SE²A Sustainable and Energy-Efficient Aviation

ScenAIR2050 / SE²A – Key Factor Projections March 2024

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Introduction

Dear SE2A cluster- and research partners,

Thank you all who participated in our workshops last summer to work on Future Projections based on the Key Factor Analysis, that you also were an intricate part of, when you took part in the surveys, we conducted as part of part of our project work.

The objective of the project ScenAIR2050 is to develop qualitative scenarios for the future of the air transport system (ATS) in 2050. The scenarios aim to provide a multi-criteria decision support for evaluating and optimizing future technologies developed within the SE2A cluster, as well as creating participatory synergies among the cluster members. The main research question revolves around what possible and plausible developments of a sustainable and energy efficient ATS until the year 2050 should be considered, taking into account not only technological advances but also socio-economic developments.

The following documentation contains projections for the 15 Key Factors identified significant based on desk research and surveys within the cluster (see Impact Uncertainty Survey, 2023). Related to the respective key factors the projections are built on current trends, uncertainties and indicators. For each Key Factor two corresponding focal aspects (dimensions) were defined in order to produce at least four distinct projections. The 60 Projections are the foundation for the scenario calculation and allow a diverse range of plausible scenarios.

Please note, that the following projections are directions but by no means forecasts. Based on our research they are plausible development lines, that allow us to explore futures as alternative trajectories for the ATS.

Content

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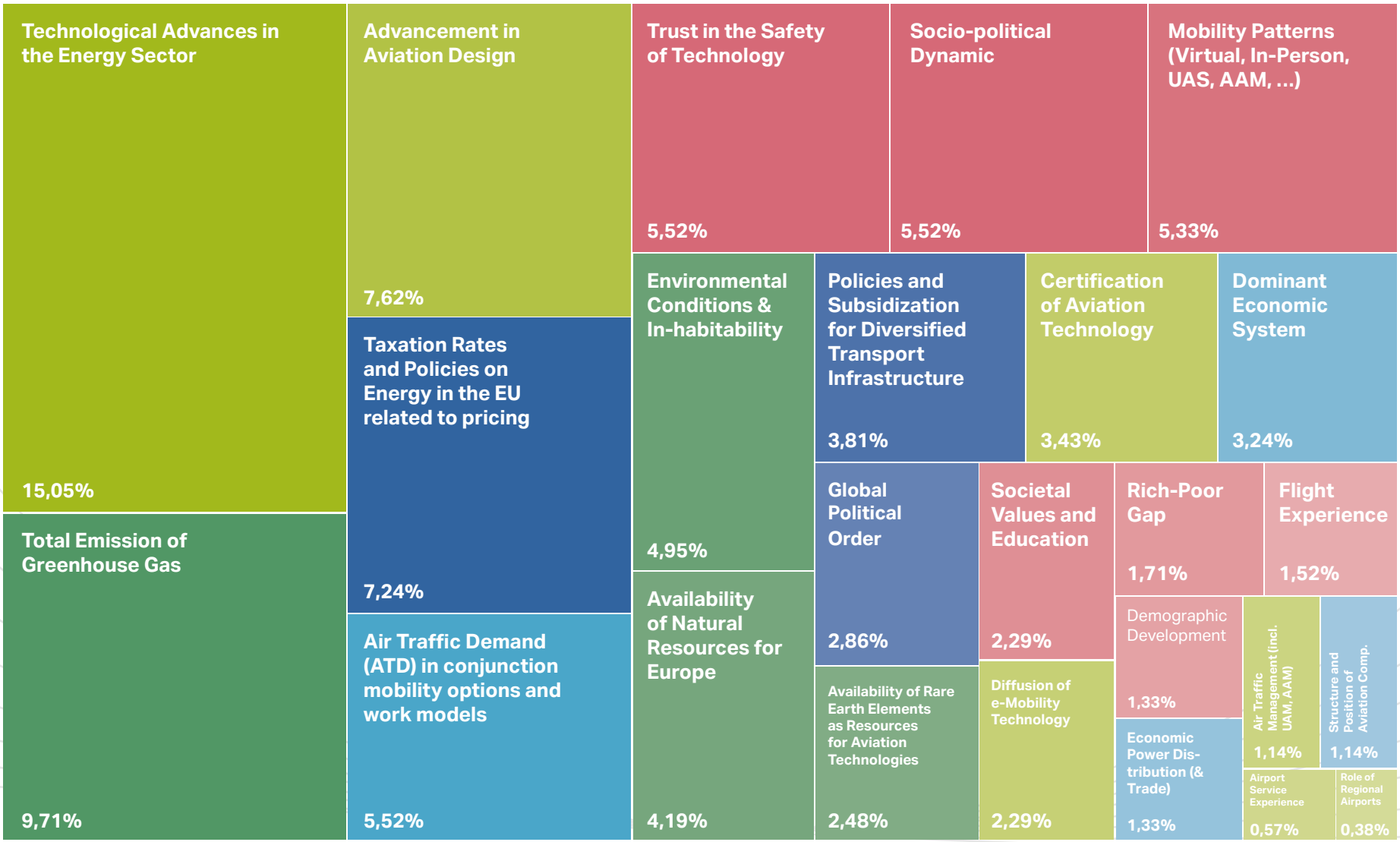
Glossary of terms

SAF	Sustainable Aviation Fuel
ATS	Air Transport System
ATD	Air Traffic Demand
ATM	Air Traffic Management
CRM	Critical Raw Materials
EEA	European Economic Area
ETS	Emissions Trading Scheme
EUA	Emissions Allowances
EU	European Union
UAM	Urban Air Mobility
AAM	Advanced Air Mobility
REE	Rare-Earth Element
GHG	Greenhouse Gases (e.g. CO^2)
GDP	Gross Domestic Product
RCP	Representative Concentration Pathways
UAS	Unmanned aerial vehicle
MaaS	Mobility as a service
BRICS	Acronym for Brazil, Russia, India, China & South Africa
NET-ZERO	Amount of emitted greenhouse gases is being compensated by the same amount of removed greenhouse gases

Ranking of the 25 Factors

Accumulated Ranking through 35 Participants (n=35)



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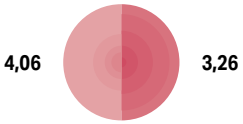
The 8 Main Key Factors

Socio-Political Dynamics



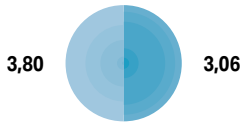
Mobility Patterns

Technological Advances in the Energy Sector

Diffusion of e-Mobility Technology

Environmental Conditions and In-habitability

Air Traffic Demand

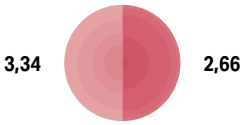


Global Political Order

Policies and Subsidization for Diversified Transport Infrastructure

The 12 Optional Key Factors

Rich-Poor Gap



Certification of Aviation Technology

Advancement in Aviation Design

Airport Service Experience and Infrastructure

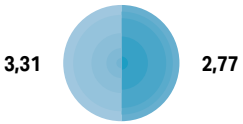
Availability of REE as Resources for Aviation Technologies

Total Emission of Greenhouse Gas

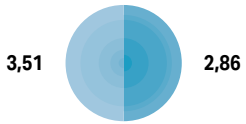
Availability of Natural Resources for Europe

Air Traffic Management

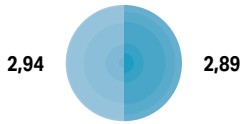
Structure and Position of Aviation Companies



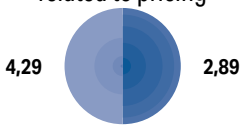
Dominant Economic System



Economic Power Distribution and Trade



Taxation Rates and Policies on Energy in the EU related to pricing



The 6 Additional Key Factors

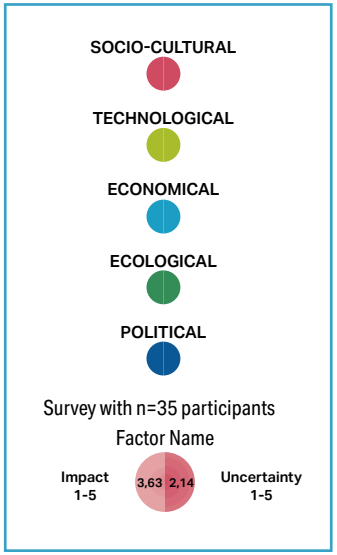
Flight Experience

Trust in the Safety of Technology

Demographic Development

Societal Values and Education

Role of Regional Airports also through Policies



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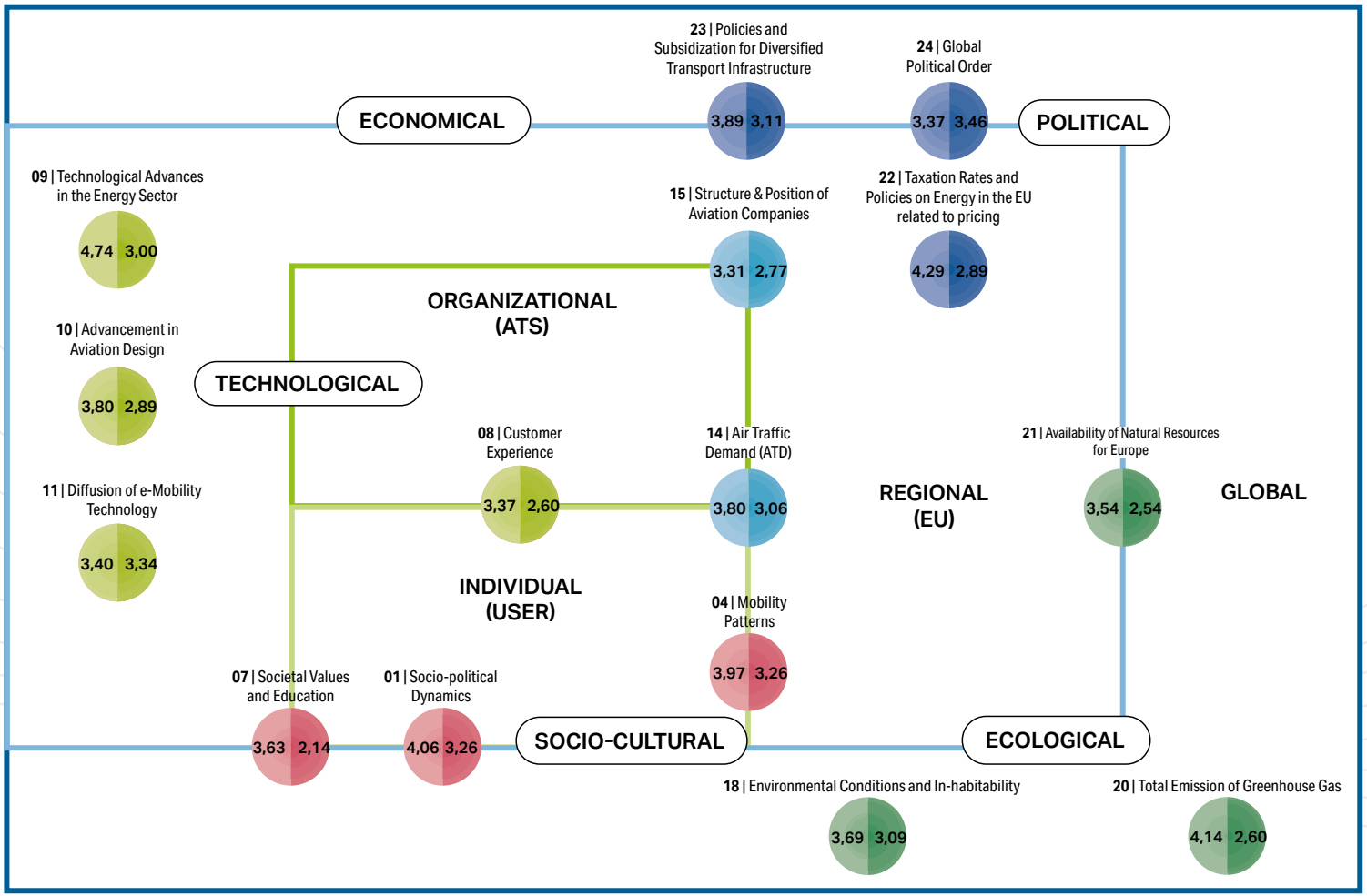
STEEP System Image with 15 Key Factors

System image of resulting 15 of 25 defined key factors with a high impact and high uncertainty.



The Key Factors were identified through a STEEP analysis following an Uncertainty /Impact Analysis. They were conducted in two survey rounds in 2022 and 2023 with experts from the SE²A excellence cluster and external experts.

SOCIO-CULTURAL

TECHNOLOGICAL

ECONOMICAL

ECOLOGICAL

POLITICAL

Survey with n=35 participants

Factor Name

Impact 1-5 — 3,63 2,14 — Uncertainty 1-5

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Factors based on STEEP Analysis

Socio-Cultural Factors

01	Socio-political Dynamics
02	Demographic Development
03	Flight Experience
04	Mobility Patterns
05	Trust in the Safety of Technology
06	Rich-Poor Gap
07	Societal Values and Education

Technological Factors

08	Customer Experience (Tech Offers)
09	Technological Advances in the Energy Sector
10	Advancement in Aviation Design
11	Air Traffic Management (ATM incl.. UAM, AAM)
12	Propulsion Technology as Driver of e-Mobility
13	Certification of Aviation Technology

Economical Factors

14	Air Traffic Demand (ATD)
15	Structure and Position of Aviation Companies
16	Economic Power Distribution (& Trade)
17	Dominant Economic System

Ecological Factors

18	Environmental Conditions and In-habitability
19	Availability of Rare Earth Elements (REE) as Resources for Aviation Technologies
20	Total Emission of Greenhouse Gases
21	Availability of Natural Resources for Europe

Political Factors

22	Taxation Rates and Policies on Energy in the EU related to pricing
23	Policies and Subsidisation for diversifying the Transport Infrastructure
24	Global Political Order
25	Role of Regional Airports also through Policies

Socio-political dynamics (01)

Description: Personal awareness and building of civic movements to act on climate change, as well as climate denial and conspiracies (Terrorism, Social Unrest, Revolutions, mass movements) in the EU.

Trends:

- Raising concern about climate change.
- Support for energy transition.
- Personal action to tackle climate change.
- Radicalization of climate protest.
- Ideological divide on climate change.
- Raise of right-wing populist nationalism.
- Willingness and capability to spend money for transport.
- Social pressure on politicians and companies for climate-neutral aviation.
- Strengthened nationalists ideologies. Many states were exposed to immense stress and responded by turning inward.
- Contentious protesters of heterogeneous groups, who share emotional experiences and mobilise through shared values, beliefs and identity. They are also engaged with policy agendas and expert knowledge.
- Criminalization and defamation of climate activists by equating them with terrorists (e.g. climate terrorists).
- Falsified weighting on opposing voices towards climate change in media.
- Threats from Foreign Information Manipulation and Interference (FIMI).
- Resurgence of increased spreading of false information since the 2016 US presidential election. Fake News continue to occur in public discourses (especially in online media) with social consequences.
- Misinformation in media has a great impact on perceived scientific consensus regarding climate change.

Uncertainties:

- Radicalization of protest groups.
- Development of anti-democratic tendencies in the EU.
- External events (pandemic, conflicts, natural disaster).
- Long-term extreme political developments (Rebellion).
- Impact of fake news and misinformation.

Indicators:

- Development of Gross Domestic Product (GDP) in Europe.
- EU-Governments election results. United Nations Climate Change Conference 2015 - "Paris Agreement" as highest level of worldwide consensus in relation to the existence of climate change, its human-made origin, and the need to implement mitigation and adaptation policies.
- Rising awareness and willingness to pay higher ticket prices to "reduce" impact on environment.
- Long-term decline of the population in Germany until 2060. Varying degrees of decline depending on the development of fertility, life expectations and migration.
- Overall population of the EU will become on average significantly older by 2050.
- More radical groups affecting environmental policy, by altering the terms of debate.
- Hostility towards institutionalized policy agendas amongst direct-action groups such as Climate Camps.
- Fundamentalist world-view of climate activists cannot categorically rule out the potential for radicalization on the scale of a terrorist organization. As long as exchanges between governments and activists continue, the potential is rather low.
- 77% of EU citizens think climate change is a very serious problem at this moment. The majority think that the European Union (56%), national governments (56%), business and industry (53%) are responsible for tackling climate change. 35% hold themselves personally responsible.
- Increase in climate change concerns are related to the level of per capita income, education, media coverage and the share of young people in the total population among other things.
- Increased environmental concern in the EU as a consequence of public controversy on climate change following the 2016 US presidential election.

Details on the data and statistics are provided in the materials on the individual key factors on the respective reference page.

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Projections: **Socio-political dynamics (01)**

Focus: Ideological - Divide vs. Consensus | Value of - Community vs. Individualism

PROJECTION 01 A

Post Truth

Description:

People are very concerned about their personal freedom. Each person has their own belief of what is true or not. Massive increase on diverging opinions with facts being less based on scientific results or common sense but more on individual beliefs.

Impact:

No consensus on climate crisis. No consensus on scientific results. Fragmentation of society. Questioning of democratic values. Increase and radicalization of climate activism.

PROJECTION 01 B

Climate Crisis is Real

Description:

People are very concerned about their personal well-being. Most have understood that there is a certain direction that is seen as being true.

Impact:

Consensus on climate crisis. Consensus on scientific results.

PROJECTION 01 C

The Many Truths

Description:

Extreme Pluralism with strong feeling of belonging to one group. There are a few opposing positions on climate change / crisis etc. Ideologies and radicalization are have risen. Ideological divides concentrating on groups with a high connectivity among members.

Impact:

Groups work against each other. In certain areas flying is not possible anymore.

PROJECTION 01 D

Together for Truth

Description:

The community stands above the individual needs. There is one strong suit of the truth.

Impact:

Society backs the need for action. Willingness for incisive measures.

References:
Socio-political dynamics (01)

Title	Category /Publication Date	Aspect	Source/Link DOI	PDF
Example Paper	Trend	Raise of civic movements for climate justice	Link to Document DOI 000.000.000.000	
DLR: DEPA 2050 - Development Pathways for Aviation up to 2050	Study report	climate-related disasters and pressure from the society, forces politocs and companies zo take actions towards climate neutral aviation	https://www.dlr.de/de/aktuelles/nachrichten/2021/02/20210526_rueckgang-der-luftfahrtemissionen-braucht-verstaerkte-anstrengungen	
Statista: Share of adults who would pay more for flight tickets to reduce the environmental or noise impact in the United Kingdom from 2017 to 2020	Statistic	Rising awareness and willingness to pay higher ticket prices to reduce impact on environment	https://www.statista.com/statistics/1185061/share-uk-adults-would-pay-more-flight-tickets-reduce-environmental-noise-impact/ [accessed October 27th 2023]	
Destatis Statistisches Bundesamt: Population projection - Population in Million	Statistics	Long-term projection of the population in Germany shows a overall decline until 2060. Depending on the development of fertility, life expectations and migration, varying degrees of decline can occur.	https://www.destatis.de/EN/Themes/Society-Environment/Population/Population-Projection/_node.html [accessed October 30 2023]	
Destatis Statistisches Bundesamt: Population projection - Population at Working Age 20 to 66 years in Million	Statistics	Germanys population at Working Age (20-66 years) will decline. Depending on the development of fertility, life expectations and migration, varying degrees of decline can occur.	https://www.destatis.de/EN/Themes/Society-Environment/Population/Population-Projection/_node.html [accessed October 30 2023]	
Destatis Statistisches Bundesamt: Population projection - Population aged 67 years and over in Million	Statistics	Germanys population over 67 years and over will increase in the long-term. Depending on the development of fertility, life expectations and migration, varying degrees of increase can occur.	https://www.destatis.de/EN/Themes/Society-Environment/Population/Population-Projection/_node.html [accessed October 30 2023]	
eurostat: Ageing Europe - statistics on population developments	Statistics	The overall population of the EU will become on average significantly older by 2050	https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Ageing_Europe_-_statistics_on_population_developments [accessed October 30 2023]	
Cambridge University Press: Pandemic Nationalism	Article	The disruption and burden on societies by COVID-19 and its consequences has further strengthened nationalists ideologies. Many states were exposed to immense stress and responded by turning inward.	https://www.cambridge.org/core/journals/nationalities-papers/article/pandemic-nationalism/A27CF38DC5E6F515EBAF3A7DB3D21AAD [accessed October 30th 2023]	
Corry O., Reiner D (2020), Protests and Policies: How Radical Social Movement Activists Engagement with Climate Policy Dilemmas	Article		https://doi.org/10.1177/0038038520943107 [accessed November 27th 2023]	
Kraushaar W. (2023), Zum Radikalisierungspotential der Klimaprotestbewegung, EICTP, Wien	Expert Paper		https://eictp.eu/eictp-expert-paper-zum-radikalisierungspotential-der-klimaprotestbewegung/ [accessed November 27th 2023]	
European Union (2023), Polls reveal citizen support for climate action and energy transition	Statistics		https://www.cleanenergywire.org/factsheets/polls-reveal-citizens-support-energiewende [accessed November 27th 2023]	
European Union (2023), Eurobarometer - Climate Change	Statistics	77% of EU citizens think climate change is a very serious problem at this moment.	https://europa.eu/eurobarometer/surveys/detail/2954 [accessed November 27th 2023]	
Baiardi D. and Morana C. (2020), Climate Change Awareness: Empirical Evidence for the European Union	Paper	"(...) environmental concern is directly related to per capita income, social trust, secondary education, the physical distress associated with hot weather, media coverage, the share of young people in the total population, and monetary losses caused by extreme weather episodes. It is also inversely related to greenhouse gas emissions, relative power position of right-wing parties in government and tertiary education."	http://dx.doi.org/10.2139/ssrn.3513061	
Cook, J., van der Linden, S., Maibach, E., & Lewandowsky, S. (2018), The Consensus Handbook	Report	Misinformation has a great impact on perceived consensus regarding climate change	DOI:10.13021/G8MM6P	
EEAS (2023), 1st EEAS Report on Foreign Information Manipulation and Interference Threats - Towards a framework for networked defence	Report	Threats from Foreign Information Manipulation and Interference (FIMI)	https://www.eeas.europa.eu/eeas/1st-eeas-report-foreign-information-manipulation-and-interference-threats_en [accessed November 28th 2023]	
Rose, J. To Believe or Not to Believe: an Epistemic Exploration of Fake News, Truth, and the Limits of Knowing (2020). *Postdigit Sci Educ* 2, 202–216	Paper	While the spreading of false information increased throughout the 1960s–1970s mainly for entertainment purposes, a resurgence can be observed since the 2016 US presidential election. Fake News occure in public discources (especially in online media) with social consequences.	https://doi.org/10.1007/s42438-019-00068-5	

Mobility Patterns (04)

Description: Mobility patterns influenced by work modes, leisure behaviour, and the general social situation. Mobility refers to the change of location as well as spatial change related to everyday life activities. Unmanned aircraft systems (UAS), advanced air mobility (AAM).

Trends:

- Digitalization of white collar (decline of middle class) / Digitalization of the workplace
- Working Modes such as remote and Home-office, working nomads.
- Autonomous mobility options.
- Automation of routine jobs.
- Ageing society – more leisure time / less leisure time.
- Nearly all road vehicles with zero-emission by 2050. Double rail freight traffic and triple high-speed rail traffic.
- Reforms for flight safety in the drone sector - basic legal framework could be used for later adaptation in civil-drone aviation?
- Higher levels of international air travel because of geographical dispersion of social networks.
- Advancing Digitalization of various areas of life during and after the COVID-19 Pandemic reduced public mobility while increasing commercial mobility (Home office, Home schooling, online meetings, online shopping and home deliveries etc..).
- Remote and hybrid work models benefit employees and organisations.
- International tourism is expected to fully recover after COVID-19 until 2025 or beyond. Can be further delayed due to challenges such as global inflation, economic insecurity, Energy constraints and labour shortages.
- Impact through Inflationary pressures.

Uncertainties:

- Effects on climate change on mobility.
- Tech Advancements of Mobility.
- Social Innovation of work and Mobility.
- Impact of economic and geopolitical uncertainties on tourism.

Indicators:

- Surveys on mobility patterns.
- Data on GHG-emissions
- Increasing demand for mobility services in relationship to GHG-emissions.
- Increasing environmental awareness and corresponding consumer culture.
- Data on digital infiltration.
- Digitalisation of mobility as an aspect of De-carbonization of the Mobility Sector towards 2050.
- Proportional relationship between travel behaviour and increase in household income.
- Data on demographic development .
- Data on work models.
- Increase in social and leisure trips as income of people with higher income levels rises.
- Ticket prices and Income Level.
- Less flexibility in residential location for low-income groups could lead to longer travel distances and less opportunities for social trips.

Details on the data and statistics are provided in the materials on the individual key factors on the respective reference page.

Projections: **Mobility Patterns (04)**

Focus: Demand - Low vs. High | Radius - Shrinking vs. Expanding

PROJECTION 04 A

New lifestyles no longer require long distances

Description:

A small part of the population makes extensive use of the privilege to travel for work, leisure and social status. The rest of the world relies on a lifestyle of shorter distances and personal contact. Travelling shorter distances is more common.

Impact:

Raise in Business class demand. Less overall demand. Increase of private aircraft.

PROJECTION 04 B

People are globally networked

Description:

Travel is becoming more affordable. Digitalisation in many parts of the work sector enables many people to work and travel at the same time. People live globally dispersed, but do not want to neglect personal social contact.

Impact:

Higher overall demand. Shrinking ticket prices.

PROJECTION0 04 C

15-Min cities & adapted in-frastructures in Europe's metropolises

Description:

Europe's implementation of the 15-minute cities has been successful and is appre-ciated by the population. The quality of life increases for many, since most work models allow remote working.

Impact:

Air transport industry is in less demand. Intermodular Traffic expanses

PROJECTION 04 D

Parallel local and global lifestyle

Description:

New working models have improved life in many areas, as more time is now freely available. New denser neighbourhoods, makes everyday life more dynamic, but also more stressful. Recreational areas are becoming more crowded. The desire to travel abroad is increasing as a result

Impact:

Local Modes for work and leisure are dominant. Flying concerns mostly long range. Strong diversion in flight demand between classes.

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References:
Mobility Patterns (04)

Title	Category /Publication Date	Aspect	Source/Link DOI	PDF
EEA: Transport and environment report 2022 Digitalisation in the mobility system: challenges and opportunities	Foresight Report	The importance of technologies in reducing the environmental impact of air travel	https://www.eea.europa.eu/publications/transport-and-environment-report-2022	
EPRS: Sustainable and smart mobility strategy	Briefing	Proposed Strategy of the European Commission on the transformation of the transport sector in alignment with the European Green Deal	https://www.europarl.europa.eu/thinktank/en/document/EPRS_BRI(2021)659455	
eurostat: Ageing Europe - statistics on population developments	Chart	Developement of european demographics	https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Ageing_Europe_-_statistics_on_population_developments [accessed September 18th 2023]	
DLR: DEPA 2050 - Development Pathways for Aviation up to 2050	Study Report	Die DLR-Studie (DEPA 2050) analysiert zwei besonders wahrscheinliche Szenarien für den Luftverkehr bis 2050. In beiden Szenarien werden die zukünftig zu erwartenden Emissionsentwicklungen und die daraus resultierende Klimawirkung mit Blick auf Flugzeugtechnologie, Luftverkehrsmanagement und nachhaltige Kraftstoffe untersucht.	https://www.dlr.de/de/aktuelles/nachrichten/2021/02/20210526_rueckgang-der-luftfahrtemissionen-braucht-verstaerkte-anstrengungen	
EEA: Greenhouse gas emissions from transport in the EU, by transport mode and scenario	Chart	Figure shows the trend in the GHG by sub-sector since 1990 and projections to 2040 of the EU-27	58254f4ccba344e398dadb42ffae043e [accessed September 19th 2023]	
Ipsos/Reuters Poll Data: Airlines Poll 05.02.2019	Survey	Ticket price is the most important factor when making air travel plans (for Americans).	https://www.ipsos.com/en-us/news-polls/reuters-ipsos-data-airline-poll-2019-05-16	
HABITABLE: A Conceptual Model of Climate Change and Human Mobility Interactions	Research report of ongoing project (2021-2024)	Effects on climate change on mobility	https://habitableproject.org/publication/conceptual-model-of-climate-change-and-human-mobility-interactions/	
European Commission, Directorate-General for Mobility and Transport: Study on new mobility patterns in European cities : final report	Study report	EU wide passenger survey on mobility patterns	https://data.europa.eu/doi/10.2832/728583 [accessed September 20th 2023]	
European Council: Drohnen: Reform der Flugsicherheit in der EU	Regulations	Regulations on unmanned aircraft system. Reforms for flight safety in the drone sector	https://www.consilium.europa.eu/de/policies/drones/ [accessed October 17th 2023]	
Krasteva P., Kuschmitz S. & Vietor T. (2021), Impact of Digitalization on the Mobility System	Conference Paper	Advancing Digitalization of various areas of life during and after the COVID-19 Pandemic reduced personal mobility while increasing commercial mobility (Home office, Home schooling, online meetings, online shopping and home deliveries etc.).	https://link.springer.com/chapter/10.1007/978-3-658-33466-6_21 [accessed November 28th 2023	
Mattiolo G. (2019), The impact of migration background and Social Network dispersion on air and car Travel in the UK	Conference Paper	geographical dispersion of friendship and family networks tends to increase both car and air travel, and related GHG emissions. The exception here is the presence of close family members abroad, for which there is suggestive evidence of a 'substitution effect', whereby higher levels of international air travel are compensated by lower levels of car travel in the host country.	https://www.researchgate.net/publication/334416115_The_impact_of_migration_background_and_social_network_dispersion_on_air_and_car_travel_in_the_UK [accessed November 28th 2023]	
OECD (2022), OECD Tourism Trends and Policies 2022, OECD Publishing, Paris	Trend report	International tourism is expected to fully recover after COVID-19 until 2025 or beyond. This can be further delayed due to challenges such as global inflation, economic insecurity, Energy constraints and labour shortages. (27) „Inflationary pressures are likely to further impact the aviation sector." (27)	https://doi.org/10.1787/a8dd3019-en	
Lucas, K., Moore, J., Bates, J., Carrasco, J.A. (2016), Modelling the Relationship between Travel Behaviour and Social Disadvantage, Transportation Research A 85 (2016) 157-273	Article	"equivalent rise in trip making for a given proportional increase in household income" (14) especially social and leisure trips have significant increase as income of people with higher income levels rises (15) "(...) low-income groups have less flexibility in their residential location (...), which could force them to travel longer distances to work (...), thus have less opportunity to perform social trips (...)." (16)	https://doi.org/10.1016/j.tra.2016.01.008	

Societal Values and Education (07)

Description: Social behaviours, lifestyles and attitudes of social groups in connection with individual value systems and educational attainment. Rich-Poor-Gap: Distribution of financial means in Europe [a] Globally [b].

Trends:

- Demographic development (ageing societies).
- Rich-Poor Gap:
- Automation of routine jobs and loss of low income jobs.
- Digitalization of white collar (decline of middle class).
- Nationalistic movements winning followers.
- Although based on country-specific causes, an increased visibility of nationalism can be observed globally.
- Migration / cultural clash.
- Negative impact of tertiary education on climate change attitudes.
- Types of education. (Public schooling vs. home-schooling)
- Lifelong learning.

Indicators:

- The average GDP per capita in the EU is more than double the average global GDP per capita. However, there are strong fluctuations between European countries.
- Highest average spendings on Flights per user are found in the US, despite discussion and awareness about climate change.
- Data on income levels.
- Distribution of Income varies between males and females.
- Significantly more internet purchases are being made by the younger part of the European population.
- The participation in tourism for personal purposes for the European population is distributed differently. Age and nationality show different proportions.
- Huge differences between the GDP's of individual European states.

Uncertainties:

- Care and educational work will rise in status.

Details on the data and statistics are provided in the materials on the individual key factors on the respective reference page.

Projections: **Societal Values and Education (07)**

Focus: Education for - Everyone vs. Elitist | Social equality - Decrease vs. Increase

PROJECTION 07 A

A fair share for everyone

Description:

Education has become a common good and is free. People have a common belief system. Everyone has a good work/life balance. Governments regulate income and industries.

Impact:

Privatization is decreasing. Decreasing of social inequality. Sufficient labour-force. Reduction of price differential.

PROJECTION 07 B

Some are more equal

Description:

Education is understood as important but other values outweigh it. Though certain people have privileges, there is a strong suit of equal opportunity.

Impact:

Building of well educated Elites. Building of strong unions for middle class labour-force. Separation of elite.

PROJECTION 07 C

Protest and Unions

Description:

Despite increasing inequality, the state retains decent basic education options for everyone. Large protest and civic disobedience. Society shifts away from money towards values for example of knowledge

Impact:

Increase in democratic activity. Increase in protest. High offer of well-educated labour-force. Increase in economic activity.

PROJECTION 07 D

Elite rules

Description:

Only rich families can afford decent education. Lack of qualification leads to lack of work force. Work/life balance is not good for most people.

Impact:

Lack of work force. Decrease in democratic activity. Insufficient work force. Reduction of economic activity.

References:
Societal Value and Education (07)

Title	Category /Publication Date	Aspect	Source/Link DOI	PDF
Will flight shaming influence the future of air travel?	Trend / observation	Responsible travel habits and raising awareness instead of shaming "No degree of carbon offsetting can diminish the sense of hypocrisy that accompanies such a carbon footprint when one then participates in discussions about climate destruction and responsible tourism. It is well established that a mere concern for climate change or pro-environmental household behaviours do not correlate with individuals' likelihood to engage in non-work-related flights.8 Shaming, or the related virtue signalling, may not be the most effective means of promoting behavioural change. Shame is a negative emotion that is regarded as an affective determinant of health." (pg. 2)	doi: 10.1093/jtm/taz088	
Statista: What would you rank as most important consideration before buying an airline ticket for personal travel?	Statistics	Ticket prices by far the most important factors regarding purchase consideration	https://www.statista.com/statistics/1017342/us-air-travel-important-aspects-booking-personal-travel/ [accessed Octobber 27th 2023]	
Statista Mobility Market Outlook: Mobility Services Report 2020	Statistics	The average GDP per capita in the EU is more than double the average global GDP per capita. However, there are strong fluctuations between European countries	2021_Recherche-PPT-oe_SO (S. 95)	
Statista Mobility Market Outlook: Mobility Services Report 2020	Statistics	Highest average spendings on Flights per user are found in the US, despite discussion about climate change	2021_Recherche-PPT-oe_SO (S. 105)	
eurostat: Mean and median income by age and sex - EU-SILC and ECHP surveys	Statistics	Distribution of Income varies between males and females (Ages 18-64)	https://ec.europa.eu/eurostat/databrowser/view/ILC_DI03__custom_2621595/default/bar?lang=en [accessed Octobber 30th 2023]	
eurostat: Ageing Europe - statistics on population developments	Statistics	The overall population of the EU will become on average significantly older by 2050	https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Ageing_Europe_-_statistics_on_population_developments [accessed October 30 2023]	
eurostat: Ageing Europe - statistics on social life and opinions	Statistics	Significantly more internet purchases are being made by the younger part (Ages 16-54) of the European population. The figure also shows strong differences in the population proportion making purchases online of individual European countries	https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Ageing_Europe_-_statistics_on_social_life_and_opinions [accessed October 30 2023]	
eurostat: Persons participating in tourism for personal purposes by age group	Statistics	The participation in tourism for personal purposes for the European population is distributed differently. Age and nationality shows different proportions	https://ec.europa.eu/eurostat/databrowser/view/tour_dem_toage/default/line?lang=en [accessed October 30 2023]	https://ec.europa.eu/eurostat/databrowser/view/tour_dem_toage/default/line?lang=en
eurostat: Real GDP per capita	Statistics	Huge differences between the GDPs of individual European states	https://ec.europa.eu/eurostat/databrowser/view/sdg_08_10/default/bar?lang=en [accessed October 30 2023]	
Florian Bieber: Is Nationalism on the Rise? Assessing Global Trends	Article	Although based on country-specific causes, an increased visibility of nationalism can be observed globally	https://www.tandfonline.com/doi/full/10.1080/17449057.2018.1532633 [accessed October 30 2023]	
Baiardi D. and Morana C. (2020), Climate Change Awareness: Empirical Evidence for the European Union	Paper	"(...) negative impact of tertiary education on climate change attitudes (...). In this respect, given the sizable economic, financial, social, and political consequences of climate change, the inclusion of climate change education into academic curricula in social sciences appears to be not only sound, but also extremely urgent."	http://dx.doi.org/10.2139/ssrn.3513061	
UBA Umweltschonender Luftverkehr lokal – national – international	Report/ 2019	Anteile der Energieverbrauchertypen in den sozialen Milieus (S. 20)	https://www.umweltbundesamt.de/publikationen/umweltschonender-luftverkehr	
UBA Umweltschonender Luftverkehr lokal – national – international	Report/ 2019	5.2.4.2 Alternatives Reiseverhalten und Trends (S. 108 ff)	https://www.umweltbundesamt.de/publikationen/umweltschonender-luftverkehr	

Customer Experience (08)

Description: Airport service experience for both passengers and cargo along with supporting Infrastructure (digitalisation, automation, security). Flight Experience: On-board flight experience (part of Intermodal modes of transport, mobility on board, internet, comfort, noise, etc..).

Trends:

- Digitalisation and Automation.
- Increased Airport and Cyber Security.
- Expansion of the non-aviation sector e.g. more leisure activities and shopping opportunities.
- Mobility as a Service (MaaS) concept for intermodal modes of transport.
- Implementation and use of AI technologies.

Indicators:

- User share of WiFi usage.
- Accessibility during the journey.
- Polls and surveys on in-flight experience.
- Polls and surveys on passenger satisfaction.
- Faster implementation of automation because of Covid-19.

Uncertainties:

- New AI Cyber-Threats e.g. on data leakages.

Details on the data and statistics are provided in the materials on the individual key factors on the respective reference page.

Projections: **Customer Experience (08)**

Focus: Delay from door to door - Low vs. High | Functionality - Technical vs. Luxury

PROJECTION 08 A

Fast-paced Airports in the City

Description:

Airports become part of many cities and replace existing infrastructures like shopping malls, conference centres, hotels, etc.. They can be reached easily and offer fully automated door to door check-in service. Transition to flight is seamless. On flight there are multiple modular options to customize your seat as bed, work station, community space, etc..

Impact:

The role of the airport changes and becomes a centre for social interaction. Access and Services are regulated through financial means. City infrastructure changes along.

PROJECTION 08 B

Boutique Airports

Description:

Airports become like fully functioning cities, offering subscribed living options for people who fly frequently. Due to their economic role, airports become mayor traffic hotspots, where all other infrastructure meets. Even though it takes time to travel, the experience is seamless and allows you to remain in your daily routine. On flight, there are multiple modular options to customize your seat as bed, workstation, community space, etc.

Impact:

Airports become shielded interconnected communities, allowing for new living models.

PROJECTION 08 C

Networked central and local airports

Description:

Networked cooperation between all Airports within the EU. Centralized Super Airports are becoming main points of approach for flights from abroad, while decentralized regional airports are mainly responsible for handling the transport of passengers to their destinations. Passengers are being distributed more efficiently by optimized sized aircraft to reduce airport congestion and environmental impact. Less delay but still moderate waiting time due to transfer

Impact:

Network of airports allows for new aircraft and traveling concepts/experiences.

PROJECTION 08 D

High security & remote central airports

Description:

Airports are becoming pure transit stations and only serve pragmatical purposes.
To reduce impact on the environment, airports are located outside of city centres. Airports are not easily accessible at all times by public transport. Extensive Security Control causes high delay. Globally rules & regulations are NOT synched.

Impact:

Airports become an obstacle for a seamless and interconnected travel experience.

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References:
Customer Experience (08)

08 Sources

Title	Category /Publication Date	Aspect	Source/Link / DOI	PDF / Image
(DLR: DEPA 2050 - Development Pathways for Aviation up to 2050)	Study Report	Die DLR-Studie (DEPA 2050) analysiert zwei besonders wahrscheinliche Szenarien für den Luftverkehr bis 2050. In beiden Szenarien werden die zukünftig zu erwartenden Emissionsentwicklungen und die daraus resultierende Klimawirkung mit Blick auf Flugzeugtechnologie, Luftverkehrsmanagement und nachhaltige Kraftstoffe untersucht. Beschleunigte Automatisierung durch Folgen von Covid-19 z.B. weniger Kontaktpunkte an Flughäfen (Siehe S. 88-90)	https://www.dlr.de/de/aktuelles/nachrichten/2021/02/20210526_rueckgang-der-luftfahrtemissionen-braucht-verstaerkte-anstrengungen	
Statista: Projected size of the global in-flight Wi-Fi market from 2021 to 2031	Statistics	In-flight Wi-Fi - market size worldwide 2021-2031	https://www.statista.com/statistics/624184/inflight-wifi-market-size/ [accessed September 19th 2023]	
Statista: Factors respondents considered to be more important for the enjoyment of inflight experience following the COVID-19 pandemic in 2020 and 2021	Statistics	Important factors for inflight experience	https://www.statista.com/statistics/1186673/factors-inflight-experience-aviation-coronavirus/	
Statista: Passenger satisfaction rate during their journey in 2019, sorted by processing steps and type of passenger	Statistics	Passenger satisfaction	https://www.statista.com/statistics/572571/airline-passengers-travel-experience-emotions-per-phase/	
EAAI HLG: The FLY AI Report Demystifying and Accelerating AI in Aviation/ATM	Research Report	Overview of ways that artificial intelligence is already applied in the aviation industry and assesses its potential to transform the sector	https://www.eurocontrol.int/publication/fly-ai-report	
Statista: Mobility-as-a-Service (MaaS) worldwide	Statistics report	Revenue forecast für 2017-2025	in 2021_Recherche-PPT-oe_SO, S.45	
Statista: How much would the following new measures improve your confidence during the flight?	Statistics	Costumer Survey on measures for better flight confidence during Covid - Covid could have impact on digitalisation and automation of flight services in general.	https://www.statista.com/statistics/1186671/confidence-measures-inflight-aviation-covid/ [accessed October 17th 2023]	
AVIATION SAFETY (EPAS) 2023-2025 VOLUME I **Strategic priorities** European Union Aviation Safety Agency	Report / 2023	Busienss Models Airports Noise Risk Assessment	https://www.easa.europa.eu/en/document-library/general-publications/european-plan-aviation-safety-epas-2023-2025#group-easa-downloads	

Technological Advances in the Energy Sector (09)

Description: The innovations in energy production and its implications on power storage solutions for aviation. Production of sustainable aviation fuels and the effect of advancements in propulsion technologies on the energy mix for aviation.

Trends:

- Central Transition Aspects: Production, Electrification, Storage.
- High Impact Technologies e.g. PV, Smart Grids, Batteries, Organic Electronics, Floating Wind Farms, Nuclear Fusion, SAFs.
- De-carbonization (private and industries).
- Alternative fuel development e.g. Sustainable Aviation Fuels. (SAF) Decentralisation of energy production and distribution.
- Raise in overall energy Demand.

Indicators:

- Technology trend reports.
- Policy advice reports.
- Current and expected energy demand.
- 80-90% global renewable Energy Production by 2050 (PV, Wind, Nuclear, eFuels, Hydrogen).

Uncertainties:

- Carbon Capture Technologies.
- Atom/Fusion Reactors.
- Computing (AI, Quantum).
- Carbon Trade.
- Degree of electrification.
- Energy demand.

Details on the data and statistics are provided in the materials on the individual key factors on the respective reference page.

Projections: **Technological Advances in the Energy Sector (09)**

Focus: Availability of resources - Rare vs. Abundant | Global energy production - Fragmented vs. Standardized

PROJECTION 09 A

Sharing is caring

Description:

Due to a lack of natural resources and acceptance renewable energy production lacks behind its targets. Negotiations for which sectors Emissions can to be reduced (e.g. Transportation, heavy industries, heating). Global arrangements guarantee the production and distribution of limited amounts green hydrogen and battery technologies. Production happens where its most effective (Africa, gulf regions) with financial and technological support from Europe.

Impact:

Fossil Fuels are still used for energy production except in a few sectors. Economical redistribution through global energy trade. Energy Price stagnates/raises.

PROJECTION 09 B

World of plenty

Description:

Renewable energy production exceeds demand due to expanded and effective use of different technologies. Huge production capacities for green hydrogen. Smart Grids enabling effective distribution of power. De-carbonization of heavy industries and heating.

Impact:

End of fossil fuels. Energy price is low.

Projection 09 C

Energy crisis

Description:

Energy becomes a political weapon for influence. Renewable Energy stagnates due to lacking resources and infrastructure.

Impact:

Due to a lack of resources prices are roaring. Inequality between states ans society.

PROJECTION 09 D

Roaring markets

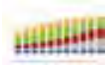
Description:

Expansion of renewable energy production. Building of new energy cartels. Economic redistribution due to electricity production. Hurdles because of different standards and technologies for energy distribution.

Impact:

Energy Prices are volatile to market development.

References:
Technological Advances in the Energy Sector (09)

Title	Category /Publication Date	Aspect	Source/Link DOI	PDF
ITONICS: Trends & Technologies Shaping the Future of the Energy Industry	Foresight Report	High Impact Technologies: PV, Smart Grids, Batteries, Organic Electronics, Floating Wind Farms, Nuclear Fusion, SAFs	https://www.itonics-innovation.com/blog/trends-and-technologies-energy-industry	
McKinsey: Global Energy Perspective 2022	Foresight Report	80-90% global renewable Energy Production by 2050	https://www.mckinsey.com/~/media/McKinsey/Industries/Oil%20and%20Gas/Our%20Insights/Global%20Energy%20Perspective%202022/Global-Energy-Perspective-2022-Executive-Summary.pdf	
McKinsey: Technology Trends Outlook 2022 Clean Energy	Foresight Report	Central Transition Aspects: Production, Electrification, Storage	https://www.mckinsey.com/spContent/bespoke/tech-trends/pdfs/mckinsey-tech-trends-outlook-2022-clean-energy.pdf	
Agora: European Energy Transition 2030: The Big Picture	Policy Advice Report	10 Megatrends: 1. Decarbonization challenge 2. Deflation of fossil fuel prices 3. Decrease in costs 4. Digitalization 5. Electrification 6. Dominance of fixed costs 7. Influential cities 8. Demographic and economic change in rural areas 9. Decentralization 10. Interdependence	https://www.agora-energiewende.de/fileadmin/Projekte/2019/EU_Big_Picture/153_EU-Big-Pic_WEB.pdf	
Statista: Energy consumption worldwide from 2000 to 2019, with a forecast until 2050, by energy source	Statistic	Raising worldwide energy demand	https://www.statista.com/statistics/222066/projected-global-energy-consumption-by-source/	
eurostat: International trade in products related to green energy	Statistics	EU trade in green energy products	https://ec.europa.eu/eurostat/statistics-explained/index.php?title=International_trade_in_products_related_to_green_energy	
Trend reportv Energy 2023 / 2024	Website / 2023		https://www.startus-insights.com/innovators-guide/top-10-energy-industry-trends-innovations-in-2021/	
EEA Energy Technology Perspectives 2023 Executive summary	Report / 2023	**The energy world is in the early phase of a new industrial age – the age of clean energy technology manufacturing.** Industries that were in their infancy in the early 2000s, such as solar PV and wind, and the 2010s, such as EVs and batteries, have mushroomed into vast manufacturing operations today. The scale and significance of these and other key clean energy industries are set for further rapid growth. Countries around the world are stepping up efforts to expand clean energy technology manufacturing with the overlapping aims of advancing net zero transitions, strengthening energy security and competing in the new global energy economy. The current global energy crisis is a pivotal moment for clean energy transitions worldwide, driving a wave of investment that is set to flow into a range of industries over the coming years. In this context, developing secure, resilient and sustainable supply chains for clean energy is vital.	https://www.iea.org/reports/energy-technology-perspectives-2023/executive-summary	
		Possible Infrastructures		

Advancement in Aviation Design (10)

Description: Linear and/or disruptive advancements in aviation design, including certification and length of Life-Cycle (production, service life and recycling/disposal).

Trends:

- Reducing In-Flight Energy.
- Aerodynamic retrofitting.
- Laminar flow control.
- Composite fuselage and wings.
- Folding wing-tips.
- Ultra-high aspect ratio Wings.
- Propulsion Systems.
- Rolls Royce Ultrafan.
- Open Fan.
- Blended Wing / Mono Wing.
- Light weight Material and Structures.
- Additive manufacturing (3D-printing). - definition
- Structural health monitoring.
- Integrated structures (Systemleichtbau) - fuel storage, heat transfer or integrated systems.
- New Tube and Wing Concepts.
- Blended Wing Body.
- Transonic truss-braced wing body.
- Changing the Fuel.
- SAF (global SAF mix will have residual emissions).
- 100% paraffinic SAF compatibility by 2030.
- ASTM Standard for Fully formulated SAF by 2024.
- Hydrogen Aircraft.
- 2022 - 2027 announced working small/medium demonstrators ZeroAvia, Universal Hydrogen, Cranfield Aerospace.
- 2035 Airbus 100+ pax aircraft.
  Role of hydrogen until 2050 is marginal (6.5%), but relevant from 2060 onwards.
- Critical Technologies: Thermal management, Low-temp fuel cells, Liquid H2 Tanks, Dry Wings, ultra-efficient electric motors.
- Batteries & Hybrid.
- Solid state Batteries (Li-S).
- Manufacturing process.
- Cabin Design innovations.
- MDO (Machine Direction Orientation).
- WINFC-project aimed to create a data driven module to collect and process information e.g. coming from weather.

Indicators:

- Certification for aviation designs.
- Cooperation between manufacturing companies.
- Planned Demonstrators.
- EU - data on funds to further tech sector (Projects like Horizon Europe etc.).
- Research on Patents.

Uncertainties:

- Certification Processes.
- Role of Technologies.
- AI Technology.
- Innovations in fuel development.
- Innovations in battery development.
- Innovations in Fuel Cell & H2 Storage development.
- Development of Infrastructures for alternatives Fuel concepts.
- Financing policies EU vs. Private sector.

Details on the data and statistics are provided in the materials on the individual key factors on the respective reference page.

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Projections: **Advancement in Aviation Design (10)**

Focus: Aircraft Classes - Open vs. Fixed | Primate - Cost efficiency & profit vs. Sustainability

PROJECTION 10 A

Alternative flight modes

Description:

Manifold aircraft manufacturers. Start-ups tracking disruptive green innovations. New Materials and energy supply options.

Impact:

Rethinking of classical modes of transport for all ranges. Bottleneck in certification.

PROJECTION 10 B

The sustainable fleet

Description:

Concentration of all R&D developments on 3 aircraft classes. Concentration of research and political efforts. Less openness to technology.

Impact:

Fast results from research and certification. Political and financial support for change of infrastructure.

PROJECTION 10 C

Ecology of Air Vehicles

Description:

Manifold of aircraft manufacturers. Development of new aircraft classes with conventional propulsion. Development of UAM. Development of air vehicles for urban areas.

Impact:

Increase of start-ups. Increase in luxury segment for private jets. Lack of regulation and certification.

PROJECTION 10 D

The profitable Aircraft

Description:

Clear design specifications to maximize production efficiency. Profit comes above any type of sustainability.

Impact:

Increase in luxury segment first class for charter flights.

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References:
Advancement in Aviation Design (10)

Title	Category /Publication Date	Aspect	Source/Link DOI	PDF
Airbus: Future aircraft - What might the future of flight look like?	Informational website	Showing off future aircraft projects by Airbus	https://www.airbus.com/en/innovation/disruptive-concepts/disruptive-design/future-aircraft [accessed October 17th 2023]	
TUDelft: Flying-V - Flying long distances energy-efficiently	Informational website	Ongoing research project of an alternative airplane concept	https://www.tudelft.nl/en/ae/flying-v [accessed October 17th 2023]	
DLR: DEPA 2050 - Development Pathways for Aviation up to 2050, S. 92	Study Report	significant reduces in aircraft noise can be achieved through hybrid-electric, pure electric or other alternative propulsion systems - changes in aircraft design for practical reasons	https://www.dlr.de/de/aktuelles/nachrichten/2021/02/20210526_zueckgang-der-luftfahrtemissionen-braucht-verstaerkte-anstrengungen	
European Commission: Weather Information Fusion and Correlation for weather and traffic situational awareness	project paper	WINFC-project aimed to create a data driven module to collect and process information e.g. coming from weather. Its function is to assist pilots to immediately detect hazard conditions while in flight.	https://trimis.ec.europa.eu/project/weather-information-fusion-and-correlation-weather-and-traffic-situational-awareness [accessed October 30th 2023]	
IATA Net Zero Raodmap	2022	Technology Roadmap for aircraft technology	https://www.iata.org/en/programs/environment/roadmaps/ [accesses 23.11.2023]	
SE2A Cluster Advancements	Various Papers	Publications	https://www.tu-braunschweig.de/en/se2a/research/publications	
Future of Aviation	Project Meeting / 2019	Forecastings of Development of Aviation industry and technological advancement	https://www.icao.int/Meetings/FutureOfAviation/Pages/default.aspx	
KPMG Aviation 2030 Disruption and its implications for the aviation sector Thriving on disruption series	Report / 2019	Disruption radar: Sector disruption radar with examples (technologies and business models) by illustrative relative maturity	https://assets.kpmg.com/content/dam/kpmg/xx/pdf/2019/12/aviation-2030.pdf	
Technology trajectory in aviation: Innovations leading to value creation (2000e2019) International Journal of Innovation Studies 6 (2022) 128e141	Article / 2022	Technololgy review in the aviation industry - separted into 5 clusters: 1.Aircraft technology 2. Innovation /technology in passenger services 3. Innovation in flying 4. Business and operational management 5. General applications	https://doi.org/10.1016/j.iis.2022.05.001	
EASA Aircraft & products	Website / 2023		https://www.easa.europa.eu/en/domains/aircraft-products	

Propulsion Technology as Driver of e-Mobility Diffusion (12)

Description: Acceptance, penetration rate and dissemination of different concepts for propulsion energy systems as well as their generation and storage, especially for the European aviation sector.

Trends:

- Easy access to low level transportation such as e-scooter and e-bikes (e-mobility as an integration into daily routine).
- Penetration of new markets in Asia and Latin America.
- Increasing global electric power demand.
- Target for low-emission transport modes.
- Research projects on alternative propulsion systems.

Indicators:

- Regulation for civil aviation.
- Data on the need for resources for certain energy sources.
- E.g. water & electrical energy to generate hydrogen.

Uncertainties:

- Prices for resources and sources of energy, especially electricity.
- Availability of resources for certain energy sources in the EU.
- Financing through policies.
- Acceptance of alternative aviation fuels / propulsion systems.

Details on the data and statistics are provided in the materials on the individual key factors on the respective reference page.

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Projections: **Propulsion Technology as Driver of e-Mobility Diffusion (12)**

Focus: Energy storage - Solid vs. Liquid | Emissions - Low vs. High

PROJECTION 12 A

Hybrid Electrical/ SAF /Turbine

Description:

Energy for mobility relies on sources with high emission. People travel a lot using vehicles with high emissions. The types of energy sources are in a solid state. Being heavy and are less useful for long haul aircraft. E-Mobility is only tolerated.

Impact:

Aircraft need to be built with lighter material. Long haul aircraft are less possible. People travel a lot using vehicles with high emissions.

PROJECTION 12 B

Kerosene / SAF Turbine

Description:

Mobility relies on fossil fuels with high emissions. The source is in a liquid state and is consumed as the source for propulsion. Fuel is consumed to generate movement. E-Mobility is rarely available.

Impact:

Aircraft design stays as is. Mobility stays a huge driver for climate crisis.

PROJECTION 12 C

Battery Powered

Description:

Mobility is almost completely based on batteries. Different types of batteries and electric energy are the main source. Solid-state source keeps the weight of the power bank constant. E-Mobility is readily available.

Impact:

Emissions are low. Long haul flights are harder to make possible. Aircraft design needs to be extremely light weight. Less long distance air travel.

PROJECTION 12 D

Hydrogen

Description:

Mobility design is so advanced and secure for the use of hydrogen. Hydrogen infrastructure needs to be built to become truly green. E-Mobility is advanced, available based on hydrogen power.

Impact:

Air travel can be understood as less safe. New business models for hydrogen / mobility may come up. New business models for hydrogen / mobility may come up.

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References:
Propulsion Technology as Driver of e-Mobility Diffusion (12)

Title	Category /Publication Date	Aspect	Source/Link DOI	PDF
Airbus: Future aircraft - What might the future of flight look like?	Presented projects	Future aircraft projects with focus on alternative propulsion systems and low-carbon energy sources such as electricity or hydrogen	https://www.airbus.com/en/innovation/disruptive-concepts/disruptive-design/future-aircraft [accessed September 20th 2023]	
European Parliament, Council of the European Union: Regulation (EU) 2018/1139 of the European Parliament and of the Council of 4 July 2018 on common rules in the field of civil aviation and establishing a European Union Aviation Safety Agency, and amending Regulations (EC)	EU Regulation	EU Regulation on civil aviation	http://data.europa.eu/eli/reg/2018/1139/oj [accessed September 20th 2023]	
EPRS: Sustainable and smart mobility strategy	Briefing	Proposed Strategy of the European Commission on the transformation of the transport sector in alignment with the European Green Deal	https://www.europarl.europa.eu/thinktank/en/document/EPRS_BRI(2021)659455	
McKinsey: Technology Trends Outlook 2022 Clean Energy	Foresight report	Central Transition Aspects: Production, Electrification, Storage	https://www.mckinsey.com/xp/Content/bespoke/tech-trends/pdfs/mckinsey-tech-trends-outlook-2022-clean-energy.pdf	
Power-to-Liquids – A scalable and sustainable fuel supply perspective for aviation. UBA, Batteiger, V., Ebner, K., Habersetzer, A., Moser, L., Schmidt, P., Weindorf, W., & Raksha, T. (2022). *Power-to-Liquids – A scalable and sustainable fuel supply perspective for aviation.*	Report / 2022	Power to Liquide aviation fuel production	https://www.umweltbundesamt.de/en/publications	
Power-to-Liquids – A scalable and sustainable fuel supply perspective for aviation. UBA, Batteiger, V., Ebner, K., Habersetzer, A., Moser, L., Schmidt, P., Weindorf, W., & Raksha, T. (2022). *Power-to-Liquids – A scalable and sustainable fuel supply perspective for aviation.*	Report / 2022	Current Technology Readiness Levels (TRL) of production pathways to renewable jet fuel	https://www.umweltbundesamt.de/en/publications	
Smart and Sustainable Mobility Adaptation Toward the Energy Transition	Chapter / 2022	In this manner and for the sake of simplicity, we will employ the following common and easy-to-apply indicators from the SUMI and SMP2.0 that give us great insights into mobility trends and if the SDG targets are being met for these two Portuguese cities. In the following sections, we will introduce and explore these indicators by explaining what they measure and why they are important. Ultimately, this macroanalysis will lead us to an easy-to-read circular graph that characterizes the cities in analysis.	https://onlinelibrary.wiley.com/doi/chapter-epub/10.1002/9783527833634.ch7	
Sustainable Aviation Fuel 'Facilitation Initiative'	Grant Agreement Docuwemnt / 2019	**Table 2** Overview of low TRL (Research Project) fuel pathways (with established production pathways added for context)	https://www.easa.europa.eu/en/document-library/research-reports/grant-agreement-easa2015fc21-0 (Accessed 01.12.2023)	
EASA Environmental Report	Report / 2022		https://www.easa.europa.eu/eco/sites/default/files/2023-02/EnvironmentalReport_EASA_summary_12-online.pdf (Accessed 01.12.2023)	
IATA Policy Net-Zero Roadmap	Report / 2022	outline the policies that will be the most needed per energy type over the 2023 – 2050 horizon.	https://www.iata.org/contentassets/8d19e716636a47c184e7221c77563c93/energy-and-new-fuels-infrastructure-net-zero-roadmap.pdf	
IATA Net zero 2050: new aircraft technology	Fact Sheet / 2023	Brief Overview of Hybrid-electric/ Fully electric Hydrogen	https://www.iata.org/en/iata-repository/pressroom/fact-sheets/fact-sheet-new-aircraft-technology/	

Air Traffic Demand (14)

Description: The demand for air travel in response to the primacy of labour models, modes of business communication and the options available for intermodular travel.

Trends:

- Intermodular mobility (combining train, aircraft, (e-)car, (e-)bike, e-scooter, bus, subway etc..). Weather conditions (caused by Climate Change) affecting air travel.
- Social-Economic developments (means to travel).
- Demographic development / Ageing Society (leisure time).
- Working Modes such as remote and Home-office, working nomads, Digitalization of the workplace.Autonomous mobility options.
- Penetration of new markets in Asia and Latin America.
- Expected growing market in China.
- "Flight-shaming" movement and investments by airlines in researching sustainable alternatives.
- VR Travelling.
- EU trend towards alternative means of travel.

Indicators:

- Ticket prices as the most important factor regarding purchase consideration.
- Expected rising growth rates for the global flight segment.
- Strongest demand for flights within Europe in 2019 was in Germany
- Highest average spendings on flights per user today are found in the US. Rising growth rates are to be expected in Europe.

Uncertainties:

- Weather changes relevant now for air travel may be not relevant through tech advances.
- Ticket-price development.
- Demand for intermodular travel options.

Details on the data and statistics are provided in the materials on the individual key factors on the respective reference page.

Projections: **Air Traffic Demand (14)**

Focus: Rich-Poor gap - Decrease vs. Increase | Main transport - Intermodality vs. Air traffic

PROJECTION 14 A

Flying for the masses

Description:

Increasing ATD because of growing mobility of middle class. High ATD because of leisure/travel despite virtual options. The market share of air travel increases globally. Air travel is for mass transportation and cheap.

Impact:

Comfort decreases. Monthly travel passes for airline.

PROJECTION 14 B

Flying for the few

Description:

Air-transport is further divided to class (wooden/luxury class). Overall demand is high. Cheap air travel is limited and the prices increase according to comfort. Pricing for air travel fluctuates.

Impact:

New market segments in first class.

PROJECTION 14 C

Local mobility pass

Description:

Increasing demand for overall travel of prospering societies. Intermodular transportation systems focus not only on local regions but on global offers. Regions such as the EU offer monthly passes for the entire transportation system. Air travel has become one of many means even for long distance. R&D focuses on the entire transportation system.

Impact:

Decreased air traffic volume. A decreased in air traffic demand can have positive environmental impacts. Taxation of companies to finance the options.

PROJECTION 14 D

Local travel for the few

Description:

Diverse but pricey intermodular Options lead to high mobility for wealthy people. Poor people can rarely afford traveling at all and are bound to their regions.

Impact:

ATD shrinks due to diversification of transport. Financial inequality makes only luxury segment profitable.

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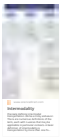
References:
Air Traffic Demand (14)

Title	Category /Publication Date	Aspect	Source/Link DOI	PDF
Decarbonisation Pathways for Transport. In *Achieving the Paris Climate Agreement Goals* (pp. 187–222)	Book Chapter	Transport demand in regard to socio-economic factors (ex GDP) plus eletrification - anaylising various means of transportion - adding to the argument of intermodal mobility	Teske, S., & Niklas, S. (2022). Decarbonisation Pathways for Transport. In *Achieving the Paris Climate Agreement Goals* (pp. 187–222). https://doi.org/10.1007/978-3-030-99177-7_8 (Teske & Niklas, 2022)	
Statista: What would you rank as most important consideration before buying an airline ticket for personal travel?	Statistic	Ticket prices by far the most important factors regarding purchase consideration	https://www.statista.com/statistics/1017342/us-air-travel-important-aspects-booking-personal-travel/ [accessed October 27th 2023]	
Statista: Market insights: Flights - Worldwide	Analyst opinion	"Leading the Asian market, the Flights market of Mainland China is expected to grow significantly in the following years. One of the reasons for this trend is that more and more Chinese people can afford traveling abroad. The European Shared Mobility market is dominated by a strong Flights market which offers low-cost airlines and thus makes flying an affordable mode of transportation for a large share of the European population."	https://www.statista.com/outlook/mmo/shared-mobility/shared-vehicles/flights/worldwide [accessed October 27th 2023]	
Statista: Market insights: Flights - Worldwide	Analyst opinion	"Nevertheless, one of the biggest challenges the market is currently facing is the increasing sentiment for sustainability among the population. The "flight shaming" movement raises public attention toward the environmental effects of flying and promotes huge investments by airlines in researching sustainable alternatives. Examples of this are sustainable aviation fuel or hydrogen technologies. In some regions, price increases due to the carbon tax continue to drive the investments in alternative ways to power aircraft."	https://www.statista.com/outlook/mmo/shared-mobility/shared-vehicles/flights/worldwide [accessed October 27th 2023]	
Statista Mobility Market Outlook: Mobility Service Report 2020	Statistics	Expected rising growth rates for the global Flights segment (2017-2025)	2021_Recherche-PPT-oe_SO (S. 96-97)	
Statista Mobility Market Outlook: Mobility Service Report 2020	Statistics	Strongest demand for flights within Europe in 2019 in Germany	2021_Recherche-PPT-oe_SO (S. 102)	
Statista Mobility Market Outlook: Mobility Service Report 2020	Statistics	Highest average spendings on Flights per user today are found in the US. Rising growth rate are to be expected in Europe	2021_Recherche-PPT-oe_SO (S. 105-106)	
Intermodality	Website / 2023	Intermodality for and against increase in air travel demnand	https://www.sciencedirect.com/topics/social-sciences/intermodality	

Structure and Position of Aviation Companies (15)

Description: Market division and dynamics (incumbents/start-ups) and political influence (Lobbyism) of aviation companies (manufacturers, airlines) in the EU (i.e. the European market).

Trends:

- Air travel seen as a major factor of climate change.
- Intermodality of travel.
- Start-ups in aviation manufacturing with alternative energy sources.
- Growing trends of air travel.
- Trends of Aviation companies.

Uncertainties:

- Decline for subsidisation of kerosene.
- Air travel is being substituted.
- Restructuring of the market (e.g. Bankruptcies of State-Airlines).

Indicators:

- Global Flights Revenues are expected to rise and catch up to the Pre COVID-19 growth rate.
- Biggest growth rate in Flight bookings in China markets.
- The United Kingdom has the biggest market among the countries in Europe.
- Expected rising penetration rate of consumers adopting flights in several countries. Based on the predicted course of innovation diffusion.
- Even if people don't fly, Cargo flights rise.

Details on the data and statistics are provided in the materials on the individual key factors on the respective reference page.

Projections: **Structure and Position of Aviation Companies (15)**

Focus: Lobby - No influence vs. High influence | Structure - Oligopoly vs. Monopolization

PROJECTION 15 A

Monopolization through forced fusion

Description:

Due to the poor crisis resistance of commercial airlines, Europe decided to take the drastic step of uniting the main European airlines under the leadership of the European Union. All economic related activity is highly regulated to fight prevent and reduce corruption and wasteful management of airline members.

Impact:

Direct economic gains for Europe. Single legal basis for the whole of Europe's airspace. New sales models for Europeans.

PROJECTION 15 B

Monopolistic European air company with high lobbyism influence

Description:

One major European airline buys up all other major airlines in Europe over time and operates them under a newly established parent company for this purpose. The EU deliberately stays out of the airline's business, which subsequently favours lobbyism.

Impact:

Less political regulation. Higher tax revenues.

PROJECTION 15 C

High competition between incumbent and start-up players

Description:

Flourishing of various specified airlines and manufacturers engaged in supporting activities. New aircraft types and propulsion technologies are researched and tested. Wide spread of companies across the market segments.

Impact:

High competitiveness against global companies in the airline industry. High investment in research and innovation.

PROJECTION 15 D

Oligopoly of competing manufacturers and airlines

Description:

Collusion among airlines and manufacturers. High influence in European politics. Hardly any new start-ups within the airline industry.

Impact:

Aligning pricing policy at European level. High ticket prices. Weakened willingness to innovate in propulsion technologies and fuels.

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References:
Structure and Position of Aviation Companies (15)

Title	Category /Publication Date	Aspect	Source/Link DOI	PDF
European Commission: Mobility and Transport/Transport Modes/Air/ Environment: **EU mechanisms to reduce emissions**	website	list of active EU measures to tackle environmental impact in the aviation sector - showing great importance because of the resources already being used for this	https://transport.ec.europa.eu/transport-modes/air/environment_en [accessed October 17th 2023]	
Statista Mobility Market Outlook: Mobility Service Report 2020	Statista/ 2020	Global Flights Revenues are expected to rise and catch up to the Pre COVID-19 growth rate	2021_Recherche-PPT-oe_SO (S. 97)	
Statista Mobility Market Outlook: Mobility Service Report 2020	Statista/ 2020	Biggest growth rate in Flight bookings in China markets	2021_Recherche-PPT-oe_SO (S. 98)	
Statista Mobility Market Outlook: Mobility Service Report 2020	Statistics/ 2020	The United Kingdom as the biggest market among the countries in Europe	2021_Recherche-PPT-oe_SO (S. 99)	
Statista Mobility Market Outlook: Mobility Service Report 2020	graph/ 2020	Expected rising penetration rate of consumer adopting Flights in several countries. Based on the predicted course of innovation diffusion.	2021_Recherche-PPT-oe_SO (S. 103)	
Statista: Leading airlines in Europe in 2022, based on passenger traffic	Statistics/ 2022	Irish budget airline Ryanair Group to be the leading airline company in Europe in 2021	https://www.statista.com/statistics/1094759/largest-airlines-in-europe-based-on-passengers/ [accessed October 30th 2023]	
Statista: Transport volume of air cargo in Germany* from 2006 to 2022	Statistics	Even if people don't fly Cargo flights may rise (as in the pandemic!)	https://www.statista.com/statistics/590498/transport-volume-air-cargo-germany/ [accessed October 30th 2023]	
Development of Passenger demand for air travel	Statistic / Nov 2023	The strong air passenger recovery continues in Q3 2023 **Revenue passenger-kilometers (RPKs) by airline region, % change for Q3 2023**	https://www.iata.org/en/iata-repository/publications/economic-reports/airline-market-share-profiles-vary-across-regions/ (accessed Dec 1, 2023)	
Study on urban mobility interconnection with air transport infrastructure: final report.	Study Report / June 2021	The study on Urban mobility interconnection with air transport infrastructure was developed under DG MOVE's Framework Contract MOVE/A3/2017-257 for Impact Assessment and Evaluation and corresponds to a support study for the evaluation of Regulation (EU) N° 1315/2013 on Union Guidelines for the development of the transEuropean transport network. The objective is to provide additional evidence on the connections between the airports of the TEN-T network and the centre of the cities they are serving, as well as between these airports and the passenger hubs which allow to connect air transport with railway nodes. This work shall contribute as additional evidence for the impact assessment for the revision of the TEN-T Regulation. Regulation (EU) No 1315/2013, of which certain provisions relate to the so-called urban nodes (i.e. the cities on the network) and to the airport connections by rail, including high-speed.	https://data.europa.eu/doi/10.2832/42145	
Future of Aviation	Project Meeting / 2019	Forecastings of Development of Aviation industry and technological advancement	https://www.icao.int/Meetings/FutureOfAviation/Pages/default.aspx	
InfluenceMap organization	Website - Report / 2022	The analysis identifies improvement in the climate lobbying positions of some airlines in Europe in 2021-22, but highlights the ongoing gap between the industry's top-line support for net-zero emissions and largely negative positioning towards near-term policies designed to achieve that goal. As a sector, aviation remains one of the most negative in Europe when it comes to climate policy engagement, and remains a powerful opponent of climate regulation. The report highlights the threat to EU climate targets if regulations are weakened by negative aviation industry climate policy engagement and is released prior to key EU decisions on climate policies proposed under the EU's 'Fit for 55 package' during the summer of 2022.	https://ca100.influencemap.org/index.html#3	 

Environmental Conditions and In-habitability (18)

Description: Impact of climate change on air transport and human living conditions. This includes the measure to restrict areas that will be prohibited for habitation, as well as no-fly zones.

Trends:

- Weather effects / Hazardous Weather.
- Catastrophes (Storms, Floods, Fires, Volcanic Activity).
- Effects of climate change: Raise of sea level, desertification, raise of temperature, etc..
- Urbanisation.
- Protected areas and reserves.
- Rapid rise of air traffic over the poles because of cost efficiency for airlines. Also rise of impact on aviation operations due to space weather effects.
- WINFC-project aimed to create a data driven module to collect and process information e.g. coming from weather. Its function is to assist pilots to immediately detect hazard conditions while in flight.

Indicators:

- Representative Concentration Pathways (RCP) 2.6 - 8.5
- Connection between consumer behaviour and weather effects. GDP can be influenced by weather patterns. Bad weather can lead to more spending, e.g. by increasing food imports in countries with bad weather.
- Heat-related conditions may pose a risk of mortality to individuals in varying locations on the globe.
- Europe as a heatwave hotspot, exhibiting upward trends that are three-to-four times faster compared to the rest of the northern mid-latitudes over the past 42 years.
- Meteorological phenomena significantly influence the operational environment of air transport.
- Weather affects all activities considering the range of ground and flight operations of air transport.
- Economical and operational impact because of irregularity on aeroplane operation.

Uncertainties:

- Degree of climate change and its effects.
- Decline / increase of political measures to protect nature (forest etc..).

Details on the data and statistics are provided in the materials on the individual key factors on the respective reference page.

Projections: **Environmental Conditions and In-habitability (18)**

Focus: Inhabitable areas - Decrease vs. Remain | Living conditions - Under control vs. Harsh

PROJECTION 18 A

Mostly local transportation due to harsh conditions

Description:

Europe's special geological position leads to moderately severe weather events. Air traffic is affected regularly and to varying degrees throughout Europe, but can react flexibly and thus remain largely in tact. There is no need for more no-fly zones yet, which means there will be no bottlenecks or complicated flight routes.

Impact:

Similar conditions as today. Flying remains affordable, but planning reliability declines in the future.

PROJECTION 18 B

Natural disasters occur frequently

Description:

Increasingly severe weather events and natural disasters are making life more difficult and making parts of the global land masses increasingly uninhabitable. The transportation sector is becoming more localized and long distance travel is limited by dependence on weather phenomena.

Impact:

Less need for long distance travel. Less planning security for travel. Increased need for flexible transport options and decentralized infrastructure.

PROJECTION 18 C

Restricted living spaces and no-fly zones avoids harsh living areas

Description:

Technological developments curb the severity of weather events and allow current lifestyles to continue. With fewer limitations, flying remains an attractive option for vacations and business trips. High emission values are compensated.

Impact:

Strong decline in flight requests. More use of public transportation. Tolerable living conditions - happier population.

PROJECTION 18 D

Impact is mitigated by technological means

Description:

Drastic measures have led to the expansion of nature reserves and restrictions on urban expansion. The result has been changes in socio-cultural structures and a reduction in resource consumption and emissions. Despite minor impact of weather events, no-fly zones remain in place. The transportation sector remains stable and has shifted to further development of public transport.

Impact:

Higher flight rates. (Green) business as usual. Increased trust in technology.

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References:
Environmental Conditions and In-habitability (18)

Title	Category /Publication Date	Aspect	Source/Link DOI	PDF
European Aviation Environmental Report 2022: Sustainability crucial for long-term viability of the sector	Report / 2022	About the report The report has been prepared by the European Union Aviation Safety Agency (EASA) in accordance with Article 87 of its Basic Regulation 2018/1139, with support from the European Environment Agency (EEA) and EUROCONTROL, and places aviation in the context of the new European Green Deal as well as European industry's Destination 2050 initiative and the Toulouse Declaration of reaching carbon neutrality by 2050 in line with the EU economy-wide objective. This joint collaboration, with input from stakeholder groups, ensures the report is a balanced and comprehensive summary on the topic of aviation environmental protection within Europe. A full overview of key facts can be found in the Executive Summary of the report, alongside Recommendations on how to further improve the level of environmental protection.	https://www.easa.europa.eu/en/newsroom-and-events/press-releases/european-aviation-environmental-report-2022-sustainability (accessed 01.12.2023)	
DLR: DEPA 2050 - Development Pathways for Aviation up to 2050, S. 92	Study report	assumed extreme pressure of society towards politics and companies to take significant actions - possible demands like protected areas and reserves?	https://www.dlr.de/de/aktuelles/nachrichten/2021/02/20210526_rueckgang-der-luftfahrtemissionen-braucht-verstaerkte-anstrengungen	
ICAO: INTERNATIONAL AIRWAYS VOLCANO WATCH OPERATIONS GROUP (IAVWOPSG) - Progress Report On The Development Of Space Weather Information (2011)	Working paper	Rapid rise of air traffic over the poles because of cost efficiency for airlines. Also rise of impact on aviation operations due to space weather effects.	https://www.icao.int/safety/meteorology/iavwopsg/IAVWOPSG_Meetings_Metadata/IAVWOPSG.6.WP.018.8.en.pdf [accessed October 29th 2023]	
Vadims Krasko: Weather Patterns As A Factor Of Consumer Behaviour	Article	Connection between consumer behavior and weather effects. GDP can be influenced by weather patterns. Bad weather can led to more spending, i.e. by increasing food imports in countries with bad weather.	https://www.researchgate.net/publication/265384635_WEATHER_PATTERNS_AS_A_FACTOR_OF_CONSUMER_BEHAVIOUR [accessed October 30th 2023]	https://www.researchgate.net/publication/265384635_WEATHER_PATTERNS_AS_A_FACTOR_OF_CONSUMER_BEHAVIOUR
European Commission: Weather Information Fusion and Correlation for weather and traffic situational awareness	project paper	WINFC-project aimed to create a data driven module to collect and process information i.e. coming from weather. Its function is to assist pilots to immediately detect hazard conditions while in flight.	https://trimis.ec.europa.eu/project/weather-information-fusion-and-correlation-weather-and-traffic-situational-awareness [accessed October 30th 2023]	
IPCC - AR6 Synthesis Report: Climate Change 2023, S. 16	Synthesis Report	Heat-related conditions may pose a risk of mortality to individuals in varying locations on the globe.	https://www.ipcc.ch/report/ar6/syr/longer-report/ [accessed November 11th 2023]	
Rousi E, Kornhuber K, Beobide-Arsuaga G, Luo F, Coumou D. Accelerated western European heatwave trends linked to more-persistent double jets over Eurasia. Nat Commun. 2022 Jul 4;13(1):3851. doi: 10.1038/s41467-022-31432-y. Erratum in: Nat Commun. 2023 Jul 28;14(1):4560. PMID: 35788585; PMCID: PMC9253148.	Peer-Reviewed Paper	Europe as a heatwave hotspot, exhibiting upward trends that are three-to-four times faster compared to the rest of the northern midlatitudes over the past 42 years.	doi: 10.1038/s41467-022-31432-y [accessed 22.11.2023]	
Škultéty F., Jarošová M. & Rostáš J. (2021), Dangerous weather phenomena and their effect on en-route flight delays in Europe	Article	"(...) summer season meteorological phenomena significantly influence the operational environment of the air transport industry." (180) "Significant weather affects all activities considering the range of ground and flight operations of the aeroplanes, e.g. ground handling, fuelling, taxing, take-offs and approaches and landings, etc." (180") "(...) irregularity on aeroplane operation (...) negatively reflects fleet utilisation, overhead cost, passenger delay compensation, fuel burn when extended flight time, etc." (181)	https://doi.org/10.1016/j.trpro.2021.11.109	
			https://www.europarl.europa.eu/RegData/etudes/STUD/2021/652227/IPOL_STU(2021)652227_EN.pdf	

Total Emission of Greenhouse Gases (20)

Description: Projected total emissions of Greenhouse Gas in relation to the manageability/mitigation of their consequences.

Trends:

- Global Mean Surface Temperature
- Sea Level Rise
- Ocean Acidification
- Arctic Sea Ice and Glacier Retreat
- Biodiversity and Ecosystem Changes

Uncertainties:

- Emission Trajectories (RCPs).
- Socio-economic Development (SSPs).
- Technological Advancements.
- Global Climate Sensitivity.
- Climate Feedback Mechanisms.
- Natural Climate Variability.
- Adaptation and Mitigation Actions.
- Regional Climate Impacts.
- Policy and International Cooperation.
- Human Behaviour and Lifestyle Changes.

Indicators:

- Shared Socioeconomic Pathways (SSPs) 1 - 5.
- Representative Concentration Pathways (RCPs) 2.6 - 8.5.
- Data on GHG-emission.
- GHG-emissions resulting from human activities continue to increase, resulting in increasing global surface temperature.
- Two-Thirds of Global Emissions are emitted by 9 countries and the EU(27).

Details on the data and statistics are provided in the materials on the individual key factors on the respective reference page.

Projections: **Total Emission of Greenhouse Gases (20)**

Focus: Total amount of Greenhouse Gases - Decline vs. Rise | Development - Reductive vs. Expansive

PROJECTION 20 A

Reduction of total CO^2 (1.5-2°C)

Description:

Immense investments in technologies and green start-ups were able to reduce overall CO2 emissions across Europe. Political requirements favoured industries that increasingly focus on efficiency and production conditions that are as environmentally neutral as possible. The global temperature increase could thus be kept at a low level.

Impact:

Difficult living conditions in some areas, but manageable consequences of global warming. Flying becomes more expensive. Less impact on the climate.

PROJECTION 20 B

Business as usual (>3-4°C)

Description:

Increasingly severe weather events and natural disasters are making life more difficult and making parts of the global land masses increasingly uninhabitable. The transportation sector is becoming more localized and long distance travel is limited by dependence on weather phenomena.

Impact:

Less need for long distance travel. Less planning security for travel. Increased need for flexible transport options and decentralized infrastructure.

PROJECTION 20 C

Radical De-growth (1.5°C)

Description:

Political Ideology of de-growth becomes mainstream. Increasingly severe weather events regularly cause massive damage to European cities and infrastructure. Most national budgets were no longer able to cover the costs incurred. Political consensus was to push through all efforts to bring CO2 emissions to zero altogether.

Impact:

Strong decline of flight requests. Structural transformation of economy and industry. No new technologies, but more efficient use.

PROJECTION 20 D

Politically managed decline (>2°C)

Description:

Due to massive pressure from the public and after long negotiations, politicians push through efforts to cap Europe-wide CO2 levels. Especially countries like Germany, France or Italy are forced to present stronger measures and targets to be taken in the coming decades. Industries are forced to adapt to further upcoming changes.

Impact:

Slow decline of CO2. Air traffic restrictions and expansion of research for new propulsion technologies. Higher prices for long distance travel.

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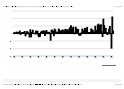
References:
Total Emission of Greenhouse Gases (20)

Title	Category /Publication Date	Aspect	Source/Link DOI	PDF
EEA: Greenhouse gas emissions from transport in the EU, by transport mode and scenario	Chart	Figure shows the trend in the GHG by sub-sector since 1990 and projections to 2040 of the EU-27	58254f4ccba344e398dadb42ffae043e [accessed September 20th 2023]	
AR6 Synthesis Report: Climate Change 2023, S. 42-45	Synthesis Report	Greenhouse gas (GHG) emissions resulting from human activities continue to increase, resulting in increasing global surface temperature	https://www.ipcc.ch/report/ar6/syr/longer-report/ [accessed November 13th 2023]	
Friedrich, Ge, Pickens (2020): This Interactive Chart ShowsChanges in the World's Top 10 Emitters	Article	Two-Thirds of Global Emissions are are emitted by 9 countries and the EU(27)	https://www.wri.org/insights/interactive-chart-shows-changes-worlds-top-10-emitters [accessed November 13th 2023]	
IEA, Global CO2 emissions from energy combustion and industrial processes, 1900-2022, IEA, Paris https://www.iea.org/data-and-statistics/charts/global-co2-emissions-from-energy-combustion-and-industrial-processes-1900-2022, IEA. Licence: CC BY 4.0	Statistic		https://www.iea.org/data-and-statistics/charts/global-co2-emissions-from-energy-combustion-and-industrial-processes-1900-2022 [accessed 22.11.23]	
IEA, Annual change in global CO2 emissions from energy combustion and industrial processes, 1900-2022, IEA, Paris https://www.iea.org/data-and-statistics/charts/annual-change-in-global-co2-emissions-from-energy-combustion-and-industrial-processes-1900-2022, IEA. Licence: CC BY 4.0	Statistic		https://www.iea.org/data-and-statistics/charts/annual-change-in-global-co2-emissions-from-energy-combustion-and-industrial-processes-1900-2022 [accessed 22.11.23]	
European Aviation Environmental Report 2022: Sustainability crucial for long-term viability of the sector	Report / 2022	About the report The report has been prepared by the European Union Aviation Safety Agency (EASA) in accordance with Article 87 of its Basic Regulation 2018/1139, with support from the European Environment Agency (EEA) and EUROCONTROL, and places aviation in the context of the new European Green Deal as well as European industry's Destination 2050 initiative and the Toulouse Declaration of reaching carbon neutrality by 2050 in line with the EU economy-wide objective. This joint collaboration, with input from stakeholder groups, ensures the report is a balanced and comprehensive summary on the topic of aviation environmental protection within Europe. A full overview of key facts can be found in the Executive Summary of the report, alongside Recommendations on how to further improve the level of environmental protection.	https://www.easa.europa.eu/en/newsroom-and-events/press-releases/european-aviation-environmental-report-2022-sustainability (accessed 01.12.2023)	
Annual European Union greenhouse gas inventory 1990–2020 and inventory report 2022 Submission to the UNFCCC Secretariat	Report / 2022	**ES-2 SUMMARY OF GREENHOUSE GAS EMISSIONS TRENDS IN THE EU** Total GHG emissions - excluding Land Use, Land Use Change and Forestry (LULUCF) and international aviation - in the EU-KP amounted to 3 708 million tonnes CO2 equivalent in 2020 (including indirect CO2 emissions). All GHG emission totals provided in this report include indirect CO2 emissions6. In 2020, total GHG emissions were 34.3 % (-1 939 million tonnes CO2 equivalents) below 1990 levels. Emissions decreased by 8.5 % or 346 million tonnes CO2 equivalent) between 2019 and 2020 (Figure ES. 1).	https://www.eea.europa.eu/publications/annual-european-union-greenhouse-gas-1 (accessed 03.12.2023)	
Umweltschonender Luftverkehr lokal-national-international Nicht-CO2-Effekte des Luftverkehrs im Detail (S 28 - 29)	Report / 2019	Als wesentliches Reaktionsprodukt aus der Verbrennung von Kerosin im Triebwerk entsteht Was-serdampf (H2O). Beim Luftverkehr wird ein großer Anteil des H2O in Reiseflughöhe, d.h. zwischen 8 und 13 km Höhe, emittiert. Dort ist die (natürliche) Hintergrundkonzentration des Wasserdampfs um mehrere Größenordnungen geringer als in Bodennähe und die atmosphärische Lebensdauer des H2O deutlich länger. Daher leitet hier der Luftverkehr einen merkbaren Beitrag zur Gesamtkonzen-ration des H2O. Dieser Effekt verstärkt sich noch bei höheren Flugniveaus. Dennoch ist die Lebens-dauer von einigen Tagen bis Wochen zu gering, um eine global homogene Verteilung des zusätzlichen H2O zu bewirken. Der zusätzliche Wasserdampf aufgrund des Luftverkehrs führt zu einer gerin-gen Erwärmungswirkung der Atmosphäre.	https://www.umweltbundesamt.de/publikationen/umweltschonender-luftverkehr	
ICAO Engine Emissions Databank – Record of Changes	Data / 2023	Overview of emissions up to 2023	https://www.easa.europa.eu/en/domains/environment/icao-aircraft-engine-emissions-databank	

Availability of Natural Resources for Europe (21)

Description: Ability to produce and/or import natural resources (Water, fertile Land, Gas, Minerals, Wood, Sand, etc..).

Trends:

- Global political crisis influencing global trading.
- Global trade agreements with the EU (TCA, Mercosur, CETA, EPA, etc..).
- Resources are depleting globally.
- EU can not cover all needed natural resources for production (in the aviation & energy sector)
- Risk of supply shortages and supply vulnerability due to the concentration of CRM's extraction and refinement in a few countries

Uncertainties:

- Political relationships with China (ex: potential conflict Taiwan).
- Resources are widely distributed, yet China plays a key role throughout the REE supply chain because of its global dominance in processing.
- Structural (dis-)functioning of ecosystems and biodiversity (availability to absorb water, resilient forests, glaciers and lakes).
- Implementation of Water Framework Directive to guarantee functioning water systems for Europe.
- Status of EU in the global market.

Indicators:

- The EU's trade in raw materials is increasing slowly. Imports are higher than exports.
- China is the major global supplier of 66% of all Critical Raw Materials.
- China provides 44% of the EU's CRM needs.
- The Raw Materials Initiative (RMI) has been drawing attention to the importance of raw materials issues and their supply situation at European level since 2008.
- REPowerEU Policy
- Save energy, produce clean energy, diversify its energy supplies.
- EU Water Framework Directive.
- Severe droughts caused a 3% annual vegetation productivity loss in affected areas from 2000-2019.
- Soil moisture in the growing season was far below the long-term average in EEA member countries plus the UK from 2000-2019.
- Europeans ecological footprint outreaches the environmental limits.
- Critical Raw Materials Act.
- Limiting and diversifying the production and import of critical raw materials.

Details on the data and statistics are provided in the materials on the individual key factors on the respective reference page.

Projections: **Availability of Natural Resources for Europe (21)**

Focus: Demand to buy - Low vs. High | Exploration & Exploitation - Decrease vs. Increase

PROJECTION 21 A

Accessing resources is becoming more difficult

Description:

Natural resources are drying up noticeably, therefore more extensive exploration is done. Producing countries secure most of the remaining raw materials for themselves and gain economic power. Europe is forced to reduce its own demand and rely on new technologies to substitute the lack of raw materials. This technology pull effect leads to an overall shrinking demand because of the use of local resources

Impact:

New technologies emerge. Technology pull for Europe's Industries. EU looses global economic status and influence.

PROJECTION 21 B

Europe meets its demands

Description:

Europe's industries are growing faster. New extraction areas for raw materials are being discovered and Europe is actively participating in the mining. EU secures itself enough rights for exploitation of natural resources. Overcapacities are exported.

Impact:

Europe's industry prospers. EU upholds global economic dominant status.

PROJECTION 21 C

EU's industrial & economic opportunities are limited

Description:

Europe can no longer meet the demand for raw materials. Advanced industries are concentrated in individual countries. The economic potential is too low to obtain more raw materials from abroad.

Impact:

EU has a production crisis. Financial struggles of various European states. Industrial decline / Bankruptcies on the rise. Societal upheaval.

PROJECTION 21 D

EU's financial strength provides market power to buy resources

Description:

EU's industries are stronger than ever and demand more raw materials, which can not be met through their own capacities. It is using its great political and financial influence on the global markets to buy resources that cannot be harvested locally.

Impact:

EU's industry prospers. Global crisis and resource wars between other countries. Lack of financial means for other sectors (social etc.).

References:
Availability of Natural Resources for Europe (21)

Title	Category /Publication Date	Aspect	Source/Link DOI	PDF
eurostat: Extra-EU trade in raw materials	Statistics / 2023	EU's trade in raw materials is increasing slowly. Imports are higher than exports.	https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Extra-EU_trade_in_raw_materials [accessed October 30th 2023]	
European Commission: Study on the EU's list of Critical Raw Materials – Final Report (2020), S. 6	Report / 2020	China is the major global supplier of 66% of all Critical Raw Materials	https://op.europa.eu/en/publication-detail/-/publication/ff34ea21-ee55-11ea-991b-01aa75ed71a1/language-en [accessed November 13th 2023]	
European Commission: Study on the EU's list of Critical Raw Materials – Final Report (2020), S. 9	Report / 2020	China provides 44% of the EU's CRM needs	https://op.europa.eu/en/publication-detail/-/publication/ff34ea21-ee55-11ea-991b-01aa75ed71a1/language-en [accessed November 13th 2023]	
Oakdene Hollins, Fraunhofer ISI (2013): Study on Critical Raw Materials at EU Level - Final Report, S. 5	Report / Dec 2013	The Raw Materials Initiative (RMI) is drawing attention to the importance of raw materials issues and their supply situation at European level since 2008	https://docslib.org/doc/4892320/study-on-critical-raw-materials-at-eu-level-final-report [accessed November 14th 2023]	
Oakdene Hollins, Fraunhofer ISI (2013): Study on Critical Raw Materials at EU Level - Final Report, S. 27	Report / Dec 2013	"Overall a greater proportion of raw materials are considered critical in this study, with 39% of the candidate materials classified as critical compared to 29% from the previous study." (Oakdene Hollins & Fraunhofer ISI, 2013)	https://docslib.org/doc/4892320/study-on-critical-raw-materials-at-eu-level-final-report [accessed November 14th 2023]	
Eurpean Parliament (2021): Critical raw materials in EU external policies - Improving access and raising global standards, S. 1-2	Briefing / May 2021	Global demand for CRMs is steadily rising over the next 40 years, especially in developing economies. CRMs are strategically important to the EUs economy and industry, yet it is dependent on a limited number of countries. A three pillars strategy (Domestic sourcing, circularity and external trade policies) tries to secure the EUs future demand.	https://www.europarl.europa.eu/thinktank/en/document/EPRS_BRI(2021)690606 [accessed November 14th 2023]	
Gielen, D. and M. Lyons (2022), Critical materials for the energy transition: Rare earth elements, International Renewable Energy Agency, Abu Dhabi. (S. 36)	Technical paper/ 2-2022	Resources are widely distributed, yet China plays a key role throughout the REE supply chain because of its global dominance in processing. "China has the ability to control production – and thus the global availability" (S. 36)	https://www.irena.org/Technical-Papers/Critical-Materials-For-The-Energy-Transition-Rare-Earth-elements [accessed November 14th 2023]	
WWF Study: WATER FOR NATURE, WATER FOR LIFE	Meta Study / Sept 2023	From crop failures to shrinking lakes, nature and people in Europe are increasingly suffering from a lack of water.	https://www.wwf.eu/?11685466/New-report-Europes-water-scarcity-challenge [accesses 23.11.23]	
EU critical raw materials act	Policy Paper	Limiting and diversifying the production and import of critical raw materials	https://single-market-economy.ec.europa.eu/publications/european-critical-raw-materials-act_en [accessed: 23.11.2023]	
EAA: Climate change impacts, risks and adaptation	Website	• **Severe droughts** caused a 3% annual vegetation productivity loss in affected areas from 2000-2019. (EEA) • **Soil moisture** in the growing season was far below the long-term average in EEA member countries plus the UK from 2000-2019. (EEA)	https://www.eea.europa.eu/en/topics/in-depth/climate-change-impacts-risks-and-adaptation?activeTab=fa515f0c-9ab0-493c-b4cd-58a32dfaae0a&activeAccordion= [accessed:23.11.2023]	

Taxation Rates and Policies on Energy in the EU related to pricing (22)

Description: Policies to regulate the taxation of aviation fuels in conjunction with the development of energy prices in Europe based on the pricing of electricity, gas and fuels from renewable sources.

Trends:

- Development of renewable energy sources in the EU.
- Further needs for fuels in other areas.
- Market-based measures to reduce environmental impact (taxes, charges, voluntary agreements, emissions offsetting, emissions-trading systems).
- Increasing awareness of the effects of climate change will contribute to more climate policy goals.
- Energy Taxation Directive (ETD).
- New minimum tax rates (Euro per Giga-joule) according to environmental content.
- Value Added Tax (VAT) on energy.
- National Renewable Energy Incentives.
- Environmental Levies and Surcharges.

Uncertainties:

- Dependency on energy procurement in the EU.
- Global and Regional Economic Conditions.
- International Cooperation on Climate Action.
- Technological Advancements.
- Energy Market Dynamics.
- Energy Security Concerns.
- Technology Adoption Rates.

Indicators:

- EU Emissions Trade System.
- World fossil fuel prices are expected to rise until 2050.
- EU ETS carbon price is projected to reach 30 €/tn CO2 in 2030. After 2030, the carbon price is projected to increase at a much faster pace (80 €/tn CO2 in 2040 & 150 €/tn CO2 in 2050).
- Average electricity prices will modestly increase until 2030. This is due to the application of carbon pricing and taxes, i.e., Emissions Trading Systems (ETS) allowance payments. And second, the higher costs for infrastructure development to support grid expansion due to the growing share of Renewable Energy Sources (RES) and their distribution.
- Policies such as EU Green Deal.
- Renewable Energy Directive (RED):
- An increased target for the share of renewable energy in the EU's final energy consumption, aiming for a minimum 32% share by 2030.
- Climate neutrality by 2050.
- 55% less emissions by 2030.
- Reduce energy consumption by 32.5% by 2030.

Details on the data and statistics are provided in the materials on the individual key factors on the respective reference page.

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Projections: **Taxation Rates and Policies on Energy in the EU related to pricing (22)**

Focus: Energy prices - Low vs. High | Regulation - Low vs. High

PROJECTION 22 A

State run energy infrastructure

Description:

Full socialist energy system (The EU is the energy dealer). Complete transformation to renewable energy. Low energy prices set for individuals and industry. Fossil fuels eliminated due to Green Deal.

Impact:
EU strategy helps renewable and new energy sources for air transport. No kerosene. Instead hydrogen and/or battery jets. Strong incentive for building infrastructure because of guaranteed prices.

PROJECTION 22 B

High CO^2 taxation

Description:

Full blown CO2 Carbon taxation. Prices are so high because renewable not fully adopted / not decentralized available. Government regulates who "may" fly or which flights are "necessary", through taxation and subsidies.

Impact:
Decrease in total flights. Decrease in earning in industry. Only renewable are "affordable", but high fossil fuel flights are possible for the very rich.

PROJECTION 22 C

Burning House

Description:

Removal of all subsidies and taxations (incl. Carbon Tax). Re-orientation towards fossil fuels. New energy reserves (ocean floor, Arctic, etc..). Climate change is NOT addressed. No incentives for flight industry to develop sustainable aviation solutions.

Impact:
2050 the industry is still running but the future looks grim and hot. Economical grow and money for a short term, then collapse possible.

PROJECTION 22 D

Splintered world

Description:

No regulations in terms of taxation/subsidies etc. Energy is limited by regional access, fossils remain an option for specific regions. Conflict about resources. High insecurity of supply chains. Electrification out of need (lack of natural resources).

Impact:
EU has problems due to necessity of renewable. Less problems in Global South. No international standards for research and production. Strong nationalism and protectionism.

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References:
Taxation Rates and Policies on Energy in the EU related to pricing (22)

Title	Category /Publication Date	Aspect	Source/Link DOI	PDF
Benito, Arturo; Alonso, Gustav: Energy efficiency and the environment, Butterworth-Heinemann, 2018	Book /2018	listing of some market based measures - adding to the argument of EU policies regarding energy and aviation	Benito, A., & Alonso, G. (2018). Energy Efficiency in Air Transportation	
DLR: DEPA 2050 - Development Pathways for Aviation up to 2050, S. 34, 40, 42	Report / 2023	Increasing environmental awareness leads to climate policy goals, such as the European Green Deal	https://www.dlr.de/de/aktuelles/nachrichten/2021/02/20210526_rueckgang-der-luftfahrtemissionen-braucht-verstaerkte-anstrengungen [accessed November 14th 2023]	
European Commission (2021): EU Reference Scenario 2020 - Energy, transport and GHG emissions - Trends to 2050, S. 32	Scenario / 2020	World fossil fuel prices are expected to rise until 2050	https://energy.ec.europa.eu/data-and-analysis/energy-modelling/eu-reference-scenario-2020_en [accessed November 14th 2023]	
European Commission (2021): EU Reference Scenario 2020 - Energy, transport and GHG emissions - Trends to 2050, S. 42	Scenario / 2021	EU ETS carbon price is projected to reach, in the Reference Scenario policy context, 30 €/tn CO2 in 2030 (+5 €/tn CO2 since 2020). After 2030, the carbon price is projected to increase at a much faster pace (80 €/tn CO2 in 2040 & 150 €/tn CO2 in 2050).	https://energy.ec.europa.eu/data-and-analysis/energy-modelling/eu-reference-scenario-2020_en [accessed November 14th 2023]	
European Commission (2021): EU Reference Scenario 2020 - Energy, transport and GHG emissions - Trends to 2050, S. 98	Scenario / 2021	Average electricity prices will modestly increase until 2030. This is due to the application of carbon pricing and taxes, i.e., Emissions Trading Systems (ETS) allowance payments. And second, the higher costs for infrastructure development to support grid expansion due to the growing share of Renewable Energy Sources (RES) and their distribution.	https://energy.ec.europa.eu/data-and-analysis/energy-modelling/eu-reference-scenario-2020_en [accessed November 14th 2023]	
KPMG Insights Paper on EU Energy Taxation Directive	Inights Paper / 2021	Energy Taxation Directive (2003/96/EC)	https://kpmg.com/xx/en/home/insights/2021/08/energy-taxation-directive.html#:~:text=What%20is%20the%20Energy%20Taxation,motor%20and%20most%20heating%20fuels.	
European Climate Law	Fact Sheet / 2023	Set the long-term direction of travel for meeting the 2050 climate neutrality objective through all policies, in a socially fair and cost-efficient manner Set a more ambitious EU 2030 target, to set Europe on a responsible path to becoming climate-neutral by 2050 Create a system for monitoring progress and take further action if needed Provide predictability for investors and other economic actors Ensure that the transition to climate neutrality is irreversible	https://climate.ec.europa.eu/eu-action/european-climate-law_en#:~:text=The%20European%20Climate%20Law%20writes,2030%2C%20compared%20to%201990%20levels.	 

Policies and Subsidisation for Diversifying the Transport Infrastructure (23)

Description: Development of public policies for subsidisation and regulation of inter-modular (diversified) transportation structure, in conjunction with environmental protection laws.

Trends:

- De-carbonizing of transport.
- Managing transport demand.
- Intermodality (MaaS, UAS, etc..).
- Public Private Partnerships.
- Green Deal (EU Mobility Strategy).
- Key Items: Sustainable, Smart, Resilient.
- Decisive action to shift towards more sustainable transport modes.
- More stringent air pollutant emissions standards.
- Internalisation of external costs.
- People are willing to switch to more sustainable modes of transport, the most important factor being costs.
- Mobility patterns and consumer behaviour are changing.
- 'Polluter pays' and 'User pays' principles.
- Paris agreement and connected policies.
- Stronger Lobbyism (of aviation industry) related in the EU and globally.

Uncertainties:

- Scope of transport policies (environmental, social, etc..).
- Financial Instruments (public funding, taxation, privatisation).
- Enforcement of EU directives on a national level.
- Role of automated mobility.

Indicators:

- Existing policy frameworks (selection):
- Renewable Energy Directive.
- Post-Euro 6/VI emission standards.
- Alternative Fuels Infrastructure Directive.
- Energy Performance of Buildings Directive.
- ReFuelEU Aviation.
- Urban Mobility Package.
- Directive on Intelligent Transport Systems.
- Trans-European Transport Network (TEN-T).
- EU Programs such as Fit for 55.
- Reducing GHG-emissions by at least 55% by 2030 compared to 1990 levels.
- Policies around EU Green Deal.
- Climate neutrality by 2050.
- 55% less emissions by 2030.
- 32% renewable energy by 2030 (RED).
- Reduce energy consumption by 32.5% by 2030.
- Biodiversity protection of 30% land/sea areas.

Details on the data and statistics are provided in the materials on the individual key factors on the respective reference page.

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Projections: **Policies and Subsidisation for Diversifying the Transport Infrastructure (23)**

Focus: Emissions - Net zero vs. High | Regulation by - Free market vs. Government

PROJECTION 23 A

EU forced Green Transition

Description:

EU restricts air transport (due to remaining climate impact or other technological factors) to only renewable technologies. No subsidies for anything fossil fuel related, instead incentivisation of renewable energy for transport (like e-mobility, hydrogen). High / Realistic carbon taxation hits kerosene hard.

Impact:

Decline in air traffic overall. EU research funding is limited to eMobility and hydrogen fuels for planes. Flying accepted only as "exception". General main attitude against air transport.

PROJECTION 23 B

Flight Budget

Description:

Air Transport is further divided into classes (wooden / luxury class). Overall demand is high. Cheap air travel is limited, and the prices increases according to comfort. Pricing for air travel fluctuates

Impact:

EU funds research to achieve a climate neutral aviation - fuels, new propulsion etc.. Research and change in air transport is slower due to lack of incentives. Higher ecological/climate impact.

PROJECTION 23 C

Green Innovation boom

Description:

Taxation for kerosene and all subsidization for transport are revoked. New fuel sources allow for market-shares in diversified transport systems. Net zero has become the most profitable energy in transport systems. The market for transportation in every sector is split-up into smaller transportation vendors. Innovative and energy-efficient technologies evolve fast. Strong need for efficiency and cost-reduction in aircraft design to be competitive with other transport systems

Impact:

2050 the industry is still running but the future looks grim and hot. Economical grow and money for a short term, then collapse possible.

PROJECTION 23 D

Free Market

Description:

E-mobility and Emission based transport compete. If ultimate free market: no subsidies for kerosene (high taxation). Individual transport (Car, Train, Sharing Options, Bike) remains main pillar of intermodular transport for short haul. Alternatives like bullet trains, self-driving trucks compete with air transport on medium haul. Long-range (>1000 km) is still air transport.

Impact:

Air traffic declines for short and mid range. Short range aircraft become obsolete due to alternatives in the market. Spread of green and emission based modes of transportation.

References:
Policies and Subsidisation for Diversifying the Transport Infrastructure (23)

Title	Category /Publication Date	Aspect	Source/Link DOI	PDF
How much can electric aircraft contribute to reaching the Flightpath 2050 CO2 emissions goal? A system dynamics approach for european short haul flights	Study (within the SE2A cluster) / 2022	Policies towards environmentally friendly aviation "Overall, the results from the studyimply that a policycombination is a better option than enacting individual policies to reach the Flightpath 2050 CO2 emissions goal. However, it must be noted that due to the higher costs to use electric aircraft corresponding to parameters used in Table 2, an extremely high value of policy parameters was required to achieve any effect in adoption. In the case of the seat tax, it was observed that only a high seat tax equivalentto an increase of 30% of the average unit cost for conventional aircraft was able to make the electric aircraft cost competitive and showcased higher adoption rates. Furthermore, a 75% reduction in the average electricity price in the form of an elec tricity subsidy was required for the considered period to have 28% electric fleet in the system." (pg.14)	https://doi.org/10.1016/j.jairtraman.2023.102455	
EU Mobility Strategy and Action Plan	EU Mobility Strategy Paper / 2021	By 2050: • nearly all cars, vans, buses as well as new heavy-duty vehicles will be zero-emission. • rail freight traffic will double. • a fully operational, multimodal Trans-European Transport Network (TEN-T) for sustainable and smart transport with high speed connectivity. • 90% reduction greenhouse gas emissions in transport by 2050	https://transport.ec.europa.eu/transport-themes/mobility-strategy_en	
THE POLICY OF THE EUROPEAN UNION IN THE AVIATION FIELD. SOME CONSIDERATIONS	Study / 2022		https://www.jopafl.com/uploads/issue17/THE_POLICY_OF_THE_EUROPEAN_UNION_IN_THE_AVIATION_FIELD_SOME_CONSIDERATIONS.pdf	
The EU's "Fit for 55" Package: what does it mean for aviation?	Article/ 2021	55% less emission by 2030 EU ETS - 2027 phase out of aviation allowances	https://www.eurocontrol.int/article/eus-fit-55-package-what-does-it-mean-aviation	
Aviation in the EU ETS and CORSIA in the 'Fit for 55' package - Fact-Sheet UBA / EU	Report / 2023	Policies within the fit55 policy package for the aviation sector: The European Commission, the European Parliament and the Council agreed on a series of legislative proposals as part of the 'Fit for 55' package, which are intended to align energy and climate policy instruments with the new climate target of reducing emissions by at least 55% compared to 1990 levels by 2030. This factsheet presents key aspects of the agreement on aviation in the framework of the European Emissions Trading Scheme (EU ETS) under Directive 2003/87/EC and the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) of the International Civil Aviation Organisation (ICAO) in a condensed form. It further outlines interaction with other 'Fit for 55' elements for the use of sustainable fuels in aviation, the Energy Tax Directive and the Renewable Energy Directive.	https://www.umweltbundesamt.de/sites/default/files/medien/11850/publikationen/09_2023_factsheet_aviation_in_the_eu_ets_and_corsia.pdf	
IATA Net Zero Raodmap	Report/ 2022	Policy is about setting a regulatory framework within which the favorable circumstances are created for the technologies to mature rapidly and scale up successfully. • minimizing administrative hurdles, • making private investment attractive, • accelerating all processes. All stakeholders of the aviation ecosystem can and must benefit from opting for these technological and operational solutions. Government policy at its best can fairly and efficiently steer the development of the selected economic activities to deliver on the objectives set at national level.	https://www.iata.org/en/programs/environment/roadmaps/ (accesses 23.11.2023)	
Roadmap Klimaneutrales Fliegen 2.0	Report / 2021	In der „Roadmap Klimaneutrales Fliegen" fassen Ralf Fücks (Zentrum Liberale Moderne), Matthias von Randow (Hauptgeschäftsführer des BDL) und Volker Thum (Hauptgeschäftsführer des BDLI) die Ergebnisse einer Gesprächsreihe mit Abgeordneten des Bundestags, der Luftfahrtwirtschaft und unabhängigen Expert/innen zusammen. Die wichtigste Erkenntnis lautet: Die Luftfahrt in Einklang mit dem Klimaschutz zu bringen, ist ein realistisches Ziel. Es ist allerdings nur zu erreichen, wenn Politik, Wirtschaft und Wissenschaft eng zusammenarbeiten. Es braucht einen angemessenen regulatorischen Rahmen für die Luftfahrt und eine große Kraftanstrengung, um technische Innovationen bis zur Marktreife zu entwickeln.	https://libmod.de/roadmap-zeigt-klimaneutrales-fliegen-ist-moeglich-6/ (accessed 01.12.2023	
Key Company and Industry Association Findings	Document / 2020	The research identifies a two-point strategy used by the sector to avoid regulation directly addressing their climate emissions. Firstly, at a European level, the aviation sector has communicated high-level support for net-zero EU aviation emissions by 2050 while opposing specific national and EU-level climate regulations to help deliver that target in their direct engagements with policymakers. Secondly, at a global level through the UN body for aviation, the International Civil Aviation Organisation (ICAO), industry has lobbied for the CORSIA offsetting scheme to take precedent over policies addressing absolute aviation emissions reductions. At the same time, using the context of the COVID-19 pandemic, industry lobbyists have successfully pushed for the scheme to be watered down further.	https://lobbymap.org/report/Aviation-Industry-Lobbying-European-Climate-Policy-131378131d9503b4d32b365e54756351 (accessed 04.12.2023)	 
Airlines and European Climate Policy An InfluenceMap report, July 2022	Website / July 2022	The analysis identifies improvement in the climate lobbying positions of some airlines in Europe in 2021-22, but highlights the ongoing gap between the industry's top-line support for net-zero emissions and largely negative positioning towards near-term policies designed to achieve that goal. As a sector, aviation remains one of the most negative in Europe when it comes to climate policy engagement, and remains a powerful opponent of climate regulation. The report highlights the threat to EU climate targets if regulations are weakened by negative aviation industry climate policy engagement and is released prior to key EU decisions on climate policies proposed under the EU's 'Fit for 55 package' during the summer of 2022.	https://influencemap.org/report/Airlines-and-European-Climate-Policy-19388 (accessed 04.12.2023)	
AVIATION SAFETY (EPAS) 2023-2025 VOLUME II **Action** European Union Aviation Safety Agency	Report / 2023	Measures all realted to safty	https://www.easa.europa.eu/en/document-library/general-publications/european-plan-aviation-safety-epas-2023-2025#group-easa-downloads	

Global Political Order (24)

Description: The development of the political structures of the national governments in European countries in relation to the power-political impact of the European Union.

Trends:

- Media and news concentration / ownership.
- Nationalism and protectionism.
- Social-Economic development / Income Levels.
- Anti-West attitudes.
- Economic and political strengthening of the Global South (BRICS).
- Although based on country-specific causes, an increased visibility of a shift towards nationalism can be observed globally. Anti-elite discourses could be behind it.
- Post COVID-19 shift for shaping societal tendencies towards nationalism, authoritarianism.
- Because of its trading policies, the EU is the largest economy of the world (measured by GDP) and an active economic and political player with growing regional and global interests.
- Raise of universal values in the younger population.

Uncertainties:

- Global crises and social inequalities (civil unrest, wars).
- Environmental events and humanitarian disasters (droughts, floods, pandemics).
- Development of the GDP.
- Position of non-state actors.
- Position of China and Global South.
- Unity of "the west".
- Global migration.
- Value orientation and trust in state.
- Global inequality.

Indicators:

- Expected increase of the GDP of the European Union until 2026.
- Individual Countries in the EU do not share the same GDP. The individual levels of GDP can have significant differences.
- Growth rate of the GDP differs from country to country. Yet developing economies are expected to have the highest growth rate in the near future.
- Increasing European imports and exports trades of high-tech products. The largest import partners are China and the United States.
- EU Migration policies.

Details on the data and statistics are provided in the materials on the individual key factors on the respective reference page.

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Projections: **Global Political Order (24)**

Focus: Mindset - Nationalist vs. European | Global power - Losing vs. Gaining

PROJECTION 24 A

Make EU great again

Description:

EU becomes pragmatic union of nationalist leaders. Right wing governments. Nominal still democracies with autocratic traits. Cooperation within EU, to gain economic and political weight.

Impact:

Change in foreign political doctrine: New alliances with other autocracies (turkey, Africa, gulf states, china). EU becomes technocratic super state, run by bureaucratic elite. Effective top-down governance allows for strong economic gain.

PROJECTION 24 B

EU as super democracy

Description:

All EU countries merge into one super democracy. Borders within the EU countries will be dissolved. Shared economy and technological development. Expansion of democratic values in the EU. Stronger cohesion within the EU. Shared values throughout the population lead to sustainable reforms in democracy.

Impact:

Significant reduction of bureaucracy leads to faster decisions and implementation of laws. Stronger cooperation in sciences and economy within the EU lead to better assertion on global power. Enthusiasm in the population.

PROJECTION 24 C

Fragmentation of EU

Description:

EU disintegrates into individual nation states (Brexit, Grexit, Spexit, Gexit, etc.). While some states somehow manage to compete on the world market, there is an overall decline in economic and political power. Fragmentation in research and Development. Missing Infrastructure. Euro currently ceases to exist.

Impact:

EU wide decline in economic and political power. Loss of Euro as leading currency weakens EU economies. Inequality and competition between EU countries.

PROJECTION 24 D

EU as slow Bureaucracy

Description:

EU remains democratic and bureaucratic (slow). The EU's voting system becomes complicated and slow.

Impact:

Future challenges are not met because of bureaucracy. Its high amount of bureaucracy slows its economical and technological advances.

References:
Global Political Order (24)

Title	Category /Publication Date	Aspect	Source/Link DOI	PDF
Statista: European Union: Gross domestic product (GDP) from 2018 to 2028	Statistics / 2023	Expected increase of the GDP of the European Union until 2026.	https://www.statista.com/statistics/527869/european-union-gross-domestic-product-forecast/ [accessed October 30th 2023]	
eurostat: Real GDP per capita	Statistics / 2023	Individual Countries in the European Union do not share the same GDP. The individual levels of GDP can have significant differences.	https://ec.europa.eu/eurostat/databrowser/view/sdg_08_10/default/bar?lang=en [accessed October 30th 2023]	https://ec.europa.eu/eurostat/databrowser/view/sdg_08_10/default/bar?lang=en
Statista: Growth of the real gross domestic product (GDP) in selected world regions from 2021 to 2024	Statistics / 2023	Growth rate of the GDP differs from country to country. Yet developing economies are expected to have the highest growth rate in the near future.	https://www.statista.com/statistics/268121/gross-domestic-product-gdp-growth-in-selected-world-regions/ [accessed October 30th 2023]	
Florian Bieber: Is Nationalism on the Rise? Assessing Global Trends	Article / 2028	Although based on country-specific causes, an increased visibility of a shift towards nationalism can be observed globally. Anti-elite discourses could be behind it.	https://www.tandfonline.com/doi/full/10.1080/17449057.2018.1532633 [accessed October 30 2023]	https://www.tandfonline.com/doi/full/10.1080/17449057.2018.1532633
Florian Bieber: Global Nationalism in Times of the COVID-19 Pandemic	Article / 2020	The COVID-19 pandemic might be responsible for shaping societal tendencies towards nationalism, the rise of authoritarianism, the rise of biases against some pandemic associated groups, the rise of borders and deglobalization and the politics of fear.	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7242722/ [accessed October 30 2023]	
European Commission: Trade - Free trade is a source of economic growth	Publication / 2016	Because of its trading policies, the EU is the largest economy of the world (measured by GDP) and an active economic and political player with growing regional and global interests.	https://op.europa.eu/en/publication-detail/-/publication/9a2c5c3e-0d03-11e6-ba9a-01aa75ed71a1 [accessed October 30 2023]	
eurostat: International trade and production of high-tech products	Statistics / 2023	Increasing European imports and exports trades of high-tech products. The largest import partners are China and the United States.	https://ec.europa.eu/eurostat/statistics-explained/index.php?title=International_trade_and_production_of_high-tech_products#EU_trade_in_high-tech_products [accessed October 30 2023]	
eurostat: Intra-EU trade in goods - main features	Statistics / 2023	Trade as an indicator of how dependent the EU is from other extra-EU countries	https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Intra-EU_trade_in_goods_-_main_features#Intra-EU_trade_in_goods_compared_with_extra-EU_trade_in_goods [accessed October 30 2023]	
New Global Scenarios	Scenarios / 2023	Key Factors for development of global political order	Scenario Management International AG (Hg.): New Global Scenarios. World Economy, Power Shift and Global. Architectures. Scenario Management International AG, Paderborn 2022; 51 Seiten ISBN 978-3-949439-04-9	

SE²A Sustainable and Energy-Efficient Aviation

Thank you for your interest!

If you have questions, please contact the ScenAIR 2050 HBK Braunschweig team at: se2a-scenair.idf@hbk-bs.de

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