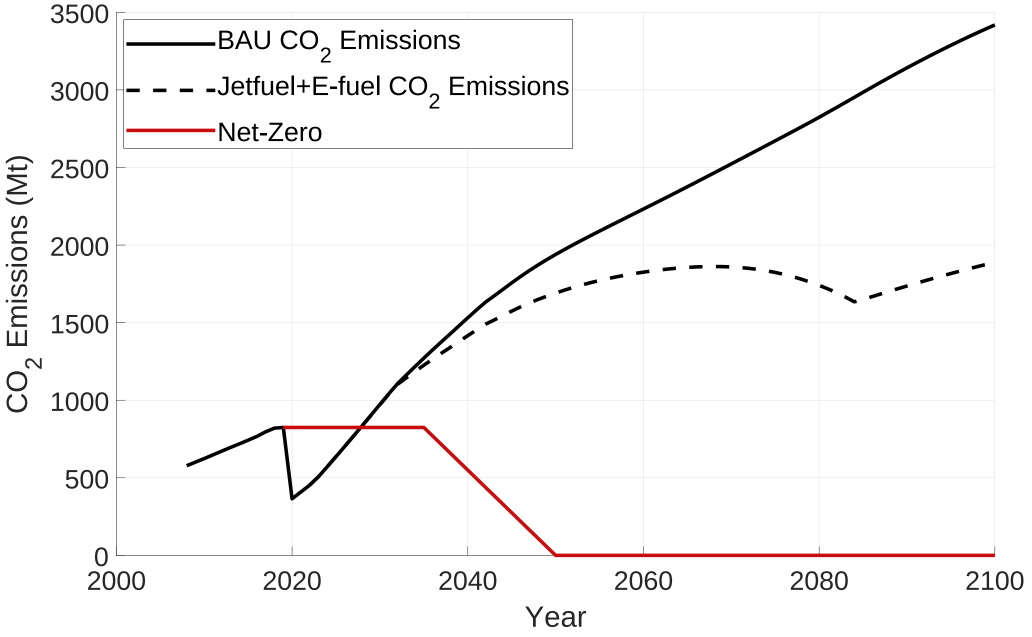


Figure 5.13: Scenario 1 with production rate of 5%.

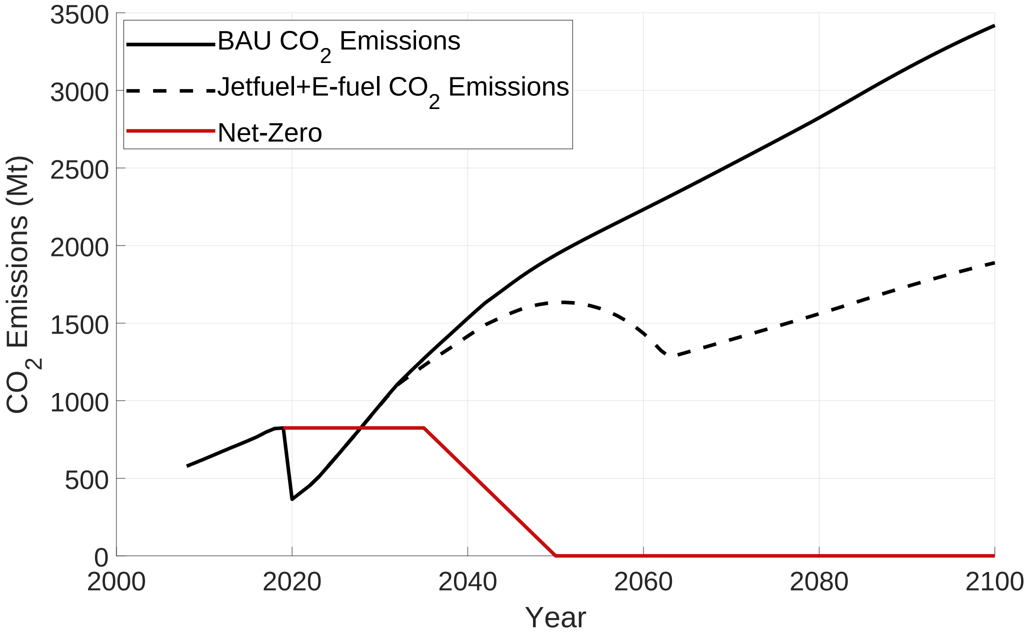


Figure 5.14: Scenario 1 with production rate of 10%.

5.2.2 Scenario 2

The next scenarios consider the possibility of using 100% e-kerosene, they differ on when this condition is introduced. Scenario 2 has a 50% blend ratio with jet fuel until 2050. After that, every 10 years the blend ratio increases 10%, which means that, from 2051 to 2060 60% of e-kerosene and 40% of jet fuel are used. When the simulation reaches 2091, the global fleet will use 100% of e-kerosene, if the production capacity case considered allows it.

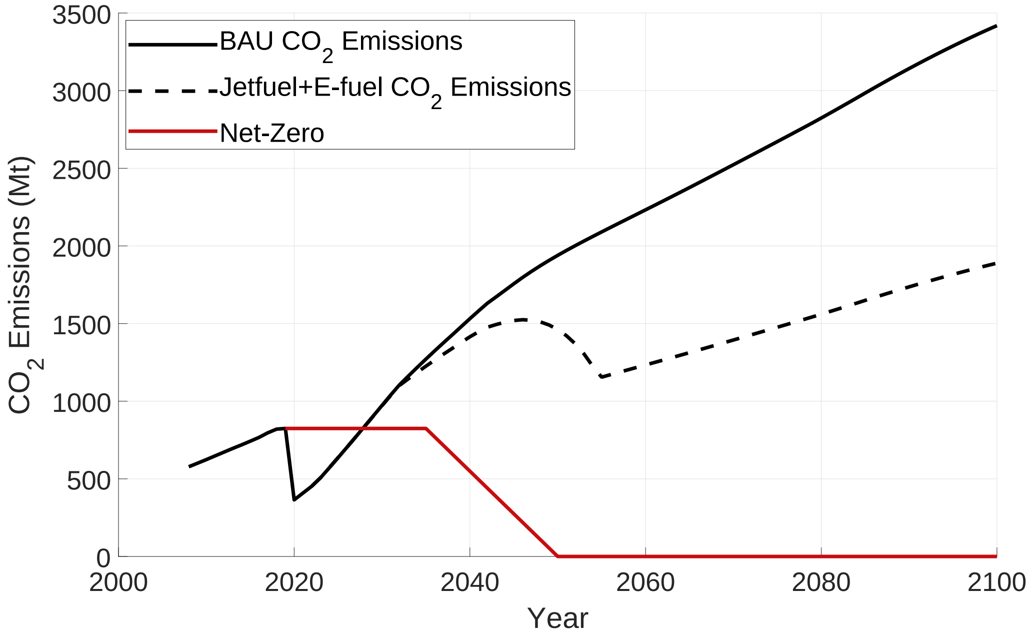


Figure 5.15: Scenario 1 with production rate of 15%.

For Case A of production capacity, Figure 5.16, CO_2 emissions start to decrease around 2035, in comparison to the BAU scenario. These CO_2 emissions will continue to reduce until 2100 since this e-kerosene production never reaches the necessary demand to supply the fleet using 100% of e-fuel, as demonstrated in Figure 4.12a. The carbon-neutral growth happens in 2067 like in Scenario 1, once it depends only on the production capacity. An important note, is that Scenario 2 Case A, is equal to scenarios 3, 4, and 5 for the same production capacity, in which will never be reached net-zero until 2100.

Relatively to other production capacity cases of Scenario 2, the results are better because they reach lower values in CO_2 emissions. Here, the cases start to take on a staircase-like shape due to the new blend ratio limits that happen every decade from 2050. Each ”level” corresponds to a percentage of e-kerosene in the fuel. For Case B, Figure 5.17, CO_2 emissions will reach carbon-neutral growth in 2051, and the necessary amount of fuel to supply the global fleet is reached in 2067 when the blend ratio is 70% of e-kerosene with jet fuel. In the other case 5.18, the fuel demand was satisfied earlier in 2057, while is consider a use of 60% of e-fuel. Scenario 2 considers the use of only e-kerosene after 2090, in which net-zero CO_2 emissions will never be reached due to the LCA values considered for jet fuel and e-kerosene, referred in 4.3.

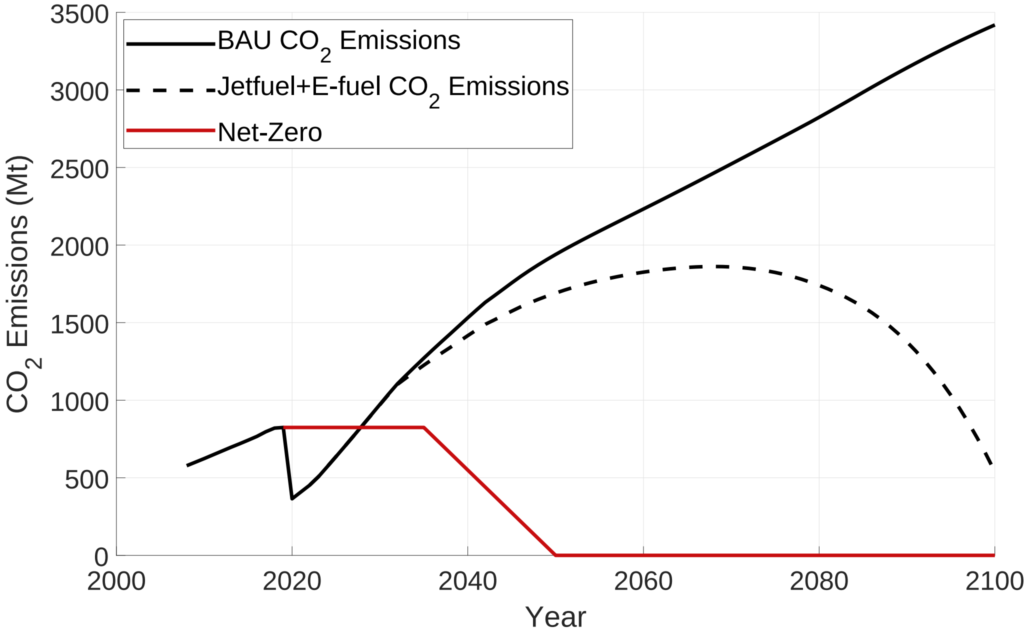


Figure 5.16: Scenario 2, 3, 4, and 5 with production rate of 5%.

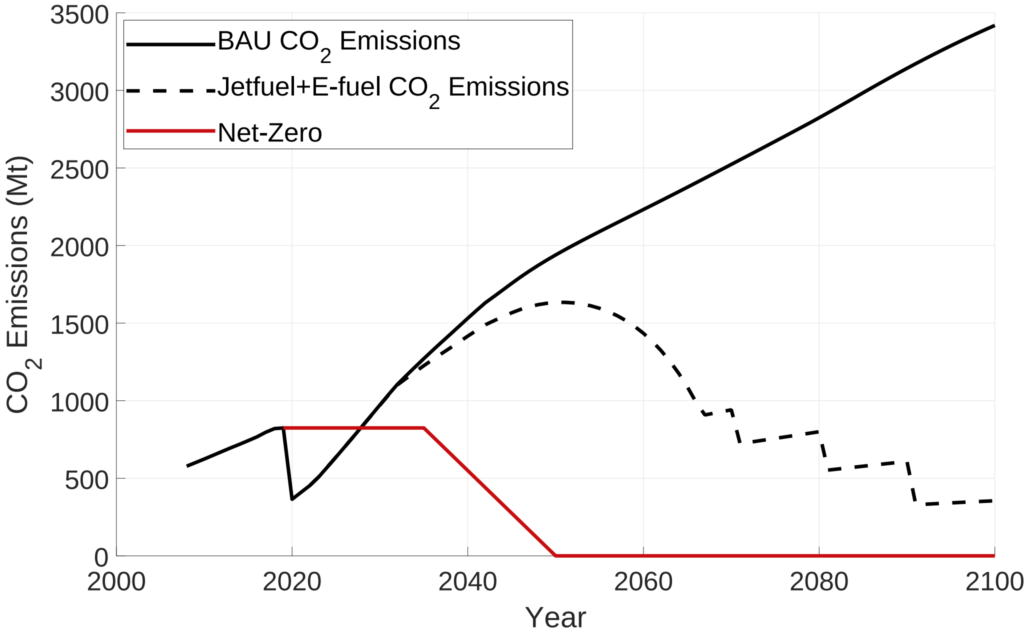


Figure 5.17: Scenario 2 with production rate of 10%.

5.2.3 Scenario 3

As mentioned, the results for a 5% production rate are equal to Scenario 2. However, the results for Case B and C of production capacity improve comparatively to the previous Scenario. The carbon-neutral growth is reached in 2051 for the 10% production case, Figure 5.19, like in Scenario 2 (since it only depends on the production capacity of

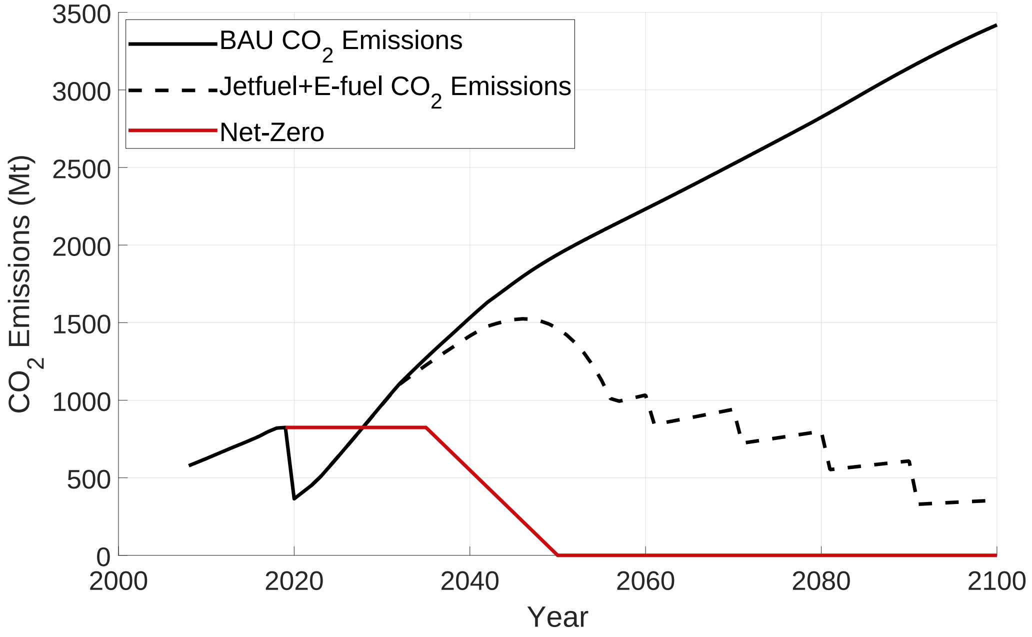


Figure 5.18: Scenario 2 with production rate of 15%.

e-kerosene). CO_2 emissions will continue to decrease until 2072, that is when the e-fuel production satisfies world fuel demand, for the corresponding blend ratio. In this case, it is achieved when the world fleet is already using solely e-kerosene. By that year, the lowest value of CO_2 emissions is reached, corresponding to 268 Mt, almost an 90% decrease in comparison to the BAU scenario. In this Scenario the use of only e-kerosene is considered starting in 2070. So, once the world supply is secured, emissions will slightly increase until 2100, where the amount of CO_2 emissions is 355 Mt, almost 10 times lower relative to BAU scenario.

Relatively to Case C, 15% production rate (Figure 5.20), after reaching carbon-neutral growth in 2046, CO_2 emissions have a fast decrease until 2058. After that, results have staircase-like shape, where each step corresponds to a blend ratio, as in Scenario 2. Here, the e-kerosene supply demand is achieved in the beginning of the steps, around 2058. By 2071, the world fleet uses only e-kerosene as fuel, reaching the lowest value of CO_2 emissions (265 Mt).

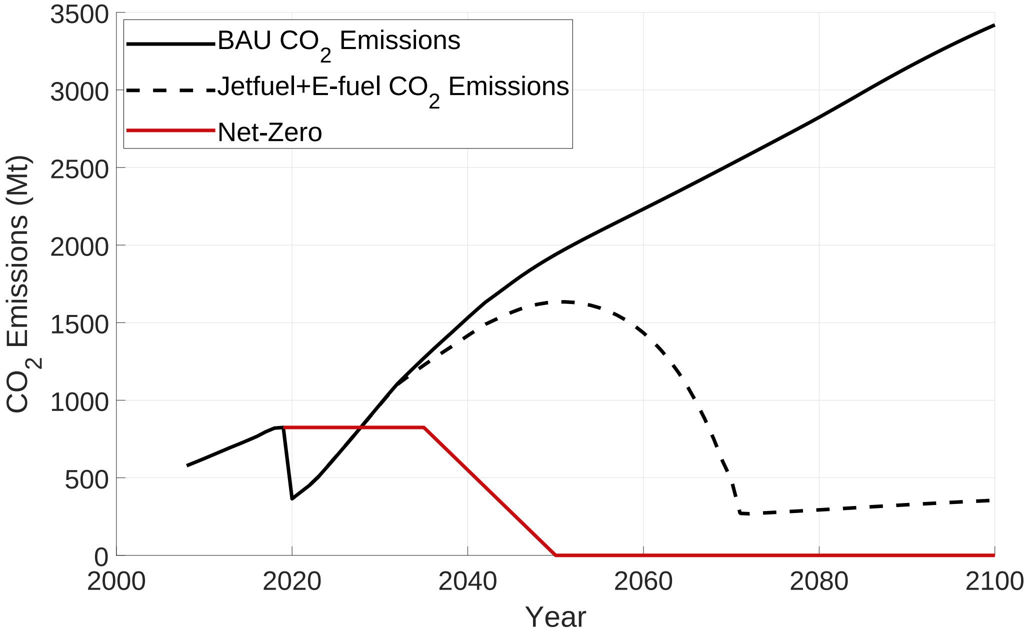


Figure 5.19: Scenario 3, 4, and 5 with production rate of 10%.

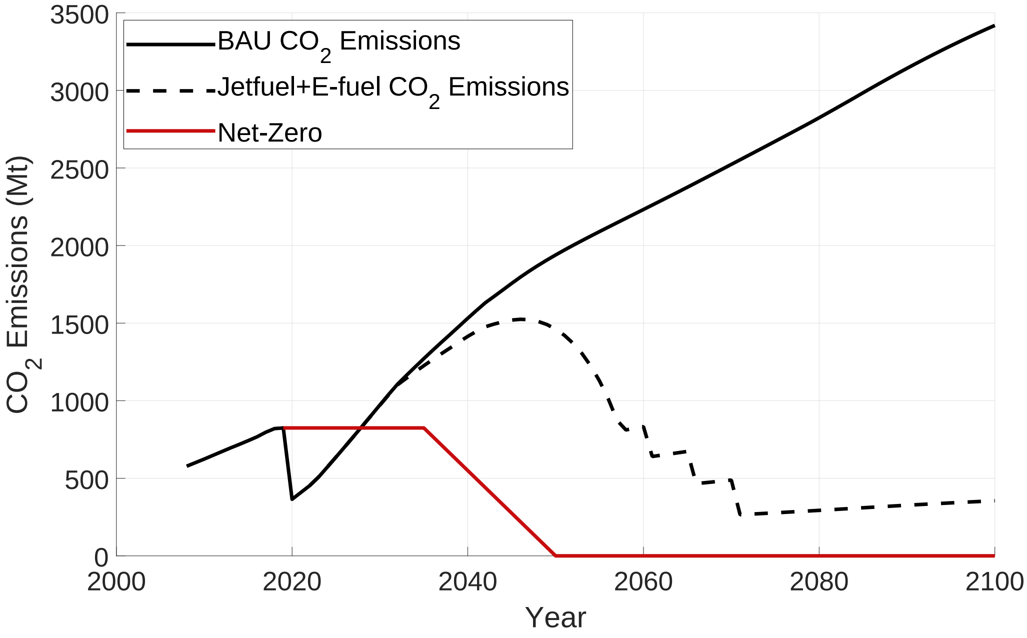


Figure 5.20: Scenario 3 with production rate of 15%.

5.2.4 Scenario 4 and 5

The last two Scenarios are very similar. For an annual production rate of 10%, the results are equal to Scenario 3, Figure 5.19. However, relatively to the next production capacity (15% production) the results differ from Scenario 3 on when the fuel demand is satisfied. According to Scenario 4, Figure 5.21, it is possible to satisfy the world fuel demand in

2058, when it is using 75% of e-kerosene. Following that, when it is considered only e-fuel, the lowest value of emitted CO_2 (235 Mt) happens in 2061. Regarding Scenario 5, Figure 5.22, the only difference is that fuel demand is accomplished in 2061, besides the fact of considering e-kerosene earlier (2051).

From all predictions, Scenarios 4 and 5 are the most promising, being the ones which the lowest value in CO_2 emissions is achieved. However, reaching net-zero becomes impossible due to e-kerosene LCA value, and the best result for CO_2 emissions can only represent almost half from the ones recorded in 2005.

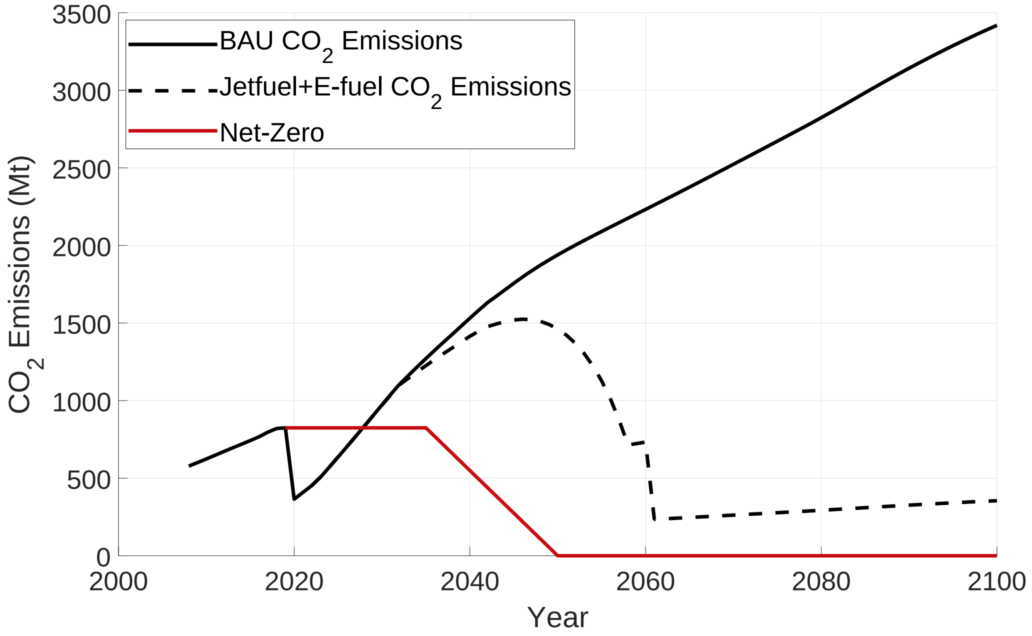


Figure 5.21: Scenario 4 with production rate of 15%.

5.3 Summary

The business-as-usual scenario provides a solid baseline, using existing data and forecasts to project fuel consumption and CO_2 emissions until 2100. It is interesting to see the impact of different scenarios based on Shared Socioeconomic Pathways (SSPs) on aviation demand and subsequent emissions. The analysis effectively outlines the key differences between SSPs, showcasing their influence on future emissions trajectories. Comparative analyses with existing industry forecasts and studies further validate the findings, highlighting alignment in long-term trends while noting discrepancies arising due to different modeling approaches and considerations.

The subsequent focus shifts to e-fuels, presenting five scenarios varying in blend ratios and production capacities. The breakdown of scenarios based on blend ratios and the transition to 100% e-kerosene offers valuable insights into potential emission reductions.

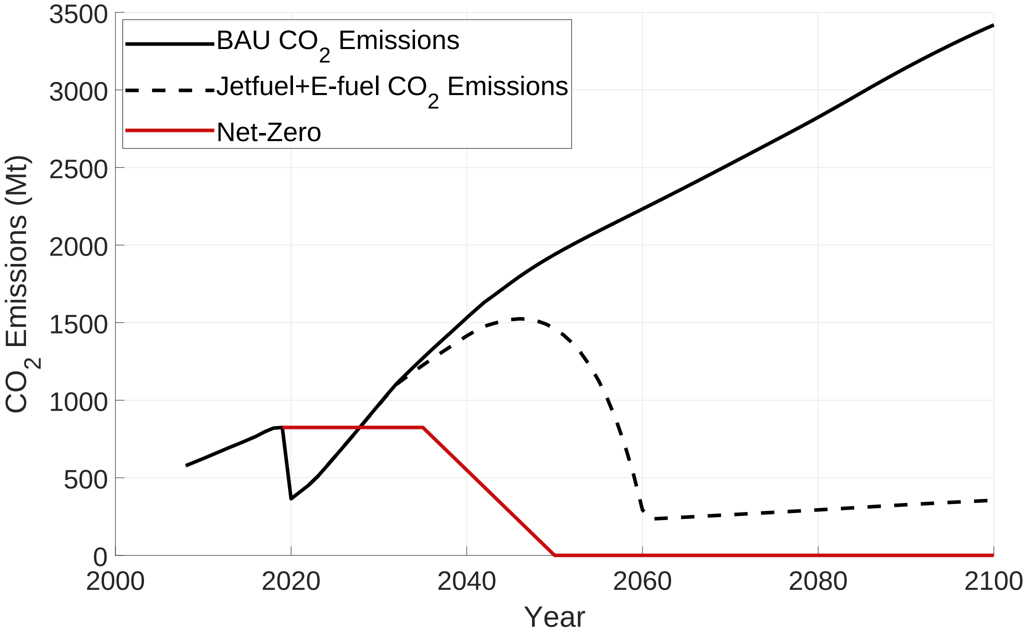


Figure 5.22: Scenario 5 with production rate of 15%.

The graphical representations and the descriptions effectively highlight the changing trends and emissions outcomes in these scenarios. Looking into Scenario 1, despite being the most conservative one, presents a significant decrease in emissions compared to BAU prediction. However, these results are far from desirable.

Two of the climate action goals set in the Paris Agreement's are reaching the carbon net value of 2020 and reduce aviation carbon emissions by 50% by the year 2050 relative to 2005. Regarding the first objective, all Scenarios, excluding Scenario 1, reach the value of net carbon emissions of 2020, even though close to 2100 for the 5% production case. For bigger production capacities the goal is achieved earlier. However, they are still far from desirable. The second goal will never be achieved in 2050, at least for the combination between the considered production capacities and fuel blend ratios. Nevertheless, when just e-kerosene and a 15% e-fuel production rate is used, this goal is reached near the year 2060.

Regarding the goal defined by ATAG, reach net-zero by 2050, the results show that is impossible to achieve it, mainly due to the LCA value of e-kerosene (9.23 gCO_2e/MJ). So, meet the climate goals established by IATA and ATAG are difficult by just considering the impact of e-fuels, and not taking into account new aircraft technologies and improvement in air traffic management. However, given an e-kerosene production rate of 15%, carbon-neutral growth can be achieved by 2046, having a huge emissions decrease after that.

Chapter 6

Conclusions and Future Work

In this dissertation the impact of a new technology like e-fuel in global fleet CO_2 emissions is studied. Firstly, FSDM was used to simulate the world fleet and obtain the fuel demand along with CO_2 emissions. Then, an approach was implemented that takes into account e-kerosene production process and its life-cycle assessment. This chapter summarizes the relevant findings and conclusions, and finishes with some suggestions of future work.

6.1 Conclusions

The aviation industry, crucial for global connectivity, faced a 60% decline in passenger traffic during the COVID-19 pandemic. Despite this setback, a robust recovery is anticipated, with a projected 111% surge in passenger numbers by 2025. However, addressing aviation's greenhouse gas emissions remains challenging. Initiatives like Waypoint 2050 by ATAG strive for net-zero carbon emissions, emphasizing sustainable aviation fuels and technological advancements. E-fuels, derived from renewable sources, offer a promising solution. This study conducts an impact analysis of e-fuels in the aviation sector until 2100, using the FSDM and a CAEP-based approach. Despite challenges, e-fuels present a viable pathway to reduce aviation's carbon footprint, aligning with global climate targets. The industry must prioritize e-fuels and implement long-term strategies for sustained emissions reduction as it expands.

Regarding the BAU scenarios obtained using FSDM, all of them (with the exception of SSP1 from Iteration 3 and 4) indicate a growing trend in CO_2 emissions until 2100. The incorporation of the Shared Socioeconomic Pathways (SSPs) concept, coupled with the insights from Franz et al. [68], proved instrumental in extending the simulations to the year 2100. Despite the absence of extensive long-term forecasts, the obtained results align well with expectations, corroborated by the linear extrapolation of ATAG values. This reinforces the validity of the methodology employed, highlighting the robustness of the findings and their alignment with anticipated trends in CO_2 emissions.

The present work shows that to reach carbon-neutral growth, the focus should be on the production capacity. Bigger the production rate, earlier the carbon-neutral growth will be achieved. For an annual e-kerosene production rate of 15%, carbon-neutral growth happens in 2046. Another aspect is the importance that the blend ratio has on CO_2 emissions. When the quantity of e-kerosene in the fuel mix increases, emissions decrease. Also, the earlier there is a transition to use solely e-kerosene, the sooner the lowest value of CO2 emissions is reached. The results show that achieving half of the emissions from 2005 is possible, but only in 2061. So, to accomplish the environmental goals until 2050 is impossible by relying just on sustainable aviation fuels, in this case, e-kerosene.

The scope explored in this work holds critical importance for aeronautical entities and industry stakeholders, focusing on the substantial reduction of CO_2 emissions through the incorporation of e-fuels in civil aviation. E-fuels emerge as a formidable asset in the ongoing battle against CO_2 emissions. A meticulous analysis of their impact on aviation unveils a promising prospect: the attainment of carbon-neutral growth and a remarkable 50% reduction in CO_2 emissions compared to the year of 2005. While this transformation may occur slightly later than initially hoped, the undeniable efficacy of e-fuels in steering the aviation industry toward sustainable practices underscores their pivotal role in shaping a greener and more environmentally conscious future.

6.2 Future Work

The field investigated in this current study holds significant relevance for the diverse entities overseeing the aeronautical sector and the enterprises it encompasses. Lately, the scientific community has been diligently striving to devise and explore optimal solutions for commercial aviation, such as e-fuel. The present work analyzes and provides quantitative data to support decision making on strategies for the decarbonization of the aeronautical sector. To expand on the research scope of this study, the following references warrant attention:

- Technological optimization of e-fuel production;
- Study on innovative strategies to reach carbon-neutral growth and net-zero by 2050;
- Techno-economic analysis of e-fuels in aviation;
- Study the impact of new technologies and operations on aviation CO_2 emissions.

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Appendix A

E-fuels Projects and Production

Table A.1: Projects and production capacity of e-kerosene.

Project name	Companies	Location	Start date	Production Capacity
Arcadia eFuels	Arcadia eFuels, Topsoe, Sasol, Technip Energies	Copenhagen, Denmark	2025	75000 tpa [72, 73]
Bilbao Decarbonization Hub	Petronor, Repsol, Aramco	Bilbao, Spain	2025	8000 lpd[a] [74]
CAC Synfuel Plant	CAC Engineering	Chemnitz, Germany	2030	1 million lpa[b] [72, 75]
INERATEC Pioneer Plant	INERATEC	Frankfurt, Germany	2024	2500 tpa [76]
Nordic Electrofuel - Plant 1	Nordic Electrofuel AS	Lysaker, Norway	2025	4.4 million lpa, 10.5 million lpa by 2026, 1 billion lpa by 2032, and 60 billion lpa by 2050 [72, 77]
Alpha Plant	Norsk e-Fuel, Sunfire, Norwegian, Carbon Centric	Vefsn, Norway	2026	50 million lpa, in 2030 will have a production capacity of 250 million lpa with 2 more production plants [78]
ReuZe Project	Infinium, Engie	Dunkirk, France	2026	100000 tpa [72, 79]
DAWN	Synhelion	Julich, Germany, and Spain	2024	a few thousand lpa in Germany, 1.25 million lpa in Spain by 2026, 875 million lpa worldwide by 2030, 50 billion lpa by 2050 [80]

Acronyms: [a] lpd: litres per day; [b] lpa: litres per annum

Table A.2: E-kerosene production capacity up to 2100.

year	Jet fuel demand [Mt]	5% Production rate [Mt]	10% Production rate [Mt]	15% Production rate [Mt]
2008	183,1040	0,0000	0,0000	0,0000
2009	190,3687	0,0000	0,0000	0,0000
2010	197,6981	0,0000	0,0000	0,0000
2011	205,3148	0,0000	0,0000	0,0000
2012	212,9049	0,0000	0,0000	0,0000
2013	220,4899	0,0000	0,0000	0,0000
2014	227,7255	0,0000	0,0000	0,0000
2015	235,2639	0,0000	0,0000	0,0000
2016	243,0128	0,0000	0,0000	0,0000
2017	252,4156	0,0000	0,0000	0,0000
2018	259,9084	0,0000	0,0000	0,0000
2019	261,2217	0,0000	0,0000	0,0000
2020	115,5331	0,0000	0,0000	0,0000
2021	129,4688	0,0000	0,0000	0,0000
2022	143,3369	0,0004	0,0004	0,0004
2023	160,5630	0,0004	0,0004	0,0004
2024	181,0006	0,0026	0,0026	0,0026
2025	201,7100	0,0765	0,0765	0,0765
2026	222,6734	0,2124	0,2124	0,2124
2027	243,8582	0,4286	0,4286	0,4286
2028	265,2201	0,6449	0,6449	0,6449
2029	286,7044	0,8612	0,8612	0,8612
2030	308,2498	1,0775	1,0775	1,0775
2031	329,7961	1,4795	1,4795	1,4795
2032	350,5048	1,8815	1,8815	1,8815
2033	368,2466	6,8185	6,8185	6,8185
2034	385,7035	11,7556	11,7556	11,7556
2035	402,8532	16,6927	16,6927	16,6927
2036	419,6804	21,6297	21,6297	21,6297
2037	436,1761	26,5668	26,5668	26,5668
2038	452,3352	31,5038	31,5038	31,5038
2039	468,7563	36,4409	36,4409	36,4409
2040	485,2350	41,3780	41,3780	41,9070
2041	501,2628	46,1216	46,1216	48,1931
2042	516,9066	50,8652	50,8652	55,4221
2043	529,9030	55,6088	55,9517	63,7354
2044	543,1367	60,3524	61,5469	73,2957
2045	556,4785	65,0960	67,7015	84,2900
2046	569,3786	69,8396	74,4717	96,9335
2047	581,5516	74,5832	81,9189	111,4736
2048	593,0788	79,3268	90,1107	128,1946
2049	604,0352	84,0704	99,1218	147,4238
2050	614,5003	88,8140	109,0340	169,5374
2051	624,5610	93,2547	119,9374	194,9680
2052	634,2989	97,9174	131,9311	224,2132
2053	643,7956	102,8133	145,1243	257,8451
2054	653,1074	107,9539	159,6367	296,5219

Table A.3: E-kerosene production capacity up to 2100. (cont.)

year	Jet fuel demand [Mt]	5% Production rate [Mt]	10% Production rate [Mt]	15% Production rate [Mt]
2055	662,2842	113,3516	175,6004	341,0002
2056	671,3675	119,0192	193,1604	392,1502
2057	680,3909	124,9702	212,4764	450,9727
2058	689,3816	131,2187	233,7241	518,6187
2059	698,3619	137,7796	257,0965	596,4115
2060	707,3503	144,6686	282,8061	685,8732
2061	716,3620	151,9020	311,0867	716,3620
2062	725,4086	159,4971	342,1954	725,4086
2063	734,5009	167,4720	376,4150	734,5009
2064	743,6452	175,8456	414,0565	743,6452
2065	752,8436	184,6379	455,4621	752,8436
2066	762,0935	193,8698	501,0083	762,0935
2067	771,3886	203,5632	551,1091	771,3886
2068	780,7205	213,7414	606,2201	780,7205
2069	790,0805	224,4285	666,8421	790,0805
2070	799,4642	235,6499	733,5263	799,4642
2071	808,8663	247,4324	806,8789	808,8663
2072	818,2789	259,8040	818,2789	818,2789
2073	827,7072	272,7942	827,7072	827,7072
2074	837,1554	286,4339	837,1554	837,1554
2075	846,6273	300,7556	846,6273	846,6273
2076	856,1273	315,7934	856,1273	856,1273
2077	865,6601	331,5831	865,6601	865,6601
2078	875,2300	348,1622	875,2300	875,2300
2079	884,8410	365,5703	884,8410	884,8410
2080	894,7296	383,8489	894,7296	894,7296
2081	904,7729	403,0413	904,7729	904,7729
2082	914,8837	423,1934	914,8837	914,8837
2083	925,0649	444,3530	925,0649	925,0649
2084	935,3194	466,5707	935,3194	935,3194
2085	945,7532	489,8992	945,7532	945,7532
2086	956,0189	514,3942	956,0189	956,0189
2087	966,1491	540,1139	966,1491	966,1491
2088	976,1388	567,1196	976,1388	976,1388
2089	985,9833	595,4756	985,9833	985,9833
2090	995,6775	625,2493	995,6775	995,6775
2091	1005,2167	656,5118	1005,2167	1005,2167
2092	1014,5960	689,3374	1014,5960	1014,5960
2093	1023,8107	723,8043	1023,8107	1023,8107
2094	1032,8559	759,9945	1032,8559	1032,8559
2095	1041,7269	797,9942	1041,7269	1041,7269
2096	1050,4190	837,8939	1050,4190	1050,4190
2097	1058,9274	879,7886	1058,9274	1058,9274
2098	1067,2474	923,7780	1067,2474	1067,2474
2099	1075,3744	969,9669	1075,3744	1075,3744
2100	1083,3036	1018,4653	1083,3036	1083,3036

Appendix B

Simulation Data

Table B.1: β factors applied in the aircraft retirement modeling. [35]

Cluster Number	β_I	β_{II}
1	2.4099	-0.1350
2	7.1835	-0.3366
3	5.8592	-0.1881
4	4.8128	-0.1942
5	6.0198	-0.2425
6	3.9517	-0.1684
7	6.9248	-0.2961
8	5.8329	-0.2556
9	6.8054	-0.3010

Table B.2: Initial aircraft fleet transport supply in 2008. [35]

Route group	Route group name	ASK supply [$\times 10^{11}$]	ATK supply [$\times 10^{11}$]
1	EUEU	7,5515	1,4132
2	EUAS	5,0806	5,4519
3	EUME	1,4101	1,7767
4	EUAF	1,765	1,0991
5	EULA	2,2044	1,5178
6	EUNA	5,5493	3,8263
7	ASAS	11,7117	6,0302
8	ASME	1,6962	1,8877
9	ASAF	0,2753	0,1802
10	ASLA	0,0408	0,0124
11	ASNA	3,858	5,0545
12	MEME	0,4618	0,1758
13	MEAF	0,4892	0,2993
14	MELA	0,0265	0,0136
15	MENA	0,4578	0,2059
16	AFAF	0,6272	0,2587
17	AFLA	0,018	0,0811
18	AFNA	0,1414	0,0598
19	LALA	1,8725	1,1236
20	LANA	2,2423	1,1351
21	NANA	12,4379	3,8539
Sum		59,9174	35,4565

Table B.3: Annual RTK growth from 2009 to 2100.

year	EUEU	EUAS	EUME	EUAF	EULA	EUNA	ASAS	ASME	ASAF	ASLA	ASNA	MEME	MEAF	MELA	MENA	AFAF	AFLA	AFNA	LALA	LANA	NANA
2008	0,80%	1,00%	6,70%	5,20%	3,00%	0,00%	1,10%	6,90%	5,40%	3,10%	0,20%	12,70%	11,10%	8,90%	5,90%	9,70%	7,40%	4,40%	5,10%	2,10%	-0,80%
2009	0,80%	1,00%	6,70%	5,20%	3,00%	0,00%	1,10%	6,90%	5,40%	3,10%	0,20%	12,70%	11,10%	8,90%	5,90%	9,70%	7,40%	4,40%	5,10%	2,10%	-0,80%
2010	0,80%	1,00%	6,70%	5,20%	3,00%	0,00%	1,10%	6,90%	5,40%	3,10%	0,20%	12,70%	11,10%	8,90%	5,90%	9,70%	7,40%	4,40%	5,10%	2,10%	-0,80%
2011	0,80%	1,00%	6,70%	5,20%	3,00%	0,00%	1,10%	6,90%	5,40%	3,10%	0,20%	12,70%	11,10%	8,90%	5,90%	9,70%	7,40%	4,40%	5,10%	2,10%	-0,80%
2012	0,80%	1,00%	6,70%	5,20%	3,00%	0,00%	1,10%	6,90%	5,40%	3,10%	0,20%	12,70%	11,10%	8,90%	5,90%	9,70%	7,40%	4,40%	5,10%	2,10%	-0,80%
2013	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2014	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2015	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2016	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2017	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2018	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2019	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2020	1,96%	1,96%	1,96%	1,96%	1,96%	1,96%	1,96%	1,96%	1,96%	1,96%	1,96%	1,96%	1,96%	1,96%	1,96%	1,96%	1,96%	1,96%	1,96%	1,96%	1,96%
2021	1,96%	1,96%	1,96%	1,96%	1,96%	1,96%	1,96%	1,96%	1,96%	1,96%	1,96%	1,96%	1,96%	1,96%	1,96%	1,96%	1,96%	1,96%	1,96%	1,96%	1,96%
2022	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2023	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2024	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2025	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2026	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2027	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2028	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2029	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2030	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2031	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2032	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2033	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2034	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2035	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2036	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2037	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2038	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2039	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2040	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2041	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2042	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2043	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2044	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2045	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2046	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2047	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2048	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2049	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2050	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2051	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2052	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2053	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2054	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2055	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%

Table B.4: Annual RTK growth from 2009 to 2100. (cont.)

year	EUEU	EUAS	EUME	EUAF	EULA	EUNA	ASAS	ASME	ASAF	ASLA	ASNA	MEME	MEAF	MELA	MENA	AFAF	AFLA	AFNA	LALA	LANA	NANA
2056	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2057	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2058	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2059	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2060	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2061	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2062	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2063	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2064	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2065	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2066	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2067	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2068	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2069	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2070	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2071	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2072	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2073	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2074	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2075	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2076	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2077	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2078	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2079	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2080	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2081	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2082	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2083	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2084	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2085	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2086	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2087	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2088	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2089	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2090	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2091	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2092	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2093	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2094	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2095	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2096	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2097	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2098	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2099	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
2100	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%

Table B.5: Annual RPK growth from 2009 to 2100 for Iteration 1.

year	EUEU	EUAS	EUME	EUAF	EULA	EUNA	ASAS	ASME	ASAF	ASLA	ASNA	MEME	MEAF	MELA	MENA	AFAF	AFLA	AFNA	LALA	LANA	NANA
2009	1,60%	1,50%	11,30%	2,20%	3,10%	0,40%	9,20%	12,90%	-5,00%	17,90%	3,70%	6,40%	15,30%	8,70%	16,40%	5,20%	17,90%	14,20%	10,80%	5,30%	0,50%
2010	1,60%	1,50%	11,30%	2,20%	3,10%	0,40%	9,20%	12,90%	-5,00%	17,90%	3,70%	6,40%	15,30%	8,70%	16,40%	5,20%	17,90%	14,20%	10,80%	5,30%	0,50%
2011	1,60%	1,50%	11,30%	2,20%	3,10%	0,40%	9,20%	12,90%	-5,00%	17,90%	3,70%	6,40%	15,30%	8,70%	16,40%	5,20%	17,90%	14,20%	10,80%	5,30%	0,50%
2012	1,60%	1,50%	11,30%	2,20%	3,10%	0,40%	9,20%	12,90%	-5,00%	17,90%	3,70%	6,40%	15,30%	8,70%	16,40%	5,20%	17,90%	14,20%	10,80%	5,30%	0,50%
2013	1,60%	1,50%	11,30%	2,20%	3,10%	0,40%	9,20%	12,90%	-5,00%	17,90%	3,70%	6,40%	15,30%	8,70%	16,40%	5,20%	17,90%	14,20%	10,80%	5,30%	0,50%
2014	7,64%	3,94%	13,31%	2,29%	3,68%	6,80%	7,88%	9,50%	6,50%	6,50%	8,56%	11,86%	8,58%	6,50%	20,67%	2,23%	5,50%	5,50%	7,55%	7,56%	5,71%
2015	9,22%	2,48%	7,36%	-0,32%	5,78%	9,25%	11,58%	14,66%	6,00%	6,00%	8,62%	15,42%	4,41%	6,00%	10,86%	4,99%	5,30%	5,30%	6,14%	1,31%	5,47%
2016	7,20%	5,15%	7,93%	7,13%	5,49%	6,82%	9,50%	10,07%	5,50%	5,50%	5,83%	5,47%	5,72%	5,50%	1,09%	2,93%	5,20%	5,20%	4,99%	5,21%	4,77%
2017	7,09%	10,74%	10,06%	8,04%	5,59%	7,61%	8,78%	4,60%	5,00%	5,00%	4,00%	3,74%	4,91%	5,00%	-4,81%	2,25%	5,00%	5,00%	7,76%	5,97%	6,09%
2018	3,26%	3,57%	6,03%	5,63%	4,49%	4,09%	3,78%	-1,30%	4,80%	4,80%	-0,32%	1,28%	0,90%	4,80%	-0,26%	4,89%	4,80%	4,80%	3,11%	-1,40%	4,35%
2019	0,87%	0,76%	0,29%	0,47%	-0,61%	0,94%	0,65%	0,01%	4,50%	4,50%	-0,82%	1,62%	0,71%	4,50%	-0,84%	1,54%	4,50%	4,50%	0,06%	0,44%	0,70%
2020	-65,03%	-78,58%	-68,63%	-71,95%	-73,99%	-77,00%	-71,28%	-71,09%	-54,70%	-54,70%	-80,55%	-66,35%	-74,72%	-54,70%	-71,41%	-69,85%	-54,70%	-54,70%	-64,88%	-72,65%	-59,22%
2021	10,44%	-21,83%	-0,34%	26,59%	33,75%	6,51%	-27,57%	-31,61%	1,72%	1,72%	-36,04%	25,82%	47,11%	1,72%	83,35%	38,09%	1,64%	1,64%	43,14%	74,95%	78,03%
2022	120,64%	131,12%	146,20%	117,30%	145,72%	226,99%	216,53%	190,28%	1,72%	1,72%	159,41%	86,13%	119,45%	1,72%	110,79%	88,83%	1,64%	1,64%	120,05%	70,85%	24,42%
2023	109,32%	122,88%	132,60%	106,55%	132,00%	205,01%	201,10%	177,10%	1,95%	1,95%	153,86%	78,61%	108,93%	1,95%	100,27%	81,77%	1,88%	1,88%	108,91%	64,73%	22,48%
2024	97,99%	114,64%	119,00%	95,79%	118,28%	183,02%	185,68%	163,92%	2,18%	2,18%	148,31%	71,09%	98,41%	2,18%	89,75%	74,70%	2,11%	2,11%	97,77%	58,60%	20,54%
2025	86,67%	106,40%	105,40%	85,04%	104,55%	161,04%	170,25%	150,74%	2,40%	2,40%	142,76%	63,57%	87,89%	2,40%	79,24%	67,63%	2,35%	2,35%	86,63%	52,48%	18,61%
2026	75,34%	98,16%	91,80%	74,28%	90,83%	139,05%	154,83%	137,56%	2,63%	2,63%	137,21%	56,05%	77,36%	2,63%	68,72%	60,56%	2,58%	2,58%	75,49%	46,36%	16,67%
2027	64,02%	89,92%	78,20%	63,53%	77,10%	117,07%	139,40%	124,38%	2,86%	2,86%	131,66%	48,53%	66,84%	2,86%	58,21%	53,50%	2,82%	2,82%	64,35%	40,24%	14,73%
2028	52,69%	81,68%	64,61%	52,77%	63,38%	95,08%	123,98%	111,20%	3,09%	3,09%	126,11%	41,01%	56,32%	3,09%	47,69%	46,43%	3,06%	3,06%	53,21%	34,12%	12,80%
2029	41,36%	73,44%	51,01%	42,02%	49,66%	73,10%	108,55%	98,02%	3,32%	3,32%	120,56%	33,49%	45,80%	3,32%	37,17%	39,36%	3,29%	3,29%	42,07%	28,00%	10,86%
2030	30,04%	65,20%	37,41%	31,26%	35,93%	51,11%	93,12%	84,84%	3,54%	3,54%	115,01%	25,97%	35,27%	3,54%	26,66%	32,29%	3,53%	3,53%	30,93%	21,87%	8,92%
2031	18,71%	56,96%	23,81%	20,51%	22,21%	29,13%	77,70%	71,65%	3,77%	3,77%	109,46%	18,45%	24,75%	3,77%	16,14%	25,23%	3,76%	3,76%	19,79%	15,75%	6,98%
2032	7,39%	48,72%	10,21%	9,75%	8,48%	7,14%	62,27%	58,47%	4,00%	4,00%	103,91%	10,93%	14,23%	4,00%	5,62%	18,16%	4,00%	4,00%	8,65%	9,63%	5,05%
2033	7,01%	44,19%	9,55%	9,16%	8,06%	6,75%	56,52%	53,11%	4,08%	4,08%	94,00%	10,23%	13,42%	4,08%	5,37%	16,96%	4,08%	4,08%	8,26%	9,14%	4,83%
2034	6,64%	39,65%	8,89%	8,57%	7,63%	6,37%	50,76%	47,75%	4,17%	4,16%	84,09%	9,54%	12,62%	4,16%	5,11%	15,76%	4,16%	4,16%	7,87%	8,64%	4,61%
2035	6,26%	35,12%	8,23%	7,98%	7,20%	5,98%	45,01%	42,39%	4,25%	4,24%	74,17%	8,85%	11,81%	4,24%	4,85%	14,56%	4,24%	4,24%	7,48%	8,14%	4,39%
2036	5,88%	30,58%	7,58%	7,39%	6,77%	5,59%	39,26%	37,02%	4,34%	4,32%	64,26%	8,16%	11,01%	4,32%	4,59%	13,36%	4,32%	4,32%	7,08%	7,65%	4,17%
2037	5,51%	26,05%	6,92%	6,80%	6,34%	5,21%	33,50%	31,66%	4,42%	4,40%	54,35%	7,47%	10,21%	4,40%	4,34%	12,16%	4,40%	4,40%	6,69%	7,15%	3,95%
2038	5,13%	21,52%	6,26%	6,21%	5,91%	4,82%	27,75%	26,30%	4,51%	4,48%	44,44%	6,77%	9,40%	4,48%	4,08%	10,96%	4,48%	4,48%	6,30%	6,66%	3,73%
2039	4,75%	16,98%	5,60%	5,62%	5,49%	4,43%	21,99%	20,93%	4,59%	4,56%	34,53%	6,08%	8,60%	4,56%	3,82%	9,76%	4,56%	4,56%	5,91%	6,16%	3,51%
2040	4,38%	12,45%	4,94%	5,03%	5,06%	4,05%	16,24%	15,57%	4,68%	4,64%	24,62%	5,39%	7,79%	4,64%	3,56%	8,55%	4,64%	4,64%	5,52%	5,66%	3,29%
2041	4,00%	7,91%	4,28%	4,44%	4,63%	3,66%	10,48%	10,21%	4,76%	4,72%	14,71%	4,70%	6,99%	4,72%	3,31%	7,35%	4,72%	4,72%	5,12%	5,17%	3,07%
2042	3,62%	3,38%	3,63%	3,85%	4,20%	3,27%	4,73%	4,85%	4,85%	4,80%	4,80%	4,01%	6,19%	4,80%	3,05%	6,15%	4,80%	4,80%	4,73%	4,67%	2,85%
2043	3,59%	3,33%	3,59%	3,81%	4,16%	3,24%	4,66%	4,77%	4,79%	4,75%	4,72%	3,96%	6,13%	4,75%	3,03%	6,09%	4,75%	4,75%	4,70%	4,63%	2,83%
2044	3,56%	3,27%	3,55%	3,78%	4,13%	3,21%	4,58%	4,70%	4,74%	4,69%	4,64%	3,92%	6,07%	4,69%	3,00%	6,02%	4,69%	4,69%	4,66%	4,59%	2,81%
2045	3,53%	3,22%	3,51%	3,74%	4,09%	3,18%	4,51%	4,62%	4,68%	4,64%	4,56%	3,88%	6,01%	4,64%	2,98%	5,95%	4,64%	4,64%	4,62%	4,55%	2,78%
2046	3,50%	3,17%	3,47%	3,70%	4,06%	3,15%	4,43%	4,54%	4,62%	4,58%	4,48%	3,83%	5,95%	4,58%	2,95%	5,88%	4,58%	4,58%	4,59%	4,51%	2,76%
2047	3,47%	3,11%	3,43%	3,66%	4,02%	3,12%	4,36%	4,47%	4,57%	4,53%	4,40%	3,79%	5,89%	4,53%	2,93%	5,81%	4,53%	4,53%	4,55%	4,47%	2,74%
2048	3,44%	3,06%	3,39%	3,62%	3,98%	3,09%	4,29%	4,39%	4,51%	4,47%	4,32%	3,75%	5,83%	4,47%	2,91%	5,74%	4,47%	4,47%	4,51%	4,43%	2,72%
2049	3,40%	3,01%	3,35%	3,58%	3,95%	3,06%	4,21%	4,32%	4,46%	4,42%	4,24%	3,70%	5,77%	4,42%	2,88%	5,67%	4,42%	4,42%	4,48%	4,39%	2,70%
2050	3,37%	2,95%	3,31%	3,54%	3,91%	3,03%	4,14%	4,24%	4,40%	4,36%	4,16%	3,66%	5,71%	4,36%	2,86%	5,60%	4,36%	4,36%	4,44%	4,35%	2,68%
2051	3,34%	2,90%	3,27%	3,50%	3,88%	3,00%	4,06%	4,17%	4,35%	4,31%	4,08%	3,62%	5,65%	4,31%	2,84%	5,53%	4,31%	4,31%	4,41%	4,30%	2,66%
2052	3,31%	2,85%	3,23%	3,46%	3,84%	2,97%	3,99%	4,09%	4,29%	4,25%	4,00%	3,58%	5,59%	4,25%	2,81%	5,46%	4,25%	4,25%	4,37%	4,26%	2,64%
2053	3,28%	2,79%	3,19%	3,42%	3,81%	2,94%	3,92%	4,02%	4,24%	4,20%	3,92%	3,53%	5,53%	4,20%	2,79%	5,40%	4,20%	4,20%	4,33%	4,22%	2,62%
2054	3,25%	2,74%	3,15%	3,38%	3,77%	2,91%	3,84%	3,94%	4,18%	4,14%	3,84%	3,49%	5,48%	4,14%	2,76%	5,33%	4,14%	4,14%	4,30%	4,18%	2,60%
2055	3,22%	2,69%	3,11%	3,34%	3,73%	2,88%	3,77%	3,87%	4,13%	4,09%	3,76%	3,45%	5,42%	4,09%	2,74%	5,26%	4,09%	4,09%	4,26%	4,14%	2,57%

Table B.6: Annual RPK growth from 2009 to 2100 for Iteration 1. (cont.)

year	EUEU	EUAS	EUME	EUAF	EULA	EUNA	ASAS	ASME	ASAF	ASLA	ASNA	MEME	MEAF	MELA	MENA	AFAF	AFLA	AFNA	LALA	LANA	NANA
2056	3,18%	2,63%	3,07%	3,30%	3,70%	2,85%	3,69%	3,79%	4,07%	4,03%	3,68%	3,40%	5,36%	4,03%	2,72%	5,19%	4,03%	4,03%	4,22%	4,10%	2,55%
2057	3,15%	2,58%	3,03%	3,26%	3,66%	2,82%	3,62%	3,72%	4,01%	3,98%	3,60%	3,36%	5,30%	3,98%	2,69%	5,12%	3,98%	3,98%	4,19%	4,06%	2,53%
2058	3,12%	2,53%	2,99%	3,22%	3,63%	2,79%	3,54%	3,64%	3,96%	3,93%	3,52%	3,32%	5,24%	3,93%	2,67%	5,05%	3,93%	3,93%	4,15%	4,02%	2,51%
2059	3,09%	2,47%	2,95%	3,18%	3,59%	2,76%	3,47%	3,57%	3,90%	3,87%	3,44%	3,27%	5,18%	3,87%	2,65%	4,98%	3,87%	3,87%	4,11%	3,98%	2,49%
2060	3,06%	2,42%	2,91%	3,14%	3,55%	2,73%	3,40%	3,49%	3,85%	3,82%	3,36%	3,23%	5,12%	3,82%	2,62%	4,91%	3,82%	3,82%	4,08%	3,94%	2,47%
2061	3,03%	2,37%	2,87%	3,10%	3,52%	2,70%	3,32%	3,41%	3,79%	3,76%	3,28%	3,19%	5,06%	3,76%	2,60%	4,84%	3,76%	3,76%	4,04%	3,90%	2,45%
2062	3,00%	2,31%	2,83%	3,06%	3,48%	2,67%	3,25%	3,34%	3,74%	3,71%	3,20%	3,14%	5,00%	3,71%	2,58%	4,77%	3,71%	3,71%	4,01%	3,86%	2,43%
2063	2,97%	2,26%	2,79%	3,02%	3,45%	2,64%	3,17%	3,26%	3,68%	3,65%	3,12%	3,10%	4,94%	3,65%	2,55%	4,71%	3,65%	3,65%	3,97%	3,82%	2,41%
2064	2,93%	2,21%	2,75%	2,99%	3,41%	2,61%	3,10%	3,19%	3,63%	3,60%	3,04%	3,06%	4,88%	3,60%	2,53%	4,64%	3,60%	3,60%	3,93%	3,77%	2,38%
2065	2,90%	2,15%	2,71%	2,95%	3,37%	2,58%	3,03%	3,11%	3,57%	3,54%	2,96%	3,02%	4,82%	3,54%	2,50%	4,57%	3,54%	3,54%	3,90%	3,73%	2,36%
2066	2,87%	2,10%	2,67%	2,91%	3,34%	2,55%	2,95%	3,04%	3,52%	3,49%	2,88%	2,97%	4,76%	3,49%	2,48%	4,50%	3,49%	3,49%	3,86%	3,69%	2,34%
2067	2,84%	2,05%	2,63%	2,87%	3,30%	2,52%	2,88%	2,96%	3,46%	3,43%	2,80%	2,93%	4,70%	3,43%	2,46%	4,43%	3,43%	3,43%	3,82%	3,65%	2,32%
2068	2,81%	1,99%	2,60%	2,83%	3,27%	2,49%	2,80%	2,89%	3,40%	3,38%	2,72%	2,89%	4,65%	3,38%	2,43%	4,36%	3,38%	3,38%	3,79%	3,61%	2,30%
2069	2,78%	1,94%	2,56%	2,79%	3,23%	2,46%	2,73%	2,81%	3,35%	3,32%	2,64%	2,84%	4,59%	3,32%	2,41%	4,29%	3,32%	3,32%	3,75%	3,57%	2,28%
2070	2,75%	1,89%	2,52%	2,75%	3,19%	2,43%	2,66%	2,74%	3,29%	3,27%	2,56%	2,80%	4,53%	3,27%	2,39%	4,22%	3,27%	3,27%	3,71%	3,53%	2,26%
2071	2,72%	1,83%	2,48%	2,71%	3,16%	2,40%	2,58%	2,66%	3,24%	3,21%	2,48%	2,76%	4,47%	3,21%	2,36%	4,15%	3,21%	3,21%	3,68%	3,49%	2,24%
2072	2,68%	1,78%	2,44%	2,67%	3,12%	2,37%	2,51%	2,59%	3,18%	3,16%	2,40%	2,71%	4,41%	3,16%	2,34%	4,09%	3,16%	3,16%	3,64%	3,45%	2,22%
2073	2,65%	1,73%	2,40%	2,63%	3,09%	2,34%	2,43%	2,51%	3,13%	3,11%	2,32%	2,67%	4,35%	3,11%	2,32%	4,02%	3,11%	3,11%	3,61%	3,41%	2,20%
2074	2,62%	1,67%	2,36%	2,59%	3,05%	2,31%	2,36%	2,44%	3,07%	3,05%	2,24%	2,63%	4,29%	3,05%	2,29%	3,95%	3,05%	3,05%	3,57%	3,37%	2,17%
2075	2,59%	1,62%	2,32%	2,55%	3,01%	2,28%	2,29%	2,36%	3,02%	3,00%	2,16%	2,59%	4,23%	3,00%	2,27%	3,88%	3,00%	3,00%	3,53%	3,33%	2,15%
2076	2,56%	1,57%	2,28%	2,51%	2,98%	2,25%	2,21%	2,28%	2,96%	2,94%	2,08%	2,54%	4,17%	2,94%	2,24%	3,81%	2,94%	2,94%	3,50%	3,29%	2,13%
2077	2,53%	1,51%	2,24%	2,47%	2,94%	2,22%	2,14%	2,21%	2,91%	2,89%	2,00%	2,50%	4,11%	2,89%	2,22%	3,74%	2,89%	2,89%	3,46%	3,24%	2,11%
2078	2,50%	1,46%	2,20%	2,43%	2,91%	2,19%	2,06%	2,13%	2,85%	2,83%	1,92%	2,46%	4,05%	2,83%	2,20%	3,67%	2,83%	2,83%	3,42%	3,20%	2,09%
2079	2,46%	1,41%	2,16%	2,39%	2,87%	2,16%	1,99%	2,06%	2,79%	2,78%	1,84%	2,41%	3,99%	2,78%	2,17%	3,60%	2,78%	2,78%	3,39%	3,16%	2,07%
2080	2,43%	1,35%	2,12%	2,35%	2,83%	2,13%	1,91%	1,98%	2,74%	2,72%	1,76%	2,37%	3,93%	2,72%	2,15%	3,53%	2,72%	2,72%	3,35%	3,12%	2,05%
2081	2,40%	1,30%	2,08%	2,31%	2,80%	2,10%	1,84%	1,91%	2,68%	2,67%	1,68%	2,33%	3,88%	2,67%	2,13%	3,46%	2,67%	2,67%	3,32%	3,08%	2,03%
2082	2,37%	1,25%	2,04%	2,27%	2,76%	2,07%	1,77%	1,83%	2,63%	2,61%	1,60%	2,28%	3,82%	2,61%	2,10%	3,40%	2,61%	2,61%	3,28%	3,04%	2,01%
2083	2,34%	1,19%	2,00%	2,23%	2,73%	2,04%	1,69%	1,76%	2,57%	2,56%	1,52%	2,24%	3,76%	2,56%	2,08%	3,33%	2,56%	2,56%	3,24%	3,00%	1,99%
2084	2,31%	1,14%	1,96%	2,20%	2,69%	2,01%	1,62%	1,68%	2,52%	2,50%	1,44%	2,20%	3,70%	2,50%	2,06%	3,26%	2,50%	2,50%	3,21%	2,96%	1,96%
2085	2,28%	1,09%	1,92%	2,16%	2,65%	1,98%	1,54%	1,61%	2,46%	2,45%	1,36%	2,16%	3,64%	2,45%	2,03%	3,19%	2,45%	2,45%	3,17%	2,92%	1,94%
2086	2,25%	1,03%	1,88%	2,12%	2,62%	1,95%	1,47%	1,53%	2,41%	2,40%	1,28%	2,11%	3,58%	2,40%	2,01%	3,12%	2,40%	2,40%	3,13%	2,88%	1,92%
2087	2,21%	0,98%	1,84%	2,08%	2,58%	1,92%	1,40%	1,46%	2,35%	2,34%	1,20%	2,07%	3,52%	2,34%	1,98%	3,05%	2,34%	2,34%	3,10%	2,84%	1,90%
2088	2,18%	0,93%	1,80%	2,04%	2,55%	1,89%	1,32%	1,38%	2,30%	2,29%	1,12%	2,03%	3,46%	2,29%	1,96%	2,98%	2,29%	2,29%	3,06%	2,80%	1,88%
2089	2,15%	0,87%	1,76%	2,00%	2,51%	1,86%	1,25%	1,31%	2,24%	2,23%	1,04%	1,98%	3,40%	2,23%	1,94%	2,91%	2,23%	2,23%	3,02%	2,76%	1,86%
2090	2,12%	0,82%	1,72%	1,96%	2,48%	1,83%	1,17%	1,23%	2,19%	2,18%	0,96%	1,94%	3,34%	2,18%	1,91%	2,84%	2,18%	2,18%	2,99%	2,71%	1,84%
2091	2,09%	0,77%	1,68%	1,92%	2,44%	1,80%	1,10%	1,15%	2,13%	2,12%	0,88%	1,90%	3,28%	2,12%	1,89%	2,78%	2,12%	2,12%	2,95%	2,67%	1,82%
2092	2,06%	0,71%	1,64%	1,88%	2,40%	1,77%	1,03%	1,08%	2,07%	2,07%	0,80%	1,85%	3,22%	2,07%	1,87%	2,71%	2,07%	2,07%	2,92%	2,63%	1,80%
2093	2,03%	0,66%	1,60%	1,84%	2,37%	1,74%	0,95%	1,00%	2,02%	2,01%	0,72%	1,81%	3,16%	2,01%	1,84%	2,64%	2,01%	2,01%	2,88%	2,59%	1,77%
2094	2,00%	0,61%	1,56%	1,80%	2,33%	1,71%	0,88%	0,93%	1,96%	1,96%	0,64%	1,77%	3,10%	1,96%	1,82%	2,57%	1,96%	1,96%	2,84%	2,55%	1,75%
2095	1,96%	0,55%	1,53%	1,76%	2,30%	1,68%	0,80%	0,85%	1,91%	1,90%	0,56%	1,73%	3,05%	1,90%	1,79%	2,50%	1,90%	1,90%	2,81%	2,51%	1,73%
2096	1,93%	0,50%	1,49%	1,72%	2,26%	1,65%	0,73%	0,78%	1,85%	1,85%	0,48%	1,68%	2,99%	1,85%	1,77%	2,43%	1,85%	1,85%	2,77%	2,47%	1,71%
2097	1,90%	0,45%	1,45%	1,68%	2,22%	1,62%	0,66%	0,70%	1,80%	1,79%	0,40%	1,64%	2,93%	1,79%	1,75%	2,36%	1,79%	1,79%	2,73%	2,43%	1,69%
2098	1,87%	0,39%	1,41%	1,64%	2,19%	1,59%	0,58%	0,63%	1,74%	1,74%	0,32%	1,60%	2,87%	1,74%	1,72%	2,29%	1,74%	1,74%	2,70%	2,39%	1,67%
2099	1,84%	0,34%	1,37%	1,60%	2,15%	1,56%	0,51%	0,55%	1,69%	1,68%	0,24%	1,55%	2,81%	1,68%	1,70%	2,22%	1,68%	1,68%	2,66%	2,35%	1,65%
2100	1,81%	0,29%	1,33%	1,56%	2,12%	1,53%	0,43%	0,48%	1,63%	1,63%	0,16%	1,51%	2,75%	1,63%	1,68%	2,15%	1,63%	1,63%	2,62%	2,31%	1,63%

Table B.7: Annual RPK growth from 2009 to 2100 for Iteration 2.

year	EUEU	EUAS	EUME	EUAF	EULA	EUNA	ASAS	ASME	ASAF	ASLA	ASNA	MEME	MEAF	MELA	MENA	AFAF	AFLA	AFNA	LALA	LANA	NANA
2009	1,60%	1,50%	11,30%	2,20%	3,10%	0,40%	9,20%	12,90%	-5,00%	17,90%	3,70%	6,40%	15,30%	8,70%	16,40%	5,20%	17,90%	14,20%	10,80%	5,30%	0,50%
2010	1,60%	1,50%	11,30%	2,20%	3,10%	0,40%	9,20%	12,90%	-5,00%	17,90%	3,70%	6,40%	15,30%	8,70%	16,40%	5,20%	17,90%	14,20%	10,80%	5,30%	0,50%
2011	1,60%	1,50%	11,30%	2,20%	3,10%	0,40%	9,20%	12,90%	-5,00%	17,90%	3,70%	6,40%	15,30%	8,70%	16,40%	5,20%	17,90%	14,20%	10,80%	5,30%	0,50%
2012	1,60%	1,50%	11,30%	2,20%	3,10%	0,40%	9,20%	12,90%	-5,00%	17,90%	3,70%	6,40%	15,30%	8,70%	16,40%	5,20%	17,90%	14,20%	10,80%	5,30%	0,50%
2013	1,60%	1,50%	11,30%	2,20%	3,10%	0,40%	9,20%	12,90%	-5,00%	17,90%	3,70%	6,40%	15,30%	8,70%	16,40%	5,20%	17,90%	14,20%	10,80%	5,30%	0,50%
2014	7,64%	3,94%	13,31%	2,29%	3,68%	6,80%	7,88%	9,50%	6,50%	6,50%	8,56%	11,86%	8,58%	6,50%	20,67%	2,23%	5,50%	5,50%	7,55%	7,56%	5,71%
2015	9,22%	2,48%	7,36%	-0,32%	5,78%	9,25%	11,58%	14,66%	6,00%	6,00%	8,62%	15,42%	4,41%	6,00%	10,86%	4,99%	5,30%	5,30%	6,14%	1,31%	5,47%
2016	7,20%	5,15%	7,93%	7,13%	5,49%	6,82%	9,50%	10,07%	5,50%	5,50%	5,83%	5,47%	5,72%	5,50%	1,09%	2,93%	5,20%	5,20%	4,99%	5,21%	4,77%
2017	7,09%	10,74%	10,06%	8,04%	5,59%	7,61%	8,78%	4,60%	5,00%	5,00%	4,00%	3,74%	4,91%	5,00%	-4,81%	2,25%	5,00%	5,00%	7,76%	5,97%	6,09%
2018	3,26%	3,57%	6,03%	5,63%	4,49%	4,09%	3,78%	-1,30%	4,80%	4,80%	-0,32%	1,28%	0,90%	4,80%	-0,26%	4,89%	4,80%	4,80%	3,11%	-1,40%	4,35%
2019	0,87%	0,76%	0,29%	0,47%	-0,61%	0,94%	0,65%	0,01%	4,50%	4,50%	-0,82%	1,62%	0,71%	4,50%	-0,84%	1,54%	4,50%	4,50%	0,06%	0,44%	0,70%
2020	-65,03%	-78,58%	-68,63%	-71,95%	-73,99%	-77,00%	-71,28%	-71,09%	-54,70%	-54,70%	-80,55%	-66,35%	-74,72%	-54,70%	-71,41%	-69,85%	-54,70%	-54,70%	-64,88%	-72,65%	-59,22%
2021	10,44%	-21,83%	-0,34%	26,59%	33,75%	6,51%	-27,57%	-31,61%	1,72%	1,72%	-36,04%	25,82%	47,11%	1,72%	83,35%	38,09%	1,64%	1,64%	43,14%	74,95%	78,03%
2022	120,64%	131,12%	146,20%	117,30%	145,72%	226,99%	216,53%	190,28%	1,72%	1,72%	159,41%	86,13%	119,45%	1,72%	110,79%	88,83%	1,64%	1,64%	120,05%	70,85%	24,42%
2023	109,32%	122,88%	132,60%	106,55%	132,00%	205,01%	201,10%	177,10%	1,95%	1,95%	153,86%	78,61%	108,93%	1,95%	100,27%	81,77%	1,88%	1,88%	108,91%	64,73%	22,48%
2024	97,99%	114,64%	119,00%	95,79%	118,28%	183,02%	185,68%	163,92%	2,18%	2,18%	148,31%	71,09%	98,41%	2,18%	89,75%	74,70%	2,11%	2,11%	97,77%	58,60%	20,54%
2025	86,67%	106,40%	105,40%	85,04%	104,55%	161,04%	170,25%	150,74%	2,40%	2,40%	142,76%	63,57%	87,89%	2,40%	79,24%	67,63%	2,35%	2,35%	86,63%	52,48%	18,61%
2026	75,34%	98,16%	91,80%	74,28%	90,83%	139,05%	154,83%	137,56%	2,63%	2,63%	137,21%	56,05%	77,36%	2,63%	68,72%	60,56%	2,58%	2,58%	75,49%	46,36%	16,67%
2027	64,02%	89,92%	78,20%	63,53%	77,10%	117,07%	139,40%	124,38%	2,86%	2,86%	131,66%	48,53%	66,84%	2,86%	58,21%	53,50%	2,82%	2,82%	64,35%	40,24%	14,73%
2028	52,69%	81,68%	64,61%	52,77%	63,38%	95,08%	123,98%	111,20%	3,09%	3,09%	126,11%	41,01%	56,32%	3,09%	47,69%	46,43%	3,06%	3,06%	53,21%	34,12%	12,80%
2029	41,36%	73,44%	51,01%	42,02%	49,66%	73,10%	108,55%	98,02%	3,32%	3,32%	120,56%	33,49%	45,80%	3,32%	37,17%	39,36%	3,29%	3,29%	42,07%	28,00%	10,86%
2030	30,04%	65,20%	37,41%	31,26%	35,93%	51,11%	93,12%	84,84%	3,54%	3,54%	115,01%	25,97%	35,27%	3,54%	26,66%	32,29%	3,53%	3,53%	30,93%	21,87%	8,92%
2031	18,71%	56,96%	23,81%	20,51%	22,21%	29,13%	77,70%	71,65%	3,77%	3,77%	109,46%	18,45%	24,75%	3,77%	16,14%	25,23%	3,76%	3,76%	19,79%	15,75%	6,98%
2032	7,39%	48,72%	10,21%	9,75%	8,48%	7,14%	62,27%	58,47%	4,00%	4,00%	103,91%	10,93%	14,23%	4,00%	5,62%	18,16%	4,00%	4,00%	8,65%	9,63%	5,05%
2033	7,01%	44,19%	9,55%	9,16%	8,06%	6,75%	56,52%	53,11%	4,08%	4,08%	94,00%	10,23%	13,42%	4,08%	5,37%	16,96%	4,08%	4,08%	8,26%	9,14%	4,83%
2034	6,64%	39,65%	8,89%	8,57%	7,63%	6,37%	50,76%	47,75%	4,17%	4,16%	84,09%	9,54%	12,62%	4,16%	5,11%	15,76%	4,16%	4,16%	7,87%	8,64%	4,61%
2035	6,26%	35,12%	8,23%	7,98%	7,20%	5,98%	45,01%	42,39%	4,25%	4,24%	74,17%	8,85%	11,81%	4,24%	4,85%	14,56%	4,24%	4,24%	7,48%	8,14%	4,39%
2036	5,88%	30,58%	7,58%	7,39%	6,77%	5,59%	39,26%	37,02%	4,34%	4,32%	64,26%	8,16%	11,01%	4,32%	4,59%	13,36%	4,32%	4,32%	7,08%	7,65%	4,17%
2037	5,51%	26,05%	6,92%	6,80%	6,34%	5,21%	33,50%	31,66%	4,42%	4,40%	54,35%	7,47%	10,21%	4,40%	4,34%	12,16%	4,40%	4,40%	6,69%	7,15%	3,95%
2038	5,13%	21,52%	6,26%	6,21%	5,91%	4,82%	27,75%	26,30%	4,51%	4,48%	44,44%	6,77%	9,40%	4,48%	4,08%	10,96%	4,48%	4,48%	6,30%	6,66%	3,73%
2039	4,75%	16,98%	5,60%	5,62%	5,49%	4,43%	21,99%	20,93%	4,59%	4,56%	34,53%	6,08%	8,60%	4,56%	3,82%	9,76%	4,56%	4,56%	5,91%	6,16%	3,51%
2040	4,38%	12,45%	4,94%	5,03%	5,06%	4,05%	16,24%	15,57%	4,68%	4,64%	24,62%	5,39%	7,79%	4,64%	3,56%	8,55%	4,64%	4,64%	5,52%	5,66%	3,29%
2041	4,00%	7,91%	4,28%	4,44%	4,63%	3,66%	10,48%	10,21%	4,76%	4,72%	14,71%	4,70%	6,99%	4,72%	3,31%	7,35%	4,72%	4,72%	5,12%	5,17%	3,07%
2042	3,62%	3,38%	3,63%	3,85%	4,20%	3,27%	4,73%	4,85%	4,85%	4,80%	4,80%	4,01%	6,19%	4,80%	3,05%	6,15%	4,80%	4,80%	4,73%	4,67%	2,85%
2043	3,44%	3,06%	3,39%	3,62%	3,99%	3,10%	4,29%	4,40%	4,41%	4,37%	4,33%	3,75%	5,84%	4,37%	2,91%	5,75%	4,37%	4,37%	4,52%	4,43%	2,72%
2044	3,25%	2,75%	3,16%	3,39%	3,78%	2,92%	3,86%	3,96%	3,98%	3,94%	3,86%	3,50%	5,49%	3,94%	2,77%	5,34%	3,94%	3,94%	4,30%	4,19%	2,60%
2045	3,07%	2,44%	2,92%	3,16%	3,56%	2,74%	3,42%	3,51%	3,54%	3,51%	3,38%	3,24%	5,14%	3,51%	2,63%	4,93%	3,51%	3,51%	4,09%	3,95%	2,48%
2046	2,88%	2,12%	2,69%	2,92%	3,35%	2,57%	2,98%	3,07%	3,11%	3,08%	2,91%	2,99%	4,79%	3,08%	2,49%	4,53%	3,08%	3,08%	3,87%	3,71%	2,35%
2047	2,70%	1,81%	2,46%	2,69%	3,14%	2,39%	2,54%	2,62%	2,67%	2,65%	2,44%	2,74%	4,44%	2,65%	2,35%	4,12%	2,65%	2,65%	3,66%	3,47%	2,23%
2048	2,51%	1,49%	2,22%	2,46%	2,93%	2,21%	2,11%	2,18%	2,24%	2,22%	1,97%	2,48%	4,09%	2,22%	2,21%	3,71%	2,22%	2,22%	3,45%	3,23%	2,10%
2049	2,33%	1,18%	1,99%	2,22%	2,72%	2,03%	1,67%	1,73%	1,80%	1,79%	1,49%	2,23%	3,74%	1,79%	2,07%	3,31%	1,79%	1,79%	3,23%	2,99%	1,98%
2050	2,15%	0,86%	1,76%	1,99%	2,50%	1,86%	1,23%	1,29%	1,37%	1,36%	1,02%	1,98%	3,39%	1,36%	1,93%	2,90%	1,36%	1,36%	3,02%	2,75%	1,85%
2051	1,96%	0,55%	1,52%	1,76%	2,29%	1,68%	0,80%	0,85%	0,93%	0,93%	0,55%	1,72%	3,04%	0,93%	1,79%	2,49%	0,93%	0,93%	2,80%	2,51%	1,73%
2052	1,78%	0,23%	1,29%	1,52%	2,08%	1,50%	0,36%	0,40%	0,50%	0,50%	0,08%	1,47%	2,69%	0,50%	1,65%	2,09%	0,50%	0,50%	2,59%	2,27%	1,61%
2053	1,69%	0,22%	1,22%	1,45%	1,97%	1,43%	0,34%	0,38%	0,47%	0,47%	0,07%	1,39%	2,55%	0,47%	1,57%	1,98%	0,47%	0,47%	2,46%	2,15%	1,52%
2054	1,60%	0,21%	1,16%	1,37%	1,87%	1,35%	0,32%	0,36%	0,45%	0,45%	0,07%	1,32%	2,42%	0,45%	1,48%	1,87%	0,45%	0,45%	2,32%	2,04%	1,44%
2055	1,50%	0,20%	1,09%	1,29%	1,76%	1,27%	0,30%	0,34%	0,42%	0,42%	0,07%	1,24%	2,28%	0,42%	1,40%	1,77%	0,42%	0,42%	2,19%	1,92%	1,36%

Table B.8: Annual RPK growth from 2009 to 2100 for Iteration 2. (cont.)

year	EUEU	EUAS	EUME	EUAF	EULA	EUNA	ASAS	ASME	ASAF	ASLA	ASNA	MEME	MEAF	MELA	MENA	AFAF	AFLA	AFNA	LALA	LANA	NANA
2056	1,41%	0,19%	1,02%	1,21%	1,66%	1,20%	0,29%	0,32%	0,40%	0,40%	0,06%	1,17%	2,14%	0,40%	1,32%	1,66%	0,40%	0,40%	2,06%	1,80%	1,28%
2057	1,32%	0,17%	0,96%	1,14%	1,55%	1,12%	0,27%	0,30%	0,37%	0,37%	0,06%	1,09%	2,00%	0,37%	1,23%	1,55%	0,37%	0,37%	1,93%	1,69%	1,20%
2058	1,23%	0,16%	0,89%	1,06%	1,44%	1,04%	0,25%	0,28%	0,35%	0,35%	0,05%	1,02%	1,87%	0,35%	1,15%	1,45%	0,35%	0,35%	1,80%	1,57%	1,12%
2059	1,14%	0,15%	0,83%	0,98%	1,34%	0,97%	0,23%	0,26%	0,32%	0,32%	0,05%	0,94%	1,73%	0,32%	1,06%	1,34%	0,32%	0,32%	1,66%	1,46%	1,03%
2060	1,05%	0,14%	0,76%	0,90%	1,23%	0,89%	0,21%	0,24%	0,30%	0,30%	0,05%	0,87%	1,59%	0,30%	0,98%	1,24%	0,30%	0,30%	1,53%	1,34%	0,95%
2061	0,96%	0,13%	0,70%	0,82%	1,13%	0,81%	0,19%	0,22%	0,27%	0,27%	0,04%	0,79%	1,46%	0,27%	0,89%	1,13%	0,27%	0,27%	1,40%	1,23%	0,87%
2062	0,87%	0,11%	0,63%	0,75%	1,02%	0,74%	0,18%	0,20%	0,25%	0,25%	0,04%	0,72%	1,32%	0,25%	0,81%	1,02%	0,25%	0,25%	1,27%	1,11%	0,79%
2063	0,83%	0,11%	0,60%	0,71%	0,97%	0,70%	0,17%	0,19%	0,23%	0,23%	0,04%	0,68%	1,25%	0,23%	0,77%	0,97%	0,23%	0,23%	1,20%	1,05%	0,75%
2064	0,78%	0,10%	0,57%	0,67%	0,92%	0,66%	0,16%	0,18%	0,22%	0,22%	0,03%	0,65%	1,18%	0,22%	0,73%	0,92%	0,22%	0,22%	1,14%	1,00%	0,71%
2065	0,74%	0,10%	0,53%	0,63%	0,86%	0,62%	0,15%	0,17%	0,21%	0,21%	0,03%	0,61%	1,12%	0,21%	0,69%	0,87%	0,21%	0,21%	1,07%	0,94%	0,67%
2066	0,69%	0,09%	0,50%	0,59%	0,81%	0,59%	0,14%	0,16%	0,20%	0,20%	0,03%	0,57%	1,05%	0,20%	0,65%	0,81%	0,20%	0,20%	1,01%	0,88%	0,63%
2067	0,65%	0,09%	0,47%	0,56%	0,76%	0,55%	0,13%	0,15%	0,18%	0,18%	0,03%	0,54%	0,98%	0,18%	0,60%	0,76%	0,18%	0,18%	0,95%	0,83%	0,59%
2068	0,60%	0,08%	0,44%	0,52%	0,71%	0,51%	0,12%	0,14%	0,17%	0,17%	0,03%	0,50%	0,92%	0,17%	0,56%	0,71%	0,17%	0,17%	0,88%	0,77%	0,55%
2069	0,56%	0,07%	0,41%	0,48%	0,66%	0,47%	0,11%	0,13%	0,16%	0,16%	0,02%	0,46%	0,85%	0,16%	0,52%	0,66%	0,16%	0,16%	0,82%	0,71%	0,51%
2070	0,52%	0,07%	0,37%	0,44%	0,60%	0,44%	0,10%	0,12%	0,15%	0,15%	0,02%	0,43%	0,78%	0,15%	0,48%	0,61%	0,15%	0,15%	0,75%	0,66%	0,47%
2071	0,47%	0,06%	0,34%	0,40%	0,55%	0,40%	0,10%	0,11%	0,13%	0,13%	0,02%	0,39%	0,71%	0,13%	0,44%	0,55%	0,13%	0,13%	0,69%	0,60%	0,43%
2072	0,43%	0,06%	0,31%	0,37%	0,50%	0,36%	0,09%	0,10%	0,12%	0,12%	0,02%	0,35%	0,65%	0,12%	0,40%	0,50%	0,12%	0,12%	0,62%	0,54%	0,39%
2073	0,41%	0,05%	0,29%	0,35%	0,47%	0,34%	0,08%	0,09%	0,11%	0,11%	0,02%	0,33%	0,61%	0,11%	0,38%	0,48%	0,11%	0,11%	0,59%	0,52%	0,37%
2074	0,38%	0,05%	0,28%	0,33%	0,45%	0,32%	0,08%	0,09%	0,11%	0,11%	0,02%	0,32%	0,58%	0,11%	0,36%	0,45%	0,11%	0,11%	0,56%	0,49%	0,35%
2075	0,36%	0,05%	0,26%	0,31%	0,42%	0,31%	0,07%	0,08%	0,10%	0,10%	0,02%	0,30%	0,55%	0,10%	0,34%	0,42%	0,10%	0,10%	0,53%	0,46%	0,33%
2076	0,34%	0,04%	0,25%	0,29%	0,40%	0,29%	0,07%	0,08%	0,10%	0,10%	0,01%	0,28%	0,51%	0,10%	0,32%	0,40%	0,10%	0,10%	0,50%	0,43%	0,31%
2077	0,32%	0,04%	0,23%	0,27%	0,37%	0,27%	0,06%	0,07%	0,09%	0,09%	0,01%	0,26%	0,48%	0,09%	0,30%	0,37%	0,09%	0,09%	0,46%	0,41%	0,29%
2078	0,30%	0,04%	0,21%	0,25%	0,35%	0,25%	0,06%	0,07%	0,08%	0,08%	0,01%	0,24%	0,45%	0,08%	0,28%	0,35%	0,08%	0,08%	0,43%	0,38%	0,27%
2079	0,27%	0,04%	0,20%	0,24%	0,32%	0,23%	0,06%	0,06%	0,08%	0,08%	0,01%	0,23%	0,42%	0,08%	0,26%	0,32%	0,08%	0,08%	0,40%	0,35%	0,25%
2080	0,25%	0,03%	0,18%	0,22%	0,30%	0,21%	0,05%	0,06%	0,07%	0,07%	0,01%	0,21%	0,38%	0,07%	0,24%	0,30%	0,07%	0,07%	0,37%	0,32%	0,23%
2081	0,23%	0,03%	0,17%	0,20%	0,27%	0,20%	0,05%	0,05%	0,07%	0,07%	0,01%	0,19%	0,35%	0,07%	0,22%	0,27%	0,07%	0,07%	0,34%	0,29%	0,21%
2082	0,21%	0,03%	0,15%	0,18%	0,25%	0,18%	0,04%	0,05%	0,06%	0,06%	0,01%	0,17%	0,32%	0,06%	0,19%	0,25%	0,06%	0,06%	0,31%	0,27%	0,19%
2083	0,20%	0,03%	0,14%	0,17%	0,23%	0,17%	0,04%	0,04%	0,06%	0,06%	0,01%	0,16%	0,30%	0,06%	0,18%	0,23%	0,06%	0,06%	0,29%	0,25%	0,18%
2084	0,19%	0,02%	0,14%	0,16%	0,22%	0,16%	0,04%	0,04%	0,05%	0,05%	0,01%	0,16%	0,28%	0,05%	0,17%	0,22%	0,05%	0,05%	0,27%	0,24%	0,17%
2085	0,18%	0,02%	0,13%	0,15%	0,21%	0,15%	0,04%	0,04%	0,05%	0,05%	0,01%	0,15%	0,27%	0,05%	0,16%	0,21%	0,05%	0,05%	0,26%	0,23%	0,16%
2086	0,17%	0,02%	0,12%	0,14%	0,20%	0,14%	0,03%	0,04%	0,05%	0,05%	0,01%	0,14%	0,25%	0,05%	0,16%	0,20%	0,05%	0,05%	0,24%	0,21%	0,15%
2087	0,16%	0,02%	0,11%	0,13%	0,18%	0,13%	0,03%	0,04%	0,04%	0,04%	0,01%	0,13%	0,24%	0,04%	0,15%	0,18%	0,04%	0,04%	0,23%	0,20%	0,14%
2088	0,15%	0,02%	0,11%	0,12%	0,17%	0,12%	0,03%	0,03%	0,04%	0,04%	0,01%	0,12%	0,22%	0,04%	0,14%	0,17%	0,04%	0,04%	0,21%	0,19%	0,13%
2089	0,13%	0,02%	0,10%	0,12%	0,16%	0,11%	0,03%	0,03%	0,04%	0,04%	0,01%	0,11%	0,20%	0,04%	0,13%	0,16%	0,04%	0,04%	0,20%	0,17%	0,12%
2090	0,12%	0,02%	0,09%	0,11%	0,15%	0,10%	0,03%	0,03%	0,03%	0,03%	0,01%	0,10%	0,19%	0,03%	0,12%	0,15%	0,03%	0,03%	0,18%	0,16%	0,11%
2091	0,11%	0,01%	0,08%	0,10%	0,13%	0,10%	0,02%	0,03%	0,03%	0,03%	0,00%	0,09%	0,17%	0,03%	0,11%	0,13%	0,03%	0,03%	0,17%	0,14%	0,10%
2092	0,10%	0,01%	0,07%	0,09%	0,12%	0,09%	0,02%	0,02%	0,03%	0,03%	0,00%	0,08%	0,16%	0,03%	0,10%	0,12%	0,03%	0,03%	0,15%	0,13%	0,09%
2093	0,10%	0,01%	0,07%	0,08%	0,11%	0,08%	0,02%	0,02%	0,03%	0,03%	0,00%	0,08%	0,15%	0,03%	0,09%	0,11%	0,03%	0,03%	0,14%	0,12%	0,09%
2094	0,09%	0,01%	0,07%	0,08%	0,11%	0,08%	0,02%	0,02%	0,03%	0,03%	0,00%	0,08%	0,14%	0,03%	0,09%	0,11%	0,03%	0,03%	0,13%	0,12%	0,08%
2095	0,09%	0,01%	0,06%	0,07%	0,10%	0,07%	0,02%	0,02%	0,02%	0,02%	0,00%	0,07%	0,13%	0,02%	0,08%	0,10%	0,02%	0,02%	0,13%	0,11%	0,08%
2096	0,08%	0,01%	0,06%	0,07%	0,10%	0,07%	0,02%	0,02%	0,02%	0,02%	0,00%	0,07%	0,12%	0,02%	0,08%	0,10%	0,02%	0,02%	0,12%	0,10%	0,07%
2097	0,08%	0,01%	0,06%	0,07%	0,09%	0,06%	0,02%	0,02%	0,02%	0,02%	0,00%	0,06%	0,12%	0,02%	0,07%	0,09%	0,02%	0,02%	0,11%	0,10%	0,07%
2098	0,07%	0,01%	0,05%	0,06%	0,08%	0,06%	0,01%	0,02%	0,02%	0,02%	0,00%	0,06%	0,11%	0,02%	0,07%	0,08%	0,02%	0,02%	0,10%	0,09%	0,06%
2099	0,07%	0,01%	0,05%	0,06%	0,08%	0,06%	0,01%	0,01%	0,02%	0,02%	0,00%	0,05%	0,10%	0,02%	0,06%	0,08%	0,02%	0,02%	0,10%	0,08%	0,06%
2100	0,06%	0,01%	0,04%	0,05%	0,07%	0,05%	0,01%	0,01%	0,02%	0,02%	0,00%	0,05%	0,09%	0,02%	0,06%	0,07%	0,02%	0,02%	0,09%	0,08%	0,05%

Table B.9: Annual RPK growth from 2009 to 2100 for Iteration 3 - SSP1.

year	EUEU	EUAS	EUME	EUAF	EULA	EUNA	ASAS	ASME	ASAF	ASLA	ASNA	MEME	MEAF	MELA	MENA	AFAF	AFLA	AFNA	LALA	LANA	NANA
2009	1,60%	1,50%	11,30%	2,20%	3,10%	0,40%	9,20%	12,90%	-5,00%	17,90%	3,70%	6,40%	15,30%	8,70%	16,40%	5,20%	17,90%	14,20%	10,80%	5,30%	0,50%
2010	1,60%	1,50%	11,30%	2,20%	3,10%	0,40%	9,20%	12,90%	-5,00%	17,90%	3,70%	6,40%	15,30%	8,70%	16,40%	5,20%	17,90%	14,20%	10,80%	5,30%	0,50%
2011	1,60%	1,50%	11,30%	2,20%	3,10%	0,40%	9,20%	12,90%	-5,00%	17,90%	3,70%	6,40%	15,30%	8,70%	16,40%	5,20%	17,90%	14,20%	10,80%	5,30%	0,50%
2012	1,60%	1,50%	11,30%	2,20%	3,10%	0,40%	9,20%	12,90%	-5,00%	17,90%	3,70%	6,40%	15,30%	8,70%	16,40%	5,20%	17,90%	14,20%	10,80%	5,30%	0,50%
2013	1,60%	1,50%	11,30%	2,20%	3,10%	0,40%	9,20%	12,90%	-5,00%	17,90%	3,70%	6,40%	15,30%	8,70%	16,40%	5,20%	17,90%	14,20%	10,80%	5,30%	0,50%
2014	7,64%	3,94%	13,31%	2,29%	3,68%	6,80%	7,88%	9,50%	6,50%	6,50%	8,56%	11,86%	8,58%	6,50%	20,67%	2,23%	5,50%	5,50%	7,55%	7,56%	5,71%
2015	9,22%	2,48%	7,36%	-0,32%	5,78%	9,25%	11,58%	14,66%	6,00%	6,00%	8,62%	15,42%	4,41%	6,00%	10,86%	4,99%	5,30%	5,30%	6,14%	1,31%	5,47%
2016	7,20%	5,15%	7,93%	7,13%	5,49%	6,82%	9,50%	10,07%	5,50%	5,50%	5,83%	5,47%	5,72%	5,50%	1,09%	2,93%	5,20%	5,20%	4,99%	5,21%	4,77%
2017	7,09%	10,74%	10,06%	8,04%	5,59%	7,61%	8,78%	4,60%	5,00%	5,00%	4,00%	3,74%	4,91%	5,00%	-4,81%	2,25%	5,00%	5,00%	7,76%	5,97%	6,09%
2018	3,26%	3,57%	6,03%	5,63%	4,49%	4,09%	3,78%	-1,30%	4,80%	4,80%	-0,32%	1,28%	0,90%	4,80%	-0,26%	4,89%	4,80%	4,80%	3,11%	-1,40%	4,35%
2019	0,87%	0,76%	0,29%	0,47%	-0,61%	0,94%	0,65%	0,01%	4,50%	4,50%	-0,82%	1,62%	0,71%	4,50%	-0,84%	1,54%	4,50%	4,50%	0,06%	0,44%	0,70%
2020	-65,03%	-78,58%	-68,63%	-71,95%	-73,99%	-77,00%	-71,28%	-71,09%	-54,70%	-54,70%	-80,55%	-66,35%	-74,72%	-54,70%	-71,41%	-69,85%	-54,70%	-54,70%	-64,88%	-72,65%	-59,22%
2021	10,44%	-21,83%	-0,34%	26,59%	33,75%	6,51%	-27,57%	-31,61%	1,72%	1,72%	-36,04%	25,82%	47,11%	1,72%	83,35%	38,09%	1,64%	1,64%	43,14%	74,95%	78,03%
2022	120,64%	131,12%	146,20%	117,30%	145,72%	226,99%	216,53%	190,28%	1,72%	1,72%	159,41%	86,13%	119,45%	1,72%	110,79%	88,83%	1,64%	1,64%	120,05%	70,85%	24,42%
2023	109,32%	122,88%	132,60%	106,55%	132,00%	205,01%	201,10%	177,10%	1,95%	1,95%	153,86%	78,61%	108,93%	1,95%	100,27%	81,77%	1,88%	1,88%	108,91%	64,73%	22,48%
2024	9,69%	9,69%	9,69%	9,69%	9,69%	9,69%	9,69%	9,69%	9,69%	9,69%	9,69%	9,69%	9,69%	9,69%	9,69%	9,69%	9,69%	9,69%	9,69%	9,69%	9,69%
2025	8,66%	8,66%	8,66%	8,66%	8,66%	8,66%	8,66%	8,66%	8,66%	8,66%	8,66%	8,66%	8,66%	8,66%	8,66%	8,66%	8,66%	8,66%	8,66%	8,66%	8,66%
2026	7,80%	7,80%	7,80%	7,80%	7,80%	7,80%	7,80%	7,80%	7,80%	7,80%	7,80%	7,80%	7,80%	7,80%	7,80%	7,80%	7,80%	7,80%	7,80%	7,80%	7,80%
2027	7,09%	7,09%	7,09%	7,09%	7,09%	7,09%	7,09%	7,09%	7,09%	7,09%	7,09%	7,09%	7,09%	7,09%	7,09%	7,09%	7,09%	7,09%	7,09%	7,09%	7,09%
2028	6,48%	6,48%	6,48%	6,48%	6,48%	6,48%	6,48%	6,48%	6,48%	6,48%	6,48%	6,48%	6,48%	6,48%	6,48%	6,48%	6,48%	6,48%	6,48%	6,48%	6,48%
2029	5,95%	5,95%	5,95%	5,95%	5,95%	5,95%	5,95%	5,95%	5,95%	5,95%	5,95%	5,95%	5,95%	5,95%	5,95%	5,95%	5,95%	5,95%	5,95%	5,95%	5,95%
2030	5,49%	5,49%	5,49%	5,49%	5,49%	5,49%	5,49%	5,49%	5,49%	5,49%	5,49%	5,49%	5,49%	5,49%	5,49%	5,49%	5,49%	5,49%	5,49%	5,49%	5,49%
2031	5,09%	5,09%	5,09%	5,09%	5,09%	5,09%	5,09%	5,09%	5,09%	5,09%	5,09%	5,09%	5,09%	5,09%	5,09%	5,09%	5,09%	5,09%	5,09%	5,09%	5,09%
2032	4,73%	4,73%	4,73%	4,73%	4,73%	4,73%	4,73%	4,73%	4,73%	4,73%	4,73%	4,73%	4,73%	4,73%	4,73%	4,73%	4,73%	4,73%	4,73%	4,73%	4,73%
2033	4,41%	4,41%	4,41%	4,41%	4,41%	4,41%	4,41%	4,41%	4,41%	4,41%	4,41%	4,41%	4,41%	4,41%	4,41%	4,41%	4,41%	4,41%	4,41%	4,41%	4,41%
2034	4,12%	4,12%	4,12%	4,12%	4,12%	4,12%	4,12%	4,12%	4,12%	4,12%	4,12%	4,12%	4,12%	4,12%	4,12%	4,12%	4,12%	4,12%	4,12%	4,12%	4,12%
2035	3,86%	3,86%	3,86%	3,86%	3,86%	3,86%	3,86%	3,86%	3,86%	3,86%	3,86%	3,86%	3,86%	3,86%	3,86%	3,86%	3,86%	3,86%	3,86%	3,86%	3,86%
2036	3,62%	3,62%	3,62%	3,62%	3,62%	3,62%	3,62%	3,62%	3,62%	3,62%	3,62%	3,62%	3,62%	3,62%	3,62%	3,62%	3,62%	3,62%	3,62%	3,62%	3,62%
2037	3,40%	3,40%	3,40%	3,40%	3,40%	3,40%	3,40%	3,40%	3,40%	3,40%	3,40%	3,40%	3,40%	3,40%	3,40%	3,40%	3,40%	3,40%	3,40%	3,40%	3,40%
2038	3,20%	3,20%	3,20%	3,20%	3,20%	3,20%	3,20%	3,20%	3,20%	3,20%	3,20%	3,20%	3,20%	3,20%	3,20%	3,20%	3,20%	3,20%	3,20%	3,20%	3,20%
2039	3,01%	3,01%	3,01%	3,01%	3,01%	3,01%	3,01%	3,01%	3,01%	3,01%	3,01%	3,01%	3,01%	3,01%	3,01%	3,01%	3,01%	3,01%	3,01%	3,01%	3,01%
2040	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%
2041	2,68%	2,68%	2,68%	2,68%	2,68%	2,68%	2,68%	2,68%	2,68%	2,68%	2,68%	2,68%	2,68%	2,68%	2,68%	2,68%	2,68%	2,68%	2,68%	2,68%	2,68%
2042	2,53%	2,53%	2,53%	2,53%	2,53%	2,53%	2,53%	2,53%	2,53%	2,53%	2,53%	2,53%	2,53%	2,53%	2,53%	2,53%	2,53%	2,53%	2,53%	2,53%	2,53%
2043	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%
2044	2,26%	2,26%	2,26%	2,26%	2,26%	2,26%	2,26%	2,26%	2,26%	2,26%	2,26%	2,26%	2,26%	2,26%	2,26%	2,26%	2,26%	2,26%	2,26%	2,26%	2,26%
2045	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%
2046	2,02%	2,02%	2,02%	2,02%	2,02%	2,02%	2,02%	2,02%	2,02%	2,02%	2,02%	2,02%	2,02%	2,02%	2,02%	2,02%	2,02%	2,02%	2,02%	2,02%	2,02%
2047	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%
2048	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%
2049	1,70%	1,70%	1,70%	1,70%	1,70%	1,70%	1,70%	1,70%	1,70%	1,70%	1,70%	1,70%	1,70%	1,70%	1,70%	1,70%	1,70%	1,70%	1,70%	1,70%	1,70%
2050	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%
2051	1,52%	1,52%	1,52%	1,52%	1,52%	1,52%	1,52%	1,52%	1,52%	1,52%	1,52%	1,52%	1,52%	1,52%	1,52%	1,52%	1,52%	1,52%	1,52%	1,52%	1,52%
2052	1,43%	1,43%	1,43%	1,43%	1,43%	1,43%	1,43%	1,43%	1,43%	1,43%	1,43%	1,43%	1,43%	1,43%	1,43%	1,43%	1,43%	1,43%	1,43%	1,43%	1,43%
2053	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%
2054	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%
2055	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%

Table B.10: Annual RPK growth from 2009 to 2100 for Iteration 3 - SSP1. (cont.)

year	EUEU	EUAS	EUME	EUAF	EULA	EUNA	ASAS	ASME	ASAF	ASLA	ASNA	MEME	MEAF	MELA	MENA	AFAF	AFLA	AFNA	LALA	LANA	NANA
2056	1,11%	1,11%	1,11%	1,11%	1,11%	1,11%	1,11%	1,11%	1,11%	1,11%	1,11%	1,11%	1,11%	1,11%	1,11%	1,11%	1,11%	1,11%	1,11%	1,11%	1,11%
2057	1,04%	1,04%	1,04%	1,04%	1,04%	1,04%	1,04%	1,04%	1,04%	1,04%	1,04%	1,04%	1,04%	1,04%	1,04%	1,04%	1,04%	1,04%	1,04%	1,04%	1,04%
2058	0,97%	0,97%	0,97%	0,97%	0,97%	0,97%	0,97%	0,97%	0,97%	0,97%	0,97%	0,97%	0,97%	0,97%	0,97%	0,97%	0,97%	0,97%	0,97%	0,97%	0,97%
2059	0,90%	0,90%	0,90%	0,90%	0,90%	0,90%	0,90%	0,90%	0,90%	0,90%	0,90%	0,90%	0,90%	0,90%	0,90%	0,90%	0,90%	0,90%	0,90%	0,90%	0,90%
2060	0,83%	0,83%	0,83%	0,83%	0,83%	0,83%	0,83%	0,83%	0,83%	0,83%	0,83%	0,83%	0,83%	0,83%	0,83%	0,83%	0,83%	0,83%	0,83%	0,83%	0,83%
2061	0,76%	0,76%	0,76%	0,76%	0,76%	0,76%	0,76%	0,76%	0,76%	0,76%	0,76%	0,76%	0,76%	0,76%	0,76%	0,76%	0,76%	0,76%	0,76%	0,76%	0,76%
2062	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%
2063	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%
2064	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%
2065	0,51%	0,51%	0,51%	0,51%	0,51%	0,51%	0,51%	0,51%	0,51%	0,51%	0,51%	0,51%	0,51%	0,51%	0,51%	0,51%	0,51%	0,51%	0,51%	0,51%	0,51%
2066	0,45%	0,45%	0,45%	0,45%	0,45%	0,45%	0,45%	0,45%	0,45%	0,45%	0,45%	0,45%	0,45%	0,45%	0,45%	0,45%	0,45%	0,45%	0,45%	0,45%	0,45%
2067	0,40%	0,40%	0,40%	0,40%	0,40%	0,40%	0,40%	0,40%	0,40%	0,40%	0,40%	0,40%	0,40%	0,40%	0,40%	0,40%	0,40%	0,40%	0,40%	0,40%	0,40%
2068	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%
2069	0,28%	0,28%	0,28%	0,28%	0,28%	0,28%	0,28%	0,28%	0,28%	0,28%	0,28%	0,28%	0,28%	0,28%	0,28%	0,28%	0,28%	0,28%	0,28%	0,28%	0,28%
2070	0,22%	0,22%	0,22%	0,22%	0,22%	0,22%	0,22%	0,22%	0,22%	0,22%	0,22%	0,22%	0,22%	0,22%	0,22%	0,22%	0,22%	0,22%	0,22%	0,22%	0,22%
2071	0,17%	0,17%	0,17%	0,17%	0,17%	0,17%	0,17%	0,17%	0,17%	0,17%	0,17%	0,17%	0,17%	0,17%	0,17%	0,17%	0,17%	0,17%	0,17%	0,17%	0,17%
2072	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%
2073	0,05%	0,05%	0,05%	0,05%	0,05%	0,05%	0,05%	0,05%	0,05%	0,05%	0,05%	0,05%	0,05%	0,05%	0,05%	0,05%	0,05%	0,05%	0,05%	0,05%	0,05%
2074	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
2075	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%
2076	-0,11%	-0,11%	-0,11%	-0,11%	-0,11%	-0,11%	-0,11%	-0,11%	-0,11%	-0,11%	-0,11%	-0,11%	-0,11%	-0,11%	-0,11%	-0,11%	-0,11%	-0,11%	-0,11%	-0,11%	-0,11%
2077	-0,17%	-0,17%	-0,17%	-0,17%	-0,17%	-0,17%	-0,17%	-0,17%	-0,17%	-0,17%	-0,17%	-0,17%	-0,17%	-0,17%	-0,17%	-0,17%	-0,17%	-0,17%	-0,17%	-0,17%	-0,17%
2078	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%
2079	-0,28%	-0,28%	-0,28%	-0,28%	-0,28%	-0,28%	-0,28%	-0,28%	-0,28%	-0,28%	-0,28%	-0,28%	-0,28%	-0,28%	-0,28%	-0,28%	-0,28%	-0,28%	-0,28%	-0,28%	-0,28%
2080	-0,34%	-0,34%	-0,34%	-0,34%	-0,34%	-0,34%	-0,34%	-0,34%	-0,34%	-0,34%	-0,34%	-0,34%	-0,34%	-0,34%	-0,34%	-0,34%	-0,34%	-0,34%	-0,34%	-0,34%	-0,34%
2081	-0,40%	-0,40%	-0,40%	-0,40%	-0,40%	-0,40%	-0,40%	-0,40%	-0,40%	-0,40%	-0,40%	-0,40%	-0,40%	-0,40%	-0,40%	-0,40%	-0,40%	-0,40%	-0,40%	-0,40%	-0,40%
2082	-0,46%	-0,46%	-0,46%	-0,46%	-0,46%	-0,46%	-0,46%	-0,46%	-0,46%	-0,46%	-0,46%	-0,46%	-0,46%	-0,46%	-0,46%	-0,46%	-0,46%	-0,46%	-0,46%	-0,46%	-0,46%
2083	-0,52%	-0,52%	-0,52%	-0,52%	-0,52%	-0,52%	-0,52%	-0,52%	-0,52%	-0,52%	-0,52%	-0,52%	-0,52%	-0,52%	-0,52%	-0,52%	-0,52%	-0,52%	-0,52%	-0,52%	-0,52%
2084	-0,58%	-0,58%	-0,58%	-0,58%	-0,58%	-0,58%	-0,58%	-0,58%	-0,58%	-0,58%	-0,58%	-0,58%	-0,58%	-0,58%	-0,58%	-0,58%	-0,58%	-0,58%	-0,58%	-0,58%	-0,58%
2085	-0,64%	-0,64%	-0,64%	-0,64%	-0,64%	-0,64%	-0,64%	-0,64%	-0,64%	-0,64%	-0,64%	-0,64%	-0,64%	-0,64%	-0,64%	-0,64%	-0,64%	-0,64%	-0,64%	-0,64%	-0,64%
2086	-0,70%	-0,70%	-0,70%	-0,70%	-0,70%	-0,70%	-0,70%	-0,70%	-0,70%	-0,70%	-0,70%	-0,70%	-0,70%	-0,70%	-0,70%	-0,70%	-0,70%	-0,70%	-0,70%	-0,70%	-0,70%
2087	-0,76%	-0,76%	-0,76%	-0,76%	-0,76%	-0,76%	-0,76%	-0,76%	-0,76%	-0,76%	-0,76%	-0,76%	-0,76%	-0,76%	-0,76%	-0,76%	-0,76%	-0,76%	-0,76%	-0,76%	-0,76%
2088	-0,83%	-0,83%	-0,83%	-0,83%	-0,83%	-0,83%	-0,83%	-0,83%	-0,83%	-0,83%	-0,83%	-0,83%	-0,83%	-0,83%	-0,83%	-0,83%	-0,83%	-0,83%	-0,83%	-0,83%	-0,83%
2089	-0,89%	-0,89%	-0,89%	-0,89%	-0,89%	-0,89%	-0,89%	-0,89%	-0,89%	-0,89%	-0,89%	-0,89%	-0,89%	-0,89%	-0,89%	-0,89%	-0,89%	-0,89%	-0,89%	-0,89%	-0,89%
2090	-0,96%	-0,96%	-0,96%	-0,96%	-0,96%	-0,96%	-0,96%	-0,96%	-0,96%	-0,96%	-0,96%	-0,96%	-0,96%	-0,96%	-0,96%	-0,96%	-0,96%	-0,96%	-0,96%	-0,96%	-0,96%
2091	-1,03%	-1,03%	-1,03%	-1,03%	-1,03%	-1,03%	-1,03%	-1,03%	-1,03%	-1,03%	-1,03%	-1,03%	-1,03%	-1,03%	-1,03%	-1,03%	-1,03%	-1,03%	-1,03%	-1,03%	-1,03%
2092	-1,10%	-1,10%	-1,10%	-1,10%	-1,10%	-1,10%	-1,10%	-1,10%	-1,10%	-1,10%	-1,10%	-1,10%	-1,10%	-1,10%	-1,10%	-1,10%	-1,10%	-1,10%	-1,10%	-1,10%	-1,10%
2093	-1,18%	-1,18%	-1,18%	-1,18%	-1,18%	-1,18%	-1,18%	-1,18%	-1,18%	-1,18%	-1,18%	-1,18%	-1,18%	-1,18%	-1,18%	-1,18%	-1,18%	-1,18%	-1,18%	-1,18%	-1,18%
2094	-1,25%	-1,25%	-1,25%	-1,25%	-1,25%	-1,25%	-1,25%	-1,25%	-1,25%	-1,25%	-1,25%	-1,25%	-1,25%	-1,25%	-1,25%	-1,25%	-1,25%	-1,25%	-1,25%	-1,25%	-1,25%
2095	-1,33%	-1,33%	-1,33%	-1,33%	-1,33%	-1,33%	-1,33%	-1,33%	-1,33%	-1,33%	-1,33%	-1,33%	-1,33%	-1,33%	-1,33%	-1,33%	-1,33%	-1,33%	-1,33%	-1,33%	-1,33%
2096	-1,42%	-1,42%	-1,42%	-1,42%	-1,42%	-1,42%	-1,42%	-1,42%	-1,42%	-1,42%	-1,42%	-1,42%	-1,42%	-1,42%	-1,42%	-1,42%	-1,42%	-1,42%	-1,42%	-1,42%	-1,42%
2097	-1,50%	-1,50%	-1,50%	-1,50%	-1,50%	-1,50%	-1,50%	-1,50%	-1,50%	-1,50%	-1,50%	-1,50%	-1,50%	-1,50%	-1,50%	-1,50%	-1,50%	-1,50%	-1,50%	-1,50%	-1,50%
2098	-1,59%	-1,59%	-1,59%	-1,59%	-1,59%	-1,59%	-1,59%	-1,59%	-1,59%	-1,59%	-1,59%	-1,59%	-1,59%	-1,59%	-1,59%	-1,59%	-1,59%	-1,59%	-1,59%	-1,59%	-1,59%
2099	-1,68%	-1,68%	-1,68%	-1,68%	-1,68%	-1,68%	-1,68%	-1,68%	-1,68%	-1,68%	-1,68%	-1,68%	-1,68%	-1,68%	-1,68%	-1,68%	-1,68%	-1,68%	-1,68%	-1,68%	-1,68%
2100	-1,78%	-1,78%	-1,78%	-1,78%	-1,78%	-1,78%	-1,78%	-1,78%	-1,78%	-1,78%	-1,78%	-1,78%	-1,78%	-1,78%	-1,78%	-1,78%	-1,78%	-1,78%	-1,78%	-1,78%	-1,78%

Table B.11: Annual RPK growth from 2009 to 2100 for Iteration 3 - SSP2.

year	EUEU	EUAS	EUME	EUAF	EULA	EUNA	ASAS	ASME	ASAF	ASLA	ASNA	MEME	MEAF	MELA	MENA	AFAF	AFLA	AFNA	LALA	LANA	NANA
2009	1,60%	1,50%	11,30%	2,20%	3,10%	0,40%	9,20%	12,90%	-5,00%	17,90%	3,70%	6,40%	15,30%	8,70%	16,40%	5,20%	17,90%	14,20%	10,80%	5,30%	0,50%
2010	1,60%	1,50%	11,30%	2,20%	3,10%	0,40%	9,20%	12,90%	-5,00%	17,90%	3,70%	6,40%	15,30%	8,70%	16,40%	5,20%	17,90%	14,20%	10,80%	5,30%	0,50%
2011	1,60%	1,50%	11,30%	2,20%	3,10%	0,40%	9,20%	12,90%	-5,00%	17,90%	3,70%	6,40%	15,30%	8,70%	16,40%	5,20%	17,90%	14,20%	10,80%	5,30%	0,50%
2012	1,60%	1,50%	11,30%	2,20%	3,10%	0,40%	9,20%	12,90%	-5,00%	17,90%	3,70%	6,40%	15,30%	8,70%	16,40%	5,20%	17,90%	14,20%	10,80%	5,30%	0,50%
2013	1,60%	1,50%	11,30%	2,20%	3,10%	0,40%	9,20%	12,90%	-5,00%	17,90%	3,70%	6,40%	15,30%	8,70%	16,40%	5,20%	17,90%	14,20%	10,80%	5,30%	0,50%
2014	7,64%	3,94%	13,31%	2,29%	3,68%	6,80%	7,88%	9,50%	6,50%	6,50%	8,56%	11,86%	8,58%	6,50%	20,67%	2,23%	5,50%	5,50%	7,55%	7,56%	5,71%
2015	9,22%	2,48%	7,36%	-0,32%	5,78%	9,25%	11,58%	14,66%	6,00%	6,00%	8,62%	15,42%	4,41%	6,00%	10,86%	4,99%	5,30%	5,30%	6,14%	1,31%	5,47%
2016	7,20%	5,15%	7,93%	7,13%	5,49%	6,82%	9,50%	10,07%	5,50%	5,50%	5,83%	5,47%	5,72%	5,50%	1,09%	2,93%	5,20%	5,20%	4,99%	5,21%	4,77%
2017	7,09%	10,74%	10,06%	8,04%	5,59%	7,61%	8,78%	4,60%	5,00%	5,00%	4,00%	3,74%	4,91%	5,00%	-4,81%	2,25%	5,00%	5,00%	7,76%	5,97%	6,09%
2018	3,26%	3,57%	6,03%	5,63%	4,49%	4,09%	3,78%	-1,30%	4,80%	4,80%	-0,32%	1,28%	0,90%	4,80%	-0,26%	4,89%	4,80%	4,80%	3,11%	-1,40%	4,35%
2019	0,87%	0,76%	0,29%	0,47%	-0,61%	0,94%	0,65%	0,01%	4,50%	4,50%	-0,82%	1,62%	0,71%	4,50%	-0,84%	1,54%	4,50%	4,50%	0,06%	0,44%	0,70%
2020	-65,03%	-78,58%	-68,63%	-71,95%	-73,99%	-77,00%	-71,28%	-71,09%	-54,70%	-54,70%	-80,55%	-66,35%	-74,72%	-54,70%	-71,41%	-69,85%	-54,70%	-54,70%	-64,88%	-72,65%	-59,22%
2021	10,44%	-21,83%	-0,34%	26,59%	33,75%	6,51%	-27,57%	-31,61%	1,72%	1,72%	-36,04%	25,82%	47,11%	1,72%	83,35%	38,09%	1,64%	1,64%	43,14%	74,95%	78,03%
2022	120,64%	131,12%	146,20%	117,30%	145,72%	226,99%	216,53%	190,28%	1,72%	1,72%	159,41%	86,13%	119,45%	1,72%	110,79%	88,83%	1,64%	1,64%	120,05%	70,85%	24,42%
2023	109,32%	122,88%	132,60%	106,55%	132,00%	205,01%	201,10%	177,10%	1,95%	1,95%	153,86%	78,61%	108,93%	1,95%	100,27%	81,77%	1,88%	1,88%	108,91%	64,73%	22,48%
2024	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%
2025	3,33%	3,33%	3,33%	3,33%	3,33%	3,33%	3,33%	3,33%	3,33%	3,33%	3,33%	3,33%	3,33%	3,33%	3,33%	3,33%	3,33%	3,33%	3,33%	3,33%	3,33%
2026	3,30%	3,30%	3,30%	3,30%	3,30%	3,30%	3,30%	3,30%	3,30%	3,30%	3,30%	3,30%	3,30%	3,30%	3,30%	3,30%	3,30%	3,30%	3,30%	3,30%	3,30%
2027	3,28%	3,28%	3,28%	3,28%	3,28%	3,28%	3,28%	3,28%	3,28%	3,28%	3,28%	3,28%	3,28%	3,28%	3,28%	3,28%	3,28%	3,28%	3,28%	3,28%	3,28%
2028	3,25%	3,25%	3,25%	3,25%	3,25%	3,25%	3,25%	3,25%	3,25%	3,25%	3,25%	3,25%	3,25%	3,25%	3,25%	3,25%	3,25%	3,25%	3,25%	3,25%	3,25%
2029	3,21%	3,21%	3,21%	3,21%	3,21%	3,21%	3,21%	3,21%	3,21%	3,21%	3,21%	3,21%	3,21%	3,21%	3,21%	3,21%	3,21%	3,21%	3,21%	3,21%	3,21%
2030	3,17%	3,17%	3,17%	3,17%	3,17%	3,17%	3,17%	3,17%	3,17%	3,17%	3,17%	3,17%	3,17%	3,17%	3,17%	3,17%	3,17%	3,17%	3,17%	3,17%	3,17%
2031	3,14%	3,14%	3,14%	3,14%	3,14%	3,14%	3,14%	3,14%	3,14%	3,14%	3,14%	3,14%	3,14%	3,14%	3,14%	3,14%	3,14%	3,14%	3,14%	3,14%	3,14%
2032	3,09%	3,09%	3,09%	3,09%	3,09%	3,09%	3,09%	3,09%	3,09%	3,09%	3,09%	3,09%	3,09%	3,09%	3,09%	3,09%	3,09%	3,09%	3,09%	3,09%	3,09%
2033	3,05%	3,05%	3,05%	3,05%	3,05%	3,05%	3,05%	3,05%	3,05%	3,05%	3,05%	3,05%	3,05%	3,05%	3,05%	3,05%	3,05%	3,05%	3,05%	3,05%	3,05%
2034	3,01%	3,01%	3,01%	3,01%	3,01%	3,01%	3,01%	3,01%	3,01%	3,01%	3,01%	3,01%	3,01%	3,01%	3,01%	3,01%	3,01%	3,01%	3,01%	3,01%	3,01%
2035	2,96%	2,96%	2,96%	2,96%	2,96%	2,96%	2,96%	2,96%	2,96%	2,96%	2,96%	2,96%	2,96%	2,96%	2,96%	2,96%	2,96%	2,96%	2,96%	2,96%	2,96%
2036	2,92%	2,92%	2,92%	2,92%	2,92%	2,92%	2,92%	2,92%	2,92%	2,92%	2,92%	2,92%	2,92%	2,92%	2,92%	2,92%	2,92%	2,92%	2,92%	2,92%	2,92%
2037	2,87%	2,87%	2,87%	2,87%	2,87%	2,87%	2,87%	2,87%	2,87%	2,87%	2,87%	2,87%	2,87%	2,87%	2,87%	2,87%	2,87%	2,87%	2,87%	2,87%	2,87%
2038	2,83%	2,83%	2,83%	2,83%	2,83%	2,83%	2,83%	2,83%	2,83%	2,83%	2,83%	2,83%	2,83%	2,83%	2,83%	2,83%	2,83%	2,83%	2,83%	2,83%	2,83%
2039	2,78%	2,78%	2,78%	2,78%	2,78%	2,78%	2,78%	2,78%	2,78%	2,78%	2,78%	2,78%	2,78%	2,78%	2,78%	2,78%	2,78%	2,78%	2,78%	2,78%	2,78%
2040	2,73%	2,73%	2,73%	2,73%	2,73%	2,73%	2,73%	2,73%	2,73%	2,73%	2,73%	2,73%	2,73%	2,73%	2,73%	2,73%	2,73%	2,73%	2,73%	2,73%	2,73%
2041	2,69%	2,69%	2,69%	2,69%	2,69%	2,69%	2,69%	2,69%	2,69%	2,69%	2,69%	2,69%	2,69%	2,69%	2,69%	2,69%	2,69%	2,69%	2,69%	2,69%	2,69%
2042	2,64%	2,64%	2,64%	2,64%	2,64%	2,64%	2,64%	2,64%	2,64%	2,64%	2,64%	2,64%	2,64%	2,64%	2,64%	2,64%	2,64%	2,64%	2,64%	2,64%	2,64%
2043	2,59%	2,59%	2,59%	2,59%	2,59%	2,59%	2,59%	2,59%	2,59%	2,59%	2,59%	2,59%	2,59%	2,59%	2,59%	2,59%	2,59%	2,59%	2,59%	2,59%	2,59%
2044	2,55%	2,55%	2,55%	2,55%	2,55%	2,55%	2,55%	2,55%	2,55%	2,55%	2,55%	2,55%	2,55%	2,55%	2,55%	2,55%	2,55%	2,55%	2,55%	2,55%	2,55%
2045	2,50%	2,50%	2,50%	2,50%	2,50%	2,50%	2,50%	2,50%	2,50%	2,50%	2,50%	2,50%	2,50%	2,50%	2,50%	2,50%	2,50%	2,50%	2,50%	2,50%	2,50%
2046	2,45%	2,45%	2,45%	2,45%	2,45%	2,45%	2,45%	2,45%	2,45%	2,45%	2,45%	2,45%	2,45%	2,45%	2,45%	2,45%	2,45%	2,45%	2,45%	2,45%	2,45%
2047	2,41%	2,41%	2,41%	2,41%	2,41%	2,41%	2,41%	2,41%	2,41%	2,41%	2,41%	2,41%	2,41%	2,41%	2,41%	2,41%	2,41%	2,41%	2,41%	2,41%	2,41%
2048	2,36%	2,36%	2,36%	2,36%	2,36%	2,36%	2,36%	2,36%	2,36%	2,36%	2,36%	2,36%	2,36%	2,36%	2,36%	2,36%	2,36%	2,36%	2,36%	2,36%	2,36%
2049	2,32%	2,32%	2,32%	2,32%	2,32%	2,32%	2,32%	2,32%	2,32%	2,32%	2,32%	2,32%	2,32%	2,32%	2,32%	2,32%	2,32%	2,32%	2,32%	2,32%	2,32%
2050	2,27%	2,27%	2,27%	2,27%	2,27%	2,27%	2,27%	2,27%	2,27%	2,27%	2,27%	2,27%	2,27%	2,27%	2,27%	2,27%	2,27%	2,27%	2,27%	2,27%	2,27%
2051	2,23%	2,23%	2,23%	2,23%	2,23%	2,23%	2,23%	2,23%	2,23%	2,23%	2,23%	2,23%	2,23%	2,23%	2,23%	2,23%	2,23%	2,23%	2,23%	2,23%	2,23%
2052	2,18%	2,18%	2,18%	2,18%	2,18%	2,18%	2,18%	2,18%	2,18%	2,18%	2,18%	2,18%	2,18%	2,18%	2,18%	2,18%	2,18%	2,18%	2,18%	2,18%	2,18%
2053	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%
2054	2,09%	2,09%	2,09%	2,09%	2,09%	2,09%	2,09%	2,09%	2,09%	2,09%	2,09%	2,09%	2,09%	2,09%	2,09%	2,09%	2,09%	2,09%	2,09%	2,09%	2,09%
2055	2,05%	2,05%	2,05%	2,05%	2,05%	2,05%	2,05%	2,05%	2,05%	2,05%	2,05%	2,05%	2,05%	2,05%	2,05%	2,05%	2,05%	2,05%	2,05%	2,05%	2,05%

Table B.12: Annual RPK growth from 2009 to 2100 for Iteration 3 - SSP2. (cont.)

year	EUEU	EUAS	EUME	EUAF	EULA	EUNA	ASAS	ASME	ASAF	ASLA	ASNA	MEME	MEAF	MELA	MENA	AFAF	AFLA	AFNA	LALA	LANA	NANA
2056	2,01%	2,01%	2,01%	2,01%	2,01%	2,01%	2,01%	2,01%	2,01%	2,01%	2,01%	2,01%	2,01%	2,01%	2,01%	2,01%	2,01%	2,01%	2,01%	2,01%	2,01%
2057	1,97%	1,97%	1,97%	1,97%	1,97%	1,97%	1,97%	1,97%	1,97%	1,97%	1,97%	1,97%	1,97%	1,97%	1,97%	1,97%	1,97%	1,97%	1,97%	1,97%	1,97%
2058	1,92%	1,92%	1,92%	1,92%	1,92%	1,92%	1,92%	1,92%	1,92%	1,92%	1,92%	1,92%	1,92%	1,92%	1,92%	1,92%	1,92%	1,92%	1,92%	1,92%	1,92%
2059	1,88%	1,88%	1,88%	1,88%	1,88%	1,88%	1,88%	1,88%	1,88%	1,88%	1,88%	1,88%	1,88%	1,88%	1,88%	1,88%	1,88%	1,88%	1,88%	1,88%	1,88%
2060	1,84%	1,84%	1,84%	1,84%	1,84%	1,84%	1,84%	1,84%	1,84%	1,84%	1,84%	1,84%	1,84%	1,84%	1,84%	1,84%	1,84%	1,84%	1,84%	1,84%	1,84%
2061	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%
2062	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%
2063	1,72%	1,72%	1,72%	1,72%	1,72%	1,72%	1,72%	1,72%	1,72%	1,72%	1,72%	1,72%	1,72%	1,72%	1,72%	1,72%	1,72%	1,72%	1,72%	1,72%	1,72%
2064	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%
2065	1,64%	1,64%	1,64%	1,64%	1,64%	1,64%	1,64%	1,64%	1,64%	1,64%	1,64%	1,64%	1,64%	1,64%	1,64%	1,64%	1,64%	1,64%	1,64%	1,64%	1,64%
2066	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%
2067	1,57%	1,57%	1,57%	1,57%	1,57%	1,57%	1,57%	1,57%	1,57%	1,57%	1,57%	1,57%	1,57%	1,57%	1,57%	1,57%	1,57%	1,57%	1,57%	1,57%	1,57%
2068	1,53%	1,53%	1,53%	1,53%	1,53%	1,53%	1,53%	1,53%	1,53%	1,53%	1,53%	1,53%	1,53%	1,53%	1,53%	1,53%	1,53%	1,53%	1,53%	1,53%	1,53%
2069	1,49%	1,49%	1,49%	1,49%	1,49%	1,49%	1,49%	1,49%	1,49%	1,49%	1,49%	1,49%	1,49%	1,49%	1,49%	1,49%	1,49%	1,49%	1,49%	1,49%	1,49%
2070	1,45%	1,45%	1,45%	1,45%	1,45%	1,45%	1,45%	1,45%	1,45%	1,45%	1,45%	1,45%	1,45%	1,45%	1,45%	1,45%	1,45%	1,45%	1,45%	1,45%	1,45%
2071	1,42%	1,42%	1,42%	1,42%	1,42%	1,42%	1,42%	1,42%	1,42%	1,42%	1,42%	1,42%	1,42%	1,42%	1,42%	1,42%	1,42%	1,42%	1,42%	1,42%	1,42%
2072	1,38%	1,38%	1,38%	1,38%	1,38%	1,38%	1,38%	1,38%	1,38%	1,38%	1,38%	1,38%	1,38%	1,38%	1,38%	1,38%	1,38%	1,38%	1,38%	1,38%	1,38%
2073	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%
2074	1,31%	1,31%	1,31%	1,31%	1,31%	1,31%	1,31%	1,31%	1,31%	1,31%	1,31%	1,31%	1,31%	1,31%	1,31%	1,31%	1,31%	1,31%	1,31%	1,31%	1,31%
2075	1,27%	1,27%	1,27%	1,27%	1,27%	1,27%	1,27%	1,27%	1,27%	1,27%	1,27%	1,27%	1,27%	1,27%	1,27%	1,27%	1,27%	1,27%	1,27%	1,27%	1,27%
2076	1,24%	1,24%	1,24%	1,24%	1,24%	1,24%	1,24%	1,24%	1,24%	1,24%	1,24%	1,24%	1,24%	1,24%	1,24%	1,24%	1,24%	1,24%	1,24%	1,24%	1,24%
2077	1,20%	1,20%	1,20%	1,20%	1,20%	1,20%	1,20%	1,20%	1,20%	1,20%	1,20%	1,20%	1,20%	1,20%	1,20%	1,20%	1,20%	1,20%	1,20%	1,20%	1,20%
2078	1,17%	1,17%	1,17%	1,17%	1,17%	1,17%	1,17%	1,17%	1,17%	1,17%	1,17%	1,17%	1,17%	1,17%	1,17%	1,17%	1,17%	1,17%	1,17%	1,17%	1,17%
2079	1,13%	1,13%	1,13%	1,13%	1,13%	1,13%	1,13%	1,13%	1,13%	1,13%	1,13%	1,13%	1,13%	1,13%	1,13%	1,13%	1,13%	1,13%	1,13%	1,13%	1,13%
2080	1,10%	1,10%	1,10%	1,10%	1,10%	1,10%	1,10%	1,10%	1,10%	1,10%	1,10%	1,10%	1,10%	1,10%	1,10%	1,10%	1,10%	1,10%	1,10%	1,10%	1,10%
2081	1,06%	1,06%	1,06%	1,06%	1,06%	1,06%	1,06%	1,06%	1,06%	1,06%	1,06%	1,06%	1,06%	1,06%	1,06%	1,06%	1,06%	1,06%	1,06%	1,06%	1,06%
2082	1,03%	1,03%	1,03%	1,03%	1,03%	1,03%	1,03%	1,03%	1,03%	1,03%	1,03%	1,03%	1,03%	1,03%	1,03%	1,03%	1,03%	1,03%	1,03%	1,03%	1,03%
2083	0,99%	0,99%	0,99%	0,99%	0,99%	0,99%	0,99%	0,99%	0,99%	0,99%	0,99%	0,99%	0,99%	0,99%	0,99%	0,99%	0,99%	0,99%	0,99%	0,99%	0,99%
2084	0,96%	0,96%	0,96%	0,96%	0,96%	0,96%	0,96%	0,96%	0,96%	0,96%	0,96%	0,96%	0,96%	0,96%	0,96%	0,96%	0,96%	0,96%	0,96%	0,96%	0,96%
2085	0,92%	0,92%	0,92%	0,92%	0,92%	0,92%	0,92%	0,92%	0,92%	0,92%	0,92%	0,92%	0,92%	0,92%	0,92%	0,92%	0,92%	0,92%	0,92%	0,92%	0,92%
2086	0,89%	0,89%	0,89%	0,89%	0,89%	0,89%	0,89%	0,89%	0,89%	0,89%	0,89%	0,89%	0,89%	0,89%	0,89%	0,89%	0,89%	0,89%	0,89%	0,89%	0,89%
2087	0,85%	0,85%	0,85%	0,85%	0,85%	0,85%	0,85%	0,85%	0,85%	0,85%	0,85%	0,85%	0,85%	0,85%	0,85%	0,85%	0,85%	0,85%	0,85%	0,85%	0,85%
2088	0,82%	0,82%	0,82%	0,82%	0,82%	0,82%	0,82%	0,82%	0,82%	0,82%	0,82%	0,82%	0,82%	0,82%	0,82%	0,82%	0,82%	0,82%	0,82%	0,82%	0,82%
2089	0,78%	0,78%	0,78%	0,78%	0,78%	0,78%	0,78%	0,78%	0,78%	0,78%	0,78%	0,78%	0,78%	0,78%	0,78%	0,78%	0,78%	0,78%	0,78%	0,78%	0,78%
2090	0,75%	0,75%	0,75%	0,75%	0,75%	0,75%	0,75%	0,75%	0,75%	0,75%	0,75%	0,75%	0,75%	0,75%	0,75%	0,75%	0,75%	0,75%	0,75%	0,75%	0,75%
2091	0,71%	0,71%	0,71%	0,71%	0,71%	0,71%	0,71%	0,71%	0,71%	0,71%	0,71%	0,71%	0,71%	0,71%	0,71%	0,71%	0,71%	0,71%	0,71%	0,71%	0,71%
2092	0,68%	0,68%	0,68%	0,68%	0,68%	0,68%	0,68%	0,68%	0,68%	0,68%	0,68%	0,68%	0,68%	0,68%	0,68%	0,68%	0,68%	0,68%	0,68%	0,68%	0,68%
2093	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%
2094	0,61%	0,61%	0,61%	0,61%	0,61%	0,61%	0,61%	0,61%	0,61%	0,61%	0,61%	0,61%	0,61%	0,61%	0,61%	0,61%	0,61%	0,61%	0,61%	0,61%	0,61%
2095	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%
2096	0,54%	0,54%	0,54%	0,54%	0,54%	0,54%	0,54%	0,54%	0,54%	0,54%	0,54%	0,54%	0,54%	0,54%	0,54%	0,54%	0,54%	0,54%	0,54%	0,54%	0,54%
2097	0,50%	0,50%	0,50%	0,50%	0,50%	0,50%	0,50%	0,50%	0,50%	0,50%	0,50%	0,50%	0,50%	0,50%	0,50%	0,50%	0,50%	0,50%	0,50%	0,50%	0,50%
2098	0,47%	0,47%	0,47%	0,47%	0,47%	0,47%	0,47%	0,47%	0,47%	0,47%	0,47%	0,47%	0,47%	0,47%	0,47%	0,47%	0,47%	0,47%	0,47%	0,47%	0,47%
2099	0,43%	0,43%	0,43%	0,43%	0,43%	0,43%	0,43%	0,43%	0,43%	0,43%	0,43%	0,43%	0,43%	0,43%	0,43%	0,43%	0,43%	0,43%	0,43%	0,43%	0,43%
2100	0,39%	0,39%	0,39%	0,39%	0,39%	0,39%	0,39%	0,39%	0,39%	0,39%	0,39%	0,39%	0,39%	0,39%	0,39%	0,39%	0,39%	0,39%	0,39%	0,39%	0,39%

Table B.13: Annual RPK growth from 2009 to 2100 for Iteration 3 - SSP5.

year	EUEU	EUAS	EUME	EUAF	EULA	EUNA	ASAS	ASME	ASAF	ASLA	ASNA	MEME	MEAF	MELA	MENA	AFAF	AFLA	AFNA	LALA	LANA	NANA
2009	1,60%	1,50%	11,30%	2,20%	3,10%	0,40%	9,20%	12,90%	-5,00%	17,90%	3,70%	6,40%	15,30%	8,70%	16,40%	5,20%	17,90%	14,20%	10,80%	5,30%	0,50%
2010	1,60%	1,50%	11,30%	2,20%	3,10%	0,40%	9,20%	12,90%	-5,00%	17,90%	3,70%	6,40%	15,30%	8,70%	16,40%	5,20%	17,90%	14,20%	10,80%	5,30%	0,50%
2011	1,60%	1,50%	11,30%	2,20%	3,10%	0,40%	9,20%	12,90%	-5,00%	17,90%	3,70%	6,40%	15,30%	8,70%	16,40%	5,20%	17,90%	14,20%	10,80%	5,30%	0,50%
2012	1,60%	1,50%	11,30%	2,20%	3,10%	0,40%	9,20%	12,90%	-5,00%	17,90%	3,70%	6,40%	15,30%	8,70%	16,40%	5,20%	17,90%	14,20%	10,80%	5,30%	0,50%
2013	1,60%	1,50%	11,30%	2,20%	3,10%	0,40%	9,20%	12,90%	-5,00%	17,90%	3,70%	6,40%	15,30%	8,70%	16,40%	5,20%	17,90%	14,20%	10,80%	5,30%	0,50%
2014	7,64%	3,94%	13,31%	2,29%	3,68%	6,80%	7,88%	9,50%	6,50%	6,50%	8,56%	11,86%	8,58%	6,50%	20,67%	2,23%	5,50%	5,50%	7,55%	7,56%	5,71%
2015	9,22%	2,48%	7,36%	-0,32%	5,78%	9,25%	11,58%	14,66%	6,00%	6,00%	8,62%	15,42%	4,41%	6,00%	10,86%	4,99%	5,30%	5,30%	6,14%	1,31%	5,47%
2016	7,20%	5,15%	7,93%	7,13%	5,49%	6,82%	9,50%	10,07%	5,50%	5,50%	5,83%	5,47%	5,72%	5,50%	1,09%	2,93%	5,20%	5,20%	4,99%	5,21%	4,77%
2017	7,09%	10,74%	10,06%	8,04%	5,59%	7,61%	8,78%	4,60%	5,00%	5,00%	4,00%	3,74%	4,91%	5,00%	-4,81%	2,25%	5,00%	5,00%	7,76%	5,97%	6,09%
2018	3,26%	3,57%	6,03%	5,63%	4,49%	4,09%	3,78%	-1,30%	4,80%	4,80%	-0,32%	1,28%	0,90%	4,80%	-0,26%	4,89%	4,80%	4,80%	3,11%	-1,40%	4,35%
2019	0,87%	0,76%	0,29%	0,47%	-0,61%	0,94%	0,65%	0,01%	4,50%	4,50%	-0,82%	1,62%	0,71%	4,50%	-0,84%	1,54%	4,50%	4,50%	0,06%	0,44%	0,70%
2020	-65,03%	-78,58%	-68,63%	-71,95%	-73,99%	-77,00%	-71,28%	-71,09%	-54,70%	-54,70%	-80,55%	-66,35%	-74,72%	-54,70%	-71,41%	-69,85%	-54,70%	-54,70%	-64,88%	-72,65%	-59,22%
2021	10,44%	-21,83%	-0,34%	26,59%	33,75%	6,51%	-27,57%	-31,61%	1,72%	1,72%	-36,04%	25,82%	47,11%	1,72%	83,35%	38,09%	1,64%	1,64%	43,14%	74,95%	78,03%
2022	120,64%	131,12%	146,20%	117,30%	145,72%	226,99%	216,53%	190,28%	1,72%	1,72%	159,41%	86,13%	119,45%	1,72%	110,79%	88,83%	1,64%	1,64%	120,05%	70,85%	24,42%
2023	109,32%	122,88%	132,60%	106,55%	132,00%	205,01%	201,10%	177,10%	1,95%	1,95%	153,86%	78,61%	108,93%	1,95%	100,27%	81,77%	1,88%	1,88%	108,91%	64,73%	22,48%
2024	8,14%	8,14%	8,14%	8,14%	8,14%	8,14%	8,14%	8,14%	8,14%	8,14%	8,14%	8,14%	8,14%	8,14%	8,14%	8,14%	8,14%	8,14%	8,14%	8,14%	8,14%
2025	7,98%	7,98%	7,98%	7,98%	7,98%	7,98%	7,98%	7,98%	7,98%	7,98%	7,98%	7,98%	7,98%	7,98%	7,98%	7,98%	7,98%	7,98%	7,98%	7,98%	7,98%
2026	7,79%	7,79%	7,79%	7,79%	7,79%	7,79%	7,79%	7,79%	7,79%	7,79%	7,79%	7,79%	7,79%	7,79%	7,79%	7,79%	7,79%	7,79%	7,79%	7,79%	7,79%
2027	7,59%	7,59%	7,59%	7,59%	7,59%	7,59%	7,59%	7,59%	7,59%	7,59%	7,59%	7,59%	7,59%	7,59%	7,59%	7,59%	7,59%	7,59%	7,59%	7,59%	7,59%
2028	7,38%	7,38%	7,38%	7,38%	7,38%	7,38%	7,38%	7,38%	7,38%	7,38%	7,38%	7,38%	7,38%	7,38%	7,38%	7,38%	7,38%	7,38%	7,38%	7,38%	7,38%
2029	7,16%	7,16%	7,16%	7,16%	7,16%	7,16%	7,16%	7,16%	7,16%	7,16%	7,16%	7,16%	7,16%	7,16%	7,16%	7,16%	7,16%	7,16%	7,16%	7,16%	7,16%
2030	6,94%	6,94%	6,94%	6,94%	6,94%	6,94%	6,94%	6,94%	6,94%	6,94%	6,94%	6,94%	6,94%	6,94%	6,94%	6,94%	6,94%	6,94%	6,94%	6,94%	6,94%
2031	6,72%	6,72%	6,72%	6,72%	6,72%	6,72%	6,72%	6,72%	6,72%	6,72%	6,72%	6,72%	6,72%	6,72%	6,72%	6,72%	6,72%	6,72%	6,72%	6,72%	6,72%
2032	6,51%	6,51%	6,51%	6,51%	6,51%	6,51%	6,51%	6,51%	6,51%	6,51%	6,51%	6,51%	6,51%	6,51%	6,51%	6,51%	6,51%	6,51%	6,51%	6,51%	6,51%
2033	6,30%	6,30%	6,30%	6,30%	6,30%	6,30%	6,30%	6,30%	6,30%	6,30%	6,30%	6,30%	6,30%	6,30%	6,30%	6,30%	6,30%	6,30%	6,30%	6,30%	6,30%
2034	6,09%	6,09%	6,09%	6,09%	6,09%	6,09%	6,09%	6,09%	6,09%	6,09%	6,09%	6,09%	6,09%	6,09%	6,09%	6,09%	6,09%	6,09%	6,09%	6,09%	6,09%
2035	5,89%	5,89%	5,89%	5,89%	5,89%	5,89%	5,89%	5,89%	5,89%	5,89%	5,89%	5,89%	5,89%	5,89%	5,89%	5,89%	5,89%	5,89%	5,89%	5,89%	5,89%
2036	5,69%	5,69%	5,69%	5,69%	5,69%	5,69%	5,69%	5,69%	5,69%	5,69%	5,69%	5,69%	5,69%	5,69%	5,69%	5,69%	5,69%	5,69%	5,69%	5,69%	5,69%
2037	5,50%	5,50%	5,50%	5,50%	5,50%	5,50%	5,50%	5,50%	5,50%	5,50%	5,50%	5,50%	5,50%	5,50%	5,50%	5,50%	5,50%	5,50%	5,50%	5,50%	5,50%
2038	5,32%	5,32%	5,32%	5,32%	5,32%	5,32%	5,32%	5,32%	5,32%	5,32%	5,32%	5,32%	5,32%	5,32%	5,32%	5,32%	5,32%	5,32%	5,32%	5,32%	5,32%
2039	5,14%	5,14%	5,14%	5,14%	5,14%	5,14%	5,14%	5,14%	5,14%	5,14%	5,14%	5,14%	5,14%	5,14%	5,14%	5,14%	5,14%	5,14%	5,14%	5,14%	5,14%
2040	4,97%	4,97%	4,97%	4,97%	4,97%	4,97%	4,97%	4,97%	4,97%	4,97%	4,97%	4,97%	4,97%	4,97%	4,97%	4,97%	4,97%	4,97%	4,97%	4,97%	4,97%
2041	4,81%	4,81%	4,81%	4,81%	4,81%	4,81%	4,81%	4,81%	4,81%	4,81%	4,81%	4,81%	4,81%	4,81%	4,81%	4,81%	4,81%	4,81%	4,81%	4,81%	4,81%
2042	4,65%	4,65%	4,65%	4,65%	4,65%	4,65%	4,65%	4,65%	4,65%	4,65%	4,65%	4,65%	4,65%	4,65%	4,65%	4,65%	4,65%	4,65%	4,65%	4,65%	4,65%
2043	4,50%	4,50%	4,50%	4,50%	4,50%	4,50%	4,50%	4,50%	4,50%	4,50%	4,50%	4,50%	4,50%	4,50%	4,50%	4,50%	4,50%	4,50%	4,50%	4,50%	4,50%
2044	4,35%	4,35%	4,35%	4,35%	4,35%	4,35%	4,35%	4,35%	4,35%	4,35%	4,35%	4,35%	4,35%	4,35%	4,35%	4,35%	4,35%	4,35%	4,35%	4,35%	4,35%
2045	4,21%	4,21%	4,21%	4,21%	4,21%	4,21%	4,21%	4,21%	4,21%	4,21%	4,21%	4,21%	4,21%	4,21%	4,21%	4,21%	4,21%	4,21%	4,21%	4,21%	4,21%
2046	4,08%	4,08%	4,08%	4,08%	4,08%	4,08%	4,08%	4,08%	4,08%	4,08%	4,08%	4,08%	4,08%	4,08%	4,08%	4,08%	4,08%	4,08%	4,08%	4,08%	4,08%
2047	3,94%	3,94%	3,94%	3,94%	3,94%	3,94%	3,94%	3,94%	3,94%	3,94%	3,94%	3,94%	3,94%	3,94%	3,94%	3,94%	3,94%	3,94%	3,94%	3,94%	3,94%
2048	3,82%	3,82%	3,82%	3,82%	3,82%	3,82%	3,82%	3,82%	3,82%	3,82%	3,82%	3,82%	3,82%	3,82%	3,82%	3,82%	3,82%	3,82%	3,82%	3,82%	3,82%
2049	3,69%	3,69%	3,69%	3,69%	3,69%	3,69%	3,69%	3,69%	3,69%	3,69%	3,69%	3,69%	3,69%	3,69%	3,69%	3,69%	3,69%	3,69%	3,69%	3,69%	3,69%
2050	3,57%	3,57%	3,57%	3,57%	3,57%	3,57%	3,57%	3,57%	3,57%	3,57%	3,57%	3,57%	3,57%	3,57%	3,57%	3,57%	3,57%	3,57%	3,57%	3,57%	3,57%
2051	3,46%	3,46%	3,46%	3,46%	3,46%	3,46%	3,46%	3,46%	3,46%	3,46%	3,46%	3,46%	3,46%	3,46%	3,46%	3,46%	3,46%	3,46%	3,46%	3,46%	3,46%
2052	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%
2053	3,24%	3,24%	3,24%	3,24%	3,24%	3,24%	3,24%	3,24%	3,24%	3,24%	3,24%	3,24%	3,24%	3,24%	3,24%	3,24%	3,24%	3,24%	3,24%	3,24%	3,24%
2054	3,13%	3,13%	3,13%	3,13%	3,13%	3,13%	3,13%	3,13%	3,13%	3,13%	3,13%	3,13%	3,13%	3,13%	3,13%	3,13%	3,13%	3,13%	3,13%	3,13%	3,13%
2055	3,03%	3,03%	3,03%	3,03%	3,03%	3,03%	3,03%	3,03%	3,03%	3,03%	3,03%	3,03%	3,03%	3,03%	3,03%	3,03%	3,03%	3,03%	3,03%	3,03%	3,03%

Table B.14: Annual RPK growth from 2009 to 2100 for Iteration 3 - SSP5. (cont.)

year	EUEU	EUAS	EUME	EUAF	EULA	EUNA	ASAS	ASME	ASAF	ASLA	ASNA	MEME	MEAF	MELA	MENA	AFAF	AFLA	AFNA	LALA	LANA	NANA
2056	2,93%	2,93%	2,93%	2,93%	2,93%	2,93%	2,93%	2,93%	2,93%	2,93%	2,93%	2,93%	2,93%	2,93%	2,93%	2,93%	2,93%	2,93%	2,93%	2,93%	2,93%
2057	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%
2058	2,74%	2,74%	2,74%	2,74%	2,74%	2,74%	2,74%	2,74%	2,74%	2,74%	2,74%	2,74%	2,74%	2,74%	2,74%	2,74%	2,74%	2,74%	2,74%	2,74%	2,74%
2059	2,65%	2,65%	2,65%	2,65%	2,65%	2,65%	2,65%	2,65%	2,65%	2,65%	2,65%	2,65%	2,65%	2,65%	2,65%	2,65%	2,65%	2,65%	2,65%	2,65%	2,65%
2060	2,56%	2,56%	2,56%	2,56%	2,56%	2,56%	2,56%	2,56%	2,56%	2,56%	2,56%	2,56%	2,56%	2,56%	2,56%	2,56%	2,56%	2,56%	2,56%	2,56%	2,56%
2061	2,47%	2,47%	2,47%	2,47%	2,47%	2,47%	2,47%	2,47%	2,47%	2,47%	2,47%	2,47%	2,47%	2,47%	2,47%	2,47%	2,47%	2,47%	2,47%	2,47%	2,47%
2062	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%
2063	2,30%	2,30%	2,30%	2,30%	2,30%	2,30%	2,30%	2,30%	2,30%	2,30%	2,30%	2,30%	2,30%	2,30%	2,30%	2,30%	2,30%	2,30%	2,30%	2,30%	2,30%
2064	2,22%	2,22%	2,22%	2,22%	2,22%	2,22%	2,22%	2,22%	2,22%	2,22%	2,22%	2,22%	2,22%	2,22%	2,22%	2,22%	2,22%	2,22%	2,22%	2,22%	2,22%
2065	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%
2066	2,06%	2,06%	2,06%	2,06%	2,06%	2,06%	2,06%	2,06%	2,06%	2,06%	2,06%	2,06%	2,06%	2,06%	2,06%	2,06%	2,06%	2,06%	2,06%	2,06%	2,06%
2067	1,98%	1,98%	1,98%	1,98%	1,98%	1,98%	1,98%	1,98%	1,98%	1,98%	1,98%	1,98%	1,98%	1,98%	1,98%	1,98%	1,98%	1,98%	1,98%	1,98%	1,98%
2068	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%
2069	1,83%	1,83%	1,83%	1,83%	1,83%	1,83%	1,83%	1,83%	1,83%	1,83%	1,83%	1,83%	1,83%	1,83%	1,83%	1,83%	1,83%	1,83%	1,83%	1,83%	1,83%
2070	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%
2071	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%
2072	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%
2073	1,54%	1,54%	1,54%	1,54%	1,54%	1,54%	1,54%	1,54%	1,54%	1,54%	1,54%	1,54%	1,54%	1,54%	1,54%	1,54%	1,54%	1,54%	1,54%	1,54%	1,54%
2074	1,47%	1,47%	1,47%	1,47%	1,47%	1,47%	1,47%	1,47%	1,47%	1,47%	1,47%	1,47%	1,47%	1,47%	1,47%	1,47%	1,47%	1,47%	1,47%	1,47%	1,47%
2075	1,40%	1,40%	1,40%	1,40%	1,40%	1,40%	1,40%	1,40%	1,40%	1,40%	1,40%	1,40%	1,40%	1,40%	1,40%	1,40%	1,40%	1,40%	1,40%	1,40%	1,40%
2076	1,33%	1,33%	1,33%	1,33%	1,33%	1,33%	1,33%	1,33%	1,33%	1,33%	1,33%	1,33%	1,33%	1,33%	1,33%	1,33%	1,33%	1,33%	1,33%	1,33%	1,33%
2077	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%
2078	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%
2079	1,12%	1,12%	1,12%	1,12%	1,12%	1,12%	1,12%	1,12%	1,12%	1,12%	1,12%	1,12%	1,12%	1,12%	1,12%	1,12%	1,12%	1,12%	1,12%	1,12%	1,12%
2080	1,05%	1,05%	1,05%	1,05%	1,05%	1,05%	1,05%	1,05%	1,05%	1,05%	1,05%	1,05%	1,05%	1,05%	1,05%	1,05%	1,05%	1,05%	1,05%	1,05%	1,05%
2081	0,98%	0,98%	0,98%	0,98%	0,98%	0,98%	0,98%	0,98%	0,98%	0,98%	0,98%	0,98%	0,98%	0,98%	0,98%	0,98%	0,98%	0,98%	0,98%	0,98%	0,98%
2082	0,91%	0,91%	0,91%	0,91%	0,91%	0,91%	0,91%	0,91%	0,91%	0,91%	0,91%	0,91%	0,91%	0,91%	0,91%	0,91%	0,91%	0,91%	0,91%	0,91%	0,91%
2083	0,84%	0,84%	0,84%	0,84%	0,84%	0,84%	0,84%	0,84%	0,84%	0,84%	0,84%	0,84%	0,84%	0,84%	0,84%	0,84%	0,84%	0,84%	0,84%	0,84%	0,84%
2084	0,77%	0,77%	0,77%	0,77%	0,77%	0,77%	0,77%	0,77%	0,77%	0,77%	0,77%	0,77%	0,77%	0,77%	0,77%	0,77%	0,77%	0,77%	0,77%	0,77%	0,77%
2085	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%
2086	0,63%	0,63%	0,63%	0,63%	0,63%	0,63%	0,63%	0,63%	0,63%	0,63%	0,63%	0,63%	0,63%	0,63%	0,63%	0,63%	0,63%	0,63%	0,63%	0,63%	0,63%
2087	0,56%	0,56%	0,56%	0,56%	0,56%	0,56%	0,56%	0,56%	0,56%	0,56%	0,56%	0,56%	0,56%	0,56%	0,56%	0,56%	0,56%	0,56%	0,56%	0,56%	0,56%
2088	0,48%	0,48%	0,48%	0,48%	0,48%	0,48%	0,48%	0,48%	0,48%	0,48%	0,48%	0,48%	0,48%	0,48%	0,48%	0,48%	0,48%	0,48%	0,48%	0,48%	0,48%
2089	0,41%	0,41%	0,41%	0,41%	0,41%	0,41%	0,41%	0,41%	0,41%	0,41%	0,41%	0,41%	0,41%	0,41%	0,41%	0,41%	0,41%	0,41%	0,41%	0,41%	0,41%
2090	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%
2091	0,26%	0,26%	0,26%	0,26%	0,26%	0,26%	0,26%	0,26%	0,26%	0,26%	0,26%	0,26%	0,26%	0,26%	0,26%	0,26%	0,26%	0,26%	0,26%	0,26%	0,26%
2092	0,18%	0,18%	0,18%	0,18%	0,18%	0,18%	0,18%	0,18%	0,18%	0,18%	0,18%	0,18%	0,18%	0,18%	0,18%	0,18%	0,18%	0,18%	0,18%	0,18%	0,18%
2093	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%
2094	0,03%	0,03%	0,03%	0,03%	0,03%	0,03%	0,03%	0,03%	0,03%	0,03%	0,03%	0,03%	0,03%	0,03%	0,03%	0,03%	0,03%	0,03%	0,03%	0,03%	0,03%
2095	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%
2096	-0,14%	-0,14%	-0,14%	-0,14%	-0,14%	-0,14%	-0,14%	-0,14%	-0,14%	-0,14%	-0,14%	-0,14%	-0,14%	-0,14%	-0,14%	-0,14%	-0,14%	-0,14%	-0,14%	-0,14%	-0,14%
2097	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%
2098	-0,32%	-0,32%	-0,32%	-0,32%	-0,32%	-0,32%	-0,32%	-0,32%	-0,32%	-0,32%	-0,32%	-0,32%	-0,32%	-0,32%	-0,32%	-0,32%	-0,32%	-0,32%	-0,32%	-0,32%	-0,32%
2099	-0,41%	-0,41%	-0,41%	-0,41%	-0,41%	-0,41%	-0,41%	-0,41%	-0,41%	-0,41%	-0,41%	-0,41%	-0,41%	-0,41%	-0,41%	-0,41%	-0,41%	-0,41%	-0,41%	-0,41%	-0,41%
2100	-0,50%	-0,50%	-0,50%	-0,50%	-0,50%	-0,50%	-0,50%	-0,50%	-0,50%	-0,50%	-0,50%	-0,50%	-0,50%	-0,50%	-0,50%	-0,50%	-0,50%	-0,50%	-0,50%	-0,50%	-0,50%

Table B.15: Annual RPK growth from 2009 to 2100 for Iteration 4 - SSP1.

year	EUEU	EUAS	EUME	EUAF	EULA	EUNA	ASAS	ASME	ASAF	ASLA	ASNA	MEME	MEAF	MELA	MENA	AFAF	AFLA	AFNA	LALA	LANA	NANA
2009	1,60%	1,50%	11,30%	2,20%	3,10%	0,40%	9,20%	12,90%	-5,00%	17,90%	3,70%	6,40%	15,30%	8,70%	16,40%	5,20%	17,90%	14,20%	10,80%	5,30%	0,50%
2010	1,60%	1,50%	11,30%	2,20%	3,10%	0,40%	9,20%	12,90%	-5,00%	17,90%	3,70%	6,40%	15,30%	8,70%	16,40%	5,20%	17,90%	14,20%	10,80%	5,30%	0,50%
2011	1,60%	1,50%	11,30%	2,20%	3,10%	0,40%	9,20%	12,90%	-5,00%	17,90%	3,70%	6,40%	15,30%	8,70%	16,40%	5,20%	17,90%	14,20%	10,80%	5,30%	0,50%
2012	1,60%	1,50%	11,30%	2,20%	3,10%	0,40%	9,20%	12,90%	-5,00%	17,90%	3,70%	6,40%	15,30%	8,70%	16,40%	5,20%	17,90%	14,20%	10,80%	5,30%	0,50%
2013	1,60%	1,50%	11,30%	2,20%	3,10%	0,40%	9,20%	12,90%	-5,00%	17,90%	3,70%	6,40%	15,30%	8,70%	16,40%	5,20%	17,90%	14,20%	10,80%	5,30%	0,50%
2014	7,64%	3,94%	13,31%	2,29%	3,68%	6,80%	7,88%	9,50%	6,50%	6,50%	8,56%	11,86%	8,58%	6,50%	20,67%	2,23%	5,50%	5,50%	7,55%	7,56%	5,71%
2015	9,22%	2,48%	7,36%	-0,32%	5,78%	9,25%	11,58%	14,66%	6,00%	6,00%	8,62%	15,42%	4,41%	6,00%	10,86%	4,99%	5,30%	5,30%	6,14%	1,31%	5,47%
2016	7,20%	5,15%	7,93%	7,13%	5,49%	6,82%	9,50%	10,07%	5,50%	5,50%	5,83%	5,47%	5,72%	5,50%	1,09%	2,93%	5,20%	5,20%	4,99%	5,21%	4,77%
2017	7,09%	10,74%	10,06%	8,04%	5,59%	7,61%	8,78%	4,60%	5,00%	5,00%	4,00%	3,74%	4,91%	5,00%	-4,81%	2,25%	5,00%	5,00%	7,76%	5,97%	6,09%
2018	3,26%	3,57%	6,03%	5,63%	4,49%	4,09%	3,78%	-1,30%	4,80%	4,80%	-0,32%	1,28%	0,90%	4,80%	-0,26%	4,89%	4,80%	4,80%	3,11%	-1,40%	4,35%
2019	0,87%	0,76%	0,29%	0,47%	-0,61%	0,94%	0,65%	0,01%	4,50%	4,50%	-0,82%	1,62%	0,71%	4,50%	-0,84%	1,54%	4,50%	4,50%	0,06%	0,44%	0,70%
2020	-65,03%	-78,58%	-68,63%	-71,95%	-73,99%	-77,00%	-71,28%	-71,09%	-54,70%	-54,70%	-80,55%	-66,35%	-74,72%	-54,70%	-71,41%	-69,85%	-54,70%	-54,70%	-64,88%	-72,65%	-59,22%
2021	10,44%	-21,83%	-0,34%	26,59%	33,75%	6,51%	-27,57%	-31,61%	1,72%	1,72%	-36,04%	25,82%	47,11%	1,72%	83,35%	38,09%	1,64%	1,64%	43,14%	74,95%	78,03%
2022	120,64%	131,12%	146,20%	117,30%	145,72%	226,99%	216,53%	190,28%	1,72%	1,72%	159,41%	86,13%	119,45%	1,72%	110,79%	88,83%	1,64%	1,64%	120,05%	70,85%	24,42%
2023	109,32%	122,88%	132,60%	106,55%	132,00%	205,01%	201,10%	177,10%	1,95%	1,95%	153,86%	78,61%	108,93%	1,95%	100,27%	81,77%	1,88%	1,88%	108,91%	64,73%	22,48%
2024	97,99%	114,64%	119,00%	95,79%	118,28%	183,02%	185,68%	163,92%	2,18%	2,18%	148,31%	71,09%	98,41%	2,18%	89,75%	74,70%	2,11%	2,11%	97,77%	58,60%	20,54%
2025	86,67%	106,40%	105,40%	85,04%	104,55%	161,04%	170,25%	150,74%	2,40%	2,40%	142,76%	63,57%	87,89%	2,40%	79,24%	67,63%	2,35%	2,35%	86,63%	52,48%	18,61%
2026	75,34%	98,16%	91,80%	74,28%	90,83%	139,05%	154,83%	137,56%	2,63%	2,63%	137,21%	56,05%	77,36%	2,63%	68,72%	60,56%	2,58%	2,58%	75,49%	46,36%	16,67%
2027	64,02%	89,92%	78,20%	63,53%	77,10%	117,07%	139,40%	124,38%	2,86%	2,86%	131,66%	48,53%	66,84%	2,86%	58,21%	53,50%	2,82%	2,82%	64,35%	40,24%	14,73%
2028	52,69%	81,68%	64,61%	52,77%	63,38%	95,08%	123,98%	111,20%	3,09%	3,09%	126,11%	41,01%	56,32%	3,09%	47,69%	46,43%	3,06%	3,06%	53,21%	34,12%	12,80%
2029	41,36%	73,44%	51,01%	42,02%	49,66%	73,10%	108,55%	98,02%	3,32%	3,32%	120,56%	33,49%	45,80%	3,32%	37,17%	39,36%	3,29%	3,29%	42,07%	28,00%	10,86%
2030	30,04%	65,20%	37,41%	31,26%	35,93%	51,11%	93,12%	84,84%	3,54%	3,54%	115,01%	25,97%	35,27%	3,54%	26,66%	32,29%	3,53%	3,53%	30,93%	21,87%	8,92%
2031	18,71%	56,96%	23,81%	20,51%	22,21%	29,13%	77,70%	71,65%	3,77%	3,77%	109,46%	18,45%	24,75%	3,77%	16,14%	25,23%	3,76%	3,76%	19,79%	15,75%	6,98%
2032	7,39%	48,72%	10,21%	9,75%	8,48%	7,14%	62,27%	58,47%	4,00%	4,00%	103,91%	10,93%	14,23%	4,00%	5,62%	18,16%	4,00%	4,00%	8,65%	9,63%	5,05%
2033	7,01%	44,19%	9,55%	9,16%	8,06%	6,75%	56,52%	53,11%	4,08%	4,08%	94,00%	10,23%	13,42%	4,08%	5,37%	16,96%	4,08%	4,08%	8,26%	9,14%	4,83%
2034	6,64%	39,65%	8,89%	8,57%	7,63%	6,37%	50,76%	47,75%	4,17%	4,16%	84,09%	9,54%	12,62%	4,16%	5,11%	15,76%	4,16%	4,16%	7,87%	8,64%	4,61%
2035	6,26%	35,12%	8,23%	7,98%	7,20%	5,98%	45,01%	42,39%	4,25%	4,24%	74,17%	8,85%	11,81%	4,24%	4,85%	14,56%	4,24%	4,24%	7,48%	8,14%	4,39%
2036	5,88%	30,58%	7,58%	7,39%	6,77%	5,59%	39,26%	37,02%	4,34%	4,32%	64,26%	8,16%	11,01%	4,32%	4,59%	13,36%	4,32%	4,32%	7,08%	7,65%	4,17%
2037	5,51%	26,05%	6,92%	6,80%	6,34%	5,21%	33,50%	31,66%	4,42%	4,40%	54,35%	7,47%	10,21%	4,40%	4,34%	12,16%	4,40%	4,40%	6,69%	7,15%	3,95%
2038	5,13%	21,52%	6,26%	6,21%	5,91%	4,82%	27,75%	26,30%	4,51%	4,48%	44,44%	6,77%	9,40%	4,48%	4,08%	10,96%	4,48%	4,48%	6,30%	6,66%	3,73%
2039	4,75%	16,98%	5,60%	5,62%	5,49%	4,43%	21,99%	20,93%	4,59%	4,56%	34,53%	6,08%	8,60%	4,56%	3,82%	9,76%	4,56%	4,56%	5,91%	6,16%	3,51%
2040	4,38%	12,45%	4,94%	5,03%	5,06%	4,05%	16,24%	15,57%	4,68%	4,64%	24,62%	5,39%	7,79%	4,64%	3,56%	8,55%	4,64%	4,64%	5,52%	5,66%	3,29%
2041	4,00%	7,91%	4,28%	4,44%	4,63%	3,66%	10,48%	10,21%	4,76%	4,72%	14,71%	4,70%	6,99%	4,72%	3,31%	7,35%	4,72%	4,72%	5,12%	5,17%	3,07%
2042	3,62%	3,38%	3,63%	3,85%	4,20%	3,27%	4,73%	4,85%	4,85%	4,80%	4,80%	4,01%	6,19%	4,80%	3,05%	6,15%	4,80%	4,80%	4,73%	4,67%	2,85%
2043	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%
2044	2,26%	2,26%	2,26%	2,26%	2,26%	2,26%	2,26%	2,26%	2,26%	2,26%	2,26%	2,26%	2,26%	2,26%	2,26%	2,26%	2,26%	2,26%	2,26%	2,26%	2,26%
2045	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%
2046	2,02%	2,02%	2,02%	2,02%	2,02%	2,02%	2,02%	2,02%	2,02%	2,02%	2,02%	2,02%	2,02%	2,02%	2,02%	2,02%	2,02%	2,02%	2,02%	2,02%	2,02%
2047	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%
2048	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%
2049	1,70%	1,70%	1,70%	1,70%	1,70%	1,70%	1,70%	1,70%	1,70%	1,70%	1,70%	1,70%	1,70%	1,70%	1,70%	1,70%	1,70%	1,70%	1,70%	1,70%	1,70%
2050	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%
2051	1,52%	1,52%	1,52%	1,52%	1,52%	1,52%	1,52%	1,52%	1,52%	1,52%	1,52%	1,52%	1,52%	1,52%	1,52%	1,52%	1,52%	1,52%	1,52%	1,52%	1,52%
2052	1,43%	1,43%	1,43%	1,43%	1,43%	1,43%	1,43%	1,43%	1,43%	1,43%	1,43%	1,43%	1,43%	1,43%	1,43%	1,43%	1,43%	1,43%	1,43%	1,43%	1,43%
2053	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%
2054	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%
2055	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%

Table B.16: Annual RPK growth from 2009 to 2100 for Iteration 4 - SSP1. (cont.)

year	EUEU	EUAS	EUME	EUAF	EULA	EUNA	ASAS	ASME	ASAF	ASLA	ASNA	MEME	MEAF	MELA	MENA	AFAF	AFLA	AFNA	LALA	LANA	NANA
2056	1,11%	1,11%	1,11%	1,11%	1,11%	1,11%	1,11%	1,11%	1,11%	1,11%	1,11%	1,11%	1,11%	1,11%	1,11%	1,11%	1,11%	1,11%	1,11%	1,11%	1,11%
2057	1,04%	1,04%	1,04%	1,04%	1,04%	1,04%	1,04%	1,04%	1,04%	1,04%	1,04%	1,04%	1,04%	1,04%	1,04%	1,04%	1,04%	1,04%	1,04%	1,04%	1,04%
2058	0,97%	0,97%	0,97%	0,97%	0,97%	0,97%	0,97%	0,97%	0,97%	0,97%	0,97%	0,97%	0,97%	0,97%	0,97%	0,97%	0,97%	0,97%	0,97%	0,97%	0,97%
2059	0,90%	0,90%	0,90%	0,90%	0,90%	0,90%	0,90%	0,90%	0,90%	0,90%	0,90%	0,90%	0,90%	0,90%	0,90%	0,90%	0,90%	0,90%	0,90%	0,90%	0,90%
2060	0,83%	0,83%	0,83%	0,83%	0,83%	0,83%	0,83%	0,83%	0,83%	0,83%	0,83%	0,83%	0,83%	0,83%	0,83%	0,83%	0,83%	0,83%	0,83%	0,83%	0,83%
2061	0,76%	0,76%	0,76%	0,76%	0,76%	0,76%	0,76%	0,76%	0,76%	0,76%	0,76%	0,76%	0,76%	0,76%	0,76%	0,76%	0,76%	0,76%	0,76%	0,76%	0,76%
2062	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%
2063	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%
2064	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%
2065	0,51%	0,51%	0,51%	0,51%	0,51%	0,51%	0,51%	0,51%	0,51%	0,51%	0,51%	0,51%	0,51%	0,51%	0,51%	0,51%	0,51%	0,51%	0,51%	0,51%	0,51%
2066	0,45%	0,45%	0,45%	0,45%	0,45%	0,45%	0,45%	0,45%	0,45%	0,45%	0,45%	0,45%	0,45%	0,45%	0,45%	0,45%	0,45%	0,45%	0,45%	0,45%	0,45%
2067	0,40%	0,40%	0,40%	0,40%	0,40%	0,40%	0,40%	0,40%	0,40%	0,40%	0,40%	0,40%	0,40%	0,40%	0,40%	0,40%	0,40%	0,40%	0,40%	0,40%	0,40%
2068	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%
2069	0,28%	0,28%	0,28%	0,28%	0,28%	0,28%	0,28%	0,28%	0,28%	0,28%	0,28%	0,28%	0,28%	0,28%	0,28%	0,28%	0,28%	0,28%	0,28%	0,28%	0,28%
2070	0,22%	0,22%	0,22%	0,22%	0,22%	0,22%	0,22%	0,22%	0,22%	0,22%	0,22%	0,22%	0,22%	0,22%	0,22%	0,22%	0,22%	0,22%	0,22%	0,22%	0,22%
2071	0,17%	0,17%	0,17%	0,17%	0,17%	0,17%	0,17%	0,17%	0,17%	0,17%	0,17%	0,17%	0,17%	0,17%	0,17%	0,17%	0,17%	0,17%	0,17%	0,17%	0,17%
2072	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%
2073	0,05%	0,05%	0,05%	0,05%	0,05%	0,05%	0,05%	0,05%	0,05%	0,05%	0,05%	0,05%	0,05%	0,05%	0,05%	0,05%	0,05%	0,05%	0,05%	0,05%	0,05%
2074	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
2075	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%
2076	-0,11%	-0,11%	-0,11%	-0,11%	-0,11%	-0,11%	-0,11%	-0,11%	-0,11%	-0,11%	-0,11%	-0,11%	-0,11%	-0,11%	-0,11%	-0,11%	-0,11%	-0,11%	-0,11%	-0,11%	-0,11%
2077	-0,17%	-0,17%	-0,17%	-0,17%	-0,17%	-0,17%	-0,17%	-0,17%	-0,17%	-0,17%	-0,17%	-0,17%	-0,17%	-0,17%	-0,17%	-0,17%	-0,17%	-0,17%	-0,17%	-0,17%	-0,17%
2078	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%
2079	-0,28%	-0,28%	-0,28%	-0,28%	-0,28%	-0,28%	-0,28%	-0,28%	-0,28%	-0,28%	-0,28%	-0,28%	-0,28%	-0,28%	-0,28%	-0,28%	-0,28%	-0,28%	-0,28%	-0,28%	-0,28%
2080	-0,34%	-0,34%	-0,34%	-0,34%	-0,34%	-0,34%	-0,34%	-0,34%	-0,34%	-0,34%	-0,34%	-0,34%	-0,34%	-0,34%	-0,34%	-0,34%	-0,34%	-0,34%	-0,34%	-0,34%	-0,34%
2081	-0,40%	-0,40%	-0,40%	-0,40%	-0,40%	-0,40%	-0,40%	-0,40%	-0,40%	-0,40%	-0,40%	-0,40%	-0,40%	-0,40%	-0,40%	-0,40%	-0,40%	-0,40%	-0,40%	-0,40%	-0,40%
2082	-0,46%	-0,46%	-0,46%	-0,46%	-0,46%	-0,46%	-0,46%	-0,46%	-0,46%	-0,46%	-0,46%	-0,46%	-0,46%	-0,46%	-0,46%	-0,46%	-0,46%	-0,46%	-0,46%	-0,46%	-0,46%
2083	-0,52%	-0,52%	-0,52%	-0,52%	-0,52%	-0,52%	-0,52%	-0,52%	-0,52%	-0,52%	-0,52%	-0,52%	-0,52%	-0,52%	-0,52%	-0,52%	-0,52%	-0,52%	-0,52%	-0,52%	-0,52%
2084	-0,58%	-0,58%	-0,58%	-0,58%	-0,58%	-0,58%	-0,58%	-0,58%	-0,58%	-0,58%	-0,58%	-0,58%	-0,58%	-0,58%	-0,58%	-0,58%	-0,58%	-0,58%	-0,58%	-0,58%	-0,58%
2085	-0,64%	-0,64%	-0,64%	-0,64%	-0,64%	-0,64%	-0,64%	-0,64%	-0,64%	-0,64%	-0,64%	-0,64%	-0,64%	-0,64%	-0,64%	-0,64%	-0,64%	-0,64%	-0,64%	-0,64%	-0,64%
2086	-0,70%	-0,70%	-0,70%	-0,70%	-0,70%	-0,70%	-0,70%	-0,70%	-0,70%	-0,70%	-0,70%	-0,70%	-0,70%	-0,70%	-0,70%	-0,70%	-0,70%	-0,70%	-0,70%	-0,70%	-0,70%
2087	-0,76%	-0,76%	-0,76%	-0,76%	-0,76%	-0,76%	-0,76%	-0,76%	-0,76%	-0,76%	-0,76%	-0,76%	-0,76%	-0,76%	-0,76%	-0,76%	-0,76%	-0,76%	-0,76%	-0,76%	-0,76%
2088	-0,83%	-0,83%	-0,83%	-0,83%	-0,83%	-0,83%	-0,83%	-0,83%	-0,83%	-0,83%	-0,83%	-0,83%	-0,83%	-0,83%	-0,83%	-0,83%	-0,83%	-0,83%	-0,83%	-0,83%	-0,83%
2089	-0,89%	-0,89%	-0,89%	-0,89%	-0,89%	-0,89%	-0,89%	-0,89%	-0,89%	-0,89%	-0,89%	-0,89%	-0,89%	-0,89%	-0,89%	-0,89%	-0,89%	-0,89%	-0,89%	-0,89%	-0,89%
2090	-0,96%	-0,96%	-0,96%	-0,96%	-0,96%	-0,96%	-0,96%	-0,96%	-0,96%	-0,96%	-0,96%	-0,96%	-0,96%	-0,96%	-0,96%	-0,96%	-0,96%	-0,96%	-0,96%	-0,96%	-0,96%
2091	-1,03%	-1,03%	-1,03%	-1,03%	-1,03%	-1,03%	-1,03%	-1,03%	-1,03%	-1,03%	-1,03%	-1,03%	-1,03%	-1,03%	-1,03%	-1,03%	-1,03%	-1,03%	-1,03%	-1,03%	-1,03%
2092	-1,10%	-1,10%	-1,10%	-1,10%	-1,10%	-1,10%	-1,10%	-1,10%	-1,10%	-1,10%	-1,10%	-1,10%	-1,10%	-1,10%	-1,10%	-1,10%	-1,10%	-1,10%	-1,10%	-1,10%	-1,10%
2093	-1,18%	-1,18%	-1,18%	-1,18%	-1,18%	-1,18%	-1,18%	-1,18%	-1,18%	-1,18%	-1,18%	-1,18%	-1,18%	-1,18%	-1,18%	-1,18%	-1,18%	-1,18%	-1,18%	-1,18%	-1,18%
2094	-1,25%	-1,25%	-1,25%	-1,25%	-1,25%	-1,25%	-1,25%	-1,25%	-1,25%	-1,25%	-1,25%	-1,25%	-1,25%	-1,25%	-1,25%	-1,25%	-1,25%	-1,25%	-1,25%	-1,25%	-1,25%
2095	-1,33%	-1,33%	-1,33%	-1,33%	-1,33%	-1,33%	-1,33%	-1,33%	-1,33%	-1,33%	-1,33%	-1,33%	-1,33%	-1,33%	-1,33%	-1,33%	-1,33%	-1,33%	-1,33%	-1,33%	-1,33%
2096	-1,42%	-1,42%	-1,42%	-1,42%	-1,42%	-1,42%	-1,42%	-1,42%	-1,42%	-1,42%	-1,42%	-1,42%	-1,42%	-1,42%	-1,42%	-1,42%	-1,42%	-1,42%	-1,42%	-1,42%	-1,42%
2097	-1,50%	-1,50%	-1,50%	-1,50%	-1,50%	-1,50%	-1,50%	-1,50%	-1,50%	-1,50%	-1,50%	-1,50%	-1,50%	-1,50%	-1,50%	-1,50%	-1,50%	-1,50%	-1,50%	-1,50%	-1,50%
2098	-1,59%	-1,59%	-1,59%	-1,59%	-1,59%	-1,59%	-1,59%	-1,59%	-1,59%	-1,59%	-1,59%	-1,59%	-1,59%	-1,59%	-1,59%	-1,59%	-1,59%	-1,59%	-1,59%	-1,59%	-1,59%
2099	-1,68%	-1,68%	-1,68%	-1,68%	-1,68%	-1,68%	-1,68%	-1,68%	-1,68%	-1,68%	-1,68%	-1,68%	-1,68%	-1,68%	-1,68%	-1,68%	-1,68%	-1,68%	-1,68%	-1,68%	-1,68%
2100	-1,78%	-1,78%	-1,78%	-1,78%	-1,78%	-1,78%	-1,78%	-1,78%	-1,78%	-1,78%	-1,78%	-1,78%	-1,78%	-1,78%	-1,78%	-1,78%	-1,78%	-1,78%	-1,78%	-1,78%	-1,78%

Table B.17: Annual RPK growth from 2009 to 2100 for Iteration 4 - SSP2.

year	EUEU	EUAS	EUME	EUAF	EULA	EUNA	ASAS	ASME	ASAF	ASLA	ASNA	MEME	MEAF	MELA	MENA	AFAF	AFLA	AFNA	LALA	LANA	NANA
2009	1,60%	1,50%	11,30%	2,20%	3,10%	0,40%	9,20%	12,90%	-5,00%	17,90%	3,70%	6,40%	15,30%	8,70%	16,40%	5,20%	17,90%	14,20%	10,80%	5,30%	0,50%
2010	1,60%	1,50%	11,30%	2,20%	3,10%	0,40%	9,20%	12,90%	-5,00%	17,90%	3,70%	6,40%	15,30%	8,70%	16,40%	5,20%	17,90%	14,20%	10,80%	5,30%	0,50%
2011	1,60%	1,50%	11,30%	2,20%	3,10%	0,40%	9,20%	12,90%	-5,00%	17,90%	3,70%	6,40%	15,30%	8,70%	16,40%	5,20%	17,90%	14,20%	10,80%	5,30%	0,50%
2012	1,60%	1,50%	11,30%	2,20%	3,10%	0,40%	9,20%	12,90%	-5,00%	17,90%	3,70%	6,40%	15,30%	8,70%	16,40%	5,20%	17,90%	14,20%	10,80%	5,30%	0,50%
2013	1,60%	1,50%	11,30%	2,20%	3,10%	0,40%	9,20%	12,90%	-5,00%	17,90%	3,70%	6,40%	15,30%	8,70%	16,40%	5,20%	17,90%	14,20%	10,80%	5,30%	0,50%
2014	7,64%	3,94%	13,31%	2,29%	3,68%	6,80%	7,88%	9,50%	6,50%	6,50%	8,56%	11,86%	8,58%	6,50%	20,67%	2,23%	5,50%	5,50%	7,55%	7,56%	5,71%
2015	9,22%	2,48%	7,36%	-0,32%	5,78%	9,25%	11,58%	14,66%	6,00%	6,00%	8,62%	15,42%	4,41%	6,00%	10,86%	4,99%	5,30%	5,30%	6,14%	1,31%	5,47%
2016	7,20%	5,15%	7,93%	7,13%	5,49%	6,82%	9,50%	10,07%	5,50%	5,50%	5,83%	5,47%	5,72%	5,50%	1,09%	2,93%	5,20%	5,20%	4,99%	5,21%	4,77%
2017	7,09%	10,74%	10,06%	8,04%	5,59%	7,61%	8,78%	4,60%	5,00%	5,00%	4,00%	3,74%	4,91%	5,00%	-4,81%	2,25%	5,00%	5,00%	7,76%	5,97%	6,09%
2018	3,26%	3,57%	6,03%	5,63%	4,49%	4,09%	3,78%	-1,30%	4,80%	4,80%	-0,32%	1,28%	0,90%	4,80%	-0,26%	4,89%	4,80%	4,80%	3,11%	-1,40%	4,35%
2019	0,87%	0,76%	0,29%	0,47%	-0,61%	0,94%	0,65%	0,01%	4,50%	4,50%	-0,82%	1,62%	0,71%	4,50%	-0,84%	1,54%	4,50%	4,50%	0,06%	0,44%	0,70%
2020	-65,03%	-78,58%	-68,63%	-71,95%	-73,99%	-77,00%	-71,28%	-71,09%	-54,70%	-54,70%	-80,55%	-66,35%	-74,72%	-54,70%	-71,41%	-69,85%	-54,70%	-54,70%	-64,88%	-72,65%	-59,22%
2021	10,44%	-21,83%	-0,34%	26,59%	33,75%	6,51%	-27,57%	-31,61%	1,72%	1,72%	-36,04%	25,82%	47,11%	1,72%	83,35%	38,09%	1,64%	1,64%	43,14%	74,95%	78,03%
2022	120,64%	131,12%	146,20%	117,30%	145,72%	226,99%	216,53%	190,28%	1,72%	1,72%	159,41%	86,13%	119,45%	1,72%	110,79%	88,83%	1,64%	1,64%	120,05%	70,85%	24,42%
2023	109,32%	122,88%	132,60%	106,55%	132,00%	205,01%	201,10%	177,10%	1,95%	1,95%	153,86%	78,61%	108,93%	1,95%	100,27%	81,77%	1,88%	1,88%	108,91%	64,73%	22,48%
2024	97,99%	114,64%	119,00%	95,79%	118,28%	183,02%	185,68%	163,92%	2,18%	2,18%	148,31%	71,09%	98,41%	2,18%	89,75%	74,70%	2,11%	2,11%	97,77%	58,60%	20,54%
2025	86,67%	106,40%	105,40%	85,04%	104,55%	161,04%	170,25%	150,74%	2,40%	2,40%	142,76%	63,57%	87,89%	2,40%	79,24%	67,63%	2,35%	2,35%	86,63%	52,48%	18,61%
2026	75,34%	98,16%	91,80%	74,28%	90,83%	139,05%	154,83%	137,56%	2,63%	2,63%	137,21%	56,05%	77,36%	2,63%	68,72%	60,56%	2,58%	2,58%	75,49%	46,36%	16,67%
2027	64,02%	89,92%	78,20%	63,53%	77,10%	117,07%	139,40%	124,38%	2,86%	2,86%	131,66%	48,53%	66,84%	2,86%	58,21%	53,50%	2,82%	2,82%	64,35%	40,24%	14,73%
2028	52,69%	81,68%	64,61%	52,77%	63,38%	95,08%	123,98%	111,20%	3,09%	3,09%	126,11%	41,01%	56,32%	3,09%	47,69%	46,43%	3,06%	3,06%	53,21%	34,12%	12,80%
2029	41,36%	73,44%	51,01%	42,02%	49,66%	73,10%	108,55%	98,02%	3,32%	3,32%	120,56%	33,49%	45,80%	3,32%	37,17%	39,36%	3,29%	3,29%	42,07%	28,00%	10,86%
2030	30,04%	65,20%	37,41%	31,26%	35,93%	51,11%	93,12%	84,84%	3,54%	3,54%	115,01%	25,97%	35,27%	3,54%	26,66%	32,29%	3,53%	3,53%	30,93%	21,87%	8,92%
2031	18,71%	56,96%	23,81%	20,51%	22,21%	29,13%	77,70%	71,65%	3,77%	3,77%	109,46%	18,45%	24,75%	3,77%	16,14%	25,23%	3,76%	3,76%	19,79%	15,75%	6,98%
2032	7,39%	48,72%	10,21%	9,75%	8,48%	7,14%	62,27%	58,47%	4,00%	4,00%	103,91%	10,93%	14,23%	4,00%	5,62%	18,16%	4,00%	4,00%	8,65%	9,63%	5,05%
2033	7,01%	44,19%	9,55%	9,16%	8,06%	6,75%	56,52%	53,11%	4,08%	4,08%	94,00%	10,23%	13,42%	4,08%	5,37%	16,96%	4,08%	4,08%	8,26%	9,14%	4,83%
2034	6,64%	39,65%	8,89%	8,57%	7,63%	6,37%	50,76%	47,75%	4,17%	4,16%	84,09%	9,54%	12,62%	4,16%	5,11%	15,76%	4,16%	4,16%	7,87%	8,64%	4,61%
2035	6,26%	35,12%	8,23%	7,98%	7,20%	5,98%	45,01%	42,39%	4,25%	4,24%	74,17%	8,85%	11,81%	4,24%	4,85%	14,56%	4,24%	4,24%	7,48%	8,14%	4,39%
2036	5,88%	30,58%	7,58%	7,39%	6,77%	5,59%	39,26%	37,02%	4,34%	4,32%	64,26%	8,16%	11,01%	4,32%	4,59%	13,36%	4,32%	4,32%	7,08%	7,65%	4,17%
2037	5,51%	26,05%	6,92%	6,80%	6,34%	5,21%	33,50%	31,66%	4,42%	4,40%	54,35%	7,47%	10,21%	4,40%	4,34%	12,16%	4,40%	4,40%	6,69%	7,15%	3,95%
2038	5,13%	21,52%	6,26%	6,21%	5,91%	4,82%	27,75%	26,30%	4,51%	4,48%	44,44%	6,77%	9,40%	4,48%	4,08%	10,96%	4,48%	4,48%	6,30%	6,66%	3,73%
2039	4,75%	16,98%	5,60%	5,62%	5,49%	4,43%	21,99%	20,93%	4,59%	4,56%	34,53%	6,08%	8,60%	4,56%	3,82%	9,76%	4,56%	4,56%	5,91%	6,16%	3,51%
2040	4,38%	12,45%	4,94%	5,03%	5,06%	4,05%	16,24%	15,57%	4,68%	4,64%	24,62%	5,39%	7,79%	4,64%	3,56%	8,55%	4,64%	4,64%	5,52%	5,66%	3,29%
2041	4,00%	7,91%	4,28%	4,44%	4,63%	3,66%	10,48%	10,21%	4,76%	4,72%	14,71%	4,70%	6,99%	4,72%	3,31%	7,35%	4,72%	4,72%	5,12%	5,17%	3,07%
2042	3,62%	3,38%	3,63%	3,85%	4,20%	3,27%	4,73%	4,85%	4,85%	4,80%	4,80%	4,01%	6,19%	4,80%	3,05%	6,15%	4,80%	4,80%	4,73%	4,67%	2,85%
2043	2,59%	2,59%	2,59%	2,59%	2,59%	2,59%	2,59%	2,59%	2,59%	2,59%	2,59%	2,59%	2,59%	2,59%	2,59%	2,59%	2,59%	2,59%	2,59%	2,59%	2,59%
2044	2,55%	2,55%	2,55%	2,55%	2,55%	2,55%	2,55%	2,55%	2,55%	2,55%	2,55%	2,55%	2,55%	2,55%	2,55%	2,55%	2,55%	2,55%	2,55%	2,55%	2,55%
2045	2,50%	2,50%	2,50%	2,50%	2,50%	2,50%	2,50%	2,50%	2,50%	2,50%	2,50%	2,50%	2,50%	2,50%	2,50%	2,50%	2,50%	2,50%	2,50%	2,50%	2,50%
2046	2,45%	2,45%	2,45%	2,45%	2,45%	2,45%	2,45%	2,45%	2,45%	2,45%	2,45%	2,45%	2,45%	2,45%	2,45%	2,45%	2,45%	2,45%	2,45%	2,45%	2,45%
2047	2,41%	2,41%	2,41%	2,41%	2,41%	2,41%	2,41%	2,41%	2,41%	2,41%	2,41%	2,41%	2,41%	2,41%	2,41%	2,41%	2,41%	2,41%	2,41%	2,41%	2,41%
2048	2,36%	2,36%	2,36%	2,36%	2,36%	2,36%	2,36%	2,36%	2,36%	2,36%	2,36%	2,36%	2,36%	2,36%	2,36%	2,36%	2,36%	2,36%	2,36%	2,36%	2,36%
2049	2,32%	2,32%	2,32%	2,32%	2,32%	2,32%	2,32%	2,32%	2,32%	2,32%	2,32%	2,32%	2,32%	2,32%	2,32%	2,32%	2,32%	2,32%	2,32%	2,32%	2,32%
2050	2,27%	2,27%	2,27%	2,27%	2,27%	2,27%	2,27%	2,27%	2,27%	2,27%	2,27%	2,27%	2,27%	2,27%	2,27%	2,27%	2,27%	2,27%	2,27%	2,27%	2,27%
2051	2,23%	2,23%	2,23%	2,23%	2,23%	2,23%	2,23%	2,23%	2,23%	2,23%	2,23%	2,23%	2,23%	2,23%	2,23%	2,23%	2,23%	2,23%	2,23%	2,23%	2,23%
2052	2,18%	2,18%	2,18%	2,18%	2,18%	2,18%	2,18%	2,18%	2,18%	2,18%	2,18%	2,18%	2,18%	2,18%	2,18%	2,18%	2,18%	2,18%	2,18%	2,18%	2,18%
2053	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%
2054	2,09%	2,09%	2,09%	2,09%	2,09%	2,09%	2,09%	2,09%	2,09%	2,09%	2,09%	2,09%	2,09%	2,09%	2,09%	2,09%	2,09%	2,09%	2,09%	2,09%	2,09%
2055	2,05%	2,05%	2,05%	2,05%	2,05%	2,05%	2,05%	2,05%	2,05%	2,05%	2,05%	2,05%	2,05%	2,05%	2,05%	2,05%	2,05%	2,05%	2,05%	2,05%	2,05%

Table B.18: Annual RPK growth from 2009 to 2100 for Iteration 4 - SSP2. (cont.)

year	EUEU	EUAS	EUME	EUAF	EULA	EUNA	ASAS	ASME	ASAF	ASLA	ASNA	MEME	MEAF	MELA	MENA	AFAF	AFLA	AFNA	LALA	LANA	NANA
2056	2,01%	2,01%	2,01%	2,01%	2,01%	2,01%	2,01%	2,01%	2,01%	2,01%	2,01%	2,01%	2,01%	2,01%	2,01%	2,01%	2,01%	2,01%	2,01%	2,01%	2,01%
2057	1,97%	1,97%	1,97%	1,97%	1,97%	1,97%	1,97%	1,97%	1,97%	1,97%	1,97%	1,97%	1,97%	1,97%	1,97%	1,97%	1,97%	1,97%	1,97%	1,97%	1,97%
2058	1,92%	1,92%	1,92%	1,92%	1,92%	1,92%	1,92%	1,92%	1,92%	1,92%	1,92%	1,92%	1,92%	1,92%	1,92%	1,92%	1,92%	1,92%	1,92%	1,92%	1,92%
2059	1,88%	1,88%	1,88%	1,88%	1,88%	1,88%	1,88%	1,88%	1,88%	1,88%	1,88%	1,88%	1,88%	1,88%	1,88%	1,88%	1,88%	1,88%	1,88%	1,88%	1,88%
2060	1,84%	1,84%	1,84%	1,84%	1,84%	1,84%	1,84%	1,84%	1,84%	1,84%	1,84%	1,84%	1,84%	1,84%	1,84%	1,84%	1,84%	1,84%	1,84%	1,84%	1,84%
2061	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%	1,80%
2062	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%
2063	1,72%	1,72%	1,72%	1,72%	1,72%	1,72%	1,72%	1,72%	1,72%	1,72%	1,72%	1,72%	1,72%	1,72%	1,72%	1,72%	1,72%	1,72%	1,72%	1,72%	1,72%
2064	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%
2065	1,64%	1,64%	1,64%	1,64%	1,64%	1,64%	1,64%	1,64%	1,64%	1,64%	1,64%	1,64%	1,64%	1,64%	1,64%	1,64%	1,64%	1,64%	1,64%	1,64%	1,64%
2066	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%
2067	1,57%	1,57%	1,57%	1,57%	1,57%	1,57%	1,57%	1,57%	1,57%	1,57%	1,57%	1,57%	1,57%	1,57%	1,57%	1,57%	1,57%	1,57%	1,57%	1,57%	1,57%
2068	1,53%	1,53%	1,53%	1,53%	1,53%	1,53%	1,53%	1,53%	1,53%	1,53%	1,53%	1,53%	1,53%	1,53%	1,53%	1,53%	1,53%	1,53%	1,53%	1,53%	1,53%
2069	1,49%	1,49%	1,49%	1,49%	1,49%	1,49%	1,49%	1,49%	1,49%	1,49%	1,49%	1,49%	1,49%	1,49%	1,49%	1,49%	1,49%	1,49%	1,49%	1,49%	1,49%
2070	1,45%	1,45%	1,45%	1,45%	1,45%	1,45%	1,45%	1,45%	1,45%	1,45%	1,45%	1,45%	1,45%	1,45%	1,45%	1,45%	1,45%	1,45%	1,45%	1,45%	1,45%
2071	1,42%	1,42%	1,42%	1,42%	1,42%	1,42%	1,42%	1,42%	1,42%	1,42%	1,42%	1,42%	1,42%	1,42%	1,42%	1,42%	1,42%	1,42%	1,42%	1,42%	1,42%
2072	1,38%	1,38%	1,38%	1,38%	1,38%	1,38%	1,38%	1,38%	1,38%	1,38%	1,38%	1,38%	1,38%	1,38%	1,38%	1,38%	1,38%	1,38%	1,38%	1,38%	1,38%
2073	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%	1,34%
2074	1,31%	1,31%	1,31%	1,31%	1,31%	1,31%	1,31%	1,31%	1,31%	1,31%	1,31%	1,31%	1,31%	1,31%	1,31%	1,31%	1,31%	1,31%	1,31%	1,31%	1,31%
2075	1,27%	1,27%	1,27%	1,27%	1,27%	1,27%	1,27%	1,27%	1,27%	1,27%	1,27%	1,27%	1,27%	1,27%	1,27%	1,27%	1,27%	1,27%	1,27%	1,27%	1,27%
2076	1,24%	1,24%	1,24%	1,24%	1,24%	1,24%	1,24%	1,24%	1,24%	1,24%	1,24%	1,24%	1,24%	1,24%	1,24%	1,24%	1,24%	1,24%	1,24%	1,24%	1,24%
2077	1,20%	1,20%	1,20%	1,20%	1,20%	1,20%	1,20%	1,20%	1,20%	1,20%	1,20%	1,20%	1,20%	1,20%	1,20%	1,20%	1,20%	1,20%	1,20%	1,20%	1,20%
2078	1,17%	1,17%	1,17%	1,17%	1,17%	1,17%	1,17%	1,17%	1,17%	1,17%	1,17%	1,17%	1,17%	1,17%	1,17%	1,17%	1,17%	1,17%	1,17%	1,17%	1,17%
2079	1,13%	1,13%	1,13%	1,13%	1,13%	1,13%	1,13%	1,13%	1,13%	1,13%	1,13%	1,13%	1,13%	1,13%	1,13%	1,13%	1,13%	1,13%	1,13%	1,13%	1,13%
2080	1,10%	1,10%	1,10%	1,10%	1,10%	1,10%	1,10%	1,10%	1,10%	1,10%	1,10%	1,10%	1,10%	1,10%	1,10%	1,10%	1,10%	1,10%	1,10%	1,10%	1,10%
2081	1,06%	1,06%	1,06%	1,06%	1,06%	1,06%	1,06%	1,06%	1,06%	1,06%	1,06%	1,06%	1,06%	1,06%	1,06%	1,06%	1,06%	1,06%	1,06%	1,06%	1,06%
2082	1,03%	1,03%	1,03%	1,03%	1,03%	1,03%	1,03%	1,03%	1,03%	1,03%	1,03%	1,03%	1,03%	1,03%	1,03%	1,03%	1,03%	1,03%	1,03%	1,03%	1,03%
2083	0,99%	0,99%	0,99%	0,99%	0,99%	0,99%	0,99%	0,99%	0,99%	0,99%	0,99%	0,99%	0,99%	0,99%	0,99%	0,99%	0,99%	0,99%	0,99%	0,99%	0,99%
2084	0,96%	0,96%	0,96%	0,96%	0,96%	0,96%	0,96%	0,96%	0,96%	0,96%	0,96%	0,96%	0,96%	0,96%	0,96%	0,96%	0,96%	0,96%	0,96%	0,96%	0,96%
2085	0,92%	0,92%	0,92%	0,92%	0,92%	0,92%	0,92%	0,92%	0,92%	0,92%	0,92%	0,92%	0,92%	0,92%	0,92%	0,92%	0,92%	0,92%	0,92%	0,92%	0,92%
2086	0,89%	0,89%	0,89%	0,89%	0,89%	0,89%	0,89%	0,89%	0,89%	0,89%	0,89%	0,89%	0,89%	0,89%	0,89%	0,89%	0,89%	0,89%	0,89%	0,89%	0,89%
2087	0,85%	0,85%	0,85%	0,85%	0,85%	0,85%	0,85%	0,85%	0,85%	0,85%	0,85%	0,85%	0,85%	0,85%	0,85%	0,85%	0,85%	0,85%	0,85%	0,85%	0,85%
2088	0,82%	0,82%	0,82%	0,82%	0,82%	0,82%	0,82%	0,82%	0,82%	0,82%	0,82%	0,82%	0,82%	0,82%	0,82%	0,82%	0,82%	0,82%	0,82%	0,82%	0,82%
2089	0,78%	0,78%	0,78%	0,78%	0,78%	0,78%	0,78%	0,78%	0,78%	0,78%	0,78%	0,78%	0,78%	0,78%	0,78%	0,78%	0,78%	0,78%	0,78%	0,78%	0,78%
2090	0,75%	0,75%	0,75%	0,75%	0,75%	0,75%	0,75%	0,75%	0,75%	0,75%	0,75%	0,75%	0,75%	0,75%	0,75%	0,75%	0,75%	0,75%	0,75%	0,75%	0,75%
2091	0,71%	0,71%	0,71%	0,71%	0,71%	0,71%	0,71%	0,71%	0,71%	0,71%	0,71%	0,71%	0,71%	0,71%	0,71%	0,71%	0,71%	0,71%	0,71%	0,71%	0,71%
2092	0,68%	0,68%	0,68%	0,68%	0,68%	0,68%	0,68%	0,68%	0,68%	0,68%	0,68%	0,68%	0,68%	0,68%	0,68%	0,68%	0,68%	0,68%	0,68%	0,68%	0,68%
2093	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%	0,64%
2094	0,61%	0,61%	0,61%	0,61%	0,61%	0,61%	0,61%	0,61%	0,61%	0,61%	0,61%	0,61%	0,61%	0,61%	0,61%	0,61%	0,61%	0,61%	0,61%	0,61%	0,61%
2095	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%	0,57%
2096	0,54%	0,54%	0,54%	0,54%	0,54%	0,54%	0,54%	0,54%	0,54%	0,54%	0,54%	0,54%	0,54%	0,54%	0,54%	0,54%	0,54%	0,54%	0,54%	0,54%	0,54%
2097	0,50%	0,50%	0,50%	0,50%	0,50%	0,50%	0,50%	0,50%	0,50%	0,50%	0,50%	0,50%	0,50%	0,50%	0,50%	0,50%	0,50%	0,50%	0,50%	0,50%	0,50%
2098	0,47%	0,47%	0,47%	0,47%	0,47%	0,47%	0,47%	0,47%	0,47%	0,47%	0,47%	0,47%	0,47%	0,47%	0,47%	0,47%	0,47%	0,47%	0,47%	0,47%	0,47%
2099	0,43%	0,43%	0,43%	0,43%	0,43%	0,43%	0,43%	0,43%	0,43%	0,43%	0,43%	0,43%	0,43%	0,43%	0,43%	0,43%	0,43%	0,43%	0,43%	0,43%	0,43%
2100	0,39%	0,39%	0,39%	0,39%	0,39%	0,39%	0,39%	0,39%	0,39%	0,39%	0,39%	0,39%	0,39%	0,39%	0,39%	0,39%	0,39%	0,39%	0,39%	0,39%	0,39%

Table B.19: Annual RPK growth from 2009 to 2100 for Iteration 4 - SSP5.

year	EUEU	EUAS	EUME	EUAF	EULA	EUNA	ASAS	ASME	ASAF	ASLA	ASNA	MEME	MEAF	MELA	MENA	AFAF	AFLA	AFNA	LALA	LANA	NANA
2009	1,60%	1,50%	11,30%	2,20%	3,10%	0,40%	9,20%	12,90%	-5,00%	17,90%	3,70%	6,40%	15,30%	8,70%	16,40%	5,20%	17,90%	14,20%	10,80%	5,30%	0,50%
2010	1,60%	1,50%	11,30%	2,20%	3,10%	0,40%	9,20%	12,90%	-5,00%	17,90%	3,70%	6,40%	15,30%	8,70%	16,40%	5,20%	17,90%	14,20%	10,80%	5,30%	0,50%
2011	1,60%	1,50%	11,30%	2,20%	3,10%	0,40%	9,20%	12,90%	-5,00%	17,90%	3,70%	6,40%	15,30%	8,70%	16,40%	5,20%	17,90%	14,20%	10,80%	5,30%	0,50%
2012	1,60%	1,50%	11,30%	2,20%	3,10%	0,40%	9,20%	12,90%	-5,00%	17,90%	3,70%	6,40%	15,30%	8,70%	16,40%	5,20%	17,90%	14,20%	10,80%	5,30%	0,50%
2013	1,60%	1,50%	11,30%	2,20%	3,10%	0,40%	9,20%	12,90%	-5,00%	17,90%	3,70%	6,40%	15,30%	8,70%	16,40%	5,20%	17,90%	14,20%	10,80%	5,30%	0,50%
2014	7,64%	3,94%	13,31%	2,29%	3,68%	6,80%	7,88%	9,50%	6,50%	6,50%	8,56%	11,86%	8,58%	6,50%	20,67%	2,23%	5,50%	5,50%	7,55%	7,56%	5,71%
2015	9,22%	2,48%	7,36%	-0,32%	5,78%	9,25%	11,58%	14,66%	6,00%	6,00%	8,62%	15,42%	4,41%	6,00%	10,86%	4,99%	5,30%	5,30%	6,14%	1,31%	5,47%
2016	7,20%	5,15%	7,93%	7,13%	5,49%	6,82%	9,50%	10,07%	5,50%	5,50%	5,83%	5,47%	5,72%	5,50%	1,09%	2,93%	5,20%	5,20%	4,99%	5,21%	4,77%
2017	7,09%	10,74%	10,06%	8,04%	5,59%	7,61%	8,78%	4,60%	5,00%	5,00%	4,00%	3,74%	4,91%	5,00%	-4,81%	2,25%	5,00%	5,00%	7,76%	5,97%	6,09%
2018	3,26%	3,57%	6,03%	5,63%	4,49%	4,09%	3,78%	-1,30%	4,80%	4,80%	-0,32%	1,28%	0,90%	4,80%	-0,26%	4,89%	4,80%	4,80%	3,11%	-1,40%	4,35%
2019	0,87%	0,76%	0,29%	0,47%	-0,61%	0,94%	0,65%	0,01%	4,50%	4,50%	-0,82%	1,62%	0,71%	4,50%	-0,84%	1,54%	4,50%	4,50%	0,06%	0,44%	0,70%
2020	-65,03%	-78,58%	-68,63%	-71,95%	-73,99%	-77,00%	-71,28%	-71,09%	-54,70%	-54,70%	-80,55%	-66,35%	-74,72%	-54,70%	-71,41%	-69,85%	-54,70%	-54,70%	-64,88%	-72,65%	-59,22%
2021	10,44%	-21,83%	-0,34%	26,59%	33,75%	6,51%	-27,57%	-31,61%	1,72%	1,72%	-36,04%	25,82%	47,11%	1,72%	83,35%	38,09%	1,64%	1,64%	43,14%	74,95%	78,03%
2022	120,64%	131,12%	146,20%	117,30%	145,72%	226,99%	216,53%	190,28%	1,72%	1,72%	159,41%	86,13%	119,45%	1,72%	110,79%	88,83%	1,64%	1,64%	120,05%	70,85%	24,42%
2023	109,32%	122,88%	132,60%	106,55%	132,00%	205,01%	201,10%	177,10%	1,95%	1,95%	153,86%	78,61%	108,93%	1,95%	100,27%	81,77%	1,88%	1,88%	108,91%	64,73%	22,48%
2024	97,99%	114,64%	119,00%	95,79%	118,28%	183,02%	185,68%	163,92%	2,18%	2,18%	148,31%	71,09%	98,41%	2,18%	89,75%	74,70%	2,11%	2,11%	97,77%	58,60%	20,54%
2025	86,67%	106,40%	105,40%	85,04%	104,55%	161,04%	170,25%	150,74%	2,40%	2,40%	142,76%	63,57%	87,89%	2,40%	79,24%	67,63%	2,35%	2,35%	86,63%	52,48%	18,61%
2026	75,34%	98,16%	91,80%	74,28%	90,83%	139,05%	154,83%	137,56%	2,63%	2,63%	137,21%	56,05%	77,36%	2,63%	68,72%	60,56%	2,58%	2,58%	75,49%	46,36%	16,67%
2027	64,02%	89,92%	78,20%	63,53%	77,10%	117,07%	139,40%	124,38%	2,86%	2,86%	131,66%	48,53%	66,84%	2,86%	58,21%	53,50%	2,82%	2,82%	64,35%	40,24%	14,73%
2028	52,69%	81,68%	64,61%	52,77%	63,38%	95,08%	123,98%	111,20%	3,09%	3,09%	126,11%	41,01%	56,32%	3,09%	47,69%	46,43%	3,06%	3,06%	53,21%	34,12%	12,80%
2029	41,36%	73,44%	51,01%	42,02%	49,66%	73,10%	108,55%	98,02%	3,32%	3,32%	120,56%	33,49%	45,80%	3,32%	37,17%	39,36%	3,29%	3,29%	42,07%	28,00%	10,86%
2030	30,04%	65,20%	37,41%	31,26%	35,93%	51,11%	93,12%	84,84%	3,54%	3,54%	115,01%	25,97%	35,27%	3,54%	26,66%	32,29%	3,53%	3,53%	30,93%	21,87%	8,92%
2031	18,71%	56,96%	23,81%	20,51%	22,21%	29,13%	77,70%	71,65%	3,77%	3,77%	109,46%	18,45%	24,75%	3,77%	16,14%	25,23%	3,76%	3,76%	19,79%	15,75%	6,98%
2032	7,39%	48,72%	10,21%	9,75%	8,48%	7,14%	62,27%	58,47%	4,00%	4,00%	103,91%	10,93%	14,23%	4,00%	5,62%	18,16%	4,00%	4,00%	8,65%	9,63%	5,05%
2033	7,01%	44,19%	9,55%	9,16%	8,06%	6,75%	56,52%	53,11%	4,08%	4,08%	94,00%	10,23%	13,42%	4,08%	5,37%	16,96%	4,08%	4,08%	8,26%	9,14%	4,83%
2034	6,64%	39,65%	8,89%	8,57%	7,63%	6,37%	50,76%	47,75%	4,17%	4,16%	84,09%	9,54%	12,62%	4,16%	5,11%	15,76%	4,16%	4,16%	7,87%	8,64%	4,61%
2035	6,26%	35,12%	8,23%	7,98%	7,20%	5,98%	45,01%	42,39%	4,25%	4,24%	74,17%	8,85%	11,81%	4,24%	4,85%	14,56%	4,24%	4,24%	7,48%	8,14%	4,39%
2036	5,88%	30,58%	7,58%	7,39%	6,77%	5,59%	39,26%	37,02%	4,34%	4,32%	64,26%	8,16%	11,01%	4,32%	4,59%	13,36%	4,32%	4,32%	7,08%	7,65%	4,17%
2037	5,51%	26,05%	6,92%	6,80%	6,34%	5,21%	33,50%	31,66%	4,42%	4,40%	54,35%	7,47%	10,21%	4,40%	4,34%	12,16%	4,40%	4,40%	6,69%	7,15%	3,95%
2038	5,13%	21,52%	6,26%	6,21%	5,91%	4,82%	27,75%	26,30%	4,51%	4,48%	44,44%	6,77%	9,40%	4,48%	4,08%	10,96%	4,48%	4,48%	6,30%	6,66%	3,73%
2039	4,75%	16,98%	5,60%	5,62%	5,49%	4,43%	21,99%	20,93%	4,59%	4,56%	34,53%	6,08%	8,60%	4,56%	3,82%	9,76%	4,56%	4,56%	5,91%	6,16%	3,51%
2040	4,38%	12,45%	4,94%	5,03%	5,06%	4,05%	16,24%	15,57%	4,68%	4,64%	24,62%	5,39%	7,79%	4,64%	3,56%	8,55%	4,64%	4,64%	5,52%	5,66%	3,29%
2041	4,00%	7,91%	4,28%	4,44%	4,63%	3,66%	10,48%	10,21%	4,76%	4,72%	14,71%	4,70%	6,99%	4,72%	3,31%	7,35%	4,72%	4,72%	5,12%	5,17%	3,07%
2042	3,62%	3,38%	3,63%	3,85%	4,20%	3,27%	4,73%	4,85%	4,85%	4,80%	4,80%	4,01%	6,19%	4,80%	3,05%	6,15%	4,80%	4,80%	4,73%	4,67%	2,85%
2043	4,50%	4,50%	4,50%	4,50%	4,50%	4,50%	4,50%	4,50%	4,50%	4,50%	4,50%	4,50%	4,50%	4,50%	4,50%	4,50%	4,50%	4,50%	4,50%	4,50%	4,50%
2044	4,35%	4,35%	4,35%	4,35%	4,35%	4,35%	4,35%	4,35%	4,35%	4,35%	4,35%	4,35%	4,35%	4,35%	4,35%	4,35%	4,35%	4,35%	4,35%	4,35%	4,35%
2045	4,21%	4,21%	4,21%	4,21%	4,21%	4,21%	4,21%	4,21%	4,21%	4,21%	4,21%	4,21%	4,21%	4,21%	4,21%	4,21%	4,21%	4,21%	4,21%	4,21%	4,21%
2046	4,08%	4,08%	4,08%	4,08%	4,08%	4,08%	4,08%	4,08%	4,08%	4,08%	4,08%	4,08%	4,08%	4,08%	4,08%	4,08%	4,08%	4,08%	4,08%	4,08%	4,08%
2047	3,94%	3,94%	3,94%	3,94%	3,94%	3,94%	3,94%	3,94%	3,94%	3,94%	3,94%	3,94%	3,94%	3,94%	3,94%	3,94%	3,94%	3,94%	3,94%	3,94%	3,94%
2048	3,82%	3,82%	3,82%	3,82%	3,82%	3,82%	3,82%	3,82%	3,82%	3,82%	3,82%	3,82%	3,82%	3,82%	3,82%	3,82%	3,82%	3,82%	3,82%	3,82%	3,82%
2049	3,69%	3,69%	3,69%	3,69%	3,69%	3,69%	3,69%	3,69%	3,69%	3,69%	3,69%	3,69%	3,69%	3,69%	3,69%	3,69%	3,69%	3,69%	3,69%	3,69%	3,69%
2050	3,57%	3,57%	3,57%	3,57%	3,57%	3,57%	3,57%	3,57%	3,57%	3,57%	3,57%	3,57%	3,57%	3,57%	3,57%	3,57%	3,57%	3,57%	3,57%	3,57%	3,57%
2051	3,46%	3,46%	3,46%	3,46%	3,46%	3,46%	3,46%	3,46%	3,46%	3,46%	3,46%	3,46%	3,46%	3,46%	3,46%	3,46%	3,46%	3,46%	3,46%	3,46%	3,46%
2052	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%	3,35%
2053	3,24%	3,24%	3,24%	3,24%	3,24%	3,24%	3,24%	3,24%	3,24%	3,24%	3,24%	3,24%	3,24%	3,24%	3,24%	3,24%	3,24%	3,24%	3,24%	3,24%	3,24%
2054	3,13%	3,13%	3,13%	3,13%	3,13%	3,13%	3,13%	3,13%	3,13%	3,13%	3,13%	3,13%	3,13%	3,13%	3,13%	3,13%	3,13%	3,13%	3,13%	3,13%	3,13%
2055	3,03%	3,03%	3,03%	3,03%	3,03%	3,03%	3,03%	3,03%	3,03%	3,03%	3,03%	3,03%	3,03%	3,03%	3,03%	3,03%	3,03%	3,03%	3,03%	3,03%	3,03%

Table B.20: Annual RPK growth from 2009 to 2100 for Iteration 4 - SSP5. (cont.)

year	EUEU	EUAS	EUME	EUAF	EULA	EUNA	ASAS	ASME	ASAF	ASLA	ASNA	MEME	MEAF	MELA	MENA	AFAF	AFLA	AFNA	LALA	LANA	NANA
2056	2,93%	2,93%	2,93%	2,93%	2,93%	2,93%	2,93%	2,93%	2,93%	2,93%	2,93%	2,93%	2,93%	2,93%	2,93%	2,93%	2,93%	2,93%	2,93%	2,93%	2,93%
2057	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%	2,84%
2058	2,74%	2,74%	2,74%	2,74%	2,74%	2,74%	2,74%	2,74%	2,74%	2,74%	2,74%	2,74%	2,74%	2,74%	2,74%	2,74%	2,74%	2,74%	2,74%	2,74%	2,74%
2059	2,65%	2,65%	2,65%	2,65%	2,65%	2,65%	2,65%	2,65%	2,65%	2,65%	2,65%	2,65%	2,65%	2,65%	2,65%	2,65%	2,65%	2,65%	2,65%	2,65%	2,65%
2060	2,56%	2,56%	2,56%	2,56%	2,56%	2,56%	2,56%	2,56%	2,56%	2,56%	2,56%	2,56%	2,56%	2,56%	2,56%	2,56%	2,56%	2,56%	2,56%	2,56%	2,56%
2061	2,47%	2,47%	2,47%	2,47%	2,47%	2,47%	2,47%	2,47%	2,47%	2,47%	2,47%	2,47%	2,47%	2,47%	2,47%	2,47%	2,47%	2,47%	2,47%	2,47%	2,47%
2062	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%	2,39%
2063	2,30%	2,30%	2,30%	2,30%	2,30%	2,30%	2,30%	2,30%	2,30%	2,30%	2,30%	2,30%	2,30%	2,30%	2,30%	2,30%	2,30%	2,30%	2,30%	2,30%	2,30%
2064	2,22%	2,22%	2,22%	2,22%	2,22%	2,22%	2,22%	2,22%	2,22%	2,22%	2,22%	2,22%	2,22%	2,22%	2,22%	2,22%	2,22%	2,22%	2,22%	2,22%	2,22%
2065	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%	2,14%
2066	2,06%	2,06%	2,06%	2,06%	2,06%	2,06%	2,06%	2,06%	2,06%	2,06%	2,06%	2,06%	2,06%	2,06%	2,06%	2,06%	2,06%	2,06%	2,06%	2,06%	2,06%
2067	1,98%	1,98%	1,98%	1,98%	1,98%	1,98%	1,98%	1,98%	1,98%	1,98%	1,98%	1,98%	1,98%	1,98%	1,98%	1,98%	1,98%	1,98%	1,98%	1,98%	1,98%
2068	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%	1,91%
2069	1,83%	1,83%	1,83%	1,83%	1,83%	1,83%	1,83%	1,83%	1,83%	1,83%	1,83%	1,83%	1,83%	1,83%	1,83%	1,83%	1,83%	1,83%	1,83%	1,83%	1,83%
2070	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%	1,76%
2071	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%	1,68%
2072	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%	1,61%
2073	1,54%	1,54%	1,54%	1,54%	1,54%	1,54%	1,54%	1,54%	1,54%	1,54%	1,54%	1,54%	1,54%	1,54%	1,54%	1,54%	1,54%	1,54%	1,54%	1,54%	1,54%
2074	1,47%	1,47%	1,47%	1,47%	1,47%	1,47%	1,47%	1,47%	1,47%	1,47%	1,47%	1,47%	1,47%	1,47%	1,47%	1,47%	1,47%	1,47%	1,47%	1,47%	1,47%
2075	1,40%	1,40%	1,40%	1,40%	1,40%	1,40%	1,40%	1,40%	1,40%	1,40%	1,40%	1,40%	1,40%	1,40%	1,40%	1,40%	1,40%	1,40%	1,40%	1,40%	1,40%
2076	1,33%	1,33%	1,33%	1,33%	1,33%	1,33%	1,33%	1,33%	1,33%	1,33%	1,33%	1,33%	1,33%	1,33%	1,33%	1,33%	1,33%	1,33%	1,33%	1,33%	1,33%
2077	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%	1,26%
2078	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%	1,19%
2079	1,12%	1,12%	1,12%	1,12%	1,12%	1,12%	1,12%	1,12%	1,12%	1,12%	1,12%	1,12%	1,12%	1,12%	1,12%	1,12%	1,12%	1,12%	1,12%	1,12%	1,12%
2080	1,05%	1,05%	1,05%	1,05%	1,05%	1,05%	1,05%	1,05%	1,05%	1,05%	1,05%	1,05%	1,05%	1,05%	1,05%	1,05%	1,05%	1,05%	1,05%	1,05%	1,05%
2081	0,98%	0,98%	0,98%	0,98%	0,98%	0,98%	0,98%	0,98%	0,98%	0,98%	0,98%	0,98%	0,98%	0,98%	0,98%	0,98%	0,98%	0,98%	0,98%	0,98%	0,98%
2082	0,91%	0,91%	0,91%	0,91%	0,91%	0,91%	0,91%	0,91%	0,91%	0,91%	0,91%	0,91%	0,91%	0,91%	0,91%	0,91%	0,91%	0,91%	0,91%	0,91%	0,91%
2083	0,84%	0,84%	0,84%	0,84%	0,84%	0,84%	0,84%	0,84%	0,84%	0,84%	0,84%	0,84%	0,84%	0,84%	0,84%	0,84%	0,84%	0,84%	0,84%	0,84%	0,84%
2084	0,77%	0,77%	0,77%	0,77%	0,77%	0,77%	0,77%	0,77%	0,77%	0,77%	0,77%	0,77%	0,77%	0,77%	0,77%	0,77%	0,77%	0,77%	0,77%	0,77%	0,77%
2085	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%	0,70%
2086	0,63%	0,63%	0,63%	0,63%	0,63%	0,63%	0,63%	0,63%	0,63%	0,63%	0,63%	0,63%	0,63%	0,63%	0,63%	0,63%	0,63%	0,63%	0,63%	0,63%	0,63%
2087	0,56%	0,56%	0,56%	0,56%	0,56%	0,56%	0,56%	0,56%	0,56%	0,56%	0,56%	0,56%	0,56%	0,56%	0,56%	0,56%	0,56%	0,56%	0,56%	0,56%	0,56%
2088	0,48%	0,48%	0,48%	0,48%	0,48%	0,48%	0,48%	0,48%	0,48%	0,48%	0,48%	0,48%	0,48%	0,48%	0,48%	0,48%	0,48%	0,48%	0,48%	0,48%	0,48%
2089	0,41%	0,41%	0,41%	0,41%	0,41%	0,41%	0,41%	0,41%	0,41%	0,41%	0,41%	0,41%	0,41%	0,41%	0,41%	0,41%	0,41%	0,41%	0,41%	0,41%	0,41%
2090	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%	0,34%
2091	0,26%	0,26%	0,26%	0,26%	0,26%	0,26%	0,26%	0,26%	0,26%	0,26%	0,26%	0,26%	0,26%	0,26%	0,26%	0,26%	0,26%	0,26%	0,26%	0,26%	0,26%
2092	0,18%	0,18%	0,18%	0,18%	0,18%	0,18%	0,18%	0,18%	0,18%	0,18%	0,18%	0,18%	0,18%	0,18%	0,18%	0,18%	0,18%	0,18%	0,18%	0,18%	0,18%
2093	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%	0,11%
2094	0,03%	0,03%	0,03%	0,03%	0,03%	0,03%	0,03%	0,03%	0,03%	0,03%	0,03%	0,03%	0,03%	0,03%	0,03%	0,03%	0,03%	0,03%	0,03%	0,03%	0,03%
2095	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%	-0,06%
2096	-0,14%	-0,14%	-0,14%	-0,14%	-0,14%	-0,14%	-0,14%	-0,14%	-0,14%	-0,14%	-0,14%	-0,14%	-0,14%	-0,14%	-0,14%	-0,14%	-0,14%	-0,14%	-0,14%	-0,14%	-0,14%
2097	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%	-0,23%
2098	-0,32%	-0,32%	-0,32%	-0,32%	-0,32%	-0,32%	-0,32%	-0,32%	-0,32%	-0,32%	-0,32%	-0,32%	-0,32%	-0,32%	-0,32%	-0,32%	-0,32%	-0,32%	-0,32%	-0,32%	-0,32%
2099	-0,41%	-0,41%	-0,41%	-0,41%	-0,41%	-0,41%	-0,41%	-0,41%	-0,41%	-0,41%	-0,41%	-0,41%	-0,41%	-0,41%	-0,41%	-0,41%	-0,41%	-0,41%	-0,41%	-0,41%	-0,41%
2100	-0,50%	-0,50%	-0,50%	-0,50%	-0,50%	-0,50%	-0,50%	-0,50%	-0,50%	-0,50%	-0,50%	-0,50%	-0,50%	-0,50%	-0,50%	-0,50%	-0,50%	-0,50%	-0,50%	-0,50%	-0,50%

Table B.21: Seat load factor for the 9 clusters.

Cluster	EUEU	EUAS	EUME	EUAF	EULA	EUNA	ASAS	ASME	ASAF	ASLA	ASNA	MEME	MEAF	MELA	MENA	AFAF	AFLA	AFNA	LALA	LANA	NANA
1	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%
2	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%
3	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%
4	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%
5	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%
6	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%
7	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%
8	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%
9	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%	86,0%

Table B.22: Freight load factor for the 9 clusters.

Cluster	EUEU	EUAS	EUME	EUAF	EULA	EUNA	ASAS	ASME	ASAF	ASLA	ASNA	MEME	MEAF	MELA	MENA	AFAF	AFLA	AFNA	LALA	LANA	NANA
1	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%
2	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%
3	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%
4	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%
5	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%
6	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%
7	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%
8	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%
9	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%	53,0%

Table B.23: Characteristic stage length. [35]

Cluster	EUEU	EUAS	EUME	EUAF	EULA	EUNA	ASAS	ASME	ASAF	ASLA	ASNA	MEME	MEAF	MELA	MENA	AFAF	AFLA	AFNA	LALA	LANA	NANA
1	253	7976	4075	6668	8604,5	7065,5	1698	2862	0	0	8543	0	0	0	0	449	6193	0	1438	0	1090,5
2	454,5	9151	4274	7819,5	8327	7045,5	2237	4590,5	10330	12688	10194,5	980	2043,5	0	9609,5	1180	6883	5750	811,5	6171,5	4209,5
3	1681	4612	3468	3562,5	9786	4495	1483,5	2517,5	3833	0	5807,5	1271,5	2704,5	0	0	2086,5	0	0	1369,5	2863	1874
4	696,5	2041	1629	1395,5	0	4582	772	1644	0	0	4758	614	1173,5	0	0	722,5	0	0	651,5	1457,5	807
5	1419	7445,5	4601	5088,5	8874,5	6771,5	2526,5	5650,5	7517	8000	7783	868,5	2927	12000	10821	2745	5506	12181	2194	4010,5	3760
6	293,5	385	444	361,5	0	0	368,5	0	0	0	0	318,5	0	0	0	333,5	0	0	342	323	345,5
7	1757	5495	3727	4378,5	8017	6333	1601	3810,5	5576,5	4908,5	7352,5	901,5	2568,5	10573	9477	1819,5	2746,5	7310	2171,5	3231,5	2269,5
8	1562,5	8438,5	4720	6747,5	8386	6808	2394	4492	8165	9834	10186,5	893,5	3742	11980,5	10580,5	2137,5	7434	7963	1731	7103	3323,5
9	992,5	2627,5	2571,5	1936,5	5954	6675,5	1002,5	2518,5	0	0	6627	805,5	1887	6577	7734	1068	0	6024	950	2195,5	1333

Table B.24: Size and age distribution of global aircraft fleet in 2008. [35]

Age	**Number of aircraft units per aircraft cluster**								
[years]	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
0	0	0	10	191	16	33	36	128	615
1	0	1	11	170	13	15	29	123	619
2	0	6	13	237	11	6	41	94	491
3	0	5	14	285	13	8	39	81	426
4	0	17	8	266	10	7	53	83	390
5	0	15	6	264	17	15	63	103	447
6	0	20	17	264	14	14	92	103	575
7	0	13	8	200	18	13	89	110	522
8	0	47	13	164	19	24	105	125	541
9	1	55	15	135	18	19	109	95	462
10	3	36	24	76	13	20	90	95	301
11	5	23	24	38	13	11	77	58	179
12	6	19	21	32	17	26	99	30	164
13	7	27	28	37	18	27	116	24	208
14	4	47	40	56	31	27	143	20	275
15	4	52	48	49	42	25	172	5	412
16	1	49	30	42	34	27	167	1	458
17	2	52	32	22	16	14	144	1	363
18	0	40	27	25	6	6	97	0	284
19	2	12	42	11	6	0	102	0	249
20	0	9	26	32	10	0	58	0	204
21	2	21	25	20	3	0	48	0	170
22	4	10	40	26	4	0	34	0	128
23	2	5	34	58	2	0	19	0	39
24	1	6	41	59	2	0	19	0	31
25	0	0	1	0	0	0	0	0	0
26-30	32	25	131	470	34	0	3	0	148
31-35	7	6	30	206	11	0	0	0	46
>35	0	1	110	72	0	0	0	0	96
sum	83	619	869	3507	411	337	2044	1279	8843

Table B.25: Total production capacity for each aircraft class.

year	Single-aisle class	Twin-aisle class
2008	1012	337
2009	1041	342
2010	1069	347
2011	1098	352
2012	1127	357
2013	1155	363
2014	1184	368
2015	1213	373
2016	1552	378
2017	1588	383
2018	1624	388
2019	1660	393
2020	1696	498
2021	1732	504
2022	1768	511
2023	1803	517
2024	1839	523
2025	1875	530
2026	1911	536
2027	1947	542
2028	1983	549
2029	2019	555
2030	2055	561
2031	2091	568
2032	2127	574
2033	2163	581
2034	2198	587
2035	2234	593
2036	2270	600
2037	2306	606
2038	2342	612
2039	2378	619
2040	2414	625
2041	2450	632
2042	2486	638
2043	2522	644
2044	2558	651
2045	2593	657
2046	2629	663
2047	2665	670
2048	2701	676
2049	2737	683
2050	2773	689
2051	2809	695
2052	2845	702
2053	2881	708
2054	2917	714

Table B.26: Total production capacity for each aircraft class. (cont.)

year	Single-aisle class	Twin-aisle class
2055	2953	721
2056	2988	727
2057	3024	733
2058	3060	740
2059	3096	746
2060	3132	753
2061	3168	759
2062	3204	765
2063	3240	772
2064	3276	778
2065	3312	784
2066	3348	791
2067	3383	797
2068	3419	804
2069	3455	810
2070	3491	816
2071	3527	823
2072	3563	829
2073	3599	835
2074	3635	842
2075	3671	848
2076	3707	854
2077	3743	861
2078	3778	867
2079	3814	874
2080	3850	880
2081	3886	886
2082	3922	893
2083	3958	899
2084	3994	905
2085	4030	912
2086	4066	918
2087	4102	925
2088	4138	931
2089	4173	937
2090	4209	944
2091	4245	950
2092	4281	956
2093	4317	963
2094	4353	969
2095	4389	976
2096	4425	982
2097	4461	988
2098	4497	995
2099	4533	1001
2100	4569	1007

Appendix C

FSDM Results

Table C.1: Fuel burn results from FSDM.

year	Iteration 1	Iteration 2	Iteration 3			Iteration 4		
			SSP1	SSP2	SSP5	SSP1	SSP2	SSP5
2008	183,104	183,104	183,104	183,104	183,104	183,104	183,104	183,104
2009	190,369	190,369	190,369	190,369	190,369	190,369	190,369	190,369
2010	197,698	197,698	197,698	197,698	197,698	197,698	197,698	197,698
2011	205,315	205,315	205,315	205,315	205,315	205,315	205,315	205,315
2012	212,905	212,905	212,905	212,905	212,905	212,905	212,905	212,905
2013	220,490	220,490	220,490	220,490	220,490	220,490	220,490	220,490
2014	227,726	227,726	227,726	227,726	227,726	227,726	227,726	227,726
2015	235,264	235,264	235,264	235,264	235,264	235,264	235,264	235,264
2016	243,013	243,013	243,013	243,013	243,013	243,013	243,013	243,013
2017	252,416	252,416	252,416	252,416	252,416	252,416	252,416	252,416
2018	259,908	259,908	259,908	259,908	259,908	259,908	259,908	259,908
2019	261,222	261,222	261,222	261,222	261,222	261,222	261,222	261,222
2020	115,533	115,533	115,533	115,533	115,533	115,533	115,533	115,533
2021	129,469	129,469	129,469	129,469	129,469	129,469	129,469	129,469
2022	143,337	143,337	143,337	143,337	143,337	143,337	143,337	143,337
2023	160,563	160,563	160,563	160,563	160,563	160,563	160,563	160,563
2024	181,001	181,001	178,088	170,958	176,342	181,001	181,001	181,001
2025	201,710	201,710	189,867	175,928	187,145	201,710	201,710	201,710
2026	222,673	222,673	201,450	181,020	198,502	222,673	222,673	222,673
2027	243,858	243,858	212,838	186,233	210,394	243,858	243,858	243,858
2028	265,220	265,220	224,047	191,561	222,803	265,220	265,220	265,220
2029	286,704	286,704	235,360	197,004	236,124	286,704	286,704	286,704
2030	308,250	308,250	246,482	202,558	250,003	308,250	308,250	308,250
2031	329,796	329,796	257,396	208,219	264,344	329,796	329,796	329,796
2032	350,505	350,505	268,103	213,986	279,126	350,505	350,505	350,505
2033	368,247	368,247	278,603	219,856	294,327	368,247	368,247	368,247
2034	385,704	385,704	288,898	225,825	309,922	385,704	385,704	385,704
2035	402,853	402,853	298,988	231,890	325,891	402,853	402,853	402,853
2036	419,680	419,680	308,872	238,050	342,210	419,680	419,680	419,680
2037	436,176	436,176	318,552	244,300	358,859	436,176	436,176	436,176
2038	452,335	452,335	328,028	250,638	376,103	452,335	452,335	452,335
2039	468,756	468,756	337,300	257,061	393,788	468,756	468,756	468,756
2040	485,235	485,235	346,368	263,565	411,774	485,235	485,235	485,235
2041	501,263	501,263	355,233	270,148	429,564	501,263	501,263	501,263
2042	516,907	516,907	363,896	276,805	447,158	516,907	516,907	516,907
2043	531,613	531,667	372,355	283,535	464,442	528,920	529,903	531,636
2044	545,664	545,798	380,612	290,333	481,427	540,749	543,137	545,753
2045	559,002	559,260	388,667	297,197	498,131	552,246	556,479	559,165
2046	571,613	572,038	396,521	304,124	514,581	563,409	569,379	571,854
2047	583,527	584,167	404,173	311,111	530,805	574,238	581,552	583,849
2048	594,803	595,708	411,625	318,155	546,827	584,729	593,079	595,205
2049	605,514	606,747	418,877	325,253	562,657	594,884	604,035	605,998
2050	615,744	616,528	425,930	332,403	578,294	604,701	614,500	616,311
2051	625,578	624,662	432,784	339,602	593,715	614,181	624,561	626,228
2052	635,096	631,106	439,440	346,848	608,890	623,324	634,299	635,829
2053	644,367	637,472	445,899	354,137	623,779	632,130	643,796	645,184
2054	653,450	643,653	452,161	361,468	638,340	640,600	653,107	654,351

Table C.2: Fuel burn results from FSDM. (cont.)

year	Iteration 1	Iteration 2	Iteration 3			Iteration 4		
			SSP1	SSP2	SSP5	SSP1	SSP2	SSP5
2055	662,394	649,637	458,228	368,838	652,534	648,737	662,284	663,380
2056	671,238	655,416	464,100	376,243	666,329	656,539	671,367	672,309
2057	680,013	660,982	469,777	383,683	679,701	664,010	680,391	681,169
2058	688,742	666,326	475,261	391,153	692,637	671,149	689,382	689,984
2059	697,443	671,441	480,552	398,651	705,135	677,958	698,362	698,772
2060	706,132	676,844	485,651	406,176	717,202	684,438	707,350	707,549
2061	714,820	682,160	490,559	413,723	728,860	690,590	716,362	716,325
2062	723,515	687,246	495,277	421,291	740,135	696,897	725,409	725,118
2063	732,225	692,261	499,804	428,877	751,065	702,927	734,501	733,950
2064	740,956	697,186	504,143	436,479	761,691	708,668	743,645	742,808
2065	749,714	702,020	508,294	444,093	772,059	714,121	752,844	751,697
2066	758,502	706,761	512,257	451,718	782,212	719,290	762,094	760,622
2067	767,323	711,407	516,034	459,351	792,193	724,174	771,389	769,585
2068	776,179	715,957	519,625	466,990	802,040	728,776	780,721	778,588
2069	785,071	720,409	523,031	474,631	811,787	733,097	790,081	787,634
2070	794,005	724,807	526,253	482,273	821,468	737,136	799,464	796,727
2071	802,979	729,141	529,309	489,913	831,105	740,895	808,866	805,866
2072	811,989	733,371	532,378	497,550	840,713	744,371	818,279	815,048
2073	821,040	737,629	535,445	505,179	850,314	747,610	827,707	824,278
2074	830,134	741,854	538,350	512,800	859,920	750,543	837,155	833,557
2075	839,272	746,047	541,095	520,409	869,546	753,172	846,627	842,889
2076	848,456	750,209	543,682	528,005	879,197	755,497	856,127	852,272
2077	857,684	754,339	546,111	535,585	888,879	757,517	865,660	861,711
2078	866,960	758,441	548,384	543,147	898,598	759,234	875,230	871,205
2079	876,284	762,514	550,501	550,689	908,359	760,648	884,841	880,758
2080	885,656	766,560	552,465	558,208	918,166	761,760	894,730	890,371
2081	895,079	770,581	554,276	565,703	928,023	762,571	904,773	900,047
2082	904,554	774,577	555,936	573,171	937,771	763,081	914,884	909,566
2083	914,081	778,590	557,447	580,610	947,034	763,293	925,065	918,625
2084	923,662	782,621	558,808	588,019	955,818	763,206	935,319	927,227
2085	933,299	786,671	560,023	595,394	964,109	762,824	945,753	935,359
2086	942,992	790,742	561,092	602,735	971,889	762,147	956,019	943,078
2087	952,743	794,836	562,016	610,038	979,143	761,177	966,149	950,863
2088	962,571	798,953	562,798	617,302	985,855	759,916	976,139	958,198
2089	972,465	803,095	563,439	624,525	992,009	758,367	985,983	965,069
2090	982,420	807,265	563,940	631,706	997,589	756,530	995,677	971,464
2091	992,653	811,463	564,302	638,841	1002,579	754,409	1005,217	977,368
2092	1003,061	815,691	564,529	645,930	1006,962	752,004	1014,596	982,769
2093	1013,532	819,970	564,620	652,971	1010,723	749,319	1023,811	987,652
2094	1024,067	824,302	564,578	659,961	1013,847	746,356	1032,856	992,005
2095	1034,971	828,689	564,404	666,899	1016,448	743,116	1041,727	995,814
2096	1046,271	833,132	564,101	673,784	1018,515	739,601	1050,419	999,065
2097	1057,672	837,633	563,670	680,613	1019,913	735,815	1058,927	1001,745
2098	1069,174	842,195	563,112	687,385	1020,993	732,440	1067,247	1003,841
2099	1080,781	846,818	562,434	694,098	1021,573	729,030	1075,374	1005,337
2100	1092,495	851,505	561,632	700,751	1021,476	725,381	1083,304	1006,222

Table C.3: CO$_2$ emissions results from FSDM.

year	Iteration 1	Iteration 2	Iteration 3			Iteration 4		
			SSP1	SSP2	SSP5	SSP1	SSP2	SSP5
2008	183,104	183,104	183,104	183,104	183,104	183,104	183,104	183,104
2009	190,369	190,369	190,369	190,369	190,369	190,369	190,369	190,369
2010	197,698	197,698	197,698	197,698	197,698	197,698	197,698	197,698
2011	205,315	205,315	205,315	205,315	205,315	205,315	205,315	205,315
2012	212,905	212,905	212,905	212,905	212,905	212,905	212,905	212,905
2013	220,490	220,490	220,490	220,490	220,490	220,490	220,490	220,490
2014	227,726	227,726	227,726	227,726	227,726	227,726	227,726	227,726
2015	235,264	235,264	235,264	235,264	235,264	235,264	235,264	235,264
2016	243,013	243,013	243,013	243,013	243,013	243,013	243,013	243,013
2017	252,416	252,416	252,416	252,416	252,416	252,416	252,416	252,416
2018	259,908	259,908	259,908	259,908	259,908	259,908	259,908	259,908
2019	261,222	261,222	261,222	261,222	261,222	261,222	261,222	261,222
2020	115,533	115,533	115,533	115,533	115,533	115,533	115,533	115,533
2021	129,469	129,469	129,469	129,469	129,469	129,469	129,469	129,469
2022	143,337	143,337	143,337	143,337	143,337	143,337	143,337	143,337
2023	160,563	160,563	160,563	160,563	160,563	160,563	160,563	160,563
2024	181,001	181,001	178,088	170,958	176,342	181,001	181,001	181,001
2025	201,710	201,710	189,867	175,928	187,145	201,710	201,710	201,710
2026	222,673	222,673	201,450	181,020	198,502	222,673	222,673	222,673
2027	243,858	243,858	212,838	186,233	210,394	243,858	243,858	243,858
2028	265,220	265,220	224,047	191,561	222,803	265,220	265,220	265,220
2029	286,704	286,704	235,360	197,004	236,124	286,704	286,704	286,704
2030	308,250	308,250	246,482	202,558	250,003	308,250	308,250	308,250
2031	329,796	329,796	257,396	208,219	264,344	329,796	329,796	329,796
2032	350,505	350,505	268,103	213,986	279,126	350,505	350,505	350,505
2033	368,247	368,247	278,603	219,856	294,327	368,247	368,247	368,247
2034	385,704	385,704	288,898	225,825	309,922	385,704	385,704	385,704
2035	402,853	402,853	298,988	231,890	325,891	402,853	402,853	402,853
2036	419,680	419,680	308,872	238,050	342,210	419,680	419,680	419,680
2037	436,176	436,176	318,552	244,300	358,859	436,176	436,176	436,176
2038	452,335	452,335	328,028	250,638	376,103	452,335	452,335	452,335
2039	468,756	468,756	337,300	257,061	393,788	468,756	468,756	468,756
2040	485,235	485,235	346,368	263,565	411,774	485,235	485,235	485,235
2041	501,263	501,263	355,233	270,148	429,564	501,263	501,263	501,263
2042	516,907	516,907	363,896	276,805	447,158	516,907	516,907	516,907
2043	531,613	531,667	372,355	283,535	464,442	528,920	529,903	531,636
2044	545,664	545,798	380,612	290,333	481,427	540,749	543,137	545,753
2045	559,002	559,260	388,667	297,197	498,131	552,246	556,479	559,165
2046	571,613	572,038	396,521	304,124	514,581	563,409	569,379	571,854
2047	583,527	584,167	404,173	311,111	530,805	574,238	581,552	583,849
2048	594,803	595,708	411,625	318,155	546,827	584,729	593,079	595,205
2049	605,514	606,747	418,877	325,253	562,657	594,884	604,035	605,998
2050	615,744	616,528	425,930	332,403	578,294	604,701	614,500	616,311
2051	625,578	624,662	432,784	339,602	593,715	614,181	624,561	626,228
2052	635,096	631,106	439,440	346,848	608,890	623,324	634,299	635,829
2053	644,367	637,472	445,899	354,137	623,779	632,130	643,796	645,184
2054	653,450	643,653	452,161	361,468	638,340	640,600	653,107	654,351

Table C.4: CO_2 emissions results from FSDM. (cont.)

			Iteration 3			Iteration 4		
year	Iteration 1	Iteration 2	SSP1	SSP2	SSP5	SSP1	SSP2	SSP5
2055	2090,515	2050,254	1446,167	1164,052	2059,398	2047,413	2090,169	2093,628
2056	2118,427	2068,493	1464,698	1187,424	2102,935	2072,038	2118,836	2121,807
2057	2146,120	2086,059	1482,617	1210,903	2145,138	2095,615	2147,314	2149,769
2058	2173,668	2102,926	1499,924	1234,478	2185,963	2118,146	2175,688	2177,589
2059	2201,131	2119,068	1516,623	1258,144	2225,405	2139,635	2204,030	2205,326
2060	2228,554	2136,120	1532,716	1281,890	2263,490	2160,086	2232,397	2233,025
2061	2255,973	2152,898	1548,205	1305,710	2300,281	2179,502	2260,838	2260,723
2062	2283,414	2168,949	1563,093	1329,595	2335,865	2199,407	2289,390	2288,474
2063	2310,902	2184,775	1577,382	1353,536	2370,360	2218,437	2318,085	2316,348
2064	2338,459	2200,319	1591,075	1377,527	2403,898	2236,555	2346,944	2344,303
2065	2366,098	2215,575	1604,175	1401,558	2436,619	2253,767	2375,974	2372,357
2066	2393,833	2230,538	1616,683	1425,623	2468,662	2270,078	2405,167	2400,523
2067	2421,672	2245,201	1628,602	1449,713	2500,161	2285,494	2434,503	2428,810
2068	2449,621	2259,561	1639,935	1473,820	2531,238	2300,018	2463,954	2457,225
2069	2477,685	2273,611	1650,686	1497,936	2562,001	2313,653	2493,494	2485,774
2070	2505,878	2287,489	1660,856	1522,054	2592,553	2326,400	2523,109	2514,470
2071	2534,201	2301,168	1670,499	1546,167	2622,968	2338,263	2552,782	2543,314
2072	2562,636	2314,519	1680,185	1570,266	2653,291	2349,234	2582,488	2572,292
2073	2591,201	2327,957	1689,863	1594,345	2683,590	2359,456	2612,244	2601,420
2074	2619,903	2341,292	1699,032	1618,396	2713,908	2368,715	2642,062	2630,707
2075	2648,744	2354,525	1707,697	1642,411	2744,288	2377,011	2671,956	2660,156
2076	2677,726	2367,658	1715,860	1666,383	2774,745	2384,348	2701,938	2689,772
2077	2706,852	2380,695	1723,526	1690,306	2805,301	2390,725	2732,023	2719,559
2078	2736,126	2393,639	1730,699	1714,172	2835,974	2396,144	2762,226	2749,524
2079	2765,551	2406,494	1737,382	1737,974	2866,780	2400,607	2792,558	2779,673
2080	2795,132	2419,264	1743,580	1761,705	2897,732	2404,116	2823,766	2810,012
2081	2824,870	2431,953	1749,296	1785,359	2928,840	2406,674	2855,463	2840,549
2082	2854,772	2444,566	1754,535	1808,928	2959,605	2408,285	2887,373	2870,590
2083	2884,839	2457,231	1759,301	1832,407	2988,838	2408,952	2919,505	2899,180
2084	2915,077	2469,952	1763,599	1855,787	3016,563	2408,679	2951,868	2926,330
2085	2945,490	2482,734	1767,432	1879,064	3042,728	2407,472	2984,797	2951,992
2086	2976,082	2495,582	1770,805	1902,230	3067,282	2405,335	3017,196	2976,355
2087	3006,858	2508,501	1773,723	1925,279	3090,177	2402,275	3049,167	3000,924
2088	3037,876	2521,495	1776,191	1948,205	3111,360	2398,296	3080,694	3024,073
2089	3069,099	2534,569	1778,212	1971,002	3130,781	2393,405	3111,763	3045,759
2090	3100,519	2547,728	1779,793	1993,664	3148,391	2387,609	3142,358	3065,940
2091	3132,814	2560,977	1780,938	2016,184	3164,138	2380,913	3172,464	3084,574
2092	3165,661	2574,321	1781,652	2038,556	3177,972	2373,325	3202,065	3101,618
2093	3198,707	2587,826	1781,940	2060,776	3189,843	2364,851	3231,147	3117,031
2094	3231,957	2601,498	1781,808	2082,837	3199,700	2355,498	3259,693	3130,769
2095	3266,369	2615,342	1781,261	2104,735	3207,910	2345,273	3287,690	3142,789
2096	3302,033	2629,365	1780,303	2126,462	3214,433	2334,182	3315,122	3153,050
2097	3338,012	2643,571	1778,942	2148,014	3218,845	2322,232	3341,975	3161,508
2098	3374,315	2657,966	1777,183	2169,386	3222,255	2311,581	3368,233	3168,121
2099	3410,946	2672,557	1775,040	2190,573	3224,086	2300,819	3393,882	3172,844
2100	3447,915	2687,349	1772,512	2211,570	3223,779	2289,302	3418,906	3175,637

Table C.5: Passenger transport supply results from FSDM.

year	Iteration 1 $[\times 10^{12}]$	Iteration 2 $[\times 10^{12}]$	Iteration 3 $[\times 10^{12}]$			Iteration 4 $[\times 10^{12}]$		
			SSP1	SSP2	SSP5	SSP1	SSP2	SSP5
2008	5,992	5,992	5,992	5,992	5,992	5,992	5,992	5,992
2009	6,246	6,246	6,246	6,246	6,246	6,246	6,246	6,246
2010	6,521	6,521	6,521	6,521	6,521	6,521	6,521	6,521
2011	6,800	6,800	6,800	6,800	6,800	6,800	6,800	6,800
2012	7,077	7,077	7,077	7,077	7,077	7,077	7,077	7,077
2013	7,352	7,352	7,352	7,352	7,352	7,352	7,352	7,352
2014	7,631	7,631	7,631	7,631	7,631	7,631	7,631	7,631
2015	7,912	7,912	7,912	7,912	7,912	7,912	7,912	7,912
2016	8,200	8,200	8,200	8,200	8,200	8,200	8,200	8,200
2017	8,556	8,556	8,556	8,556	8,556	8,556	8,556	8,556
2018	8,828	8,828	8,828	8,828	8,828	8,828	8,828	8,828
2019	8,875	8,875	8,875	8,875	8,875	8,875	8,875	8,875
2020	2,686	2,686	2,686	2,686	2,686	2,686	2,686	2,686
2021	3,185	3,185	3,185	3,185	3,185	3,185	3,185	3,185
2022	3,943	3,943	3,943	3,943	3,943	3,943	3,943	3,943
2023	4,706	4,706	4,706	4,706	4,706	4,706	4,706	4,706
2024	5,475	5,475	5,162	4,863	5,089	5,475	5,475	5,475
2025	6,250	6,250	5,609	5,025	5,495	6,250	6,250	6,250
2026	7,031	7,031	6,046	5,191	5,923	7,031	7,031	7,031
2027	7,816	7,816	6,475	5,361	6,373	7,816	7,816	7,816
2028	8,603	8,603	6,894	5,535	6,843	8,603	8,603	8,603
2029	9,391	9,391	7,305	5,713	7,333	9,391	9,391	9,391
2030	10,175	10,175	7,706	5,894	7,842	10,175	10,175	10,175
2031	10,956	10,956	8,098	6,079	8,370	10,956	10,956	10,956
2032	11,688	11,688	8,481	6,267	8,914	11,688	11,688	11,688
2033	12,410	12,410	8,855	6,458	9,475	12,410	12,410	12,410
2034	13,119	13,119	9,220	6,653	10,052	13,119	13,119	13,119
2035	13,815	13,815	9,575	6,850	10,644	13,815	13,815	13,815
2036	14,495	14,495	9,922	7,050	11,250	14,495	14,495	14,495
2037	15,159	15,159	10,259	7,253	11,869	15,159	15,159	15,159
2038	15,805	15,805	10,587	7,458	12,500	15,805	15,805	15,805
2039	16,433	16,433	10,906	7,665	13,143	16,433	16,433	16,433
2040	17,041	17,041	11,216	7,874	13,797	17,041	17,041	17,041
2041	17,628	17,628	11,517	8,086	14,443	17,628	17,628	17,628
2042	18,193	18,193	11,809	8,299	15,075	18,193	18,193	18,193
2043	18,732	18,733	12,091	8,515	15,696	18,628	18,665	18,734
2044	19,242	19,245	12,365	8,731	16,303	19,049	19,140	19,248
2045	19,724	19,730	12,629	8,950	16,899	19,457	19,618	19,732
2046	20,176	20,186	12,884	9,169	17,484	19,850	20,079	20,188
2047	20,601	20,617	13,130	9,390	18,060	20,229	20,513	20,616
2048	21,000	21,023	13,367	9,611	18,626	20,594	20,920	21,018
2049	21,376	21,408	13,595	9,834	19,184	20,945	21,304	21,398
2050	21,733	21,744	13,814	10,057	19,734	21,282	21,668	21,758
2051	22,073	22,017	14,023	10,281	20,275	21,605	22,016	22,102
2052	22,400	22,223	14,224	10,505	20,805	21,913	22,350	22,432
2053	22,717	22,421	14,415	10,730	21,323	22,208	22,674	22,752
2054	23,025	22,612	14,597	10,954	21,827	22,489	22,989	23,064

Table C.6: Passenger transport supply results from FSDM. (cont.)

year	Iteration 1 [$\times 10^{12}$]	Iteration 2 [$\times 10^{12}$]	Iteration 3 [$\times 10^{12}$]			Iteration 4 [$\times 10^{12}$]		
			SSP1	SSP2	SSP5	SSP1	SSP2	SSP5
2055	23,326	22,794	14,770	11,179	22,317	22,755	23,298	23,369
2056	23,623	22,967	14,934	11,404	22,791	23,008	23,602	23,669
2057	23,916	23,132	15,089	11,628	23,247	23,246	23,903	23,966
2058	24,205	23,286	15,235	11,851	23,686	23,471	24,201	24,260
2059	24,493	23,431	15,371	12,075	24,107	23,681	24,498	24,551
2060	24,779	23,566	15,498	12,297	24,510	23,877	24,794	24,841
2061	25,063	23,690	15,617	12,519	24,897	24,059	25,089	25,129
2062	25,347	23,803	15,726	12,739	25,268	24,228	25,384	25,417
2063	25,630	23,912	15,826	12,959	25,625	24,382	25,680	25,703
2064	25,912	24,015	15,917	13,177	25,969	24,522	25,976	25,989
2065	26,193	24,113	15,999	13,393	26,301	24,648	26,273	26,275
2066	26,475	24,206	16,071	13,608	26,625	24,760	26,570	26,561
2067	26,756	24,294	16,135	13,822	26,940	24,857	26,867	26,847
2068	27,038	24,375	16,189	14,033	27,249	24,941	27,165	27,133
2069	27,319	24,452	16,234	14,242	27,552	25,011	27,462	27,418
2070	27,600	24,522	16,270	14,450	27,852	25,066	27,758	27,704
2071	27,882	24,587	16,297	14,655	28,148	25,108	28,054	27,991
2072	28,163	24,646	16,315	14,857	28,442	25,136	28,348	28,277
2073	28,444	24,702	16,324	15,057	28,734	25,149	28,641	28,563
2074	28,725	24,755	16,324	15,254	29,025	25,148	28,934	28,849
2075	29,007	24,806	16,314	15,448	29,314	25,134	29,225	29,136
2076	29,288	24,853	16,295	15,639	29,603	25,105	29,516	29,423
2077	29,569	24,898	16,268	15,827	29,892	25,062	29,807	29,710
2078	29,851	24,940	16,231	16,011	30,180	25,005	30,097	29,998
2079	30,133	24,978	16,185	16,192	30,468	24,934	30,387	30,285
2080	30,414	25,014	16,129	16,370	30,756	24,849	30,676	30,574
2081	30,696	25,047	16,065	16,544	31,044	24,750	30,966	30,862
2082	30,978	25,077	15,992	16,713	31,327	24,637	31,255	31,143
2083	31,260	25,105	15,909	16,879	31,590	24,510	31,545	31,404
2084	31,543	25,132	15,818	17,040	31,833	24,369	31,835	31,646
2085	31,825	25,157	15,717	17,198	32,056	24,214	32,128	31,868
2086	32,107	25,181	15,607	17,350	32,257	24,044	32,413	32,068
2087	32,390	25,203	15,488	17,498	32,437	23,861	32,690	32,246
2088	32,673	25,224	15,360	17,641	32,593	23,663	32,957	32,402
2089	32,956	25,243	15,222	17,780	32,727	23,452	33,216	32,535
2090	33,239	25,261	15,076	17,913	32,837	23,226	33,464	32,645
2091	33,522	25,277	14,920	18,041	32,923	22,986	33,704	32,730
2092	33,806	25,292	14,755	18,164	32,983	22,733	33,933	32,790
2093	34,090	25,306	14,582	18,281	33,018	22,465	34,151	32,824
2094	34,374	25,319	14,399	18,392	33,026	22,183	34,360	32,832
2095	34,658	25,332	14,207	18,498	33,007	21,887	34,557	32,814
2096	34,943	25,344	14,005	18,597	32,961	21,577	34,743	32,767
2097	35,228	25,355	13,795	18,691	32,886	21,253	34,918	32,693
2098	35,513	25,365	13,576	18,778	32,782	20,915	35,081	32,590
2099	35,799	25,375	13,347	18,859	32,649	20,563	35,233	32,457
2100	36,085	25,384	13,109	18,934	32,485	20,196	35,372	32,295

Appendix D

E-kerosene CO_2 Emissions Scenario Results

Table D.1: CO_2 emissions of Scenario 1.

year	Case A [Mt]	Case B [Mt]	Case C [Mt]
2022	452,944	452,944	452,944
2023	507,378	507,378	507,378
2024	571,954	571,954	571,954
2025	637,187	637,187	637,187
2026	703,046	703,046	703,046
2027	769,378	769,378	769,378
2028	836,269	836,269	836,269
2029	903,547	903,547	903,547
2030	971,018	971,018	971,018
2031	1037,966	1037,966	1037,966
2032	1102,266	1102,266	1102,266
2033	1144,347	1144,347	1144,347
2034	1185,528	1185,528	1185,528
2035	1225,738	1225,738	1225,738
2036	1264,929	1264,929	1264,929
2037	1303,072	1303,072	1303,072
2038	1340,152	1340,152	1340,152
2039	1378,059	1378,059	1378,059
2040	1416,149	1416,149	1414,650
2041	1453,361	1453,361	1447,494
2042	1489,360	1489,360	1476,454
2043	1516,994	1516,023	1493,977
2044	1545,377	1541,994	1508,718
2045	1574,102	1566,722	1519,739
2046	1601,431	1588,312	1524,693
2047	1626,462	1605,686	1521,978
2048	1649,453	1618,910	1511,046
2049	1670,640	1628,010	1491,205
2050	1690,274	1633,006	1461,643
2051	1709,489	1633,916	1421,408
2052	1727,055	1630,718	1369,349
2053	1743,198	1623,361	1304,104
2054	1758,063	1611,683	1223,985
2055	1771,774	1595,468	1154,930
2056	1784,425	1574,436	1170,770
2057	1796,084	1548,242	1186,505
2058	1806,797	1516,473	1202,184
2059	1816,593	1478,654	1217,844
2060	1825,484	1434,240	1233,519
2061	1833,474	1382,618	1249,234

Table D.2: CO_2 emissions of Scenario 1. (cont.)

year	Case A [Mt]	Case B [Mt]	Case C [Mt]
2062	1840,550	1323,097	1265,010
2063	1846,695	1280,866	1280,866
2064	1851,874	1296,812	1296,812
2065	1856,039	1312,853	1312,853
2066	1859,122	1328,983	1328,983
2067	1861,039	1345,193	1345,193
2068	1861,701	1361,466	1361,466
2069	1861,009	1377,789	1377,789
2070	1858,880	1394,152	1394,152
2071	1855,219	1410,548	1410,548
2072	1849,923	1426,963	1426,963
2073	1842,924	1443,404	1443,404
2074	1834,149	1459,881	1459,881
2075	1823,517	1476,398	1476,398
2076	1810,946	1492,965	1492,965
2077	1796,349	1509,589	1509,589
2078	1779,633	1526,277	1526,277
2079	1760,699	1543,037	1543,037
2080	1740,177	1560,282	1560,282
2081	1717,555	1577,796	1577,796
2082	1692,429	1595,428	1595,428
2083	1664,671	1613,182	1613,182
2084	1634,149	1631,065	1631,065
2085	1649,260	1649,260	1649,260
2086	1667,162	1667,162	1667,162
2087	1684,827	1684,827	1684,827
2088	1702,248	1702,248	1702,248
2089	1719,415	1719,415	1719,415
2090	1736,321	1736,321	1736,321
2091	1752,956	1752,956	1752,956
2092	1769,312	1769,312	1769,312
2093	1785,381	1785,381	1785,381
2094	1801,154	1801,154	1801,154
2095	1816,624	1816,624	1816,624
2096	1831,782	1831,782	1831,782
2097	1846,619	1846,619	1846,619
2098	1861,128	1861,128	1861,128
2099	1875,301	1875,301	1875,301
2100	1889,128	1889,128	1889,128

Table D.3: CO_2 emissions of Scenario 2.

year	Case A [Mt]	Case B [Mt]	Case C [Mt]
2022	452,944	452,944	452,944
2023	507,378	507,378	507,378
2024	571,954	571,954	571,954
2025	637,187	637,187	637,187
2026	703,046	703,046	703,046
2027	769,378	769,378	769,378
2028	836,269	836,269	836,269
2029	903,547	903,547	903,547
2030	971,018	971,018	971,018
2031	1037,966	1037,966	1037,966
2032	1102,266	1102,266	1102,266
2033	1144,347	1144,347	1144,347
2034	1185,528	1185,528	1185,528
2035	1225,738	1225,738	1225,738
2036	1264,929	1264,929	1264,929
2037	1303,072	1303,072	1303,072
2038	1340,152	1340,152	1340,152
2039	1378,059	1378,059	1378,059
2040	1416,149	1416,149	1414,650
2041	1453,361	1453,361	1447,494
2042	1489,360	1489,360	1476,454
2043	1516,994	1516,023	1493,977
2044	1545,377	1541,994	1508,718
2045	1574,102	1566,722	1519,739
2046	1601,431	1588,312	1524,693
2047	1626,462	1605,686	1521,978
2048	1649,453	1618,910	1511,046
2049	1670,640	1628,010	1491,205
2050	1690,274	1633,006	1461,643
2051	1709,489	1633,916	1421,408
2052	1727,055	1630,718	1369,349
2053	1743,198	1623,361	1304,104
2054	1758,063	1611,683	1223,985
2055	1771,774	1595,468	1127,009
2056	1784,425	1574,436	1010,841
2057	1796,084	1548,242	993,799
2058	1806,797	1516,473	1006,932
2059	1816,593	1478,654	1020,048
2060	1825,484	1434,240	1033,177
2061	1833,474	1382,618	843,446

Table D.4: CO_2 emissions of Scenario 2. (cont.)

year	Case A [Mt]	Case B [Mt]	Case C [Mt]
2062	1840,550	1323,097	854,097
2063	1846,695	1254,909	864,803
2064	1851,874	1177,194	875,569
2065	1856,039	1088,988	886,399
2066	1859,122	989,218	897,290
2067	1861,039	908,234	908,234
2068	1861,701	919,222	919,222
2069	1861,009	930,242	930,242
2070	1858,880	941,291	941,291
2071	1855,219	723,267	723,267
2072	1849,923	731,683	731,683
2073	1842,924	740,114	740,114
2074	1834,149	748,562	748,562
2075	1823,517	757,032	757,032
2076	1810,946	765,526	765,526
2077	1796,349	774,050	774,050
2078	1779,633	782,607	782,607
2079	1760,699	791,201	791,201
2080	1740,177	800,043	800,043
2081	1717,555	552,767	552,767
2082	1692,429	558,944	558,944
2083	1664,671	565,164	565,164
2084	1634,149	571,429	571,429
2085	1601,047	577,803	577,803
2086	1564,110	584,075	584,075
2087	1523,276	590,264	590,264
2088	1478,356	596,367	596,367
2089	1429,152	602,382	602,382
2090	1375,458	608,304	608,304
2091	1317,057	329,426	329,426
2092	1253,725	332,500	332,500
2093	1185,223	335,520	335,520
2094	1111,305	338,484	338,484
2095	1031,712	341,391	341,391
2096	946,171	344,240	344,240
2097	854,400	347,028	347,028
2098	756,101	349,755	349,755
2099	650,962	352,418	352,418
2100	538,657	355,017	355,017

Table D.5: CO_2 emissions of Scenario 3.

year	Case A [Mt]	Case B [Mt]	Case C [Mt]
2022	452,944	452,944	452,944
2023	507,378	507,378	507,378
2024	571,954	571,954	571,954
2025	637,187	637,187	637,187
2026	703,046	703,046	703,046
2027	769,378	769,378	769,378
2028	836,269	836,269	836,269
2029	903,547	903,547	903,547
2030	971,018	971,018	971,018
2031	1037,966	1037,966	1037,966
2032	1102,266	1102,266	1102,266
2033	1144,347	1144,347	1144,347
2034	1185,528	1185,528	1185,528
2035	1225,738	1225,738	1225,738
2036	1264,929	1264,929	1264,929
2037	1303,072	1303,072	1303,072
2038	1340,152	1340,152	1340,152
2039	1378,059	1378,059	1378,059
2040	1416,149	1416,149	1414,650
2041	1453,361	1453,361	1447,494
2042	1489,360	1489,360	1476,454
2043	1516,994	1516,023	1493,977
2044	1545,377	1541,994	1508,718
2045	1574,102	1566,722	1519,739
2046	1601,431	1588,312	1524,693
2047	1626,462	1605,686	1521,978
2048	1649,453	1618,910	1511,046
2049	1670,640	1628,010	1491,205
2050	1690,274	1633,006	1461,643
2051	1709,489	1633,916	1421,408
2052	1727,055	1630,718	1369,349
2053	1743,198	1623,361	1304,104
2054	1758,063	1611,683	1223,985
2055	1771,774	1595,468	1127,009
2056	1784,425	1574,436	1010,841
2057	1796,084	1548,242	872,753
2058	1806,797	1516,473	811,679
2059	1816,593	1478,654	822,253
2060	1825,484	1434,240	832,835
2061	1833,474	1382,618	640,552

Table D.6: CO$_2$ emissions of Scenario 3. (cont.)

year	Case A [Mt]	Case B [Mt]	Case C [Mt]
2062	1840,550	1323,097	648,641
2063	1846,695	1254,909	656,771
2064	1851,874	1177,194	664,948
2065	1856,039	1088,988	673,173
2066	1859,122	989,218	465,597
2067	1861,039	876,691	471,276
2068	1861,701	750,090	476,977
2069	1861,009	607,969	482,696
2070	1858,880	488,429	488,429
2071	1855,219	270,708	265,079
2072	1849,923	268,164	268,164
2073	1842,924	271,254	271,254
2074	1834,149	274,350	274,350
2075	1823,517	277,454	277,454
2076	1810,946	280,567	280,567
2077	1796,349	283,691	283,691
2078	1779,633	286,828	286,828
2079	1760,699	289,977	289,977
2080	1740,177	293,218	293,218
2081	1717,555	296,509	296,509
2082	1692,429	299,823	299,823
2083	1664,671	303,159	303,159
2084	1634,149	306,520	306,520
2085	1601,047	309,939	309,939
2086	1564,110	313,304	313,304
2087	1523,276	316,623	316,623
2088	1478,356	319,897	319,897
2089	1429,152	323,123	323,123
2090	1375,458	326,300	326,300
2091	1317,057	329,426	329,426
2092	1253,725	332,500	332,500
2093	1185,223	335,520	335,520
2094	1111,305	338,484	338,484
2095	1031,712	341,391	341,391
2096	946,171	344,240	344,240
2097	854,400	347,028	347,028
2098	756,101	349,755	349,755
2099	650,962	352,418	352,418
2100	538,657	355,017	355,017

Table D.7: CO_2 emissions of Scenario 4.

year	Case A [Mt]	Case B [Mt]	Case C [Mt]
2022	452,944	452,944	452,944
2023	507,378	507,378	507,378
2024	571,954	571,954	571,954
2025	637,187	637,187	637,187
2026	703,046	703,046	703,046
2027	769,378	769,378	769,378
2028	836,269	836,269	836,269
2029	903,547	903,547	903,547
2030	971,018	971,018	971,018
2031	1037,966	1037,966	1037,966
2032	1102,266	1102,266	1102,266
2033	1144,347	1144,347	1144,347
2034	1185,528	1185,528	1185,528
2035	1225,738	1225,738	1225,738
2036	1264,929	1264,929	1264,929
2037	1303,072	1303,072	1303,072
2038	1340,152	1340,152	1340,152
2039	1378,059	1378,059	1378,059
2040	1416,149	1416,149	1414,650
2041	1453,361	1453,361	1447,494
2042	1489,360	1489,360	1476,454
2043	1516,994	1516,023	1493,977
2044	1545,377	1541,994	1508,718
2045	1574,102	1566,722	1519,739
2046	1601,431	1588,312	1524,693
2047	1626,462	1605,686	1521,978
2048	1649,453	1618,910	1511,046
2049	1670,640	1628,010	1491,205
2050	1690,274	1633,006	1461,643
2051	1709,489	1633,916	1421,408
2052	1727,055	1630,718	1369,349
2053	1743,198	1623,361	1304,104
2054	1758,063	1611,683	1223,985
2055	1771,774	1595,468	1127,009
2056	1784,425	1574,436	1010,841
2057	1796,084	1548,242	872,753
2058	1806,797	1516,473	714,053
2059	1816,593	1478,654	723,355
2060	1825,484	1434,240	732,665
2061	1833,474	1382,618	234,764

Table D.8: CO$_2$ emissions of Scenario 4. (cont.)

year	Case A [Mt]	Case B [Mt]	Case C [Mt]
2062	1840,550	1323,097	237,729
2063	1846,695	1254,909	240,708
2064	1851,874	1177,194	243,705
2065	1856,039	1088,988	246,720
2066	1859,122	989,218	249,751
2067	1861,039	876,691	252,797
2068	1861,701	750,090	255,855
2069	1861,009	607,969	258,923
2070	1858,880	448,753	261,998
2071	1855,219	270,708	265,079
2072	1849,923	268,164	268,164
2073	1842,924	271,254	271,254
2074	1834,149	274,350	274,350
2075	1823,517	277,454	277,454
2076	1810,946	280,567	280,567
2077	1796,349	283,691	283,691
2078	1779,633	286,828	286,828
2079	1760,699	289,977	289,977
2080	1740,177	293,218	293,218
2081	1717,555	296,509	296,509
2082	1692,429	299,823	299,823
2083	1664,671	303,159	303,159
2084	1634,149	306,520	306,520
2085	1601,047	309,939	309,939
2086	1564,110	313,304	313,304
2087	1523,276	316,623	316,623
2088	1478,356	319,897	319,897
2089	1429,152	323,123	323,123
2090	1375,458	326,300	326,300
2091	1317,057	329,426	329,426
2092	1253,725	332,500	332,500
2093	1185,223	335,520	335,520
2094	1111,305	338,484	338,484
2095	1031,712	341,391	341,391
2096	946,171	344,240	344,240
2097	854,400	347,028	347,028
2098	756,101	349,755	349,755
2099	650,962	352,418	352,418
2100	538,657	355,017	355,017

Table D.9: CO_2 emissions of Scenario 5.

year	Case A [Mt]	Case B [Mt]	Case C [Mt]
2022	452,944	452,944	452,944
2023	507,378	507,378	507,378
2024	571,954	571,954	571,954
2025	637,187	637,187	637,187
2026	703,046	703,046	703,046
2027	769,378	769,378	769,378
2028	836,269	836,269	836,269
2029	903,547	903,547	903,547
2030	971,018	971,018	971,018
2031	1037,966	1037,966	1037,966
2032	1102,266	1102,266	1102,266
2033	1144,347	1144,347	1144,347
2034	1185,528	1185,528	1185,528
2035	1225,738	1225,738	1225,738
2036	1264,929	1264,929	1264,929
2037	1303,072	1303,072	1303,072
2038	1340,152	1340,152	1340,152
2039	1378,059	1378,059	1378,059
2040	1416,149	1416,149	1414,650
2041	1453,361	1453,361	1447,494
2042	1489,360	1489,360	1476,454
2043	1516,994	1516,023	1493,977
2044	1545,377	1541,994	1508,718
2045	1574,102	1566,722	1519,739
2046	1601,431	1588,312	1524,693
2047	1626,462	1605,686	1521,978
2048	1649,453	1618,910	1511,046
2049	1670,640	1628,010	1491,205
2050	1690,274	1633,006	1461,643
2051	1709,489	1633,916	1421,408
2052	1727,055	1630,718	1369,349
2053	1743,198	1623,361	1304,104
2054	1758,063	1611,683	1223,985
2055	1771,774	1595,468	1127,009
2056	1784,425	1574,436	1010,841
2057	1796,084	1548,242	872,753
2058	1806,797	1516,473	709,571
2059	1816,593	1478,654	517,618
2060	1825,484	1434,240	292,640
2061	1833,474	1382,618	234,764

Table D.10: CO_2 emissions of Scenario 5. (cont.)

year	Case A [Mt]	Case B [Mt]	Case C [Mt]
2062	1840,550	1323,097	237,729
2063	1846,695	1254,909	240,708
2064	1851,874	1177,194	243,705
2065	1856,039	1088,988	246,720
2066	1859,122	989,218	249,751
2067	1861,039	876,691	252,797
2068	1861,701	750,090	255,855
2069	1861,009	607,969	258,923
2070	1858,880	448,753	261,998
2071	1855,219	270,708	265,079
2072	1849,923	268,164	268,164
2073	1842,924	271,254	271,254
2074	1834,149	274,350	274,350
2075	1823,517	277,454	277,454
2076	1810,946	280,567	280,567
2077	1796,349	283,691	283,691
2078	1779,633	286,828	286,828
2079	1760,699	289,977	289,977
2080	1740,177	293,218	293,218
2081	1717,555	296,509	296,509
2082	1692,429	299,823	299,823
2083	1664,671	303,159	303,159
2084	1634,149	306,520	306,520
2085	1601,047	309,939	309,939
2086	1564,110	313,304	313,304
2087	1523,276	316,623	316,623
2088	1478,356	319,897	319,897
2089	1429,152	323,123	323,123
2090	1375,458	326,300	326,300
2091	1317,057	329,426	329,426
2092	1253,725	332,500	332,500
2093	1185,223	335,520	335,520
2094	1111,305	338,484	338,484
2095	1031,712	341,391	341,391
2096	946,171	344,240	344,240
2097	854,400	347,028	347,028
2098	756,101	349,755	349,755
2099	650,962	352,418	352,418
2100	538,657	355,017	355,017