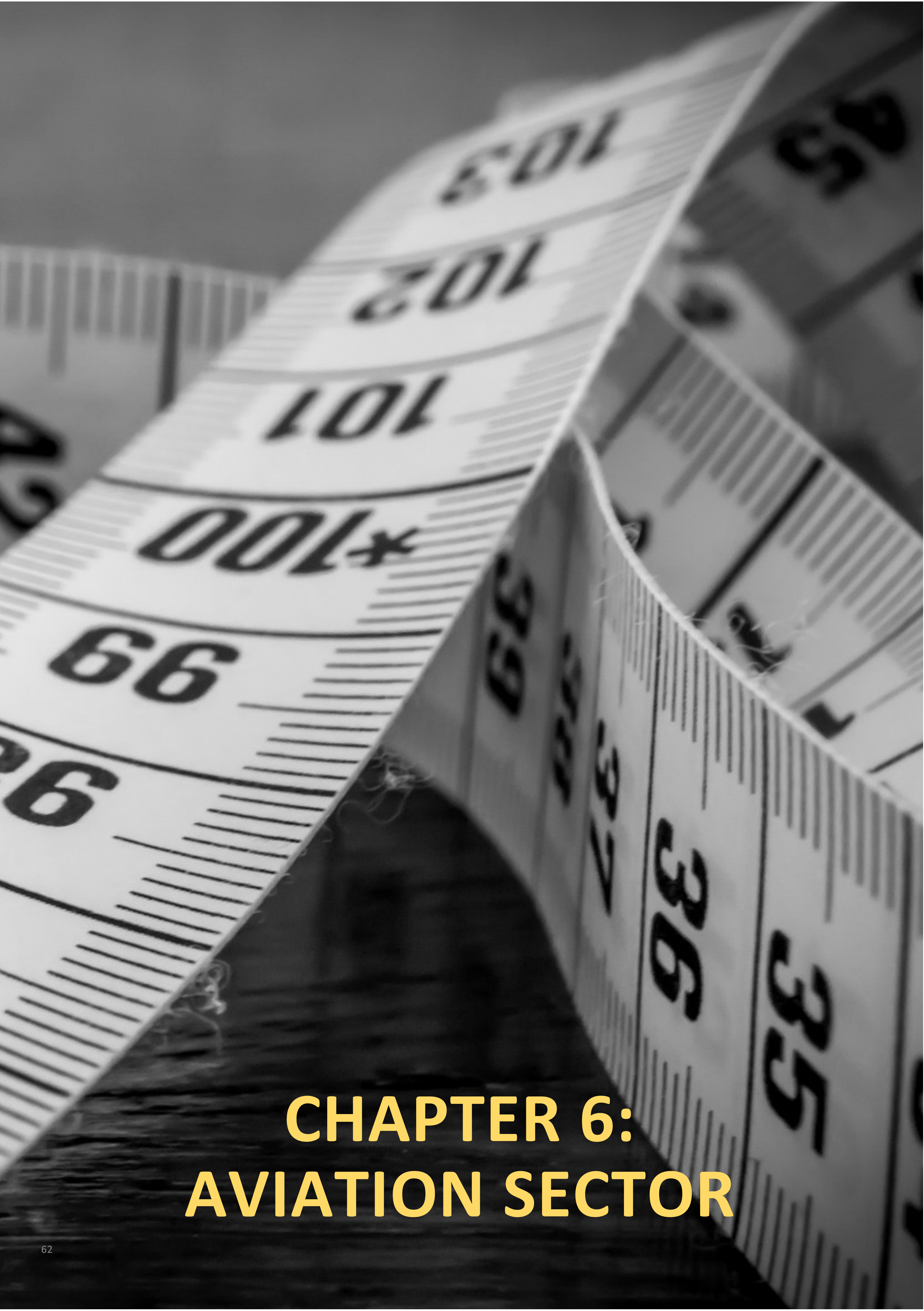


CHAPTER 6: AVIATION SECTOR

6 AVIATION SECTOR

GENERAL OVERVIEW

The transition risk story for the aviation sector articulates itself through three trends:

- **Changes in volume.** Demand for international flights is expected to grow on average 4%-5% annually in the coming decades (ICAO 2016a). In contrast, a 2°C transition would be associated with a low-demand scenario for air travel as consumers switch to rail, information technology, and local travel. Policy signals (e.g. carbon prices, incentives for rail travel, etc.) are likely to impact this. Modal switch, whether market or consumer driven, may thus play a key role in shifting volume, as well as unexpected macro trends (e.g. terrorism, pandemics, etc.).

- **Scaling of alternative fuels**. The scale up of alternative fuels will respond to evolving market standards (e.g. approval of blends for commercial use), development of country-specific policy goals (e.g. targets on biofuel consumption) and further extension of international organizations and coalition targets (e.g. continuation of IATA's and ICAO's fuel efficiency targets through to 2050).

- **Efficiency gains.** Fuel efficiency gains will come from two main sources: technological improvements related to the airplane itself (e.g. aerodynamics, designs, material substitution) and more sophisticated traffic management and infrastructure use (e.g. satellite navigation, optimization of control centres). The International Civil Aviation Organization (ICAO) has set a medium-term goal to improve fleet-fuel efficiency by 2% per year through 2020. Over the last years, this goal has been surpassed with annual average improvements of 3.9% IEA 2016a.

The scenarios presented here cover passenger aviation.

The scenario involves the following parameters:

PRODUCTION & TECHNOLOGY	
Demand (passenger-kilometres) Fuel efficiency (g fuel/revenue passenger km)	Biofuel Penetration (%)
MARKET PRICING	
Jet fuel prices (USD / gallon)	
POLICY MANDATES, INCENTIVES & TAXES	
Carbon credit mandates (# and Euro/t CO_2) Fuel efficiency standards (kg/km)	

5 THINGS BEFORE GETTING STARTED

1. **International vs. National Aviation.** Distinction between perspectives in international and national aviation are necessary to reduce the uncertainty around the quantification of transition risks. It is estimated that under the ACT Scenario, aviation will be near equally affected by carbon taxes and the shift to rail transport, while the first affects both international and domestic segments, the second is expected to represent a higher risk for domestic aviation (Table 6.1).

2. **Governance.** Governance in the aviation sector follows a two-fold approach. Governments are responsible for setting measures to decrease or control domestic emissions, while international emissions are covered by the measures set by the International Civil Aviation Organization (ICAO). Thus, alignment and coordination between both parties is required to follow an efficient application of the measures.

3. **International Targets.** ICAO has set two main goals: to improve annual fuel efficiency by 2% and to stabilize international aviation emissions at 2020 levels. To achieve this, it has developed a set of measures including, the CO_2 Emissions Certification Standard (see Page 69) targeting technology improvements, a Global Air Navigation Plan targeting operational improvements and a carbon-offsetting program (see Page 68) to compensate those emissions that surpass 2020 levels. ICAO has however not set any targets on the uptake of Sustainable Alternative Fuels (SAF). In the countries in scope, the initiatives come from governments (e.g. US and EU) and the private sector (e.g. Mexico and Germany).

4. **Biofuel Prices.** The price of biofuels will have a major role in increasing the uptake of Sustainable Alternative fuels. Currently there are few scenarios modelling the changes in biofuel prices for aviation. In the US, the Energy Information Administration has estimated that in 2020 prices could be in the range of 1€/L - 1.4€/L, an increase of 0.6€/L and 1€/L respect to jet fuel prices under a low oil price scenario. Recent estimates for Europe suggest that the additional costs could reach 1.20 €/L, representing an increase of 4.3€ per passenger in a 1000 km flight (Insight_E 2015).

5. **Market-based Measures.** The Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) is the first scheme regulating international emissions. It applies to all international routes except those to or from Least Developed Countries, Small Island Developing States or Landlocked Developed Countries. The program will start in 2021 in a voluntary basis until 2026. It is currently scheduled to last until 2035. The application of CORSIA is seen as a potential material risk for companies. Changes in three factors will determine the impact of the measure to the company: i.) fuel efficiency; ii.) demand, and iii.) the cost of an offset.

TABLE 6.1 REDUCTION OF WORLD AIR TRANSPORT BY DRIVER (GPKM & SHARE IN TOTAL GPKM) (SOURCE: AUTHORS, BASED ON IEA 2016)

Driver	2020	2025	2030	2035	2040
Carbon tax	162 (2%)	553 (6%)	1 066 (9%)	1 783 (13%)	2 541 (16%)
Rail transport	214 (3%)	566 (6%)	1 024 (9%)	1 588 (12%)	2 335 (14%)

6.1 DEMAND

Overview. ICAO estimates that global passenger traffic is expected to grow from 5 billion to more than 13 billion RPK (Revenue Passenger-Kilometer) over the period 2010-2030 (i.e. average annual growth rate of 4.9%). Under the scenarios developed here, the demand captures changes that could correspond to: i.) Modal shifts from air travel to High-Speed Rail (HSR); and ii.) Changes in the economics of air travel due to carbon pricing or other policy instruments.

Risk pass-through mechanism. A change in demand can be translated to a change in the average load factor of a company, thus having a direct effect on passenger revenues. Companies with long-term ownership of long-term assets purchased under growth assumptions that will not materialize are likely to be the most exposed to changes in volume.

Sources. Demand is generally modelled using external variables such as GDP and population projections, however, long-term changes are generally modelled using assumptions around changes in the connectivity of supply networks (e.g. OECD 2016, Boeing 2016) or substitution of air by rail transport (e.g. IEA 2016a, Greenpeace 2015). Modelling the sector's demand requires considering changes in domestic and international operations as both segments may behave differently in the transition, thus having a different impact at company level. Most scenarios either cover the sector as a whole (e.g. ETP) or one of the segments (e.g. Greenpeace 2015), limiting the analysis of a company's risk.

Method LCT. The LCT takes the estimates of IEA 4DS 2016. It does not model changes in the domestic segment as the scenarios follow the same demand levels under business as usual.

Method ACT. Two models are used, IEA's 2DS scenario which presents general sector changes, and an integrated assessment model developed by the International Centre for Research on Environment and Development (CIRED) which models domestic demand for selected regions. European countries estimates are build based the current country demand share (e.g. number of passengers) reported in EUROSTAT. The share is assumed to be constant across scenarios, in line with the low demand forecast of Eurocontrol 2017 and 2013. Domestic transport estimates for Brazil and Mexico were not built due to the lack of a granular regional breakdown.

Results. Under the ACT scenario demand's annual growth rate will be cut nearly by half compared to the LCT due to the effect of carbon-related policy instruments and the shift to rail transport. Brazil and Mexico are the economies that will experience the highest growth explained by macro-economic factors and the expansion of national and international routes (see Table 6.2). Companies with high domestic operations are the most exposed to the transition as global demand is expect to increase only by 27% through 2035 compared to current levels (see Table 6.3).

TABLE 6.2 AIR TRANSPORT DEMAND IN THE ACT AND LCT SCENARIOS (BILLION PKM) (SOURCE: AUTHORS, BASED ON IEA 2016A)

Year	World		Brazil		France		Germany		Italy		Mexico		US	
	ACT	LCT	ACT	LCT	ACT	LCT	ACT	LCT	ACT	LCT	ACT	LCT	ACT	LCT
2015	6 290		113		264		201		169		56		1 470	
2020	15%	21%	8%	12%	7%	15%	7%	15%	7%	15%	18%	25%	9%	13%
2025	32%	49%	30%	42%	10%	30%	10%	30%	10%	30%	37%	55%	16%	29%
2030	49%	82%	55%	80%	12%	45%	12%	45%	12%	46%	55%	89%	22%	44%
2035	65%	119%	85%	124%	14%	62%	14%	62%	14%	62%	71%	125%	29%	61%
2040	80%	158%	114%	171%	17%	80%	17%	80%	17%	80%	86%	161%	37%	80%

TABLE 6.3 GROWTH RATE OF AIR DOMESTIC TRANSPORT UNDER ACT (BILLION PKM) (SOURCE: AUTHORS BASED ON AEA 2016, EUROSTAT 2016, IATA 2016, CIRED 2016)

Year	World	France	Germany	Italy	US
2015	2 314	22	18	23	1 018
2020	-41%	-28%	-28%	-28%	-64%
2025	-28%	87%	87%	87%	-81%
2030	0%	179%	179%	179%	-59%
2035	27%	305%	305%	305%	-41%

6.2 FUEL EFFICIENCY

Overview. Fuel efficiency in the aviation sector relates both to policy measures and market trends. As part of the ICAO process, policymakers have agreed to define fuel efficiency standards that will be implemented in the course of the next decade. In parallel, fuel efficiency will also be driven by market forces. These relate to the evolution of aircraft design, the growing demand for efficiency and the expected associated cost benefits.

Risk pass-through mechanism. Fuel efficiency in the aviation sector is generally expressed in terms of fuel used or burned by kilometre travelled. The more fuel is consumed per kilometre travelled, the higher the costs, and therefore, the lower the gross profit margin. According to a study from ICCT, accelerated efficiency gains could save airlines $3 for every $1 invested (ICCT 2016b).

Sources. Scenarios present results around fuel efficiency generally at macro level (e.g. IEA 2016a, Greenpeace 2015). As an example, under IEA's 2DS scenario ICAO's goal of 2% annual reduction in energy use per passenger-kilometre a year is surpassed, the energy intensity decreases annually by 2.6% from 2015 to 2050. Other scenarios present results at a micro level allowing for a bottom-up analysis, but not necessarily solving for a specific climate target (e.g. ICCT 2016). Opting for one or another depends on the granularity of model used to assess financial risks.

Method. Fuel efficiency for both scenarios is taken from the scenarios developeby the ICCT (2016). In line with the philosophy of a 'market optimist' approach, the ACT scenario takes the most ambitious scenario developed by ICCT, which implements "all cutting-edge fuel-saving technologies in development for conventional airframe designs, irrespective of whether they are likely to be economically reasonable." Under a 2°C transition, it is assumed that this aggressive scenario materializes due to changes in the economics that allow for more ambitious fuel savings. This scenario complies with the 2.6% annual fuel efficiency needs estimated in ETP 2DS scenario. The LCT scenario takes a 'moderate' scenario that assumes modest technology improvements driven by policy factors. This scenario slightly exceeds ICAO's annual 2% efficiency target through 2034.

Results. Results are presented in Table 6.4 and apply to new aircraft that come online. The ambitious climate scenario envisions higher fuel savings of around 8 to 10% by 2024 and 4 to 5% by 2034 compare to the limited climate scenario. Years should be interpreted more as 'generations' of fleets rather than specific years given the nature or aircraft development. Values for 2020 and 2030 where interpolated using a polynomial function. To put these results into context, they largely reflect the results of the NASA ERA project (Nickol & Haller 2016).

TABLE 6.4 FUEL BURN (G FUEL BURNED/REVENUE PASSENGER-KM) BY TYPE OF AIRCRAFT UNDER THE ACT AND LCT SCENARIOS (SOURCE: AUTHORS, BASED ON ICCT 2016)

	Single Aisle		Small Twin Aisle		Regional Jet	
Year	ACT	LCT	ACT	LCT	ACT	LCT
2016	20		24		33	
2020	16.1 (-20%)	16.7 (-17%)	18.8 (-21%)	13.7 (-17%)	26.1 (-20%)	27.2 (-17%)
2024	12.1 (-40%)	13.2 (-34%)	13.7 (-43%)	15.9 (-33%)	19.6 (-40%)	21.8 (-33%)
2030	11.4 (-43%)	12.5 (-38%)	13.1 (-45%)	14.3 (-40%)	18.5 (-43%)	20.4 (-37%)
2034	10.9(-46%)	12.0 (-40%)	12.7 (-47%)	13.3 (-44%)	17.7 (-46%)	19.5 (-40%)

6.3 BIOFUEL PENETRATION

Overview. Sustainable Alternative Fuels (SAF) are one of the main sources that will enable the reduction of carbon emissions in the sector. ICAO estimates that to achieve their 2020 net zero emissions target under BAU, alternative fuels could potentially close the emissions gap that cannot not be addressed by technological and operational improvements. This however can only be possible provided 100% of petroleum-based jet fuel is replaced with sustainable alternative jet fuel by 2050. However, such a shift may not be feasible due to technical barriers (e.g. availability of technologies for commercial scale production), limits on feedstock yields and land requirements and pace of capital investment.

Risk pass-through mechanism. The impact of increased biofuels uptake on a company is uncertain. Higher fuel prices will impact costs, however, the emissions associated with the use of polluting fuels will require buying carbon offset credits (see Page 68). Thus, there exists the possibility of a compensation effect.

Sources. Several scenarios model changes in the uptake of biofuels, these are however limited to global estimates and do not disclose changes at regional nor country level. This split is relevant given the importance that the domestic market has in some countries. In general, scenarios estimate that the uptake of biofuels in the sector will start being representative in 2020 (IEA 2016a, Greenpeace 2015).

Method ACT. In designing an ambitious climate transition scenario, the scenario is based on the following assumptions. Countries in scope reach a global estimated biofuels market share of 3% by 2020 (ICAO 2016a). Non-European countries reach the IEA 2DS estimated share of biofuels of 55% by 2050. The final energy demand of biofuels in Europe is 77% by 2050 (Insight_E 2015). Analyst could as well use the IEA 2DS scenario estimated share. 2030 and 2040 values were extrapolated using a linear regression.

Method LCT. The LCT considers the estimates of Energy Technology Perspectives. In its 4DS scenario, ETP 2016 suggest a share of 3% of second generation biofuels by 2050.

Results. Table 7.5.6 presents the share of biofuels under an ambitious climate transition. The increase in the uptake needed to achieve the targets is substantial and it raises the question of ICAO's and governments role to enable deployment of these technologies. The ACT requires that current national commitments are surpassed, while levels required under an LCT could be reached already in 2020 following ICAO's estimations.

TABLE 6.5 SHARE OF SUSTAINABLE ALTERNATIVE FUELS UNDER AN ACT SCENARIO (SOURCE: AUTHORS, BASED ON EC 2011, IATA 2015, ICAO 2016, IEA 2016A AND INSIGHT_E 2015)

Year	Brazil	France	Germany	Italy	Mexico	USA
2020	3%	3%	3%	3%	3%	3%
2025	12%	16%	16%	16%	12%	12%
2030	20%	28%	28%	28%	20%	20%
2035	29%	40%	40%	40%	29%	29%
2040	38%	52%	52%	52%	38%	38%

6.4 JET FUEL PRICES

Overview. Jet fuel is the main fuel used today in air transport, the expectations around its price will thus be influenced by the decisions on fuel efficiency measures and the uptake of sustainable alternative fuels.

Risk pass-through mechanism. An increase in jet fuel prices will increase the operational expenses related to fuel costs, ceteris paribus, this translates in a decrease of the operating income.

Sources. There are no scenarios modelling the price of jet fuel oil under both an ambitious climate transition scenario nor a limited climate transition scenario.

Method. Jet fuel prices are highly correlated with crude oil Brent prices, thus under the ACT and LCT jet fuel prices are based on oil prices. Using historical correlation, a constant jet-fuel to oil ratio of 0.028 is applied for both scenarios.

Results. Table 6.6 presents the estimates for Jet fuel prices under the ACT and LCT. Under the ACT a decrease in prices is expected, this decrease will be responding to a decrease in jet fuel demand that is expected to halve by 2040 respect to 2030 levels.

TABLE 6.6 JET FUEL PRICE DEVELOPMENT (USD / GALLON) (SOURCE: AUTHORS, BASED ON ETP 2016 AND INDEX MUNDI)

Year	ACT	LCT
2014	2.7	2.7
2020	2.2	2.2
2025	2.4	2.7
2030	2.7	3.2
2035	2.7	3.4
2040	2.7	3.6

6.5 CARBON CREDIT MANDATE

Overview. International aviation emissions, which fall out of the scope of the Kyoto Protocol, are, since 2016, covered by the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) (see Page 63). Several other voluntary instruments exist (e.g. Clean Development Mechanisms, Verified Carbon Standard, the Gold Standard), however, in the aviation sector, as in general in the transport sector, the uptake is rather low.

Risk pass-through mechanism. The application of CORSIA will affect companies' operational expenses in the form of higher costs associated with the purchase of carbon offsets.

Sources. The only scenarios available modelling the effects of a market-based measure such as carbon offsetting programs have been developed by ICAO 2013, ICAO scenarios have however not been adjusted to include recent developments around CORSIA. Moreover, these scenarios do not intend to address the needs under a 2°C policy target but rather model the different avenues needed to reach the sector's targets.

Method. Under CORSIA only those emissions surpassing 2020 levels will be offset. This mean that under an ambitious climate transition scenario companies won't be required to offset their emissions, however, under a limited climate transition scenario companies will have to abide to the scheme. The role of CORSIA in risk assessment is defined then by two situations:

- The sector reaches its international emissions peak around 2020 (see Fig. 6.7). Companies do not have to buy offsets as emissions are under 2020 levels.
- The sector continues emitting over 2020 levels and carbon offsets must be purchased to achieve the sector's carbon neutral goal.

Results. The number of carbon offsets (see Annex 5) to be purchased by a company will depend on the overall total emissions of the countries participating in CORSIA, however, the impact of the measure on the emissions reduction will be conditional upon the cost of an offset. There is still high uncertainty around the cost of each offset and how it will articulate with measures set up at national level. The analysis can be conducted using either the expected carbon prices under the LCT (see page 26), thus reaching a maximum of 50 EUR/tCO_2 in 2040 or the "alternative" low carbon prices (see Table 6.8) that ICAO is currently including in its CORSIA roadshows.

FIGURE 6.7 PROJECTED DEMAND FOR OFFSETS UNDER AN MBM SCHEME (GT CO_2) (2020 - 2035) (SOURCE: AUTHORS, BASED ON ICCT 2013, 2016 AND ENVI 2015)

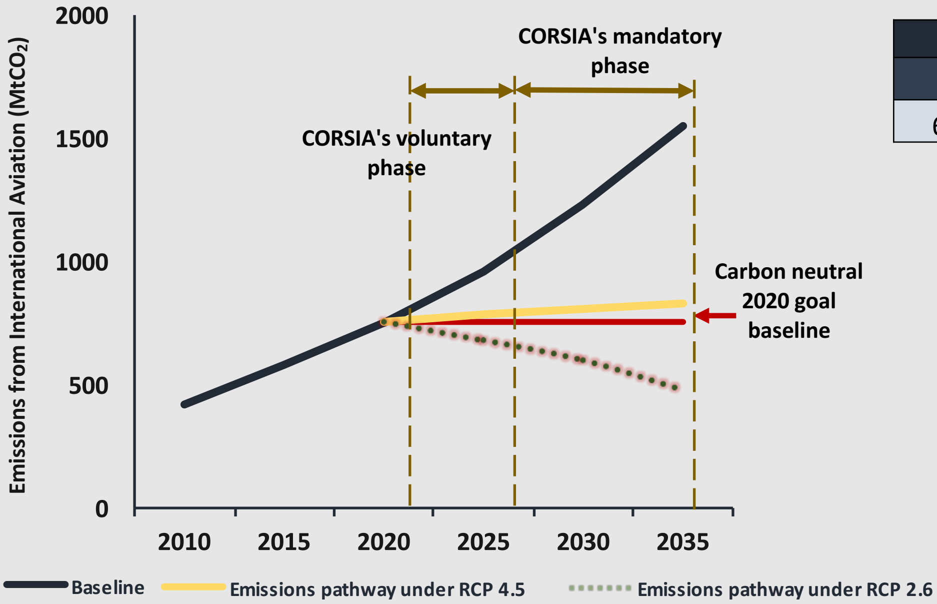


TABLE 6.8 ALTERNATIVE CARBON OFFSET PRICE UNDER CORSIA (USD/TCO_2) (SOURCE: AUTHORS, BASED ON ICAO 2016B)

Carbon offset price		
2020	2030	2035
6 \$/tCO_2	10 \$/tCO_2	12 \$/tCO_2

6.6 FUEL EFFICIENCY STANDARDS

Overview. Fuel efficiency standards are mainly based on emissions reduction through technology deployment. Two major standards, namely the non-volatile Particulate Matter (nvPM) standard for engines and the CO_2 Emissions Certification Standard have been recently adopted and will frame aircraft design in the following years. The focus is given to the latter standard, as the direct impact of the nvPM standard on climate change lies on the reduction of black carbon emissions (i.e. emissions from incomplete combustion), which do not fall under the scope of the study.

The ICAO developed in 2016 the first global CO_2 Emissions Certification Standard for new aircraft to support efficiency gains based on the adoption of fuel efficient technologies into airplane system design (e.g. propulsion, aerodynamics and structures). The standard will apply to new type (NT) designs of subsonic jet and turboprop airplanes launched after 2020 and those that will be in-production (InP) from 2023. Airplanes not meeting the standard can no longer be produced from 2028. The standard makes a distinction based on the maximum take-off weight of the aircraft (MTOM) and sitting capacity, it assigns a higher reduction of CO_2 to larger airplanes with a MTOM higher that 60 tonnes.

Risk pass-through mechanism. Compliance with a standard will require in general companies to increase their expenditure in fuel efficient measures. These expenses will most likely have a negative impact in the short run company's net income margins under and ACT. Under an LCT the expenditures will be compensated by the savings. However, since the stringency of the standards is low on average companies won't be affected by it.

Sources. There are currently no scenarios that put into context the application of the CO_2 Emissions Certification Standard. However, the requirements of the standard can be compared to the ICCT estimations on required fuel efficiency under the aggressive and moderate scenarios (see Page 65). ICCT "business as usual scenario" estimates an increase in fuel efficiency of 27% on average for new types in 2024 (ICCT 2016a).

Method. To date, there is no reference on the potential strengthening of the standard. Therefore, estimations around future values are not developed. The description and analysis of the standard is therefore intended to inform on the misalignment of current policy and needs under the scenarios developed.

Results. Under both scenarios companies will be on average already complying to the standard. Considering today's requirements, companies manufacturing and/or having a fleet complying with the minimum threshold won't be contributing to the achievement of either scenario. It is estimated that the standard will contribute to an average increase in fuel efficiency of 4% in 2020 (see Table 6.9), however, to achieve the efficiency levels required under the ACT and the LCT an average increase of 40% and 33% is already needed in 2024 (see Page 65). The standard therefore does not pose additional cost to companies under the selected scenarios – assuming they get implemented by companies.

TABLE 6.9 ESTIMATED METRIC VALUE (KG/KM) REDUCTION REQUIRED FOR NEW IN-PRODUCTION AND NEW TYPES AIRCRAFT BY AIRCRAFT CATEGORY UNDER BOTH SCENARIOS (SOURCE: AUTHORS, BASED ON ICCT 2016)

New in-production						
Aircraft type	Very large aircraft	Twin aisle	Single aisle	Regional jets	Business jets	Freighters
2015 average	2.9	1.7	0.9	0.7	0.6	2.1
2028 target	2.6	1.8	0.9	0.7	0.6	1.9
Reduction	10%	0%	6%	0%	0%	7%
New types						
New design aircraft average[5]	2.8	1.5	0.8	0.6	0.5	-
Required metric value (2020 – 2028)	2.5	1.7	0.8	0.7	0.6	-
Reduction	10%	0%	0%	0%	0%	-

MEET THE BUILDERS - ET RISK CONSORTIUM

The ET Risk consortium, funded by the European Commission, is working to develop the key analytical building blocks (Fig. 0.1) needed for Energy Transition risk assessment and bring them to market over the coming two years.

1. TRANSITION SCENARIOS

The consortium will develop and publicly release two transition risk scenarios, the first representing a 'soft' transition extending current and planned policies and technological trends (e.g. an IEA NPS trajectory), and the second representing an ambitious scenario that expands on the data from the IEA 450S /2DS, the project's asset level data work (see Number 2), and relevant third-party literature. The project will also explore more accelerated decarbonization scenarios.

2. COMPANY & FINANCIAL DATA

Oxford Smith School and 2° Investing Initiative will jointly consolidate and analyze asset level information across six energy-relevant sectors (power, automotive, steel, cement, aircraft, shipping), including an assessment of committed emissions and the ability to potentially 'unlock' such emissions (e.g. reducing load factors).

3. VALUATION AND RISK MODELS

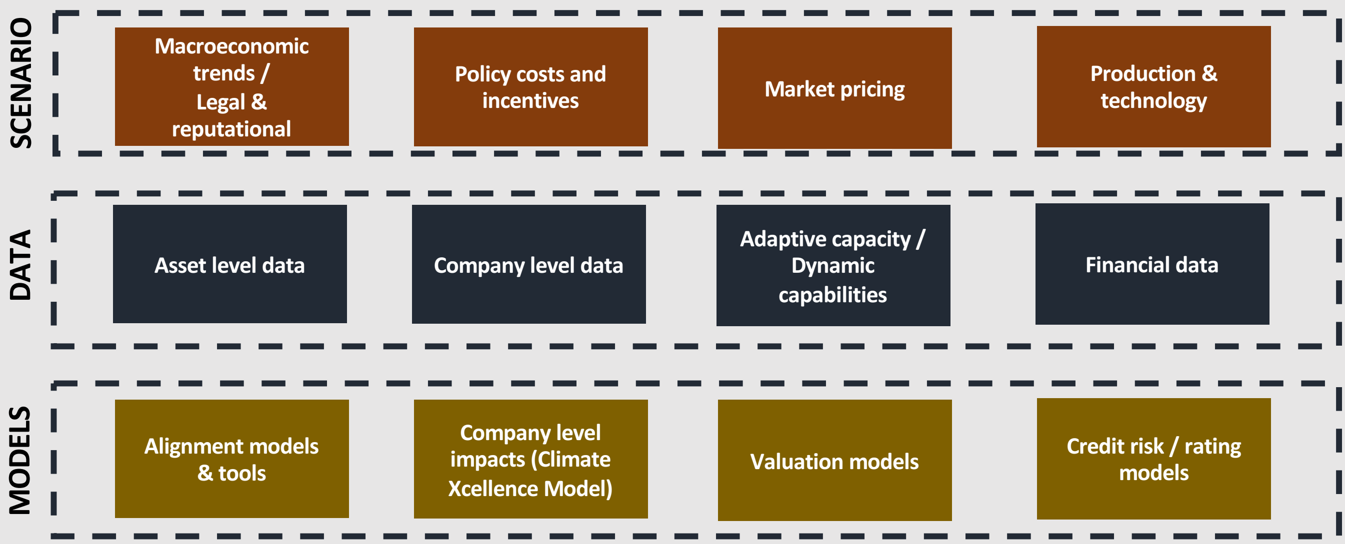
a) **2°C portfolio assessment – 2° Investing Initiative.** 2° Investing Initiative will seek to integrate the project results into their 2°C alignment model and portfolio tool and analytics developed as part of the SEI metrics project.

b) **ClimateXcellence Model – The CO-Firm**. This company risk model comprises detailed modeling steps to assess how risk factors impact margins and capital expenditure viability at the company level.

c) **Valuation models – Kepler Cheuvreux.** The above impact on climate- and energy-related changes to company margins and cash flows can be used to feed discounted cash flow and other valuation models of financial analysts. Kepler Cheuvreux will pilot this application as part of their equity research.

d) **Credit risk rating models – S&P Global.** The results of the project will be used by S&P Global to determine if there is a material impact on a company's creditworthiness. S&P Dow Jones Indices, a S&P Global Division, will explore the potential for developing indices integrating transition risk.

FIG. 0.0: ASSESSING TRANSITION RISK ACROSS THE INVESTMENT CHAIN (SOURCE: AUTHORS)



ABOUT 2° INVESTING INITIATIVE

The 2° Investing Initiative [2° ii] is a multi-stakeholder think tank working to align the financial sector with 2° C climate goals. Our research work seeks to align investment processes of financial institutions with climate goals; develop the metrics and tools to measure the climate friendliness of financial institutions; and mobilize regulatory and policy incentives to shift capital to energy transition financing. The association was founded in 2012 and has offices in Paris, London, Berlin, and New York City.

ABOUT THE CO-FIRM

The CO-Firm GmbH is a boutique consultancy specialized in developing climate and energy strategies for financial services providers, industry, and utilities. Based on financial risk modelling under a range of climate and energy scenarios, the proprietary ClimateXcellence Toolset, and a dataset of more than 200.000 assets and more than 15.000 different technical mitigation measures, The CO-Firm supports its clients in identifying, evaluating and realizing their specific economic opportunities in the national and global climate transition. Specifically, the CO-Firm serves its clients in adjusting their strategies, setting Science Based Targets, creating new business models, and identifying cost savings in their operations and their supply chain. Additionally, the consultancy provides regulatory monitoring services.

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