UNIVERSITY OF NORDLAND

BODØ GRADUATE SCHOOL OF BUSINESS

MASTER THESIS

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MBA i Luftfartsledelse
BE326E

Commercial Opportunities of a Proactive CO_2 Emission Policy for Norwegian Airlines

I - Abstract

Introduction:

In this thesis I discuss how airlines can benefit from reducing CO_2-emissions in a commercial way and benefit from possible future legislation.

Problem statement:

"Which commercial opportunities are created for the Norwegian airline industry by new CO_2-regulations*?"*

Procedure:

I start with fact finding, supplemented with relevant theory. From there, I discuss commercial opportunities created by a sustainability-policy.

Results:

I found a relationship between sustainability and profitability. However, it was not possible to conclude that, in my case studies, increased profitability was a direct result of a sustainability policy or vice versa.

(Main) Conclusions:

1. Additional research is required to determine the exact relation between cause and effect.
2. Airlines might benefit from the willingness to pay for sustainable air transport.
3. The Norwegian authorities adopt a restrictive policy for their employees in relation to air travel and encourage the use video conferencing. Video conferencing might become a substitute for air travel.
4. HSR – High Speed Rail is not expected to become a rival for the airlines offering domestic services in Norway.
5. The use of aviation biofuels is expected play a significant role in mitigation of CO_2-emissions.

II - Acknowledgements

I would like to take this opportunity to express my gratitude and appreciation to:

- ✓ Øystein Nystad for his guidance and supervision.
- ✓ Hilde Høiem, for the interview I had with her on March 28. 2014.

And, of course,

a big thank you for Charlotta (my wife) and Magne, Max and Marius (our 3 boys) for all their patience when their husband and dad was working on his thesis after he had finished his working day at the office.

III - Preface

The master thesis you are about to read, is the result of 6 months research into aviation profitability and sustainability.

The aviation industry has been my working place for 20 years. For my personal and professional development, I started a MBA-aviation course in 2010. This paper is the completion of that study.

It was not always easy to correctly distinguish between the essential and the ancillary. Despite that challenge, it was a great pleasure to work the thesis out. It was very much an education to find the relation between problem statement, theory and final conclusions and to discover that finding the complete answers is not always easy. I was faced with several valuable learning moments. Throughout the project I realized that more specific research on the subject is required.

I consider the completion of this thesis as a start of a next step in my dedication to profitable and sustainable aviation and hope you will enjoy reading it.

IV - Abbreviations

ADP: Air Passenger Duty

ATAG: Air Transport Action Group

ATM: Air Traffic Management

BLS: Bureau of Labor Statistics

CTDC: Civil Transport Development Corporation

DfT: Department of Transport

EBIT: Earnings Before Interest and Tax

EC: European Commission

EEA: European Economic Area

EFTA: European Free Trade Association

EP: European Parliament

EU: European Union

EU ETS: European Union Emission Trading Scheme

FAA: Federal Aviation Authorities (USA)

FSC: Full Service Carrier

FTK: Freight Tonne Kilometer

GDR: Gross Domestic Product

GHG: Green House Gases

HSR: High Speed Rail

IATA: International Air Transport Association

ICAO: International Civil Aviation Organization

JADC: Japan Aircraft Development Corporation

LCC: Low Cost Carriers

MBM:	Marked Based Measurements
PC:	Phone Conference
PKM:	Passenger Kilometer
ROIC:	Return On Invested Capital
RPK:	Revenue Passenger Kilometer
RTK:	Revenue Tonne Kilometer
VC:	Video Conference
WACC:	Weighted Average Cost of Capital

V - Table of Contents

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VIII - Term Glossary

Barriers to entry:[1]

The hurdles a new entrant would have to surmount in order to enter an industry. Low entry barriers lower the industry's average profitability. The threat of new entrants is one of the five forces.

Bio fuel (definition IEA)[2]*:*

Biofuels are fuels derived from biomass or waste feedstocks; includes ethanol and biodiesel.

Biomass (definition IEA)[3]*:*

Biomass is any organic, *i.e.* decomposing, matter derived from plants or animals available on a renewable basis. Biomass includes wood and agricultural crops, herbaceous and woody energy crops, municipal organic wastes as well as manure.

Certification requirement (definition from Airbus):

The combination of metrics, procedures, instrumentation, measurement methodology (ies), and compliance requirements.

Certified level (definition from Airbus):

Approved for a specific product by a certification authority to demonstrate compliance with a regulatory level, as determined by the certification requirement.

Competition[4]*:*

The term is commonly used to refer to rivals and rivalry, but for Porter, this definition is too narrow. Competition is the tug-of-war over profits that occurs not just between rivals but also between a company and its customers, its suppliers, makers of sustitutes, and potential new entrants.

[1] Understanding Michael Porter, Joan Magretta, 2012 page 211
[2] http://www.iea.org/topics/biofuels/
[3] http://www.iea.org/topics/biofuels/
[4] Understanding Michael Porter, Joan Magretta, 2012 page 212

Continuity[5]*:*

Porter uses the term to refer to stability in the core value proposition. Without continuity of direction, a company would be unable to develop and deepen its competitive advantage.

Corporate strategy[6]*:*

The overall strategy for a corporation that consists of diversified businesses in multiple industries.

Cost driver[7]*:*

The factors that influence cost.

Differentiation[8]*:*

The term is used to describe how one offering is positioned in relation to others. Porter uses this term to refer to a company's ability to command a higher relative price than rivals because its offering has increased customers' willingness to pay.

Diversification[9]*:*

The expansion of a company into different businesses. Porters thinking about diversification is directly linked to the value chain and its activities.

Five forces[10]*:*

Porters' seminal framework for assessing competition in any industry by analyzing the industry's structure. The framework explains the large and sustained differences in profitability from one industry to another. Five forces analysis is the first step in thinking about strategy, about how to shift the forces in your favor, and where you might be able to establish a unique positioning.

Flash point (definition from Air Transport Action Group):

The temperature at which the fuel ignites in the engine to cause combustion to occur.

[5] Understanding Michael Porter, Joan Magretta, 2012 page 213
[6] Understanding Michael Porter, Joan Magretta, 2012 page 214
[7] Understanding Michael Porter, Joan Magretta, 2012 page 214
[8] Understanding Michael Porter, Joan Magretta, 2012 page 215
[9] Understanding Michael Porter, Joan Magretta, 2012 page 215
[10] Understanding Michael Porter, Joan Magretta, 2012 page 216

Frameworks[11]:

The term Porter uses to distinguish his approach from formal economic models.

Freezing point (definition from Air Transport Action Group):

The temperature at which the fuel would freeze.

Generic strategies[12]:

Broad characterizations of the key themes of strategic positioning. A focused strategy chooses to limit the scope of customers and needs that a company serves. A differentiation strategy allows a company to command a premium price, while cost leadership allows it to compete by offering a low relative price.

Operational effectiveness (OE):[13]

Porter's umbrella term for a company's ability to perform the same or similar activities better than rivals.

Parameter:

A measured or calculated quantity that describes a characteristic of an aircraft.

Porter hypothesis (PH):[14]

Name given to Porter's argument that corporate pollution is often a sign of economic waste. Improving environmental performance, then, will often increase productivity and, in some cases, even offset the cost of making improvements. Corporations therefore should see environmental improvement not as a regulatory nuisance but as an essential part of improving productivity and competitiveness. Smart environmental regulation, Porter argues, encourages product and process innovation.

Procedures:

Specific certification procedures, including applicability requirements.

[11] Understanding Michael Porter, Joan Magretta, 2012 page 216
[12] Understanding Michael Porter, Joan Magretta, 2012 page 216
[13] Understanding Michael Porter, Joan Magretta, 2012 page 217
[14] Understanding Michael Porter, Joan Magretta, 2012 page 218

Regulatory level:

A limit which a certified level must meet.

Relative cost:[15]

Cost per unit relative to that of the rival. A relative cost advantage can come from two possible sources: Performing the same activities better (competing to be the best) or choosing to perform different activities (competing to be unique).

Relative price:[16]

Price per unit relative to that of your rivals. A relative price advantage comes from differentiation that produces buyer value (from producing something distinctive for which customers are willing to pay more.

Return on invested capital (ROIC)[17]*:*

A financial measure that weighs the profits a business generates versus the capital invested in it. Porter considers this the best financial measure of success because it captures how effectively a company uses its resources to generate economic value.

Standard:

Combination of a certification requirement and a regulatory level.

Strategy[18]*:*

The set of integrated choices that define how you will achieve superior performance in the face of competition.

Substitute[19]*:*

A product from another category that a consumer might choose to meet the same need the product serves. The threat of substitute is one of Porters five forces.

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[15] Understanding Michael Porter, Joan Magretta, 2012 page 219
[16] Understanding Michael Porter, Joan Magretta, 2012 page 219
[17] Understanding Michael Porter, Joan Magretta, 2012 page 219
[18] Understanding Michael Porter, Joan Magretta, 2012 page 219
[19] Understanding Michael Porter, Joan Magretta, 2012 page 220

Value chain:[20]

The set of all the discrete activities a firm performs in creating, producing, marketing and delivering its good or service.

Value creation:[21]

The process by which organizations transform inputs into goods and services that are worth more than the sum of those inputs.

Value proposition:[22]

The core element of strategy that defines the kind of value a company will create for its customers. A value proposition answers three questions: Which customers are you going to serve? Which needs are you going to meet? What relative price will you charge?

Value system[23]*:*

The full set of end-to-end activities involved in creating value for the end user.

Wide body aircraft:

Passenger aircraft with 2 aisles.

[20] Understanding Michael Porter, Joan Magretta, 2012 page 221
[21] Understanding Michael Porter, Joan Magretta, 2012 page 221
[22] Understanding Michael Porter, Joan Magretta, 2012 page 221
[23] Understanding Michael Porter, Joan Magretta, 2012 page 221

1. Introduction

Motivation and background:

This paper is my Master Thesis for the MBA-aviation management course at “Universitetet i Nordland” in Bodø - Norway.

Increasing air traffic and reducing carbon dioxide CO2-emissions seem to be contradictory at first sight. As an aviation- and nature enthusiast, I want next generations to benefit of the advantages of air transport while living on a planet where sustainability and respect for the nature are fundamental elements of society. In my opinion, we have responsibility to hand over “Planet Earth” with minimum negative consequences of our way of life to the next generations.

The aviation sector is a commercial driven industry. For airlines it is important not only to implement new regulations just because the law has changed but to look at the developments from a commercial point of view. I consider CO_2-reduction as a business opportunity for the air transport industry and try to find out whether it is possible to combine corporate social responsibility with increasing revenue and better economic performances. I am convinced that a proactive CO_2-policy can create competitive advantages and face the challenge to prove that that is correct. Last, but not least, I try to find out “how” that goal can be achieved.

The problem statement of the paper is:

“Which commercial opportunities are created for the Norwegian airline industry by new CO_2-regulations?”

CO_2-emission is not the only environmental challenge of the aviation industry; Other emissions include, but are not limited to, NOx (nitric oxide and nitrogen oxide contribute to the creation of ozon), sulfur oxides (SO2), aircraft noise, pollution of water and ground during aircraft handling and maintenance, creation of contrails and several other emissions. I have chosen to limit the paper to CO_2-emissions. The reason is that I have to delimit the scope of my thesis and it gives me the opportunity to create a more in depth research in the area of CO- possibilities. Another reason is that there is much information available about CO-emissions and that the public, policy makers and the industry mainly focus on CO_2-emissions. It is also a compromise of factors such as availability of research and available resources as time and personal knowledge.

From a geographic point of view, I have decided to delimit the paper to Norway. This does however not mean that it cannot be used for other countries/areas. Due to resources available, I have to delimit the thesis as a global approach would require a disproportional amount of research and time for a MBA-thesis. Another reason is that Norway is a country with an intensive domestic network; 3 of 10 busiest airport pairs in Europe counted per number of daily flights are domestic flights in Norway. That fact alone, illustrates that the Norwegian aviation industry faces its own specific environmental challenges.

In order to find answers to the problem statement, I take the reader through fascinating topics as the need of air transport in a globalizing world, the economic importance of the aviation industry, environmental consequences of the airline industry, political decision making processes, the role of stake holders, technical developments, business opportunities of sustainable aviation, research and development and other fascinating elements when balancing economic performance and sustainability.

While working on this thesis, I became more and more aware that many issues I refer to but which I do not discuss into detail. Those issues are however, relevant for the aviation industry, policy makers and stakeholders. In order to encourage others to join forces for sustainable aviation, I will share a couple of suggestions for further research which can be relevant for other students at "Universitetet i Nordland" or other scientific institutions.

I invite you to share my drive to encourage sustainable aviation.

Aim and objectives:

The aim of the thesis is to develop an understanding of commercial opportunities for Norwegian airlines when introducing CO_2-policy resulting in a decrease of CO_2-emissions without decreasing capacity.

The first objective of the thesis is to identify the importance of reducing CO_2-emissions, including the contribution of CO_2-emissions from the aviation industry.

The second objective of the thesis is to identify and validate ways to reduce CO_2-emissions, including the introduction of biofuels.

The third objective of the thesis is to develop an understanding of the technical challenges and possibilities to reduce CO_2-emissions.

The fourth objective of the thesis is to develop an understanding of political process behind the legal framework of CO_2-reduction, including the influence of NGO's.

The fifth objective of the thesis is to develop an understanding of the vision and policy of the airline industry in order to reduce CO_2-emissions.

The sixth objective of the thesis is to develop an understanding of demographic and economic challenges creating an increase of air traffic.

The seventh objective of the thesis is to develop an understanding of the policy of the Norwegian authorities in relation to CO_2-emissions from the aviation industry.

2. Thesis structure

In this chapter, I explain the structure of my thesis.

In chapter 1, I explained my motivation to choose the subject of the thesis and defined the problem statement, aim and objectives.

Chapter 3 contains an in-depth study of the economic, environmental, legal, and technological framework. The main purpose of that chapter is to share as many relevant facts as possible for the discussion, conclusions and final reflections. The chapter is primarily meant as a "fact finding chapter".

Chapter 4 describes the evaluation of theoretical selections. Theoretical models are discussed and I make a shortlist as starting point for the discussion. I start that chapter with linking profitability and sustainability and from there, I try to match the information with the most relevant theory.

Chapter 5 is used to discuss methodology. I explain why I choose a qualitative research.

I evaluate the performed interview in chapter 6. I regret that I did not receive the questionnaires on time.

In chapter 7, I discuss the problem statement in relation to theory and link that theory to the conclusions.

Chapter 8 is used to share the conclusions of my research.

Chapter 9 offers me the opportunity to share suggestions for follow up research.

My final reflections are shared in the final chapter, chapter 10.

3. Background analysis

The main purpose of this chapter is to discuss 4 different frameworks which I use as a basis for chapter 7discussion, chapter 8 (conclusions) and chapter 10 (final reflections). Chapter 3 can be considered as a “fact finding paragraph”. Unless specified, theoretical models will not be discussed, nor reflected.

The frameworks to be discussed are:

- The economic framework
- The environmental frame work
- The legal framework
- The technological framework

3.1 describes the economic framework. In that paragraph, I analyze the economic importance of the aviation industry, (global) market forecasts and the role of aviation in a more and more globalizing world.

3.2 describes the environmental framework and the environmental impact of aviation as well as the climate change effects of the aviation industry.

3.3 describes the legal framework of CO_2-emissions. I start with the Rio convention (1992) which was the basis for the Kyoto-protocol. The paragraph also describes attempts from the EU to reduce CO_2-emissions, relevant Norwegian environmental regulations as well as the effect of taxes on airline tickets. I will also discuss initiatives from some countries to decrease CO_2-emissions from the airline industry.

3.4 analyses the technological framework. That paragraph describes technological possibilities to reduce emissions, including introduction of biofuels, the influence of aircraft design on CO_2-emissions and possibilities the ATM infrastructure offers to reduce CO_2-emissions

3.1 The economic framework

3.1.1 Economical theory in relation to the aviation industry

My starting point is to place the economic framework in relation to the problem statement and aim and objectives of the thesis. In order to find a theory which I can use as a starting point of this paragraph, I use keywords which clearly describe the essence of the purpose of the thesis.

The keywords I use are:

Commercial opportunities, competition, creating value, profitability, customer preferences, strategy, innovation and substitutions.

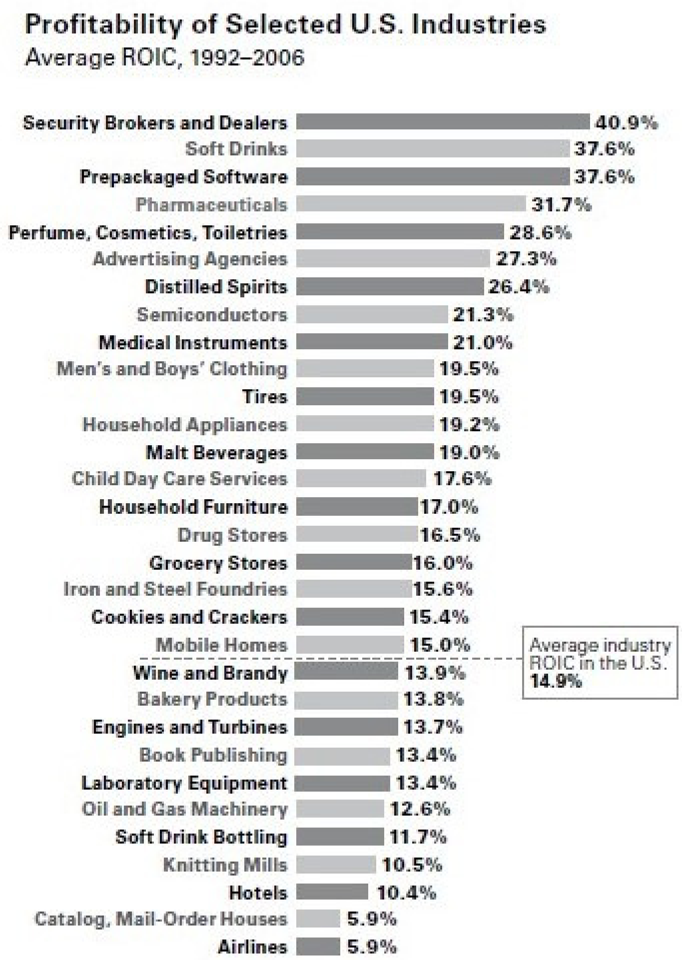
In his article “The five competitive forces that shape strategy – Harvard Business Review 2008”, Michael E. Porter describes how the following forces shape competition and influence profitability: Supplier power, customer power, established rivals, new entrants and substitutes. The article is an updated and extended version of Porters’ original article “How Competitive Forces Shape Strategy” from 1979.

My motivations to reflect the economic framework with Porter’s theory about the five competitive forces that shape strategy are:

- The theory helps to create a strategy which is unique for the industry.
- The theory can be used for a 2-step approach; analyzing the airline industry and analyzing a specific airline.
- Porter’s vision is that an organization will become (more) profitable by creating competitive advantages, not by offering the cheapest products/ services.
- All forces have a direct relationship to profitability.
- The theory takes substitutes and new entrants into account.
- The theory is applicable in all industries.
- The theory shows how the forces impact profitability.
- By using the five forces, it is possible to create a clear understanding of the competition. As a result, the organization can develop a strategy around the areas where the 5 forces are weakest.
- The theory builds on the economic relationship between relative price and relative cost in order to understand how organizations can create competitive advantage.
- The forces can show chances an organization was not aware of before analyzing the 5 forces.

- Analyzing the forces creates an opportunity to reshape the forces in the favor of the company.

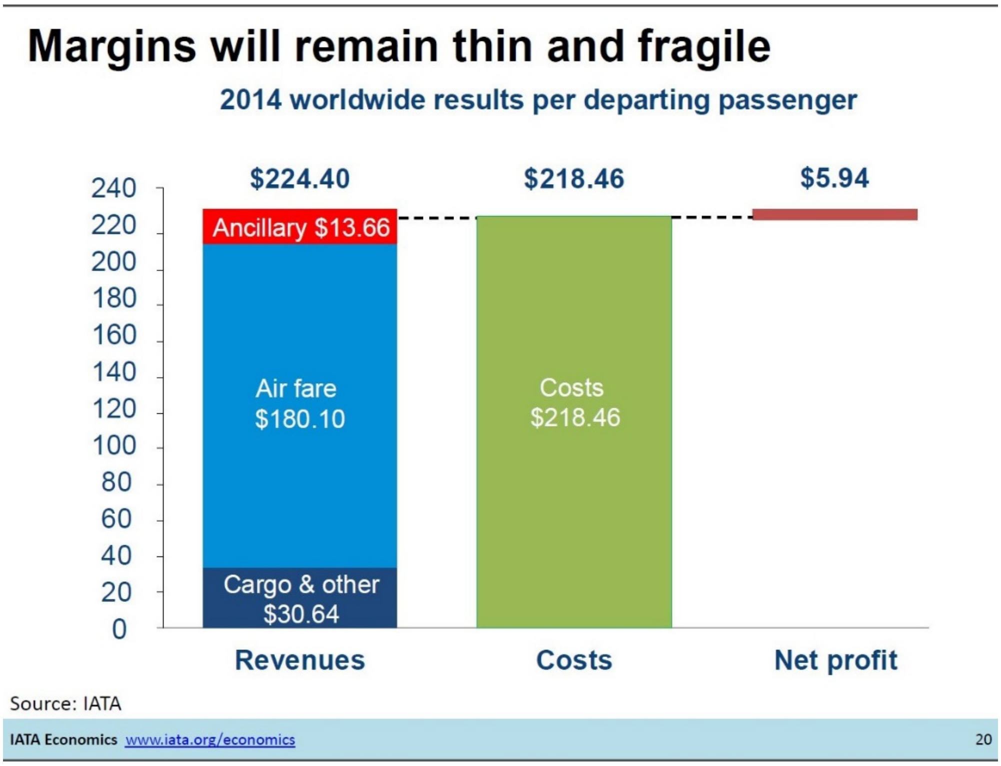
Porter describes the airline industry as one of the least profitable industries because all 5 forces are strong. In the period 1992 – 2006, the airline industry was the industry with the lowest ROIC – Return on Invested Capital of a selected group of industries in the USA. The average ROIC in the USA was 14,9%, while the airline industry achieved a ROIC of 5,9%. For a detailed summary, please refer to figure 1.



Figur 1, Source: Harvard Business Review

The weak profitability is confirmed by IATA's – International Air Transport Association - estimation "2014 worldwide results per departing passenger".

For 2014, IATA estimates that the average cost for the airline per departing passenger is $218,46. The average revenue per passenger in 2014 is estimated to $224,40, resulting in a net profit per passenger of $5,94[24]. That is a net margin of 2,7% per passenger in relation to costs per passenger (figure 2).



Figur 2, source: IATA

IATA argues that the nature of government intervention is a key reason for poor airline profitability. Other reasons mentioned in "Vision 2050" are lack of differentiation in the airline industry and the behavior of powerful suppliers.

Other indicators, illustrating the profitability of the airline industry are[25]:

[24] IATA - Vision 2050, Singapore 12 February 2011
[25] IATA – Vision 2050, Singapore 12 February 2011

- The global average EBIT generated by the airline industry is 0,7% during the 2000s.
- The global airline industry has generated an average annual post-tax profit of just over 0,1% of revenues over the past 4 decades.
- Airlines are unable to generate a return on invested capital (ROIC) equal to the weighted average cost of capital (WACC).

3.1.1.1 Air transport in a global macro economical perspective:

In this paragraph, I will discuss the macro-economic environment of the air transport industry. In order to get an understanding of the economic importance of air transport, I approach the economic framework from a global, European and Norwegian perspective.

ICAO – International Civil Aviation Organization, the civil aviation organization of the United Nations, estimates that each US $ output produced in the air transport industry creates a demand of $3.25 in other industries and that each job in the air transport industry creates 6.1 jobs in other industries. ICAO also ascertains that demand for air transport services is primarily driven by economic development. Increase in economic development creates an even bigger increase in air transport. On a global basis, the output of the airline industry increased by a factor of 30 between 1960 and 2002 while the worldwide GDP - Gross Domestic Product - increased with a factor of almost 4 in the same period. Research and empirical evidence indicate that approximately 2/3 of the global increase in air transport is directly GDP related and the other 1/3 is explained by other factors. The long term research also indicates that there is a pro-cyclical relationship between economic development and increase in air traffic.[26]

ICAO's findings are confirmed by the traffic numbers published by IATA – International Air Transport Association - of the period 2004 – 2012. In that period, the demand for air transport decreased during the credit crisis and regained an increase when the global economy started to recover in 2010.[27] Details are shown in table 1.

	2004	2005	2006	2007	2008	2009	2010	2011	2012
WEG%	4,3	3,9	4,4	4,3	1,8	-1,7	4,3	3,1	2,5
ΔP%	13,7	8,1	6,2	7,5	2,6	-2,4	8,8	6,9	4,9
ΔC%	10,3	2,5	6,4	4,7	-0,7	-8,8	19,4	0,4	-1,0

[26] Economic Contribution of Civil Aviation – Ripples of prosperity, ICAO, 2004
[27] Fact sheet; Industry statistics, IATA, March 2014

Table 1. Relation air traffic and WEG

WEG%: World Economic Growth

ΔP%: Passenger growth expressed in RPK

ΔC%: Cargo growth expressed in FTK

In a study performed for ATAG – Air Transport Action Group, Oxford Economics estimates that the aviation industry supported 3,5% of global GDP in 2012.[28] Other macro-economic data calculated in the same research include:

- The global economic impact of the aviation industry is estimated to $ 2,2 trillion.
- 56,6 million people are employed worldwide by aviation and related tourism.
- 35% of the values of world trade shipments is transported by air.
- 0,5% of the volume of world trade shipments is transported by air.
- 34,5 million jobs in tourism are supported by air transport.
- 51% of international tourists travel by air.
- Air transports contribution to world GDP related tourism is estimated to $ 762 billion.
- The world airfare in real terms has decreased from approximately $2,50 in 1970 to approximately $0,80 in 2010, making air travel more accessible.

The European Commission has published the following indicators which show the economic importance of the aviation industry for the EU-27 – EU including Norway, Iceland and Switzerland[29]:

- Air transport counts for 0,1% of the intra EU-27 freight transport, based on ton - kilometers.
- Air transport counts for 22,8% of value of the intra EU-27 import and export.
- Expressed in tons, 10,4 million tons (1,8% of total export) was exported by air.
- Expressed in value, €423,2 billion (27,1% of export value) was exported by air.
- Expressed in tons, 3,8 million tons (0,2% of total import) was imported by air.
- Expressed in value, €324,6 billion (18,9% of import value) was imported by air.

[28] Aviation, benefits beyond borders, ATAG 2013

[29] EU Transport in figures, statistical pocketbook 2013

- 394.400 people were employed in the air transport industry in2012.
- Intra EU-27 air transport contributed with 8,8% of the total person transport of 6.569 billion PKM (passenger kilometer). Total intra EU-27 passenger air transport amounted for 578 million PKM in 2012.
- The turnover of the air transport is estimated to be €122.097 million based on Eurostat estimations.
- The consumer price for air tickets in the EU has increased since 2001. The yearly increase is shown in table 2, with 2005 as reference year (index = 100):

Table 2, Consumer prices for passenger transport by air											
2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
89,5	91,8	93,4	94,5	100,0	100,7	100,3	110,9	110,0	112,2	120,3	126,2

- The EU-27 passenger aircraft fleet consisted of 3.953 units on December 31, 2012.

In "Vision 2050", IATA – International Air Transport Association – describes its vision of the airline industry until 2050. "Vision 2050" was published in February 2011.

From the report, it becomes clear that the center of gravity of the airline industry is moving eastward.

Due to increasing efficiency of new aircraft, higher utilization of aircraft, constant rise of labor productivity and improving operational performance of airlines, travel costs have declined by more than 60% over the past 40 years.

3.1.1.2 Forecast:

In order to get an impression of the position of air transport in the coming decades (until approximately 2030), I have analyzed air transport forecasts from the following organizations:

- Japan Aircraft Development Corporation (Consortium of Japanese aircraft industries for the development of commercial airplanes).
- Boeing (manufacturer of passenger aircraft from 120 passengers and cargo aircraft)
- Airbus (manufacturer of passenger aircraft from 100 passengers and cargo aircraft)
- Bombardier commercial aircraft (manufacturer of business aircraft, amphibious aircraft and passenger aircraft from 70 – 149 seats)

- FAA (Federal Aviation Authorities USA)
- Department of Transport (United Kingdom)
- Eurocontrol (nominated by the European Commission)

3.1.2 JADC Worldwide Market Forecast 2013 – 2032

JADC – Japan Aircraft Development Corporation is a non-profit foundation established for the enhancement of Japanese aircraft industry with the approval of the Japanese government. The foundation was established in 1973 as the Civil Transport Development Corporation (CTDC). The name was changed to JADC in 1982.[30]

The sources JADC used as a basis for the worldwide market forecast are IATA, ICAO, OAG, Ascend and Global Insight.

JADC uses the following macro-economic estimations for the forecast:

- Average annual growth of world GDP of 3,2%
- Air passenger traffic demand will increase annually with an average of 4,8% (in terms of RPK)
- Air cargo traffic demand will increase annually with an average of 5,1% (in terms of RTK)
- Number of aircraft in operation (cargo and passenger) will increase, on average, with 2,6% annually.
- The air transport industry (cargo and passenger) will require 32.348 new aircraft in the forecast period.
- The largest market for new aircraft will be the Asia-Pacific region with 14.606 of 32.348 new aircraft deliveries

➢ *Average economic growth*

JADC expects that emerging countries will drive the world economy in the forecast period and includes downside risks as a result of credit concerns in Europe and fiscal problems in the USA not being cleared completely away in the estimation. JADC expects an average of 3,2% global economic growth.

➢ *Air passenger demand forecast*

JADC expects an average increase of 4,8% annually, expressed in RPK. If that estimation is correct, RPK will be 2,6 times larger in 2032 than it was 2012. The Asia Pacific share will

[30] http://www.jadc.or.jp/outline_jadc_e.htm

rise from 27% in 2012 to 37% in 2032. The Asia Pacific region will become the largest passenger market in the world..

- *Air cargo demand forecast*

JADC expects an average increase of 5,1% annually, expressed in RTK. If that estimation is correct, RTK will 2,7 times larger in 2032 than in 2012. The Asia Pacific share will rise from 36% in 2012 to 41% in 2032. The Asia Pacific region will become the largest cargo market in the world.

Other expectations published by JADC for the period 2013 – 2032:

- ✓ Emerging markets will drive global air traffic demand
- ✓ Productivity of passenger jets will improve by increasing load factor and airplane size
- ✓ The greatest demand for new passenger jet aircraft will be in the Asia Pacific region
- ✓ Productivity of cargo jets will improve by increasing load factor and airplane size
- ✓ JADC expects a bullish air traffic demand and increasing yields for airlines. Due to increasing fuel prices, the net profit of the global airline industry will decline.
- ✓ In order to compensate for reducing net-profits, airlines will find new sources of revenue (check in baggage, seat reservation etc.). Despite increase in demand, the financial situation of airlines will worsen as a result of increasing fuel prices, increasing security costs and the effects of the global financial crisis. JADC expects more airline-mergers in order to reduce costs and increase market share.
- ✓ JADC expects increasing competition on the short haul market (flights of 1 to 2 hours) from high speed trains.
- ✓ JADC expects that the market share of LCC – Low Cost Carriers will mature due to the increase of fuel price. As a result of the increasing fuel price, the cost advantage of LCC's is shrinking as fuel cost account for a higher share of the operating expenses of a LCC than for a FSC – Full Service Carrier.
- ✓ JADC expects a decrease in the total number of turboprop aircraft. The decrease is explained by the disappearance of aircraft segments between approximately 15-60 seats as airlines are constantly focusing on decreasing the unit costs. The turboprop aircraft offered are manly in the market segment of 60 – 80 passengers and the developments of 90 – 100 seat turboprops are considered. Turboprop aircraft are more efficient that jet aircraft on short routes with relatively small passenger numbers.

- ✓ For the air cargo market, JADC sees that the cargo business is much more volatile in relation to economic changes. Air cargo operators face competition from trucks, freight trains and container ships which makes the market more challenging than the passenger market. The cargo airlines are more and more facing competition from passenger airlines which transport cargo on board in the lower holds and LCC's entering the cargo market. JADC expects that the cargo yield will drop with 0,8% annually over the forecast period. The company expects that the global jet freighter fleet will increase from 1.719 units in 2012 to 3.020 units in 2032.
- ✓ JADC expects that air passenger traffic, expressed in billions RPK, will increase from 5.407 in 2012 to 13.894 in 2032. For the air cargo market, JADC expects that the traffic, expressed in billions RTK, will increase from 203 in 2012 to 549 in 2032.

3.1.3 Boeing forecast 2013:

Aircraft manufacturer Boeing, one of 2 manufacturers of medium and large airline aircraft[31], estimates the growth between 2012 and 2032, based on the following prerequisites:

- Average annual growth of world GDP: 3,2%
- Average annual growth of airline passengers: 4,1%
- Annual growth of airline traffic (RPK): 5,0%
- Annual growth of cargo traffic (RTK): 5,0%

Taking these 4 key prerequisites into consideration, Boeing expects that the world fleet will grow from 20.310 units in 2012 to 41.240 units in 2032.

Boeing estimates that nearly half of the world's air traffic growth will take place in the Asia Pacific region. The company expects that the region's fleet size will increase from 5.090 aircraft in 2012 to 14.750 units in 2032[32]

The forecast is mainly based on the following market drivers and considerations:

- Market liberalization
- Airplane capabilities
- Environment
- High speed rail
- Fuel price
- Emerging markets
- Airline strategies and business models
- Infrastructure
- Economic growth
    - ➢ *Market liberalization*

The main consequence of market liberalization is a stimulation of competition, offering more choices to the customer and generally reduced ticket prices. As a result, the demand for air transport increases.

- ➢ *Airplane capabilities*

[31] Deloitte, 2014 Global Aerospace and Defense Industry outlook
[32] Boeing current market outlook 2013-2032

Boeing foresees an increase of the size of aircraft in order to reduce the unit costs of airlines (especially increased fuel costs).

- *Environment*

Boeing mentions 3 main areas of environmental challenges: Developing more efficient airplanes, greater operational efficiency of the global ATM-infrastructure and commercialization of sustainable aviation fuels.

- *HSR - High Speed Rail*

Boeing expects a limited impact on air transport due to the introduction of HSR. The manufacturer expects limited consequences for airlines operating in high-volume, high yield markets but that market only represents a small portion of the air transport market. Boeing sees market opportunities in intermodal transportation systems which combine the advantages of HSR and air transport.

- *Fuel price*

Fuel price is considered a major challenge to airline profitability. Boeing illustrates the impact by comparing the effect of fuel cost between 2002 and 2012. In 2002, fuel costs were approximately 13% of the costs of an airline and that percentage has increased to approximately 34%. Fuel costs are now the largest costs for an airline.

- *Emerging markets*

Boeing estimates that emerging and developing economies will account for 60% of global growth between 2012 and 2032 with fastest growing economies in the Asia Pacific region. As a result of the economic growth of the emerging markets, the average household income will rise, the educational level of the population increases, urbanization continues resulting in an increase of demand for international services and goods which will generate an increase in the demand of air transport.

- *Airline strategies and business models*

The demand for single aisle aircraft is mainly driven by low cost airlines while network carriers are the primary customers of wide body aircraft used in a global network.

- *Infrastructure*

Congestions on major airports is considered a main issue. Noise and other environmental concerns can limit the scope of expansion of the air traffic industry. As a method to reduce the pressure on the infrastructure, airlines have several ways to reduce the pressure on the infrastructure, including:

- Use of larger aircraft resulting in decrease of the number of aircraft movements at airports.
- Creating secondary hubs and expanding services to secondary airports.
- Airline alliances allow airlines to expand route systems while decreasing the pressure on the infrastructure

On average, Boeing expects that the global cargo market will more than double over the next 20 years with an average grow of 5,2% per year. Boeing expects that the growth will mainly take place in emerging markets with a yearly domestic demand increase in China of 8,0% and intra-Asia with 6,9%.

3.1.4 Airbus forecast

"Future Journeys 2013 – 2032" is Airbus' most recent global market forecast. Airbus describes that air traffic has doubled every 15 years and expects to double again the next 15 years. Airbus ascertains that the average seat capacity of airliners in use is increasing. The combination of higher seat capacity per aircraft and introduction of new aircraft technologies results in a significant reduction of unit costs and emissions per passenger kilometer.

The forecast demand for air travel is mainly based on the following elements:

- Economy
- Market drivers
- Network development

Airbus mentions 2 main factors which drive the demand for air transport: Economic growth, expressed in GDP, and air ticket pricing.

Airbus argues that the average ticket price in the USA, in real $, has decreased with approximately 40% since the 1980's. In relative terms the decrease of ticket prices, since the 1940's, is illustrated by comparing the ticket price with an average income. In 1941, a trip from Los Angeles to Hong Kong would have cost more than a year income of an average US-citizen. In 2013, the same citizen had to work less than a week to pay the same trip. Airbus uses these illustrations to show that air travel has become affordable for more people resulting in an increase of demand for air transport.

In the Global Market Forecast, Airbus takes into account that 70% of the world economic growth between 2027 and 2032 will be created in emerging economies. As a result of that development, Airbus anticipates on a significant growth in demand for air traffic in emerging markets.

- *Economy*

Airbus considers an increase in GDP as the main economic indicator creating demand for air travel. Other macro-economic indicators which are considers as strong drivers for demand for air transport are real consumption and trade, population growth and the size of the middle-class in a country. Taken all these indicators into consideration, Airbus expects the largest growth in the Asia-Pacific region. The company expects that the Asia-Pacific region will take delivery of 36% of global new aircraft deliveries between 2013 and 2032 Airbus expects a trend towards increasing oil prices and that price volatility will not diminish in the short term. The rise in oil prices forces airlines to minimize fuel consumption and fuel costs. Airbus states that airlines reduce their seat mile costs by purchasing larger aircraft.

The Global Market Forecast also describes increasing globalization, liberalization of air transport and the entry of new, more capable, long range aircraft as economic key factors which increase the demand for air travel.

For the period between 2013 and 2032, Airbus expects that the global traffic growth will be dominated by emerging markets.

- *Market drivers*

Airbus states that demographic developments are explanatory variables in relation to demand for air travel. Airbus mentions 3 major demographic drivers for the airline industry: Population growth, urbanization and new middle-class emerge in developing countries as these factors give an explanation for the reasons and frequency of travel. Other demographic variables which are mentioned to have an impact on the demand for travel are migration and the number of students studying abroad.

The United Nations expects that the largest population centers are focused in Asia in 2025. Airbus considers urbanization as an important variable as the company states that urbanization goes hand in hand with the emergence of a middle-class. Airbus estimates that the global middle-class will increase from 2,228 billion people in 2013 to 5,211 billion people in 2032. In Asia-Pacific, the middle-class is expected to increase from 856 million people in 2013 to 3,526 million people in 2032.

Due to amongst other economic globalization and the resulting increase in air transport demand, aviation networks have grown for decades. Airbus refers to an Oxford Economics study included in the IATA Annual review 2013 which states that the increase in connectivity in the past 20 years has provided an additional $200 billion in global GDP. As increase in GDP is a key driver for air transportation, Airbus reasons the creation of a kind of virtuous circle.

Network development

Between 1990 and 2012 both short haul and long haul traffic showed a more or less constant growth. Long haul traffic grew faster (4,2% annual growth) than short haul traffic (2,9% annual growth). Airbus defines short haul traffic as “flights of less than 2.000NM”.The company estimates that long haul traffic is more price sensitive than short haul traffic. The estimation is based on the negative impact of economic shocks on long haul traffic. Airbus indicates that this sensitivity can be explained by the fact that those trips represent a higher proportion of an individual income.

Airbus expects that long haul traffic will be more and more concentrated on “Mega-City’s”. An “Aviation Mega-City” is defined as “a city that handles more than 10.000 long-haul passengers per day”. The definition was created by Airbus. The Global Market Forecast indicates that there were 42 mega cities worldwide in 2012.

In 2012, 93% of global long haul traffic (0,8 million passengers daily) passed through one of the 42 mega cities.

Airbus estimates that the number of mega cities will grow to 89 in 2032. According to Airbus’ estimations, 99% of global long haul traffic (2,2 million passengers daily) will pass through a mega city in 2032.

In 2012, most mega cities were located on the northern hemisphere. In 2032, the majority of mega cities will be located on the southern hemisphere.

The growth is not only expected to take place in the Asia Pacific region. The number of mega cities in Latin America is expected to increase from 2 in 2012 to 10 in 2032. In Africa, Airbus expects that the number of mega cities will increase from 1 in 2012 to 8 in 2032.

7 airports handled more than 50.000 long haul passengers in 2012. In 2032, Airbus expects that that number has increased to 26.

Following these estimations, long haul traffic will be more concentrated on mega-cities.

Due to several airline-mergers, Airbus notices that the number of airlines offering long haul services has decreased for the first time in 40 years.

For the short haul market, Airbus notices that the average seat capacity has decreased since 2000. The traffic growth in the short haul segment has been created by the opening of new routes and the introduction of the low cost model in new regions.

3.1.5 Bombardier forecast

Bombardier is a Canadian manufacturer of regional aircraft with a seating capacity between 70 and 149 seats. Bombardier's most recent commercial aircraft market forecast reflects the company's market expectations between 2012 and 2031. The company's most recent global aerospace forecast reflects Bombardier's market expectations between 2013 and 2032. The global aerospace forecast is less detailed, but more recent, than the commercial aircraft market forecast. The company manufactures turboprop and jet airliners.

The company sees one concerning factor in airline economics over the forecast period: The rise of oil prices as predicted by the EIA – United States Energy Information Administration. Bombardier states that airlines were successfully able to manage increasing fuel costs in recent years by increasing ticket prices but expects that the cost increase will reach the tipping point of consumer's price resistance soon.[33] For the manufacturer this development means that it anticipates on an increasing market share of turboprop aircraft. Bombardier is of the opinion that turboprop aircraft are most efficient for short- and medium haul flights, while jet aircraft are most efficient on longer routes.

It is Bombardiers expectation that airlines will be more and more focusing on unit costs resulting in the purchase of larger regional aircraft. As a result of that development, Bombardier expects that the 100- to 149 seat aircraft segment will show the strongest growth in the forecast period.[34]

Bombardier describes the following market indicators for the airline industry[35]:

- Economic growth expressed in GDP
- New aircraft order intake

The manufacturer expects a 3,26% average global GDP - increase between 2012 – 2031. Non-North American or European economies are expected to account for 61% of the growth.

Bombardier states that demand for air travel is reflected in orders for new aircraft. In the market segment of aircraft for in the category 20 – 220 passengers, the net orders more than quadrupled between 2009 and 2011. For details, please refer to table 3.

[33] Bombardier commercial market forecast 2012-2031
[34] Bombardier commercial market forecast 2012-2031
[35] Bombardier commercial market forecast 2012-2031

New aircraft orders of passenger airliners carrying 20 – 220 seats more than quadrupled between 2009 and 2011	2009	2010	2011
Aircraft net orders 20 – 220 seat segment:	556	1.414	2.381
Table 3. Source: Bombardier			

In the global aerospace forecast, Bombardier describes the following long term commercial aircraft market drivers:

- Economic growth
- Fuel prices
- Fuel volatility
- Replacement demand
- Emerging markets
- Environmental regulations
- Environmental fees
- Labour trends

Bombardier's commercial aircraft market forecast is mainly based on 2 key macro-economic indicators: 3,26% average economic growth in global GDP and an average oil price of $126/BBL based on EIA's estimations.[36]

➢ *Economic growth*

Increase in GDP is considered the primary driving force for increase in air traffic. The secondary driving force is the removal of barriers as taxes and barriers for market penetrations by amongst others low cost airlines.

With 3.710 units, Bombardier expects that North America will be the largest market for regional airliners between 2012 and 2031.

➢ *Fuel price and volatility*

[36] Bombardier commercial market forecast 2012-2031

Bombardier expects increasing oil prices resulting in higher fuel prices. Airlines try to compensate the increasing fuel price and negative effects of fuel price fluctuations by purchasing larger regional aircraft in an attempt to reduce unit costs.

- *Emerging markets*

The urbanization in emerging markets is considered as an important drive for economic growth which is reflected by an increase of GDP.

The company uses UN estimations as a basis for the urbanization forecasts. Based on the UN-estimations, Bombardier expects a strong increase in urbanization in emerging markets resulting in an increase in demand for air travel in emerging markets.

For a more detailed overview of market drivers influencing commercial aircraft demand, as expected by Bombardier, please refer to figure 3.

Figure 3, Source: Bombardier

3.1.6 FAA forecast

In the “FAA Aerospace Forecast Fiscal Years 2013 – 2033”, the FAA describes to expect an average US passenger growth of 2,2% annually between 2013 and 2033. The growth is closely related to the GDP-development. FAA expects that the economic growth in the USA between 2013 and 2033 will be at 2,5% average annually, compared to a global 3,2% annual economic growth. In table 4 (next page)

In the forecast, the FAA states that the demand for air cargo is driven by economic activity. FAA also mentions that the air cargo industry faces competition from other alternative shipping modes like trains, ships and trucks. The FAA does not refer to US –government’s policy to introduce a high speed train network in the USA which might influence the domestic air travel demand.[37]

[37] High speed rail strategic plan, Federal Railroad Administration, April 2009.

	2013	2033	Growth in %
Load factor domestic flights, expressed in % of ASM	83,8	85,2	1,7
Load factor international, expressed in % ASM	81,6	82,1	0,6
Load factor total, expressed in % ASM	83,1	84,0	1,1
Revenue passengers (millions) carried by US airlines	736,7	1.146,8	55,7
Revenue passenger miles (billions) carried by US airlines	826,0	1.462,0	77,0
Revenue passengers (millions) on International flights to/from USA. U.S. and foreign carriers.	176,4	402,9	128,4
Revenue passengers (millions) on Atlantic flights to/from USA. U.S. and foreign carriers.	60,2	134,0	122,6
Revenue passengers (millions) on Latin America flights to/from USA. U.S. and foreign carriers.	62,2	155,0	149,2
Revenue passengers (millions) on Pacific flights to/from USA. U.S. and foreign carriers.	30,3	70,1	131,4
Revenue passengers (millions) on U.S./Canada flights. U.S. and foreign carriers.	23,6	43,9	86,0
Passenger jet aircraft of U.S. mainline air carriers	3.744	4.907	31,1
US commercial air carrier all-cargo revenue ton miles (millions)	28.999,4	73.317,2	152,8
US commercial air carrier cargo revenue ton miles (millions) carried by passenger aircraft	7.539,4	15.651,3	107,6
Total US commercial air carrier cargo revenue ton miles (millions)	36.538,8	88.968,5	143,5
Cargo jet aircraft of U.S. mainline air carriers	827	1.211	46,4
Table 4			

In the forecast, the FAA states that the demand for air cargo is driven by economic activity. FAA also mentions that the air cargo industry faces competition from other alternative shipping modes like trains, ships and trucks. The FAA does not refer to US –government's policy to introduce a high speed train network in the USA which might influence the domestic air travel demand.[38]

[38] High speed rail strategic plan, Federal Railroad Administration, April 2009.

3.1.7 Department for Transport forecast (UK)

The DfT - Department for Transport, published the "UK Aviation Forecasts" in January 2013. The DfT analyzed the historic correlation between demand for air transport and economic indicators. 2 key indicators were found to explain the historic growth in air transport demand: Growth in income and decreasing ticket prices. The DfT states that increasing costs in relation to CO_2-emissions, makes a further decline in ticket prices unlikely.

Income as demand driver:

The DfT anticipates that the aviation market in the United Kingdom will slowly mature and will become less responsive to changes of the value of key-indicators. In the period 1970 to 2010, the number of UK terminal passengers increased with an average of 5% annually. In the period 2010 – 2050, the DfT expects that the average growth will decrease to 1% - 2% annually. In the forecast, the 5 largest South - East airports are expected to have reached the maximum capacity in 2030.

In the forecast, DfT publishes the price elasticity's of passenger demand in relation to the 2 key drivers for demand: Income and air fares.

As a foreign passenger demand driver, DfT has established an annual real growth foreign GDP projection for the period 2008 - 2050. The projection is has the following input:

- Projections for 2008 – 2015 are based in IMF World Economic Outlook (WEO), October 2012.
- The projections for 2016 – 2050 were produced by the research and consulting company "Enerdata" and calibrated to the World Energy Outlook 2011.
- The projections were thereafter weighted by the proportion of traffic travelling between the UK and relevant countries in 2008.

DfT expectations are further based on the following prerequisites:

- The growth rates for visible trade volumes have historically followed those of GDP. The assumptions are based on the correlation between trade with UK and foreign GDP-growth.
- The growth rate of trade with Western Europe and other OECD members grows at the same rate as the local GDP of those regions (based on historical data).
- Trade with NICs – New Industrialized Countries and LDCs – Developing Countries, are considered to grow at the same rate as UK GDP (based on historical data)

The growth projections (used as foreign passenger demand driver) are split by 4 geographic regions as shown in table 5

Annual average real growth foreign GDP used as foreign passenger demand driver	
	Annual average growth 2008 - 2050
Western Europe	1,70%
OECD (non-European) countries	2,10%
NICs	5,20%
LDCs	4,30%
Table 5	

Decreasing ticket price as demand driver:

The ticket price is strongly related to airline costs. Reducing cost will create opportunities to further decrease ticket prices. The DfT discusses the following costs:

- Fuel costs
- Carbon costs
- APD - Air Passenger Duty
- Other airline costs
- Load factors
- Trip length

➢ *Fuel costs*

The relationship between fuel price and oil price is, according to DfT estimations, based on the following assumptions:

- The oil price in $ per barrel is converted to oil price in £ per barrel
- Based on historical data, it is assumed that a £10 increase in the oil price per barrel. Leads to a 7 pence per litre increase in aviation fuel prices.
- The fuel price per litre is adjusted for forecasted changes in fuel efficiency.

DfT expects that world oil prices, based on 2008 prices, increase to more than $120 in 2030 and are held constant in real terms from 2030.

As oil prices are volatile, DfT uses a range of uncertainty. In the low oil price scenario, DfT expects an oil price of $73 per barrel (2008 price) in 2030. In the high price scenario, DfT expects an oil price of $174 per barrel (2008 price) in 2030.

- *Carbon costs*

DfT forecast are in line with DECC's – Department of Energy and Climate Change 2012 projections of the traded prices of carbon. The volume of CO_2-emissions is estimated from the expected fuel consumption. DfT assumes that, during the forecast period, a policy has been implemented that ensures that the aviation industry pays for CO_2-emissions. The most recent DECC projections assume that the cost of a tonne of traded CO_2-equivalent emissions will be £70 in 2030 and almost £200 in 2050.

- *Fuel efficiency*

Replacement of less fuel efficient current aircraft types by new more fuel efficient aircraft is considered as the primary source of fuel efficiency gains. Other means to achieve fuel efficiency gains are reducing the distances flown (ATM-infrastructure) and operational practices (e.g. optimized payloads and selection of altitudes, routes and speeds). DfT expects that the effect of the use of new and more fuel efficient aircraft will be a further reduction of air fares with 4% in 2030 and 19% by 2050.

- *Air Passenger Duty*

The Air Passenger Duty costs are considered to remain constant in real terms (rates rising with inflation) for the forecast period (until 2050).

- *Other airline costs*

Other airline costs (staff, maintenance, marketing etc.) had a downwards trend in the last decade. Non-fuel costs in real terms declined by, on average, 2% annually between 1998 and 2010.

DfT explains the decrease of "other airline costs" by:

- Increasing competition
- Convergence of low cost and full service airline business models
- Evolution of non-fare revenue streams by airlines

The decrease in "other airline costs" are expected to continue but at a slowing rate. DfT assumes that those costs will continue to decline with an average of 1% annually until 2030. After 2030 the costs are expected to be held constant.

- *Load factor*

The load factor is used to calculate the average fare level. The higher the load factor is, the lower the unit cost. As airline costs do not generally increase with the number of passengers, load factor can be used as an input for the ticket price and is therefore considered as a demand driver correlated with airline costs.

- *Trip length*

Fuel estimates are generally based on a seat kilometer basis. Trip length is therefore considered as a demand driver which is correlated with airline costs.

Availability of substitutes

DfT refers to the CCC – Committee on Climate Change report "*Meeting the UK aviation target – options for reducing emissions to 2050*".

In that report the CCC discusses videoconferencing and high speed rail as possible substitutes for flying. Based on the CCC report, DfT does not expect significant changes in passenger behavior due to the availability of substitutes. I will discuss a selection of the findings of the CCC-report in the paragraph "substitutes".

Based on the research, DfT expects the following market development:

- Taking the capacity constraints of the airport infrastructure into account, the number of passengers at UK airports is expected to increase from 219 million passengers in 2011 to 315 million passengers in 2030. The number will continue to increase to 445 million in 2050.
- The major airports in the South East area of the UK are forecast to be full by 2030. Due to uncertainties in the projections that situation can be reached as early as in 2025.
- Demand for air travel will increase with 1-3% a year up to 2050. That is significantly lower than the average of 5% increase in air travel between 1970 and 2010. The decrease in growth is explained by market maturity and a slower decline of air fares compared to 1990 – 2010.

- The average trip length is expected to increase from 1.746km in 2010 to 1.822km in 2030.
- The capacity offered by airlines, expressed in millions of available seat kilometers, will increase from 781.938 in 2010 to 1.125.053 in 2030.
- The demand for air freight, carried on dedicated cargo aircraft, is expected to increase with 0,4% per year until 2050. The relative moderate increase is explained by e.g. increase in the share of cargo transported on passenger aircraft, increasing aviation fuel prices and increasing capacity and frequency of shipping possibilities.

3.1.8 Eurocontrol

Eurocontrol is a civil-military intergovernmental organization with 40 European Member States and the EU - European Union[39].

Eurocontrol is involved in almost every aspect of air traffic management in corporation with stakeholders including airspace users, air navigation service providers, airports, aviation regulators, the aeronautics industry and international aviation organizations[40].

Eurocontrol estimates that the aviation sector supports approximately 4 million jobs in Europe and expects that number to rise with 1,5 million in 2023[41]. The number of 4 million refers to the whole of Europe, contrary to the number of 394.400 estimated by the EC in 3.1.1. It has to be mentioned that the EU-27 number refers to transportation and storing activities only. Eurocontrol's estimation corresponds with ICAO's estimations of 4,2 million jobs published in 2005[42]. That number includes direct, indirect and induced employment.

I have selected 3 Eurocontrol 3 reports, describing the IFR – Instrument Flight Rules -traffic movement expectations for the European airspace.

The 3 reports are:

- Eurocontrol Seven – Year forecast February 2014, Flight Movements and Service Units 2014 -2020. The report was published in 2014 and uses 2013 as reference year.
- Challenges of growth 2013, Task 4: European Air Traffic 2035. The report was published in 2013 and uses 2012 as reference year.
- Challenges of growth 2013, Task 7: European Air Traffic 2050. The report was published in 2013 and uses 2012 as reference year.

Eurocontrol reports that 9,4 million IFR-flights were conducted in Europe in 2012 and that that number increased to 9,5 million IFR-flights in 2013.

3 member states showed an increase of IFR – movements in 2013 compared to 2012: Turkey, Norway and the UK. As a direct result of the financial crisis in Europe, all other member states showed a decrease in flight movements.

[39] https://www.eurocontrol.int/articles/member-states
[40] http://www.eurocontrol.int/articles/stakeholders#internationalorganisations
[41] https://www.eurocontrol.int/articles/eurocontrol-economics-and-business-cases
[42] http://www.icao.int/Meetings/wrdss2011/Documents/JointWorkshop2005/ATAG_SocialBenefitsAirTransport.pdf

For the scope of the thesis, I consider the difference of 0,1 million yearly flights between 2012 and 2013 as negligible in relation to the long term forecasts.

Eurocontrol uses 2 forecast units; Constrained and unconstrained forecasts. Unless specified, all forecasts mentioned in this paragraph are constrained forecasts. Contrary to unconstrained forecasts, constrained forecasts take capacity constraints of the infrastructure into account.

In the base scenario, Eurocontrol expects the number of IFR-movements to increase to 11,2 million in 2020. That implies a 19% increase in traffic movements compared with the reference year 2013. The forecast includes downside risks (e.g. capacity reductions due to weaker demand) and upside risks (high load factors might not be able to absorb the passenger demand when the traffic starts to grow).

Due to macroeconomic and geopolitical uncertainties, the aim of the 2050 forecast is to analyze and explain factors shaping future air traffic. The aim is not to estimate exact traffic counts.

Due to the uncertainties influencing demand for air traffic after 2020, Eurocontrol has developed 4 scenarios for the period until 2050.

1. Scenario A (Global growth). This scenario is characterized by strong economic growth in an increasingly globalized world. This scenario reflects the highest growth.
2. Scenario C (Regulated Growth). This scenario is an extension/extrapolation to today's situation. In this scenario economic growth is considered to be moderate.
3. Scenario C' (Happy Localism). This scenario is characterized by European economies mainly focusing on local exchanges.
4. Scenario D (Fragmenting World). This scenario represents a world with increasing tensions between regions, security threats and weakening economies. Initially, traffic is expected to grow to 11,2 million flights in 2035. The growth in air traffic will mainly come from countries outside Europe. A 6% traffic decline is expected between 2035 and 2050. The decline is considered to be a result of a lack of political of economic adaptability.

Table 6 illustrates the expected growth in the number of IFR-flights in relation to each scenario

	IFR-movements (million)			Multiple	Multiple
	2012	2035	2050	2012/2035	2012/2050
Scenario A	9,5	17,3	26,1	1,8	2,7
Scenario C	9,5	14,4	18,6	1,5	2,0
Scenario C’	9,5	13,8	17,7	1,4	1,9
Scenario D	9,5	11,2	10,5	1,2	1,1
Table 6					

Eurocontrol states trends which, to a greater or lesser extent, are applicable for all scenarios. The trends which I consider most applicable in relation to this thesis are:

- Flights to and from Europe are accountable for the major growth.
- The northwestern region of Europe is the area with the highest number of IFR-movements.
- A trend to increasing proportion of medium- to long-haul flights.
- There is unaccommodated demand by 2050. The majority of that demand is in the Mediterranean area.

Eurocontrol discusses the following demand drivers:

- GDP development
- Demographic factors
- Airspace and airport constraints
- Purpose of a journey
- Substitutes for air transport
- EU ETS – European Union Emission Trading Scheme

GDP development

GDP is considered to be the main driver for travel demand. In the base scenario, Eurocontrol expects a GDP-development for ESRA08 as shown in table 7.

2014	2015	2016	2017	2018	2019	2020
1,5%	1,9%	2,0%	2,1%	2,1%	2,1%	2,0%

Table 7

ESRA = Eurocontrol Statistical Reference Area. ESRA is used for high-level reports when referring to "total Europe", including non-member states e.g. Latvia.

On the long term, Eurocontrol expects that EU-27's share of the world economy will shrink from 29% in 2010 to 23% in 2025. After 2025, Europe's share is expected to further decrease to 17% in 2050.

Eurocontrol uses GDP multipliers to convert economic growth into growth into passenger numbers. The value of the multiplier is not published in the forecasts.

Demographic factors

Eurocontrol mentions 2 demographic factors which influence passenger demand: Size of population and age composition of the population.

The age composition of the population is an important demand driver, as air passengers aged 25 – 54 represent a disproportionate number of air passengers.

Eurocontrol uses the UN-estimations as bases for the forecast. Based on those estimations, Eurocontrol expects the world population to rise to 8,9 billion people in 2050 (with a low growth scenario of 7,4 billion and a high growth scenario of 10,6 billion people). The population of less-developed areas is expected to increase with 58% over the period 2000 – 2050. The population of more developed areas is expected to increase with 2% over the same period.

In Europe, Eurocontrol expects an overall decline of an aging population. In the UN-medium variant, Europe's share of global population is expected to shrink from 11% in 2000 to 7% in 2050.

Airport constraints

Eurocontrol expects that capacity constraints will increasingly affect the demand in Europe from 2018.

Due to the airport constraints, Eurocontrol estimates that the demand for unconstrained 144.000 flights cannot be accommodated by 2020. As a result of the airport constraints, Eurocontrol estimates a 1,3% growth reduction (0,2% yearly reduction) in 2020.

In 2035, the number of unaccommodated demand is expected to have reached 1,9 million flights, accounting for 12% of the demand.

A complicating factor in relation to airport constraint is the economic situation in Europe. Recent traffic reduction contributes to the constraint problem of the future. As fewer flights cause less revenue for airports, their possibilities to finance expansion plans are limited.

The number of IFR-flights decreased between 2011 and 2013, as shown in table 8.

2011	2012	2013
9.784.000	9.548.000	9.447.000

Table 8.. Number of IFR – flights in Europe 2011 – 2013, source Eurocontrol

The biggest mismatch between demand and capacity in 2035 is expected in Turkey (30% of demand which can't be accommodated), followed by other states mostly located in Eastern Europe (Bulgaria, Hungary, Romania), with an estimated mismatch between 17% - 22%. The mismatch in Norway is estimated to be 10-15%.

The air transport industry and governments responds to that constraint in several ways. Examples are:

- Airlines use aircraft with larger seating capacity or they move elsewhere.

- Airports invest in infrastructure.
- Governments invest in alternative transport modes as high speed rail.

Purpose of travel

Passengers belonging to different market segments are responding differently to demand drivers like income and ticket fares.

The market for leisure travel has been found to be price elastic. The link between air travel and migration is variable. Migrations are expected to be driven by economic reasons. Eurocontrol expects that the market for business travelers might get competition from virtual technologies as a new generation grows up with constantly improving technologies. Finally, the market for air freight is strongly correlated to overall world trade.

Eurocontrol does not specify a forecast about air travel demand of the segments mentioned but shows that different market segments respond differently to new market circumstances.

Substitutes for air transport

The Eurocontrol report discusses 3 possible substitutes for air travel:

- HSR – High Speed Rail
- Maglevs
- Virtual technologies

  - HSR

Eurocontrol indicates that HSR both competes with and complements passenger air transport on the short-haul network. The expansion of HSR is expected to reduce the demand for short haul flights by 0,6% in 2035. On the other hand, the air transport capacity is expected to be used on routes without competition of high speed trains. As a result, the expansion of the HSR - network is expected to reduce the pressure at congested airports instead of reducing the number of flights.

The strongest reduction in demand for flights as a result of introduction or expansion of the HSR - network is shown in table 9.

Table 9. Reduction in “unconstrained” demand for flights in 2035 due to HST. Source: Eurocontrol

Denmark	France	Germany	Italy	Spain	Sweden	Switzerland	UK
-0,8%	-2,5%	-0,5%	-0,7%	-2,5%	-3,0%	-0,7%	-0,6%
Table 9							

- Maglevs

A way of transportation which may influence air travel demand in 2050, is the maglev. That is a train which is suspended by a magnetic field. These trains can achieve speeds up to 500 km/h. A maglev line is proposed between Berlin and Moscow reducing travel time between the 2 cities to 4 hours.

- Virtual technologies

Eurocontrol anticipates on a reduction of business travel due to the introduction of new virtual technologies (improved video conferencing possibilities) but does not give a quantitative estimation of possible decrease in business air travel demand.

ETS

The EU introduced the EU ETS - EU Emission Trading Scheme - for the aviation industry in 2012. Due to global political disagreement about introducing a worldwide CO_2-emissions system, the EU has decided to temporarily suspend enforcement of the EU ETS requirements in 2010, 2011 and 2012 for flights from or to non- EU countries. As the EU ETS application and its impact are reduced and the fact that carbon prices are relatively low, Eurocontrol estimates that the impact of EU ETS on flight demand is negligible.

3.1.9 The economic framework of aviation in Norway

Samferdselsdepartementet – The Norwegian Ministry of Transport and Communications published "Strategi for norsk luftfart" in 2008, describing the strategy for Norwegian Aviation.

Due to the geographic characteristics of Norway, including relative long distances, orographic terrain, climatological elements and challenging topographic conditions there is a relative large demand for transportation by air.[43] Other demand drivers for (domestic) air travel in Norway air: Decreasing prices of air tickets, increasing seating capacity and a high income per inhabitant. After Luxemburg, Norway had the highest income per capita in 2011.[44]

In 2011, Norway was ranked number 4 in European number of air trips per person after Malta, Cyprus and Iceland.[45] [46] The ranking is based on information from Eurostat.

An overview of the number of passengers in relation to the size of the population is given in table 10[47]

Number of air passengers in relation to population 2011. Source: Eurostat and Aftenposten	
Malta	8,4
Cyprus	8,3
Iceland	7,7
Norway	6,5
Switzerland	5,2
Ireland	5,1
Denmark	4,6
Spain	3,6
Table 10	

The ranking of Malta and Cyprus are explained by the number of incoming foreign tourists in relation to the size of the population[48].

[43] Strategi for norsk luftfart, Samferdelsdepartementet, 2008
[44] http://www.oecd-library.org
[45] http://www.dn.no/nyheter/naringsliv/2012/11/21/nordmenn-flyr-mest-i-europa
[46] http://www.aftenposten.no/okonomi/Nordmenn-flyr-mest-i-Europa-7050587.html#.U3j9Dfl_voE
[47] http://www.aftenposten.no/okonomi/Nordmenn-flyr-mest-i-Europa-7050587.html#.U3kRzvl_voE
[48] http://www.aftenposten.no/okonomi/Nordmenn-flyr-mest-i-Europa-7050587.html#.U3kRzvl_voE

The ranking of Iceland can be explained by geographic and topographic situation and transfer passengers on transatlantic flights. In 2011, Reykjavik – Keflavik airport, handled 412.000 transatlantic transfer passengers[49]. In the same year, on January 1st, the country had a population of 318.452 people[50]. The Icelandic airline Icelandair, which uses Keflavik airport as a hub for its transatlantic flights, offers flights to 14 destinations in the USA and Canada with connecting flights from several European destinations[51]. The Scandinavian airline SAS offers transatlantic flights to 4 destinations in the USA[52] (increasing to 5 in the summer of 2014) and the Norwegian airline Norwegian offers flights to 5 destinations in the USA[53].

The Norwegian ranking can be placed into perspective with other countries by a few examples[54]:

- The number of air trips, in relation to the size of population, is 100% higher than in Sweden.
- The number of air trips, in relation to the size of population, is 40% higher than in Denmark.
- Norwegian airports handled 32 million passengers (population 4,9 million[55]) in 2011. Swedish airports handled 30 million passengers (population 9,5 million[56] in the same year.
- Norway had 14,6 million singe domestic air trips in 2011. That is 100% more than Sweden and approximately 35% less than the United Kingdom. The size of the population in the United Kingdom was 63,2 million in 2011[57].

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[49] http://www.icenews.is/2012/03/08/keflavik-international-airport-expects-passenger-traffic-increase-for-2012/
[50] http://www.statice.is/
[51] http://www.icelandair.co.uk/destinations/
[52] http://www.flysas.com/
[53] http://boarding.no/art.asp?id=54904
[54] http://www.aftenposten.no/okonomi/Nordmenn-flyr-mest-i-Europa-7050587.html#.U3kRzvl_voE
[55] http://www.ssb.no/
[56] http://www.scb.se/sv_/Hitta-statistik/Statistik-efter-amne/Befolkning/Befolkningens-sammansattning/Befolkningsstatistik/25788/25795/Behallare-for-Press/Befolkningsstatistik-2011---folkokning/
[57] http://www.ons.gov.uk/ons/rel/census/2011-census/population-and-household-estimates-for-the-united-kingdom/stb-2011-census--population-estimates-for-the-united-kingdom.html

Another source which illustrates the role of air transport is the ranking amongst most trafficked city pairs in Europe. In the top 10- of the city pairs with most flights on a daily basis, Norway is represented by 3 domestic routes.[58] For detailed information, please refer to table 11

Rank	Departure Airport	Arrival Airport	Average Daily Movements*	Growth on 2012
1	BARCELONA	MADRID BARAJAS	62	-19.1%
2	ISTANBUL-ATATURK	IZMIR-ADNAN-MENDERES	59	12.5%
3	TOULOUSE BLAGNAC	PARIS ORLY	51	0.6%
4	TRONDHEIM/VAERNES	OSLO/GARDERMOEN	49	4.3%
5	MILANO LINATE	ROME FIUMICINO	48	1.9%
6	OSLO/GARDERMOEN	BERGEN/FLESLAND	48	-2.2%
7	PARIS ORLY	NICE	46	1.6%
8	ISTANBUL-ATATURK	ANTALYA	44	6.4%
9	OSLO/GARDERMOEN	STAVANGER/SOLA	44	2.0%
10	ISTANBUL-ATATURK	ANKARA-ESENBOGA	42	4.3%

* both directions

Table 11. Busiest city pairs per number of daily flights, 2012. Source: Eurocontrol

In “Strategi for norsk luftfart” the following main points of strategy are mentioned:

- The civil aviation industry is an international industry. The industry in mainly regulated through international regulations and agreements.
- Safety has the highest priority.
- More sustainable civil aviation. The question is raised whether the growth of air traffic can continue in relation to global climate challenges. The Government and the Ministry of Transport and Communications will work for global solutions to climate change.
- Nationwide infrastructure.
- Guaranteeing air services and passenger rights.
- Education, work environment and labour market.

As an EFTA – European Free Trade Association member and EEA – European Economic Area state, Norway is part of the internal market between EU and EEA.

As a result of the agreement between The EU and EEA, the Norwegian aviation market was deregulated in the 1990’s. For Norway that means that every airline which is authorized in one EU- or EEA -country has free access to the internal market of another EEA- or EU-

[58] Source: Eurocontrol,

member state. There are some exceptions on that rule, but those exceptions are not discussed in this paper.

The Norwegian aviation market is dominated by 3 airlines: SAS, Norwegian and Widerøe. SAS and Norwegian operate a domestic and international network with jet aircraft with a seating capacity between approximately 90 and 190 in the domestic and international market. On intercontinental routes to/from Norway the airlines also use widebody aircraft with a seating capacity between approximately 250 – 300 passengers. Widerøe is a regional airline using turboprop aircraft with a seating capacity between approximately 35 – 78 seats.

In the 17 years previous to the publication of the report in 2008, the number of air passengers in Norway more than doubled from approximately 19 million in 1990 to more than 40 million in 2007. The traffic increase continued and in 2013, Norwegian airports handled 52 million passengers[59].

TØI – Transportøkonomisk Institutt/ Stiftelsen for Norsk senter for samferdselsforskning (Institute of Transport economics/ Norwegian centre for Transportation research) published the report «Luftfartens betydning i en global verden» (The significance of aviation in a globalised world) in 2011. The report analyses the economic significance of aviation for the Norwegian industry. The report discusses e.g. the increase in services by low cost airlines, the importance of air cargo for the Norwegian industry and presents 2 scenarios for future aviation developments towards 2030. Avinor is the client of the report.

The TØI-report indicate that Norwegian companies are more and more integrated in the global production network. Globalization makes that air travel together with ICT - information- and communication technology get a more and more important role. Despite the fact that air travel is strongly correlated to economic cyclical fluctuations, the demand for air travel by Norwegian companies is increasing, especially to the USA and Asia. The demand for air cargo shows the same trend as the demand for air travel; It is increasing, mainly triggered by customers in the USA and Asia importing fresh salmon from Norway. Other industries increasing demand for air cargo are humanitarian organizations offering relief work and the petroleum industry.

The report describes driving forces behind globalization which are important in relation to the demand for air transport to/from Norway:

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[59] Source: SSB

- Liberalization of world trade, the development of the single European market and integration of emerging markets as China and India.
- Reduced cost of transportation and communication and the development and implementation of ICT.
- Competition which is not limited by national boundaries any more.

The TØI report states that high Norwegian labour cost is a strong driver for Norwegian companies to offshore activities. High labour costs are confirmed by data received from Eurostat and from BLS Bureau of Labor Statistics (USA).

In the period 2008-2013, Norway had the highest labour unit cost expressed in €/hour of all European countries, every single year[60]. Over the same period, labour costs increased with 28,2% which is the highest increase in labour cost after Bulgaria between 2008 and 2013.

BLS publishes an overview of labour costs per unit, based on a global approach. A global comparison of labour costs per unit in Norway, expressed in $/hour, is given in table 12

Year:	2010	2011	2012
Country:			
Norway	57,66	64,76	63,36
Brazil	10,01	11,67	11,20
Canada	34,36	36,34	36,59
China*	1,21	1,59	1,74
India**	1,46	Not available	Not available
Japan	31,75	35,71	35,34
Mexico	6,14	6,49	6,36
Philippines	1,89	2,02	2,10
Republic of South Korea	17,89	19,25	20,72
Singapore	19,42	23,13	24,16
United States of America	34,81	35,51	35,67
Table 12[61]			

[60] http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/File:Labour_costs_per_hour_in_EUR,_2008-2013_whole_economy_excluding_agriculture_and_public_administration.png
[61] http://www.bls.gov/fls/country.htm

* Labour costs for China were available until and including 2009. The costs mentioned in are the labour costs in 2007 (column 2010), 2008 (column 2011) and 2009 (column 2012) respectively.

** Labour costs for India were available until and including 2010

TØI has concluded that outsourcing activities create additional (business) travel demand as Norwegian companies are located on more and more locations worldwide.

The report describes the possible substitution of air travel by ICT. Based on the research performed by TØI, it can be concluded that there might be substitution up to a certain degree, but the effect on the demand for business travel will be limited. The main reasons are:

- Physical meetings are considered very important for networking/ relation building with partners with non-Norwegian cultural background. This is especially important in the Asian/ Pacific region where the largest economic growth is expected.
- It is considered important to be able to visit regions for more or less “random” business contacts which can be developed to a supply-customer relation in the future. Examples are visiting exhibitions and conferences.
- Physical meetings are considered important when discussing complex projects which require a high level of knowledge. As a general rule it can be stated that the more complex a project is, the higher the need for immediate coordination will be.

Substitutes for air transport in Norway

HSR:

In 2007, VWI (a German consultancy group) concluded that it was commercially possible to introduce HSR in Norway on the routes Oslo-Trondheim and Oslo-Gothenburg. As a basis for its research, VWI made use of a German calculation model. The research was ordered by “Jernbaneverket” on behalf of the Ministry of Transport and Communication in 2006. The final report was published in 2007[62]

On behalf of the Ministry of Transport and Communications, the consultancy company Econ performed a bca - benefit-cost analysis of introducing high speed trains on 2 routes to and

[62] High-Speed Railway Lines in Norway. Concept Evaluation, Cost Estimate and Uncertainty Analysis, October 2007

from Oslo using the Norwegian calculation model. The report of the analysis was published in 2008.

Econ concluded that introducing HSR between Oslo–Trondheim and Oslo–Gothenburg, will not be create the benefits required to justify the investments[63]. The main arguments for the conclusion are:

- The traffic volume is too low (1,95 million on the route Oslo-Trondheim and 2,23 million for the route Oslo-Gothenburg).
- For society as a whole, the benefits of transferring passengers from aircraft to train are too small (reduction CO_2-emissions is not in relation to additional travel time).

As a reference point for its conclusions, Econ used the EC-guideline for bca, applicable in 2008: "*only under exceptional circumstances (a combination of low construction costs plus high time savings) could a new HSR line be justified with a level of patronage below 6 million passengers per annum in the opening year; with typical construction costs and time savings, a minimum figure of 9 million passengers per annum is likely to be needed*"[64].

VC:

The Norwegian public sector promotes the use of VC instead of travel. Based on research performed in 2009, it is concluded that if 1 out of 5 business trips of state employees is replaced by VC, the result will be a reduction of 14.600 tons CO_2-equivalent emissions and annual savings of NOK 320 million.[65]

The Ministry of the Environment (now the Ministry of Climate and Environment) published the relation between the number of PC – Phone Conferencing and VC and air trips of the Ministry. The Ministry did not report how much PC/VC substituted actual travel. For details, please refer to table 13.

	2006	2007	2008	2009	2010	2011
PC in relation to air trips	8%	11%	14%	21%	19%	12%
VC in relation to air trips	1%	2%	3%	6%	8%	4%
Table 13						

[63] Nytte-kostnadsanalyse av høyhastighetstog I Norge, Econ-ropport nr. 2008-154, ISBN 978-82-8232-033-7
[64] Nytte-kostnadsanalyse av høyhastighetstog I Norge, Econ-ropport nr. 2008-154, ISBN 978-82-8232-033-7, page 8
[65] Rapport 2009-082, IKT og klimagassutslipp; http://www.regjeringen.no/upload/FAD/Vedlegg/IKT-politikk/IKT_klimagassutslipp.pdf#search=videokonferanse erstatte flyreise&regj_oss=1

Despite the promotion of PC/VC as substitute for actual travelling, the number of air trips performed by employees in the public sector increased with 8.400 from 2010 to 2011 to 665.000 trips causing 150.000 tonnes CO_2-equivalent emissions.[66]

I could not find reliable information confirming that the demand for air travel will be significantly affected as a result of that policy.

66 http://www.nrk.no/norge/statsansatte-flyr-stadig-mer-1.8090607

3.1.10 The economic importance of aviation for Norway.

The Norwegian economy is an open, export-orientated economy. In 2012, export accounted for 54% of the total GDP[67].

In 2010, Norwegian companies had 3000 subsidiaries abroad[68]. For companies operating globally, it is of great importance that the Norwegian air transport system is integrated to the global air transport network as it creates several new opportunities for the Norwegian economy[69]:

- Increase of possibilities for export to new foreign markets.
- Decreasing transportation costs, especially over long distances. Lower (transportation) costs make Norwegian companies more competitive.
- Increased effectiveness of logistic processes as "just in time" – processes.
- Increased possibilities for the Norwegian economy to focus on those areas creating the highest added value.
- Increased flexibility of labour supply.
- Improved connectivity makes it easier for Norwegian companies to invest outside Norway (FDI – Foreign Direct Investment).
- Countries with higher connectivity (measured relative to their GDP), are in general more successful at attracting FDI.

To give an overall impression of the importance of the air transport sector, I share some selected key data of the sector in Norway:

- The aviation sector contributes with 2% to the Norwegian GDP.[70]
- The aviation sector supports 61.000 jobs in Norway.[71]
- The average air transport services employee generates Kr 998,539 in GVA annually, which is over 20% more productive than the average in Norway.[72]
- In 2011, 0,1% of Norwegian import and export was carried by air cargo.
- The air cargo represented 7% of the value of Norwegian import and 5% of the value of Norwegian export.

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[67] Konkurranseutsatte næringer i Norge, SSB rapport 58/2013
[68] http://www.ssb.no/
[69] Economic Benefits from air transport in Norway – Oxford economics 2011
[70] Economic Benefits from air transport in Norway – Oxford economics 2011
[71] Economic Benefits from air transport in Norway – Oxford economics 2011
[72] Economic Benefits from air transport in Norway – Oxford economics 2011

- 73% of the exported air cargo, measured in tons, was represented by the export of fresh seafood. Quick transportation of the product is necessary to obtain the highest possible revenue (freshnes).
- The total air cargo export in 2011 was 94000 tons, while the import in the same year was 35000 tons[73].
- The number of international passengers increased with average 9% annually between 2003 and 2013.
- The number of domestic passengers increased with an annual average of 3,7% between 2003 and 2013.
- The number of international passengers increased with an annual average of 6,6% between 2003 and 2013.
- The total number of passengers increased with an annual average of 4,9% between 2003 and 2013.[74]
- For both leisure and business segment, the average trip distance increases.[75]
- Contribution of aviation to Norwegian taxes: 23 billion.[76]

[73] http://www.ssb.no
[74] http://www.ssb.no
[75] http://www.avinor.no
[76] Economic Benefits from air transport in Norway – Oxford economics 2011

TØI describes 2 possible scenarios of Norwegian air transport towards 2040[77].

The first scenario outlines a situation of more or less economic stagnation and oil price rises to $250 per barrel. The growth in demand for air travel is weak and prices for air tickets are expected to rise by 50% for intercontinental flights in relation to the prices in 2010. Prices for tickets to European destinations are expected to rise with 30-40% compared with the prices in 2010. The traffic growth is expected to be weak. Oslo airport – Gardermoen will not have a network carrier offering intercontinental flights. Another effect will be that the consolidation in the aviation industry will continue due to cost increases and stagnation in European air services.

The second scenario outlines a situation of growth. Annual average economic increase, expressed in GDP, is expected to be 2% in the EU and 3% in Norway. In this scenario, TØI expects a strong increase in air traffic between Norway and Asian destinations. Oil price is expected to increase to $130 a barrel. Gardermoen is expected to have 15 intercontinental destinations in 2040. On intercontinental flights to the USA, Gardermoen is expected to handle additional traffic from Nordic countries, creating the opportunity for increased frequencies. TØI expects that the increase in intercontinental traffic will create demand for an additional 2 million passengers for intercontinental destinations (traffic demand creates new traffic demand at the airport).

[77] Luftfartens betydning i en global verden, TØI 2011

3.1.11 Findings

Based on the research discussed in chapter 3.1 – 3.1.11, I have found the following elements of the economic framework:

- The demand for air transport, both passenger and cargo, is expected to increase in the coming years until 2050.
- The growth of the air transport sector is correlated with economic growth, globalization, demographic factors, market liberalization and geo-political circumstances.
- Fuel costs are expected to increase.
- Airlines try to reduce unit costs by ordering larger aircraft.
- The distance travelled per passenger is increasing.
- The capacity of the infrastructure is expected to become a limiting factor for growth in Europe.
- The airline industry is one of the least profitable industries.
- Although there are substitutes for aircraft available (high speed train and ICT), only limited impact on the demand of air travel is expected.
- Air transport creates (indirect) jobs and increases the possibilities for a stronger development of a country's economy.
- The air transport industry contributes approximately 3,5% to the global GDP. In Norway, the industry contributes approximately 2% to the GDP.

3.2 The environmental framework

Carbon Dioxide (CO_2-emissions) by aircraft are a direct result of fuel consumption. A reduction of 1kg in fuel consumption, results in a reduction of emissions of 3,16 kg-CO2-equivalent [78].

CO_2 is not the only emission of aircraft. Other emissions include[79]:

- Water Vapor (H_2O)
- Carbon Monoxide (CO)
- Hydrocarbons (HC)
- Organic Carbon (OC)
- Nitric Oxide (NO)
- Nitrogen Oxide (NO2)
- Sulfor Dioxide (SO2)
- Sulfor Trioxide (SO3)
- Sulfate (SO4)
- Black Carbon (BC), also called "soot"
- Particulate Matter (PM)
- Radiative Forcing (RF)

It is expected that emissions from the aviation industry will continue to increase in the coming years.[80] CO_2 and H_2O are the GHG – Green House Gases, creating the so-called greenhouse effect. As a result of that effect, the temperature on earth increases. [81]

Research estimates that 1% of air-quality-related premature deaths are related to aircraft emissions (approximately 10.000 premature deaths per year).[82]

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[78] American Institute of Aeronautics and Astronautics, "Reducing Aviation's Environmental Impact Through Large Aircraft For Short Range".

[79] Aeronautics Research Mission Directorate/NASA Facts; The global impact of the transport sectors on atmospheric aerosol: Simulations for year 2000 emissions/ European Geosciences Union; The climate impact of aviation aerosols/ Geophysical Research Letters, Vol. 40, 1-5, doi:10.1002/grl.50520, 2013; Vista Analyse AS Rapport 2011/05, Utslippskutt I luftfart? Tor Homleid og Ingeborg Rasmussen, Vista Analyse AS, ISBN 978-82-8126-018-4; Intergovernmental Panel on Climate Change (IPCC). Aviation and the Global Atmosphere, Cambridge University Press, Cambridge, 1999.

[80] Aeronautics Research Mission Directorate/NASA Facts; IPPC 1999; Vista Analyse AS Rapport 2011/05, Utslippskutt I luftfart? Tor Homleid og Ingeborg Rasmussen, Vista Analyse AS, ISBN 978-82-8126-018-4

[81] Luftfart og klima – En oppdatert oversikt over status for forskning på klimaeffekter an utslipp fra fly, CIENS-rapport 3-2011, ISBN 978-82-92935-08-8

[82] The climate impact of aviation aerosols/ Geophysical Research Letters, Vol. 40, 1-5, doi:10.1002/grl.50520, 2013; Barrett et al. (2010)

In this paper, I delimit aircraft emissions to CO_2-emissions only. As CO_2-emissions are a direct result of fuel consumption, I will mainly discuss the technological challenges in reduction of (fossil) fuel consumption and the use of aircraft fuels creating less emissions of CO_2 than the current jet fuel A1.

Reducing CO_2-emissions is a mean to achieve sustainable development. In this thesis I use the description used in the report of the World Commission on Environment and Development entitled "Our Common Future" in 1987 : "sustainable development, which implies meeting the needs of the present without compromising the ability of future generations to meet their own needs".[83]

Aviation CO_2-emissions represent 2-2,5%, but increasing, component of global CO_2-emissions In Europe, civil aviation represented 3,5% of CO_2-emissions in 2011.[84]

In Norway, the aviation industry had an emission of 2,486,334 million kg CO_2-equivalent CO_2 in 2012. The total CO_2-emissions in Norway was 51,7 million kg CO_2-equivalent in the same year[85]. Based on these numbers, it can be concluded that 4,8% of CO_2-emissions in Norway originates from Air Transport. That percentage is significantly higher than the average percentage in Europe (3-3,5%) and the rest of the world (approximately 2%). Total CO_2-emissions from the Norwegian aviation industry increased with 55% between 1990 and 2008.[86]

Avinor, a Norwegian ANSP - Air Navigation Service Provider and airport owner, argues that there are 3 main areas which can be used to mitigate CO_2-emissions from the Air Transport Industry: Fleet renewal, increased efficiency of the airspace and introduction of biofuels[87].

Most initiatives to reduce CO_2-emissions are related to technical developments. I discuss the techniques to mitigate emissions, including operational improvements, in 3.5 (the technological framework). In this chapter, I will discuss 1 tool in the process of mitigating CO_2-emissions: The use of biofuel.

[83] http://www.un.org/documents/ga/res/42/ares42-187.htm
[84] Performance Review Report Eurocontrol, 2011
[85] Avinor Samfunnsrapport 2013
[86] Luftfart og klima – En oppdatert oversikt over status for forskning på klimaeffekter an utslipp fra fly, CIENS-rapport 3-2011, ISBN 978-82-92935-08-8
[87] Avinor Samfunnsrapport 2013

In my research, I use the definitions of IEA – International Energy Agency to define “biofuel” and “biomass”. For the exact definitions, please refer to the term glossary.

The approval of drop-in fuels in 2009 for the Air Transport industry is considered to be a breakthrough in the development of sustainable aviation fuels[88]. The U.S. Department of Energy describes drop-in biofuels as: “Drop-in biofuels are hydrocarbon fuels substantially similar to gasoline, diesel, or jet fuels. These fuels can be made from a variety of biomass feedstocks including crop residues, woody biomass, dedicated energy crops, and algae. The goal for drop-in fuels is to meet existing diesel, gasoline, and jet fuel quality specifications and be ready to "drop-in" to existing infrastructure by being chemically indistinguishable from petroleum derived fuels. This minimizes infrastructure compatibility issues, which are a barrier to fast commercialization of biofuels like ethanol and biodiesel. Drop-in fuels are in a research and development phase with pilot- and demonstration-scale plants under construction. The current focus is aimed at replacing gasoline, diesel, and jet fuel, which may fuel vehicles that aren't good candidates for electrification”[89].

The reduction in CO_2-emissions by using biofuels is not a result of decreased fuel consumption but is achieved through a reduction of the emissions generated by the use of the fuel itself[90].

In 2012, the price of fossil jet fuel was approximately $925,00 per ton. The price of aviation biofuel, at the same time, was $2.100,00 per ton.[91] If biofuels will become a real alternative to fossil fuel, significant progression must be realized in decreasing the cost-price as soon as possible. With several examples, I will illustrate that the air transport industry, authorities, science institutions, aircraft manufacturers and many other stakeholders manage to corporate in different ways to achieve that goal.

Biofuels can be classified in 4 generations. In this paper, I refer to the description used by DNV - Det Norske Veritas.[92]:

1st Generation biofuels:

[88] ICAO, Environmental Report 2013
[89] http://www.afdc.energy.gov/fuels/emerging_dropin_biofuels.html
[90] http://www.icao.int/environmental-protection/Pages/AlternativeFuels-QuestionsAnswers.aspx
[91] The future of climate-friendly aviation: Ten percent alternative aviation fuels by 2025
[92] Biofuels 2020, A policy driven logistics and business challenge, Research and Innovation, Position paper 02 - 2010

"Biofuels rely on crops that have readily accessible sugars, starches and/or oils as their feedstock, such as corn, soy, palm, rapeseed and sugarcane. Production of biofuels involves either fermenting the sugars or transesterfication of fatty oils. Net energy losses, minimal greenhouse gas savings and conflicts with food production are some of the issues here. Biofuel distribution companies are working almost exclusively with food cropbased biofuels, as those represent the bulk quantities of what is currently available.

2nd Generation biofuels:

"Biofuels use lignocellulosic biomass as feedstock, and can use forest and agricultural production wastes, such as corn stalks, as well as dedicated biofuel crops like switchgrass. The fuel is made by breaking down the cellulose using enzymes/ microorganisms into sugar, or by using a thermochemical route. Second generation biofuel technologies convert a greater proportion of the feedstock biomass into biofuels."

3rd Generation biofuels:

"Biofuels have often been defined as algae biofuels"

4th Generation biofuels:

"Biofuels have been considered to be production usinbg midified organisms or advanced biochemical methods of production."

The production of the 1st generation of biofuels raised sustainability questions. The potential to significantly reduce GHG emissions was limited and the production of the first generation bio fuels competed with food production resulting in increased food prices.[93]

[93] World Bank, Second-Generation Biofuels, Economics and Policies, Policy Working Paper 5406

Biofuels and legislation

Although I will discuss legislation in more detail in 3.3 (legal framework), I mention 2 EU directives with EEA relevance (meaning they are applicable for Norway) addressing the use of biofuels in order to reduce CO_2-emissions. The directives are:

1. Directive 2003/30/EC of the European Parliament and the council of 8 May 2003[94]
2. Directive 2009/28/EC of the European Parliament and the council of 23 April 2009[95]

Application of Directive 2003/30/EC and Directive 2009/28/EC[96]:

"Under the Directive 2003/30/EC on the promotion of the use of biofuels or other renewable fuels for transport, EU established the goal of reaching a 5.75% share of renewable energy in the transport sector by 2010.

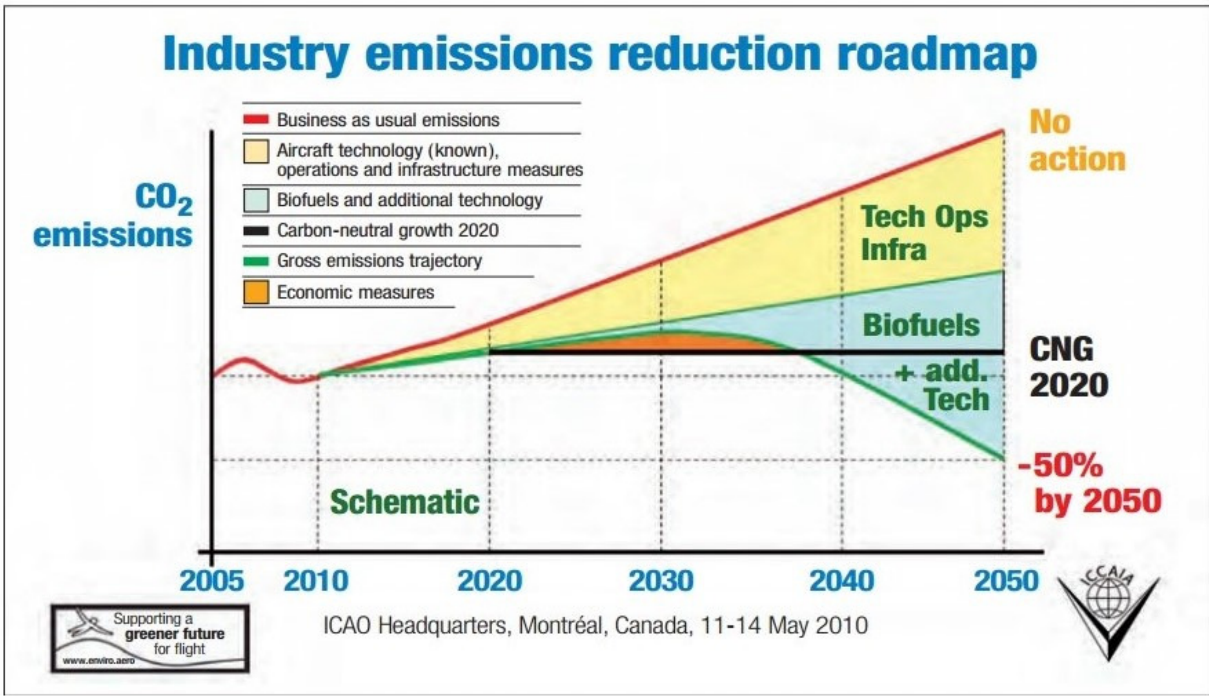
Under the Directive 2009/28/EC on the promotion of the use of energy from renewable sources this share rises to a minimum 10% in every Member State in 2020. Regarding the expand of biofuels use in the EU, the Directive aims to ensure the use of sustainable biofuels only, which generate a clear and net GHG saving without negative impact on biodiversity and land use."

[94] http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32003L0030
[95] http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32009L0028
[96] http://ec.europa.eu/energy/renewables/biofuels/biofuels_en.htm

Global initiatives to reduce CO_2-emissions:

ICAO[97]:

- "Resolution A37-19, adopted by the 37th Session of the ICAO Assembly in 2010, set forth an overarching policy for the Organization to address climate change issues related to international aviation, and was instrumental in making international aviation the first sector with global aspirational goals for improving annual fuel efficiency by 2%, and stabilizing its global CO_2-emissions at 2020 levels.[98]" After 2020, the ICAO and IATA aim to reduce CO_2-emissions of the air transport industry with 50% in relation to the reference year 2005. The ambition is illustrated in figure 4



Figur 4. IATA CO2 reduction roadmap. Source: ICAO

- Improvements of standards and technology, including the development of CO_2-emissions certification standards for aircraft. Examples include an updated version of the manual "Operational opportunities to reduce fuel burn and emissions" and "environmental assessment guidance for proposed air traffic management operational changes"
- Improvement of operational procedures to minimize fuel consumption, including the development of updated guidance materials.

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[97] ICAO Environmental report 2013

[98] ICAO Environmental report 2013, page 96

- Supporting the development of sustainable alternative fuels for aviation, creating a win-win-win situation as they contribute to 3 pillars of sustainable development: Environmental, social and economic. ICAO created GFAAF – Global Framework for Aviation Alternative Fuels. The purpose of GFAAF is to be a platform to provide up-to-date information on recent developments related to alternative fuels.
- The development of a global MBM-framework.
- Supporting Member States with state actions plans to mitigate CO_2-emissions by organizing training workshops and developing guidance materials and other tools to support Member States in the development of state action plans to reduce aviation CO_2-emissions.
- Financial and technical assistance to developing countries in their efforts to reduce CO_2-emissions.

IATA[99]:

- IATA has developed a 4-pillar strategy to achieve a carbon-neutral growth from 2020. The 4 pillars are: Technology, Operations, Infrastructure improvement and Economic measures (MBM).
- Improving fuel efficiency by 1,5% annually to 2020
- Capping net emissions by 2020 (from 2020, carbon neutral growth)
- Reduce net emissions by 2050 compared with 2005 (gross net trajectory)
- In 2050, taxiing has to be performed emission-free[100].
- Encourage the use of biofuels. IATA aims that the sector is using 10% alternative fuels by 2017.[101]

Other examples of (international) initiatives to reduce CO_2-emissions:

- ATAG developed 2 publications with background information: "Powering the future of flight – The six easy steps to growing a viable aviation biofuels industry" and "Beginner's Guide to Aviation Biofuels"[102].
- SAFUG - Sustainable Aviation Fuel Users Group. "The group is focused on accelerating the development and commercialization of sustainable aviation biofuels. All members have signed a Sustainable Pledge, and believe that a key driver to a carbon neutral

[99] http://www.iata.org/policy/environment/Pages/climate-change.aspx
[100] IATA, Vision 2050, Singapore, 2011
[101] http://www.iata.org/about/sp/areas/Documents/Environment.pdf
[102] http://www.atag.org/our-publications/latest.html

industry is advancing and adopting sustainable aviation biofuels. This shall significantly reduce life cycle GHG emissions over conventional petroleum based aviation fuels"[103]. Members are airlines including SAS, Air China, British Airways, KLM, Air France, Lufthansa and others.[104]

- SBRC - Sustainable Bioenergy Research Consortium. Situated in Dhabi, United Arab Emirates, SBRC is a not-for-profit research consortium for development and commercialization of sustainable biofuels and biomaterials for the aviation industry. The consortium corporates closely with global partners in the aviation industry like Boeing, Honeywell and Etihad Airways. For the purpose to produce aviation biofuel has launched the Masdar project. By the Masdar project, SBRC develops the ISEAS – Integrated Seawater Energy and Agriculture System.[105] "The fact that the Masdar project utilizes a salt-tolerant crop that is not used to feed people and can be raised in marginal lands with little fresh water is what attracted Boeing to the project, said Darrin Morgan, the director of sustainable biofuel strategy at Boeing."[106]
- CAAFI – Commercial Aviation Alternative Fuels Initiative. Established in 2006, "CAAFI is a coalition of airlines, aircraft and engine manufacturers, energy producers, researchers, international participants and U.S. government agencies. Together these stakeholders are leading the development and deployment of alternative jet fuels for commercial aviation. CAAFI's goal is to promote the development of alternative jet fuel options that offer equivalent levels of safety and compare favorably on cost with petroleum based jet fuel, while also offering environmental improvement and security of energy supply for aviation"[107]
- The US Government funds projects to develop biofuels. The funding is part of a national approach of the US government to stimulate the development of biofuel. Several departments are involved in the different projects. [108]
- Clean Sky JTI. "Public Private Partnership between the European Commission and the Aeronautical Industry, was set up to bring significant step changes regarding the environmental impact of aviation. Clean Sky will speed up technological breakthrough developments and shorten the time to market for new and cleaner solutions tested on full

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[103] http://www.safug.org/
[104] http://www.safug.org/members/
[105] http://sbrc.labs.masdar.ac.ae/
[106] http://www.thenational.ae/news/uae-news/plant-fuel-test-for-jets-nears-take-off
[107] http://www.caafi.org/about/caafi.html
[108] http://www.faa.gov/news/press_releases/news_story.cfm?newsId=13254

scale demonstrators, thus contributing significantly to reducing the environmental footprint of aviation (i.e. emissions and noise reduction but also green life cycle) for our future generations"[109] The mission of Clean Sky is: "to develop breakthrough technologies to significantly increase the environmental performances of airplanes and air transport, resulting in less noisy and more fuel efficient aircraft, hence bringing a key contribution in achieving the Single European Sky environmental objectives."[110]

- Launch of the European Advanced Biofuels Flightpath in 2011 with the production target of 2 million tons of aviation biofuel annually in 2020. The flightpath was launched by the EC, Airbus and high-level representatives of the Aviation and Biofuel producers.[111]
- ITAKA – Initiative Towards sustainable Kerosene for Aviation. In order to achieve the goal, addressed in the European Advanced Biofuels Flightpath, the supply chain from biomass to the aircraft engine had to be properly managed. "ITAKA will link supply and demand by establishing a relationship under guaranteed conditions between feedstock grower, biofuel producer, distributor and airlines."[112]
- Biotfuel, an initative of 6 French companies aiming to commercially produce 200.000 tons of biodiesel and bio-jet fuel via thermochemical conversion by 2020. The concept is based on converting lignocellulosic biomass, such as straw, forest waste and dedicated energy crops, into biofuels.[113]
- Bioquerosino is a Spanish initiative to develop alternative fuels for the aviation sector. "After two years of work (2010 and 2011) with agents of the sector, the Biokerosene Initiative was formalized on 27 of October of 2011, with the signing of an agreement between the Ministry of Industry, Energy, and Tourism (through IDAE), the Ministry of Public Works (through AESA), the Ministry of Agriculture, Food, and Environmental Affairs (MAGRAMA), SENASA and several companies related to production of raw materials, refining technologies, aeronautical logistics and sustainability processes.

  This initiative is structured as a meeting platform among the agents involved therein, that is to say, it intends to act as a bridge for the exchange of information, identification of needs and acting fields between the public sector involved and the private agents that collaborate in the same. The participant entities, in addition to the abovementioned public

[109] http://www.cleansky.eu/?arbo_id=35
[110] http://www.cleansky.eu/content/homepage/about-us
[111] http://ec.europa.eu/energy/technology/initiatives/doc/20110622_biofuels_flight_path_launch.pdf
[112] http://www.itaka-project.eu/nav/pages/about.aspx
[113] http://total.com/en/energies-expertise/renewable-energies/biomass/projects-achievements/biotfuel

organisms, are the firms, and the companies interested in joining the initiative and which signed the relevant Agreement that, until now, it means a participation of 14 companies representing all and each one of the phases involved in the value chain of the biokerosene production, from the production of raw material to the use of biokerosene by the final users, that is to say, the aircraft operators."[114]

- Aireg - Aviation Initiative for Renewable Energy in Germany e.V, is a coalition of German airlines, German scientific organizations, suppliers of biofuel and other mainly German stakeholders. "The objective of aireg is to support the production and use of such alternative aviation fuels. aireg's target is for biofuels to make up ten per cent of the jet fuel consumed domestically by 2025. The biofuels initiative of the German aviation industry was founded in 2011 and combines the engagement and know-how of airlines, airports, research organisations and companies in the aviation and feedstock industries."[115].
- AISAF – Australian Initiative for Sustainable Aviation Fuels. "AISAF was founded on 8 August 2012 as public private partnership supported by the aviation industry and the Australian Government. In August 2013, AISAF joined forces with Aviation Aerospace Australia (A/AA; aviationaerospace.org.au) the not-for-profit and independent association, with an overarching objective to contribute to the long-term health and sustainability of Australia's aviation and aerospace sector".[116]
- NISA – Nordic Initiative for Sustainable Aviation. "NISA is an active Nordic association working to promote and develop a more sustainable aviation industry, with a specific focus on alternative sustainable fuels for the aviation sector…. The goal of NISA is to accelerate the development and the commercialization of sustainable aviation fuels. This is achieved by organizing activities, strengthening the cooperation across the value chain and by focusing on opportunities in the Nordic region." Members of NISA are: SAS, Swedavia, Avinor, Copenhagen Airport, Boeing, Airbus, Finnair, Finavia, Atlantic Airways, Air Greenland, Molmö Aviation, Icelandair, Brancheforeningen Dansk Luftfart, NHO Luftfart, IATA, Föreningen Svenskt Flyg, Svenske Flygbranchen, Ministry of

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[114] http://www.bioqueroseno.es/nav/en/iniciativa_en.aspx
[115] The future of climate-friendly aviation: Ten percent, alternative fuels 2050.
[116] http://www.icao.int/environmental-protection/GFAAF/Pages/Project.aspx?ProjectID=29

Transport and Communications – Finland, Trafikstyrelsen – Danish Transport Agency, Isavia, Swedish Transport Agency and TraFi – Finnish Transport Safety Agency."[117]

- In Norway, Avinor has allocated NOK 100 million over a 10-year period, for measures and projects which can contribute to realizing the production of biofuel in Norway based on biomasses from Norwegian forests. Based on research performed by Rambøll in 2013[118], Avinor concludes that it is realistic to start production of biofuel in Norway for the Air Transport Industry between 2020 and 2025. The result of the measure will be a reduction of CO_2-emissions of the Norwegian Air Transport sector of 10-45%, depending on the quantity of biomass originated from Norwegian forests. Avinor corporates with Norwegian airlines, NHO – Luftfart - Næringslivets Hovedorganisasjon – Luftfart (Federation of Norwegian Aviation Industries), the corporation of forest owners "Viken Skog", ZERO (Zero Emissions Resource Organization – Independent not-for-profit foundation working for zero emission solutions to the global climate challenge) and several other organizations involved in the initiative[119]. As the biomass originates from forests not used for the food-chain, the biofuel is considered as a second generation biofuel.

[117] http://www.cphcleantech.com/home/services/matchmaking--sector-networks/nisa---nordic-initiative-for-sustainable-aviation
[118] Utredning bærekraftig biodrivstoff for luftfart, Rambøll, 1/2013
[119] Avinor Samfunnsrapport 2013

CO_2-emissions of Norwegian airlines

In order to check CO_2-emissions from the 2 largest Norwegian airlines, expressed in number of passengers carried in 2013, I visited their respective webpage to retrieve relevant information. The airlines checked are Norwegian and SAS.

I found out that both airlines have an extensive quantity of information regarding their environmental policy. Both airlines publish the CO_2-emissions expressed in kg/km CO_2-equivalent per passenger. The details of the main findings are published in table 14[120]

	2013	2012	2011	2010
Norwegian	87	88	92	97
SAS*	113	117	122	121
CO_2-emissions, expressed in grams, per passenger kilometer				
Table 14				

*Fiscal year from 01-11 until 31-10

In paragraph 3.5 (the technological framework), I will discuss actions taken by the Norwegian airlines to mitigate CO_2-emissions and I will explain which factors influence the emissions per passenger kilometer.

[120] Annual reports Norwegian and SAS 2010 - 2013

3.3 The legal framework

As per today, there is no global legislation on CO_2-emissions. ICAO is in a developing stage of certification standards for aircraft and in the process of introducing market-based measures for CO_2-emissions.

Global certification standards

In 2013, ICAO's CAEP – Committee on Aviation Environmental Protection - reached agreement on the introduction of CO_2-emissions certification standards for new aircraft.[121] The system is based on measuring fuel burn performance. As CO_2-emissions are directly related to fuel burn, the method reflects aircraft CO_2-emissions. The system is common for all aircraft categories. The system is based on 3 input variables:[122]

- Cruise point fuel burn
- Aircraft size
- Aircraft weight

Official approval to introduce the system is expected this year (2014).

Aviation stakeholders as Boeing, Airbus, IATA and AIA – Aerospace Industries Association and ICSA – International Coalition for Sustainable Aviation, welcomed the introduction of global certification standards[123].

Despite positive feedback, the system has also been met with criticism. ICCT – The International Council on Clean Transportation - summarizes some shortcomings[124]:

- Non-cruise fuel burn is not measured. As a result, fuel reduction improvements for takeoff, landing and ground operations are not integrated in the system.
- Divergence of test conditions from real operations is not taken into account.
- The use of lightweight materials (composites) is not credited.
- The system is not based on future technology but based on empirical comparisons between today's aircraft.

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[121] http://www.icao.int/Newsroom/Pages/ICAO-environmental-protection-committee-delivers-progress-on-new-aircraft-CO2-and-noise-standards.aspx
[122] ICAO Fact sheet, Aircraft CO2-Emissions Standard Metric System
[123] http://www.greenaironline.com/news.php?viewStory=1568
[124] http://www.theicct.org/sites/default/files/publications/ICCTupdate_ICAO_CO2cert_aug2013a.pdf

Global MBM

On a global level, there is no political agreement on the introduction of MBM. The last attempt to reach a global policy was during the 38th General Assembly of ICAO in Montreal in 2013. The ICAO member states were able to reach an agreement to develop a global MBM for adoption in 2015 and implementation in 2016. Arguments for introducing global MBM, as mentioned in the proposal, are[125]:

- Based on research performed by the Manchester Metropolitan University, It is not realistic to expect that target levels for CO_2-emissions in 2050 will be reached by technology, improved operations, biofuels and the extension of current regional MBM. Global MBM is considered the only feasible mechanism to close that gap.
- Emissions from the Air Transport industry are increasing rapidly.
- Based on estimates available to ICAO, biofuels would have a minimal climate impact by 2050.
- ICAO is convinced that MBM provides certainty that environmental targets will be met.

The IMF – International Monetary Fund – summarizes the legal obstacles to pricing (taxing) fuels used in International Aviation in "Marked –Based Instruments for International Aviation and Shipping as a source of Climate Finance"[126]:

- "The 1944 Chicago Convention, under the auspices of the ICAO, itself prohibits only the taxation of fuel arriving in aircrafts' tanks. But subsequent ICAO resolutions, consolidated in 1999—having essentially the same effect as treaty provisions—enjoin contracting States to grant reciprocal exemption of fuels taken up for international aviation (commercial and private).1 The rationale for these provisions is the —development and expansion of international trade and travel.‖
- Bilateral Air Service Agreements (BSAs)—of which there around 4,000—differ, but generally provide similar exemption.

Amendment of the Chicago convention requires approval by a two-thirds majority (128 States), and would not be binding on States that did not subsequently ratify it. Importantly, the

[125] http://www.icao.int/Meetings/a38/Documents/WP/wp288_en.pdf
[126] IMF - Marked –Based Instruments for International Aviation and Shipping as a source of Climate Finance, November 2011, page 19

ICAO Council has indicated that it would review its policies if its present position on environmental charges and taxes were to change in some relevant way."[127]

The first global step in fighting the consequences of climate change was the United Nations Conference on Environment and Development "Earth Summit" in Rio de Janeiro, Brazil in 1992. The conference resulted in United Nations Framework Convention on Climate Change. In the years after the "Earth Summit", several countries realized that the emission reduction provisions in the Convention were inadequate to mitigate the consequences of emissions on climate change. In 1997, The KP - Kyoto Protocol was adapted. The KP legally binds developed countries to emission reduction targets[128].

Emissions related to international aviation are excluded from the KP. The exclusion of international air transport is described in article 2.2:

"Annex I Parties shall pursue limitation or reduction of emissions of greenhouse gases from aviation and marine bunker fuels, working through the International Civil Aviation Organization (ICAO) and the International Maritime Organization (IMO), respectively."[129]

MBM on European level

The EC argues that MBM are the most cost-efficient and environmentally effective option for controlling aviation emissions. Since 2012, the flights within the EU are included in the EU ETS – European Union Emissions Trading Scheme. From 2013, the EU ETS is also applicable for flights within the EEA. The EC argues that application of MBM for flights to and from countries outside the EEA is compatible with international law[130]. On the other hand, several non EEA-countries oppose the EU ETS. "On July 31 to August 1, 2012, the Department of State and the FAA hosted a meeting with 16 other countries opposing inclusion of aviation in the EU ETS"[131]. The 16 other countries were: Australia, Brazil, Canada, Chile, China, India, Japan, South Korea, Mexico, Nigeria, Russia, Saudi Arabia, Singapore, South Africa and the United Arab Emirates[132]. In order to allow time for

[127] Market-Based Instruments for International Aviation and Shipping as a source of Climate Finance, International Monetary Fund, November 2011, page 19
[128] https://unfccc.int/essential_background/items/6031.php
[129] Kyoto Protocol to The United Nations Framework Convention on Climate Change, United Nations, 1998, page 2
[130] http://ec.europa.eu/clima/policies/transport/aviation/index_en.htm
[131] Aviation and the European Union's Emission Trading Scheme, Congressional Research Service, August 2, 2012, page 27
[132] Aviation and the European Union's Emission Trading Scheme, Congressional Research Service, August 2, 2012

negotiations with countries from outside the EEA-area, flights to and from those countries are not included in the EU ETS. The EC expects that ICAO will reach a global agreement to include International Air Transport in a global MBM during the 2016 ICAO General Assembly.[133]

MBM in Norway

Domestic air transport in Norway as well as international air transport between Norway and countries in the EEA was included in EU ETS in 2012.[134]

Aviation market and MBM:

Introduction of MBM is 1 of 4 pillars of IATA's strategy to mitigate CO_2-emissions. During the 69th Annual General Meeting in 2013, the resolution "Implementation of the Aviation Carbon-Neutral Growth (CNG2020) Strategy was endorsed. The Association of European Airlines supports the resolution. Not only the aviation industry but also environmental NGO's like EDF – Environmental Defense Fund and NRDC – National Resources Defense Council supported IATA's initiative. If the concept of IATA is globally introduced, basically the same rules are applicable for every airline. On the other hand, the resolution was not supported by airlines from emerging markets like China and India. Airlines from those countries argued that that emerging economies are exempted from global MBM under the UN climate principle of CBDR - Common But Differentiated Responsibility.[135]

Norwegian Aviation environmental policy

In order to understand the Norwegian governments viewpoint and intentions on environment and aviation, I studied the "Political platform for a government formed by the Conservative Party and the Progress Party", also referred to as "Sundvolden-erklæringen".[136] In the platform, both an environmental paragraph as well as an aviation paragraph is included.

The governments vision regarding environment and emissions are described in chapter 13 "Environment and climate" and in chapter 14 "oil and energy".

In chapter 13, the government declares:

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[133] http://ec.europa.eu/clima/policies/transport/aviation/index_en.htm
[134] http://www.miljostatus.no/Tema/Klima/Klimanorge/Tiltak-og-virkemidler/CO2-avgift/
[135] http://www.greenaironline.com/news.php?viewStory=1699
[136] http://www.regjeringen.no/nb/dep/smk/dok/rapporter_planer/rapporter/2013/politisk-plattform.html?id=743014

“We have a responsibility to ensure that the world we leave our children is in at least a good a state as it was when we inherited it from our forefathers. The Government will pursue a proactive climate policy and will strengthen the agreement on climate policy reached in the Storting, cf. the Cooperation Agreement. We must step up the development of renewable energy (Chapter 14).”[137]

And,

“Norway will take a leading role in setting an international price for CO_2-emissions and establishing effective, well-functioning international carbon markets. Norway will work to strengthen the EU Emissions Trading System (EU ETS) as an instrument for achieving European climate targets after 2020.
The Government will pursue an ambitious national climate policy based on long-term transition to a low-emission society by 2050. The Government will increase investment in research and environmental technology. An ambitious national policy is essential in helping to reduce global greenhouse gas emissions. This will involve giving consideration to the ramifications of the EU ETS, the risk of carbon leakage and industrial competitiveness.”[138]

And, in chapter 14:

“The Government wants Norway to be a leading nation in environment-friendly consumption and production of energy, including hydropower, wind power, bioenergy and other forms of renewable energy.”[139]

The vision on aviation is described in chapter 15 – Transport and communication”. Regarding transportation and communication in general, the government states:

- “The Government wants Norway to have a state-of-the-art transport and communications network on a par with comparable countries.”[140]

And, specified for aviation (the whole paragraph):

- “**Air transport**
  The Government will implement a competitive air transport policy based on a recognition of air transport as a key part of the Norwegian transport network. Where appropriate, the

[137] Sundvolden-erklæringen, English version, page 59
[138] Sundvolden-erklæringen, English version, page 60
[139] Sundvolden-erklæringen, English version, page 61
[140] Sundvolden-erklæringen, English version, page 64

Government will encourage fewer, larger and more competitive airports. The Government will:

- Change the licensing terms for Moss Airport Rygge to ensure that the ceiling on the number of flight movements is raised and the opening hours extended.
- Establish a framework for municipalities and private individuals to participate in development activities at and in the proximity of airports.
- Ensure that air traffic control and security services are subject to competition.
- Lay the foundations for simplified transfers, at Oslo Airport in the first instance".[141]

Other relevant Norwegian CO_2-legislation/policy:

- In 2008, the Norwegian Parliament accepted "Klimaforliket". Main point of "Klimaforliket" was the ambition that Norway has to be CO_2-emission neutral by 2030 instead of the original schedule 2050.[142]
- "Klimaforliket" was renewed in 2012. The government addresses that EU ETS and MBM on the use of fossil fuels will be the most important MBM for the aviation industry. [143]

[141] Sundvolden-erklæringen, English version, page 67
[142] Avtale om klimameldingen, 17.January 2008
[143] Meld. St.21 (2011-2012), Melding til Stortinget, Norsk klimapolitikk; http://www.regjeringen.no/nb/dep/kld/dok/regpubl/stmeld/2011-2012/meld-st-21-2011-2012.html?id=679374

3.4 The technological framework

Carbon Dioxide (CO_2)-emissions by aircraft are a direct result of fuel consumption. A reduction of 1kg in fuel consumption, results in a reduction of 3,16 kg CO_2- equivalent emissions[144].

CO_2 is not the only emission of aircraft. Other emissions include[145]:

- Water Vapor (H2O)
- (CO)
- (HC)
- (OC)
- Nitric Oxide (NO)
- Nitrogen Oxide (NO2)
- Sulfor Dioxide (SO2)
- Sulfor Trioxide (SO3)
- Sulfate (SO4)
- Black Carbon (BC), also called "soot"
- Particulate Matter (PM)
- Radiative Forcing (RF)

It is expected that emissions from the aviation industry will continue to increase in the coming years.[146] CO_2 and H_2O are the GHG – Green House Gases,, creating the so-called greenhouse effect. As a result of thateffect, the temperature on earth increases. [147]

Research estimates that 1% of air-quality-related premature deaths are related to aircraft emissions (approximately 10.000 premature deaths per year).[148]

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[144] American Institute of Aeronautics and Astronautics, "Reducing Aviation's Environmental Impact Through Large Aircraft For Short Range".
[145] Aeronautics Research Mission Directorate/NASA Facts; The global impact of the transport sectors on atmospheric aerosol: Simulations for year 2000 emissions/ European Geosciences Union; The climate impact of aviation aerosols/ Geophysical Research Letters, Vol. 40, 1-5, doi:10.1002/grl.50520, 2013; Vista Analyse AS Rapport 2011/05, Utslippskutt I luftfart? Tor Homleid og Ingeborg Rasmussen, Vista Analyse AS, ISBN 978-82-8126-018-4; Intergovernmental Panel on Climate Change (IPCC). Aviation and the Global Atmosphere, Cambridge University Press, Cambridge, 1999.
[146] Aeronautics Research Mission Directorate/NASA Facts; IPPC 1999; Vista Analyse AS Rapport 2011/05, Utslippskutt I luftfart? Tor Homleid og Ingeborg Rasmussen, Vista Analyse AS, ISBN 978-82-8126-018-4
[147] Luftfart og klima – En oppdatert oversikt over status for forskning på klimaeffekter an utslipp fra fly, CIENS-rapport 3-2011, ISBN 978-82-92935-08-8
[148] The climate impact of aviation aerosols/ Geophysical Research Letters, Vol. 40, 1-5, doi:10.1002/grl.50520, 2013; Barrett et al. (2010)

In this paper, I delimit aircraft emissions to CO_2-emissions only. As CO_2-emissions are a direct result of fuel consumption, I will mainly discuss the technological challenges in reduction of (fossil) fuel consumption and the use of aircraft fuels creating less emissions of CO_2 than the current jet fuel A1.

Aviation fuel emissions represent 2-2,5%, but increasing, component of global CO_2-emissions.[149] In Europe, civil aviation represented 3,5% of CO2-emissions in 2011.[150]

In Norway, the aviation industry had an emission of 3,285 million kg CO_2-equivalent emissions in 2012. The total CO_2-emissions in Norway were 55,211 million kg-equivalent of CO_2 in the same year[151]. These numbers suggest that the percentage of the airline industry in Norway is 5,95%. That number does however not represent an accurate number as it includes CO_2-emissions by Norwegian registered aircraft operated abroad. The aircraft of SAS are mainly registered in Norway[152] but perform flights out of their bases in for example Stockholm and Copenhagen to and from non-Norwegian destinations. The same applies for the airline Norwegian with several bases throughout Europe, transporting millions of passengers not arriving in, nor departing from Norway. An exact percentage of the contribution of the Norwegian aviation industry-emissions (domestic flights in Norway and international flights to/from Norway) in relation to total CO_2-emissions in Norway is not available. On the other hand, it is possible to make an estimation. In 2011, CO2-emissions from domestic flights represented 1,2 million kg CO_2-equivalent emissions. In 2010, CO_2-emissions from international flights (flights to/from Norway) had an emission of 1,3 million kg CO_2-equivalent emissions[153]. As both domestic and international traffic increased in both 2010 and 2011[154], I assume that the total emissions of the Norwegian airline industry is not less than 1,2 (domestic 2011) + 1,3 (international 2010) = 2,5 million kg CO_2 - equivalent emissions in 2011. In that year, the total CO_2-emission in Norway was 53,3 million kg CO_2-equivalent.[155]I estimate the total contribution of the airline industry to at least 4,69% of total emissions in Norway. That percentage is significantly higher than the average percentage in

[149] IPPC 1999; Luftfart og klima – En oppdatert oversikt over status for forskning på klimaeffekter an utslipp fra fly, CIENS-rapport 3-2011, ISBN 978-82-92935-08-8
[150] Performance Review Report Eurocontrol, 2011
[151] www.miljøstatus.no; www.ssb.no
[152] www.flysas.com/fleet; www.luftfartstilsynet.no/luftfartøyregister; www.norwegian.no; www.nho-luftfart.no;
[153] Utredning bærekraftig biodrivstoff for luftfart, by Ramboll
[154] www.avinor.no; www.ssb.no
[155] www.miljostatus.no; www.ssb.no

Europe (3-3,5%) and the rest of the world (approximately 2%). Total CO_2-emissions from the Norwegian aviation industry increased with 55% between 1990 and 2008.[156]

During the literature study, I found the following main technical possibilities to reduce CO_2-emissions [157]:

- ATM-challenges. Find the most fuel – efficient transit through the airspace.
- Operational improvements of the airline.
- Operational improvements on airports.
- Improvements of airframe- and propulsion technology.
- Use of biofuels as replacement of fossil fuels.
- Increasing aircraft size and reducing flight frequencies (reduces fuel consumption per passenger kilometer).
- Limiting short haul operations (reduces fuel consumption per passenger kilometer).

ATM-challenges. Find the most fuel – efficient transit through the airspace.

The ATM-infrastructure offers several possibilities to reduce CO_2-emissions. IPPC estimates that improvements of the ATM infrastructure can reduce fuel burn per trip by 6-12%.[158] Areas of improvement, for the global ATM-infrastructure, which I found during my literature study include[159]:

1. Create more possibilities to fly direct routes (great circle routes) instead of pre-defined route segments.
2. Limited airport capacity results in congestions and creates delays.
3. Lack of shared awareness and decision making among ATC-units.
4. Operational limitations due to noise regulations, can have a negative effect on access to and from key airports.
5. Onboard automation is underutilized as ground based systems which the on board systems depend on are limited available.
6. Published departure and arrival procedures often inflexible, indirect and inefficient.

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[156] Luftfart og klima – En oppdatert oversikt over status for forskning på klimaeffekter an utslipp fra fly, CIENS-rapport 3-2011, ISBN 978-82-92935-08-8
[157] Aeronautics Research Mission Directorate/NASA Facts; Vista Analyse AS Rapport 2011/06, Biodrivstoff: hva er netto klimaeffekt? – en oversikt over nyere forskning, Karin Ibenholt, Vista Analyse 9. mars 2011, ISBN 978-82-8126-019-1
[158] Aviation and the Global Atmosphere, IPPC 1999.
[159] Aviation and the Global Atmosphere, IPPC 1999; http://www.aviator.edu/129/section.aspx/59/post/principles-of-flying-understanding-jet-streams;

7. Lack of international coordination in ATC systems cause inefficient flight operations. Example: Airliners are not able to fly on the optimum, most fuel efficient, cruising altitude.
8. Timeliness, presentation and accuracy of meteorological information. Example: Headwind increases flight time and consequently fuel flow. Tailwind reduces the flight time and consequent fuel consumption. With accurate weather information, the flight crew is able to select the most effective route and/or cruising altitude. In order to pick up a jet stream, it can be fuel efficient to select a lower cruising altitude than the optimum altitude for the aircraft in standard (no wind conditions). For a cross continental flight in the USA, picking up the west to east jet stream can reduce the flight time with approximately 30 minutes. On a flight from Tokyo to Honolulu, flight time can be reduced with approximately a third (from 18 to 11,5 hours) . The examples are used to illustrate the value of accurate and up to date weather information in order to achieve the best possible fuel efficiency for the flight.
9. Restricted and Military airspace. Due to amongst other technological limitations and geopolitical considerations several countries limit the use of their airspace causing inefficient use of the airspace.
10. Due to a fixed-route network on En Route and Oceanic operations, results in concentrated traffic flows over specific areas/points. Due to the traffic concentration the risk of delays are increased (as the ATM infrastructure has to create the required separation between aircraft).
11. Lack of a global integrated and flexible ATM-system which enables airlines to fly the most efficient route and adjust the flight profile with amended information received during the flight.
12. The gap between traffic demand and capacity provided by the ATM system has become critical in some areas. Automation and use of data links can help to decrease the gap.

Research by Rocky Mountain Institute, Snowmass, Colorado, USA - learns that using the latest information technology available, 5-10% of fuel savings can be created[160]..

[160] Winning the Oil Endgame: Innovation for Profits, Jobs, and Security. Rocky Mountain Institute, Snowmass, Colorado, USA - 2004

The fuel efficiency of an airliner depends mainly on aircraft weight, engine efficiency, ratio of aerodynamic lift/drag and load factor[161]. The most critical factor for fuel efficiency is aircraft weight[162].

I use 3 different publications which illustrate the influence of weight on CO_2-emissions.

The first publication refers to research performed in Australia and published by the Australian Government Department of Industry.[163] The results are shown in table 15.

	Saving in energy during operational lifetime	Expressed in kg/fuel[164]	Expressed in kg CO_2-equivalent emissions
Short haul	10-20TJ	214.025-428.050	676.320-1.352.640
Long haul	20-30TJ	428.050-676.319	1.352.640-2.028.960

Table 15. Energy saving as published by the Australian Government Department of Industry as a result of 100 kg weight saving.

Table 15 shows that a weight saving of 100kg airplane weight, results in a reduction of fuel consumption for short haul aircraft of between 214 and 428 tons during the aircraft lifetime. A long haul aircraft is expected to reduce fuel consumption with 428 - 676 tons during its operational lifetime for every 100kg weight saved.

Research in the USA has learned that a weight reduction of 1 kg generates an annual saving of 124 kg of fuel of an average aircraft used by airlines in the USA.[165] If that aircraft is in operational use for 25 years, 100 kg weight reduction will reduce the CO_2-emissions with 124*100*25*3,16 = 979.600 kg CO_2-equivalent emissions throughout its operational life.[166]

There are several parameters which influence fuel saving due to weight fluctuations. In order to illustrate the influence of average trip distance in relation to weight reduction, I use 2

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161 Greene 2004

162 ICAO Environmental report 2013

163 http://eex.gov.au.technologies/transport-technologies/opportunities/#Aerodynamic_aeroplanes

164 http://www.statcan.gc.ca/pub/57-601-x/2010004/appendix-appendice1-eng.htm

165 Winning the Oil Endgame: Innovation for Profits, Jobs, and Security, Rocky Mountain Institute, Snowmass, Colorado, USA

166 Presentation "Saving fuel, it's a team sport". IATA Maintenance Cost Conference - October 2012. Published by Airbus

examples published by Airbus. Airbus compares 1 aircraft used for medium range flights (Airbus A330-300 used on a 1.300NM sector) and a long range aircraft (Airbus A340-500 used on a 6.300NM sector). Please note that contrary to the research in the USA and Australia, Airbus refers to weight increase and not weight decrease. The figures published by Airbus are shown in table 15[167].

[167] Presentation "Best practices for Fuel Economy" during ICAO Measures Workshop / Montreal, 20/21 September 2006. Published by Airbus

	Extra weight in kg.	Extra fuel used per trip in kg.	Extra fuel used over 1 year in kg. (25 years)	Increase CO2-emissions over 25 years*
Airbus A330-300	100	6	5.650 (141.250)	446.350
(1.300NM=2.408km sector)	500	26	24.500 (612.500)	1.935.500
	1.000	52	49.000 (1.225.000)	30.625.000
Airbus A340-500 (6.300NM=11.668km sector)	100	45	14.694 (367.350)	9.183.750
	500	226	73.800 (1.845.000)	46.125.000
	1.000	453	147.900 (3.697.500)	92.437.500
*Expressed in kg CO_2-equivalent emissions				
Table 16				

The aircraft engine and aircraft weight are important factors in reducing fuel consumption and therefore the most important areas of the aircraft to focus on in reducing CO_2-emissions. Engine manufacturers are constantly improving the engine technology in order to reduce fuel consumption. Over the period 1960 - 2000, fuel efficiency of passenger jet aircraft has improved by 75%[168]. That is an average yearly improvement of 3,4%. However, the average yearly improvement between 1960 and 1980 was 5,4%. The average yearly improvement decreased to 1,4% between 1980 and 2000.

The decrease can partly be explained by the increasing capacity of aircraft between 1960 and 1980 (wide body aircraft like the Boeing 747 and DC10 were introduced in the beginning of the 1970's). The period between 1980 and 2000 was characterized by a levelling of in average aircraft size[169].

[168] Fuel and air transport, A report for the European Commission prepared by Air Transport Department, Cranfield University

[169] Fuel and air transport, A report for the European Commission prepared by Air Transport Department, Cranfield University

Engine manufactures, aircraft manufactures and airlines face the challenge to continue to improve the effectiveness in order to reduce total emissions while traffic is expected to increase in the years ahead.

In this paragraph, I will discuss some examples of measures which can help an airline to reduce CO_2-emissions in the commercial environment the company is operating.

- Modernizing aircraft fleet with more fuel-efficient aircraft.
  - Reduction of CO_2-emissions can be achieved by renewing the current fleet with the newest aircraft equipped with the newest and most fuel efficient engines. New aircraft are significantly more fuel efficient than their predecessors. The average economic life of an airliner is estimated to 25 years[170]. Replacing an airliner with a new model of the latest generation, creates an average improvement in fuel efficiency of 20-25%.[171] By introducing the Boeing 787-9, the British airline Virgin Atlantic estimates that the new aircraft is 28% more efficient on a seat basis than similar (older) aircraft the Boeing 787-9 is replacing[172]. In Scandinavia, SAS has ordered new Airbus wide body aircraft which will replace the current Airbus fleet from 2015. After completing the fleet renewal program for the long haul fleet, SAS expects that the fuel consumption per long haul seat will be reduced by 30%[173].

    In order to illustrate the evolution of fuel efficiency throughout the period 1950's until the 2010's, I have calculated the fuel consumption per seat for some aircraft throughout the period.

The results of the calculations are shown in table 17(next page).

[170] http://www.afm.aero/magazine/trading-legal-and-finance/item/570-aircraft-economic-life-is-age-just-a-number

[171] [171] Fuel and air transport, A report for the European Commission prepared by Air Transport Department, Cranfield University

[172] http://www.greenaironline.com/news.php?viewStory=1769

[173] http://news.cision.com/sas/r/sas-signs-with-airbus--total-renewal-of-long-haul-fleet,c9433660

Table 17							
Generation	Type	Seats	Company	Range in km.	Fuel in kg.	Fuel per seat in kg.	Fuel per km per seat in kg.
1950's	Caravelle 1	80	SAS	2.000	8.550	107	0,054
1960's	DC8-43	177	Manufacturer	7.745	64.505	364	0,047
1960's	DC8-63	198	SAS	8.378	71.214	360	0,043
1960's	DC9-21	75	SAS	2.810	13.491	180	0,064
1960's	DC9-41	105	SAS	2.130	14.089	134	0,063
1970's	DC10-30	226	SAS	10.000	114.087	505	0,051
1970's	Boeing 747-100/200/300	353	SAS	10.186	159.250	451	0,044
1980's	Boeing 757-200	169	United	6.667	34.260	202	0,030
1980's	Boeing 757-200	233	Thomsonfly	5.556	31.865	137	0,025
1980's	Boeing 767-300	183	United	8.264	56.211	307	0,037
1980's	Boeing 767-300	283	Thomsonfly	6.837	46.711	165	0,024
1980's	Boeing 747-400	352	Lufthansa	13.581	173.425	493	0,036
1990's	MD-11	298	Manufacturer	12.594	117.636	395	0,032
1990's	Boeing 777-200	266	United	10.464	82.380	310	0,030
1990's	Airbus A330-300	264	SAS	10.100			0,027
1990's	Airbus A340-300	245	SAS	12.800			0,031
2000's	Embraer 190LR	100	KLM	4.815	12.971	130	0,027

2010's	Boeing 787-8	219	United	14.816	89.781	410	0,028
2010's	Boeing 787-8	291	Norwegian	13.399	82.941	165	0,024
2010's	Boeing 747-8	467	Boeing standard	13.909	191.565	410	0,029
2010's	Boeing 747 -8	362	Lufthansa	14.909	191.565	529	0,035

Table 17 Evolution of fuel consumption, specified for different types of aircraft based on maximum range with maximum payload.

- Upgrading of existing fleet (winglets, equipment, interior).
- Installing so called "winglets" (vertical wingtip extensions), reduces drag. As a result, the average fuel consumption is reduced by approximately 2,5-4,4%. The exact saving depends on aircraft type- and characteristics and the operational environment (is the aircraft mainly used for short/ medium or long haul flights). Another environmental advantage of the installation of winglets is the reduction of noise produced by the aircraft.[174] United Parcel Services has equipped its entire fleet of Boeing 767 cargo aircraft with winglets and estimates that the winglets will save more than 22 million kg CO_2-equivalent emissions.[175]
- Introduction of fuel efficiency tools allow airlines to constantly monitor and analyze fuel efficiency initiatives. As the efficiency tools collect and consolidate hundreds of fuel relevant parameters per flight, they allow the airline to identify potential risks for arrival delays, optimum calculation of most fuel efficient flight profile, optimum performance calculations etc. etc..[176]
- Upgrading aircraft with upgrading packages offered by the manufacturer. Boeing offers a so called "PIP package" (Performance Improvement Package) for the Boeing 777-fleet airlines are operating. The package includes improved technology for ram air, ailerons and vortex generators. After installation of the "PIP-package", a reduction of 1% of CO_2-emissions is realized.[177] For United Airlines, the installation of the PIP-

[174] http://www.boeing.com/commercial/aeromagazine/articles/qtr_03_09/article_03_1.html
[175] http://www.environmentalleader.com/2013/05/08/ups-aircraft-fleet-saves-fuel-reduces-emissions-with-winglets/
[176] http://www.greenaironline.com/news.php?viewStory=1769
[177] http://www.boeing.com/commercial/aeromagazine/articles/qtr_03_09/article_02_1.html

package on the Boeing 777-fleet resulted in an annual reduction of more than 69 million kg CO_2-equivalent emissions and a reduction of more than $20 million of the annual fuel costs.[178]

- Replacing steel brakes by carbon brakes. By replacing steel brakes by carbon brakes, an aircraft weight reduction between 250 – 443 kg is achieved on Boeing aircraft, resulting in reduced fuel consumption and CO_2-emissions. Carbon brakes are included in the standard equipment of the newest aircraft models from Boeing (Boeing 747-8 and Boeing 787).[179] For the Boeing 737NG-fleet (used by SAS and Norwegian), the manufacturer of the carbon brakes estimates annual fuel savings of approximately $50.000 per aircraft[180]. Based on a fuel price of $950 per 1.000 kg of jet fuel in Europe[181] that means an annual saving of approximately 166.000 kg CO_2-equivalent emissions per Boeing 737NG aircraft.

  Upgrading of aircraft interior including seats, use of light weight baggage/cargo containers, catering carts, replacing route documentation by an electronic flight bag etc.

➢ Transition to biofuels.

Biofuels, from the second generation and beyond, can be used in aircraft engines without the need of engine modifications as they satisfy the specific requirements of the air transport industry. The main (technical) challenges are:[182]

1. A flashpoint of minimum 38^0C.
2. A freezing point of maximum -47^0C.
3. Combustion heat of minimal 42,8MJ/kg.
4. Viscosity of maximum 8.000.
5. Sulphur content of maximum 0,30.
6. Density between 0,775 – 0,840 kg/l.

In the ICAO Environmental report 2013, CO_2-emissions from biofuel are considered as neutral[183]. In case of biofuels from plants, the CO_2-emissions from an aircraft engine is more or less equal as the CO_2 the plant absorbed during life.[184]

178 http://www.hemispheremagazine.com/2014/04/01/dont-burn-this/
179 http://www.boeing.com/commercial/aeromagazine/articles/qtr_03_09/article_05_1.html
180 http://www.safranmbd.com/IMG/pdf/MBD_737NGbrake.pdf
181 http://www.iata.org/publications/economics/fuel-monitor/Pages/price-analysis.aspx
182 Beginner's guide to Aviation Biofuels. Air Transport Action Group 2009
183 ICAO 2013 Environmental report
184 Beginner's guide to Aviation Biofuels, Air Transport Action Group 2009

In the paragraph “Environmental Framework”, I will discuss biofuels in more detail.

- Adapt new flight operational procedures which require less fuel consumption.
- Reduce fuel consumption by minimizing the use of aircraft engines on the ground.

  By using new lighter weight baggage containers on the long haul operation, Air France achieves a reduction of 8.000 tonnes CO_2-equivalent emissions (corresponding to approximately 2.500 tonnes of fuel). The new containers are made of composite fiber panels, resulting in a weight reduction of 11 kg per container in relation to the old version. Air France replaced a total of 3.650 baggage containers.

- Air France, KLM and Martinair replaced cargo nets by new, lighter versions made of fibers instead of iron. The nets are stronger and weigh 9 kg, while the older versions weighted between 12 and 18 kilos. The 3 airlines (working through one holding company) replaced 24.000 cargo nets.

Increasing aircraft size and reducing flight frequencies (reduces fuel consumption per passenger kilometer).

More than 90% of high frequency routes are between airports located less than 1.500NM (2.778km) from each other[185]. Although fuel consumption for large aircraft generally is higher than for smaller aircraft, a CO_2-reduction can be achieved by reducing flight frequencies and using larger, and more fuel efficient, aircraft in order to transport the same quantity of passengers on high frequency-routes. This is illustrated by the following example:

For the regional network, SAS uses the CRJ900 (88 passenger seats) and the Boeing 737-800(186 passenger seats)[186].

In this example, SAS flies 10 times a day between city “A” and “B”. The distance between “A” and “B” is 500km. By reducing the number of flights to 5, the airline will be able to reduce fuel consumption with 4.115 liters (10.455 kg CO_2-equivalent), and even increasing seat capacity between “A” and B” with 50 seats, as illustrated in table 18.

The example is used to illustrate that, from the context of the technological framework, it is possible to reduce CO_2-emissions on high frequency routes by reducing flight frequencies and

[185] American Institute of Aeronautics and Astronautics, “Reducing Aviation’s Environmental Impact Through Large Aircraft For Short Range”.
[186] Source: http://www.sasgroup.net

introducing larger aircraft. In this example a reduction of 23% of CO_2-emissions can be achieved, with even increasing seating capacity.

Whether an airline actually is willing to use the method depends on many other (commercial) factors. For delimitation purposes, I will not start that discussion in this paper.

Aircraft type	Seats[187]	Daily seat capacity	Number of flights	Fuel in l/seat km[188]	Total fuel (liters)	Emissions[189]
CRJ900	88	880	10	0,040	17.600[190]	44.715
Boeing 737-800	186	930	5	0,029	13.485[191]	34.261
Table 18						

Reducing the number of aircraft movements reduces the risk of delays (both on the ground and in the air). As a result, the flight time is reduced. Due to a reduction of the flight time, both local air pollution and emission of greenhouse gases are reduced[192].

Research for the US-market has shown that using large aircraft designed for short haul operations (Boeing 787-10 and special versions of the Airbus A350-900) can reduce emissions of CO_2 by 5,4% and reduce operational costs by 9,43% compared to the use of an Airbus A320.[193]

In Europe, EasyJet has a target of reducing CO_2-emissions per passenger by 2,5% by 2017 and by 5% in 2022. The airline will start taking delivery of new Airbus A320neo in 2017. In 2022, the airline aims the fleet to compromise of 35% of the new Airbus A320neo. The A320neo has a 13-15% lower fuel consumption than the aircraft in the airline's current fleet.

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[187] Source: http://www.sasgroup.net
[188] Source: http://www.sasgroup.net
[189] Specification calculation: 1l fuel = 0,804kg. Emissions = 3,16kg CO2 equivalent per kg. fuel
[190] 0,040*88*500*10=17.600l
[191] 0,029*186*500*5= 13.485l
[192] Comparing the environmental impact from using large and small passenger aircraft on short haul routes.
[193] American Institute of Aeronautics and Astronautics, "Reducing Aviation's Environmental Impact Through Large Aircraft For Short Range".

In the calculation of the targets, EasyJet assumes a similar sector length and route network as in the reference year 2013[194].

[194] http://corporate.easyjet.com/corporate-responsibility/our-environment/easyJets-carbon-emissions.aspx?sc_lang=en

Limiting short haul operations (reduces fuel consumption per passenger kilometer).

Fuel consumption of jet aircraft is optimal on high altitudes (between approximately 30.000' and 40.000'). When flying short distances, the time limitation to destination does not allow the flight crew to reach the optimum flight altitude. To illustrate that, I use operational flight plans of KLM (Royal Dutch Airlines). All flights are based on the Fokker 70, an aircraft used for regional operations with a seating capacity of 80 passengers. The details are shown in table 19:

Flight	Cruising altitude[195]	Distance[196]	Trip fuel	Fuel consumption	Flight time
Amsterdam-Kristiansand	35.000'	441NM	2.300kg	5,22 kg/NM	1:42
Amsterdam-Luxemburg	23.000'	207NM	1.300kg	6,28 kg/NM	0:38
Amsterdam-Brussels	15.000'	108NM	864kg	8,00 kg/NM	0:25
Table 19					

In the table, it is shown that fuel consumption, expressed in kg/NM, increases significantly on shorter trips where it is not possible to reach the optimum cruising altitude. Another reason for the high fuel consumption on short distances is the fact that the time used to climb to the cruising altitude is a larger percentage of the total flight time than on longer flights. As the fuel consumption during climb is significantly higher than during the cruising and descending phase, the fuel consumption per NM increases on short trips[197]. On the flight Amsterdam – Kristiansand, the fuel needed to reach 35.000' is 1.000kg of the total trip fuel of 2.300kg (43% of the total trip fuel). On the flight from Amsterdam to Brussels, the fuel needed to reach 15.000' is 500kg of the total trip fuel of 864 kg (58% of the total trip fuel)[198].

[195] 1' (1 foot) = 0,30480m
[196] 1NM = 1,852km
[197] Mathematically Modelling Aircraft Fuel Consumption, Kevin Pyatt and Jacqueline Coomes, Eastern Washington University, Cheney, WA, USA
[198] Operational flightplans KLM – Royal Dutch Airlines

CO_2 Reduction initiatives from the airline industry.

IATA has developed a 4-pillar strategy to achieve a carbon-neutral growth from 2020. The 4 pillars are: Technology, Operations, Infrastructure and Economic measures.[199]

The pillar "Technology" includes new airframe and technology, retrofits of existing fleets and sustainable alternative fuels. IATA launched "TERESA" – Technology Roadmap for Environmentally Sustainable Aviation in 2008. TERESA followed a so called "bottom-up" process. It was based on the combined effect of individual technologies and their implementation into the worldwide aircraft fleet. The project was carried out in cooperation IATA, DLR – German Aerospace Centre and ASDL – Aircraft System and Design Laboratory of the Georgia Institute of Technology (Georgia Tech). The project included 4 phases:

Phase 1: 2008 Subject matter expert assessments.

Phase 2: 2009-2010 Physics based assessments.

Phase 3: 2011-2012 Model impact in world fleet. Calculation of fuel burn improvement to derive fuel burn potential for 8 aircraft sizes.

Phase 4: 2012-2013 Customers influence on aircraft design

The technologies evaluated have been grouped into various categories, related to time horizons, all with their specific target to reduce CO_2-emissions.

Based on a 2005-baseline, IATA expects to achieve a reduction of 50% of CO_2-emissions in 2050. The categories are: Retrofit, modifications, new aircraft design before 2020 and new aircraft design after 2020.

[199] IATA Technology roadmap 4th edition June 2013

CO_2-mitigation measurements initiated by Norwegian airlines.

Many of the measurements discussed in this chapter have already been implemented by Norwegian airlines. I limit my research to Norwegian and SAS. Both airlines share the information on their webpages.

Measurements taken by Norwegian to mitigate CO_2-emissions

Norwegian has a clear environmental goal regarding mitigation of CO_2-emissions:

- Reducing emission per flown passenger by 30% in the period 2008-2015.[200]

CO_2-reduction actions include[201]:

- Fleet renewal program, purchasing the newest aircraft with lowest possible CO_2-emissions per passenger kilometer.
- “Green” approaches and landings. In corporation with Air Navigation Service Providers, Norwegian participates in several operational projects to reduce emissions during descent and approach. When executing a “green approach”, or CDA – Constant Descent Approach, the descent profile in such a way that a continues glide slope towards the runway is assured, enabling the engines to run at idle during most of descent phase of flight.
- Use of winglets. In the case of Norwegian winglets create a 3-5% reduction in fuel consumption.
- Aircraft weight reductions. Example: Norwegian was the first European airline to operate Boeing 737 with carbon brakes.
- Replacing traditional paper books in the cockpit with an EFB – Electronic Flight Bag. Digitalizing the cockpit environment creates an annual reduction of 17.000 tons CO_2-equivalent emissions.
- Network structure which has as many direct flights as possible, limiting the use of hubs as much as possible.
- Engine and aircraft wash. Norwegian runs an engine wash program 2-3 times a year per aircraft. Cleaning the inside of the engine reduces drag and reduces fuel consumption.

[200] http://www.norwegian.com/uk/about-norwegian/corporate-responsibility/environment/
[201] Norwegian annual report 2012

Regular external cleaning and polishing of the aircraft also reduces drag and fuel consumption. The combined actions (engine and aircraft wash) create an annual reduction of CO_2-emissions of approximately 16.000 tons CO_2-equivalent emissions.

- In Norway is involved in the CO2-emission reduction group together with Avinor and NHO-Luftfart (it is the same project as discussed earlier in this chapter in which Avinor invests NOK 100 million.)
- In Sweden, Norwegian is involved in a project named “Green Flights”, involving other actors in Swedish aviation as well as the Swedish Civil Aviation Authority.

Measurements taken by SAS to mitigate CO_2-emissions

In this paragraph, I will present actions initiated by SAS in order to reduce CO_2-emissions. SAS has a clear environmental goals regarding CO_2-mitigation[202]:

- Reduce flight emissions by 20% in 2015 compared with 2005.
- Reduce ground-vehicle consumption of fossil fuels by 10% at SAS’ major airports in Scandinavia by 2015 compared with 2010.

CO_2-reduction actions include[203]:

- Fleet renewal program. Example: MD-80 aircraft were replaced by Airbus A320 aircraft. The A320 has a 20% lower fuel consumption and can carry 18 more passengers.
- Fleet consisting of aircraft of different sizes. This creates flexibility to adjust aircraft size to demand. As a result, the optimum aircraft can be chosen in relation to the number of bookings.
- Participating in NISA – Nordic Initiative Sustainable Aviation.
- Aerodynamic measurements, for example installing winglets/ sharklets reducing fuel consumption with 1-5%.
- Weight reduction measurements, for example replacing brakes with carbon brakes, refurnishing aircraft with light weight seats, replacing catering carts with lighter version carts, replacing glass bottles by plastic bottles, optimize water quantity for the flight to be performed (catering and lavatory use).
- Technical upgrade of aircraft engines delivered prior to 2006. After the upgrade, fuel consumption is reduced by approximately 3%.

[202] SAS Sustainability Report November 2012 – October 2013
[203] SAS Sustainability Report November 2012 – October 2013

CO_2-mitigation initiatives of Avinor[204]*:*

- Participating in the project to initiate the production of biofuel in Norway together with Norwegian, SAS and NHO – Luftfart. The result of the measure is estimated to be a reduction of CO_2-emissions of the Norwegian Air Transport sector of 10-45%, depending on the quantity of biomass originated from Norwegian forests used for the purpose. In this project, Avinor also corporates with Norwegian airlines, NHO – Luftfart - Næringslivets Hovedorganisasjon – Luftfart the corporation of forest owners "Viken Skog", ZERO (Zero Emissions Resource Organization – Independent not-for-profit foundation working for zero emission solutions to the global climate challenge) and several other organizations involved in the initiative. As the biomass originates from forests not used for the food-chain, the biofuel is considered as a second generation biofuel.
- Avinor uses its influence to redesign the airspace structure as well as optimizing approach and departure procedures.

[204] Avinor Samfunnsrapport 2013

4. Theory

I use this theoretical chapter as an interface between the problem statement and the discussion and conclusions.

When looking at the problem statement “Which commercial opportunities are created for the Norwegian airline industry by new CO_2-regulations?” I find 2 key elements: The first one is “commercial opportunities” and the second one is “CO_2-regulations”.

“Commercial opportunities” are related to profitability and “CO_2-regulations” are related to sustainability. In essence, the starting point of the theory is to check whether I can find a relationship between profitability and sustainability in the airline industry.

In my search to an answer to that question, I start with checking facts. During my research, I found a sustainability and a profitability ranking of the airline industry.

Greenopia, ranks companies on sustainability. For the airline industry 2 rankings are published: One for US-airlines and one ranking for non-US airlines.

Name	Average Fleet Age	Rating
Virgin America	3 yrs	4/4
Alaska Airlines	8.9 yrs	3/4
United	13 yrs	3/4
Jet Blue	6.2 yrs	3/4
Delta	15.7 yrs	3/4
US Airways	12.6 yrs	2/4
Southwest	12 yrs	2/4
Air Canada	11.6 yrs	1/4
American	14.9 yrs	1/4

Figure 5, Sustainability ranking US-airlines[205].

[205] http://76.74.159.164/LO/airline_search.aspx?category=Airline&Listpage=0&input=Name-or-product&subcategory=None

Name	Average Fleet Age	Rating
Air France-KLM	9.5 yrs	4/4
Lufthansa	13.3 yrs	3/4
British Airways	12.7 yrs	3/4
Virgin Atlantic	9.6 yrs	3/4
EasyJet	4.1 yrs	3/4
Cathay Pacific	10.6 yrs	2/4
Ryanair	3.8 yrs	2/4
Air New Zealand	9.6 yrs	1/4
SAS	12.7 yrs	1/4
Aer Lingus	6.3 yrs	1/4

Figure 6 Sustainability ranking non-US airlines[206]

[206] http://76.74.159.164/LO/airline_search.aspx?category=Airline&Listpage=0&input=Name-or-product&subcategory=None

I crosscheck the sustainability ranking with the global top 10-profitability (expressed in profit margin and in $) ranking of 2013 published by Airline Weekly.[207] The results are shown in table 20 and 21.

Airline	US-sustainability ranking	Non-US-sustainability ranking
Copa Panama (Panama)	N/A	No
Spirit (USA)	No	N/A
Allegiant (USA)	No	N/A
Air Asia (Malaysia)	N/A	No
Japan Air Lines (Japan)	N/A	No
Ryanair (Ireland)	N/A	Yes, #7
Alaska Airlines (USA)	Yes#2	N/A
Aegean (Greece)	N/A	No
Easyjet (UK)	N/A	Yes, #5
Westjet (Canada)	N/A	No

Table 20 Top 10 airline profitability 2013, expressed in profit margin

Conclusion:

Expressed in profit margin, 1 out of the top-10 global performers is represented in the top-9 US sustainable airline index list.

Expressed in profit margin, 2 out of the top-10 global performers are represented in the top-10 non-US sustainable airline index list. Both airlines are the number 1 and 2 low cost carriers in Europe, expressed in market share[208].

Despite the sustainability performance of Ryanair and Easyjet, based on this overview, I cannot argue that there is a direct relationship between profitability and sustainability in the airline industry.

[207] http://www.deseretnews.com/article/865601066/Delta-tops-list-of-most-profitable-airlines-in-2013.html?pg=all

[208] http://www.airportwatch.org.uk/?p=1230

Relation sustainability ranking and profitability expressed in $.

Airline	US-sustainability ranking	Non-US-sustainability ranking
Delta Airlines (USA)	Yes, #5	N/A
American Airlines (USA)	Yes, #9	N/A
Japan Air Lines (Japan)	N/A	No
United Airlines (USA)	Yes, #3	N/A
Lufthansa (Germany)	N/A	Yes, #2
Southwest Airlines (USA)	Yes, #7	N/A
Ryanair (Ireland)	N/A	Yes, #7
Emirates (United Arab Emirates)	N/A	No
Easyjet (UK)	N/A	Yes, #5
IAG (British Airways and Iberia, UK and Spain)	N/A	Yes, #3 (British Airways)
Table 21 Top 10 airline profitability 2013, expressed in $		

Conclusions:

- Based on profit expressed in $, 4 out of the top-10 global performers are represented in the top-9 US sustainable airline index list.
- Based on profit expressed in $, 4 out of the top-10 global performers are represented in the top-10, non-US sustainable airline index list. All 4 are European airlines.
- Ryanair and Easyjet, are the only 2 airlines which are represented in all 3 tables (sustainability, profit expressed in profit margin and profit expressed in $).

Based on the overview expressing the relationship between sustainability and profit expressed in $, I assess that there is a relationship between profitability and sustainability in the airline industry. In order to find a confirmation of that impression, I performed some additional research. The findings are:

- 4 out of 5 leading airlines, based on market value in 2014[209] are represented in the overviews of most sustainable airlines.

[209] http://www.statista.com/statistics/275944/brand-value-of-airlines/

- 7 out of 10 leading airlines, based on passenger kilometer flown in 2012[210], are represented in the overviews of most sustainable airlines.
- The top-6 airlines, based on revenue in 2013[211], are represented in the overviews of most sustainable airlines.
- 6 out if the top-9 airlines, based on number of passengers carried in 2012[212] are represented in both sustainability overviews.
- Based on ASK in 2013[213], the top-3 of the world low cost carriers (Southwest Airlines, Ryanair and Easyjet) are represented in both the tables indicating sustainability performance and profitability expressed in $.

I consider these additional facts as useful as they strengthen my impression that, in general terms, profitability and sustainability are positively correlated in the airline industry.

Before selecting evaluating theories, I want to have 3 additional questions answered:

1. What do the researches of Greenopia say about the number 1 (Virgin America and Air France – KLM respectively)?
2. What do the researchers say about the only Norwegian airline (SAS) represented their rating?
3. What is the economic performance of Air France – KLM?

1. About Virgin America, Greenopia states (#1 in the rating of US-airlines)[214]:

"***Efforts:*** *Virgin is positioning itself as a green leader in air travel and its actions back up its claims. Since Virgin is a relatively new airline, it has the most current fleet (about 3years old on average). This means that Virgin's planes are very efficient in both fuel consumption and emissions. Virgin installs winglets on its planes which lead to better fuel efficiency (and therefore fewer emissions). Virgin has made progress with biofuels and has even done several flights with planes solely powered by biofuels. Virgin has a comprehensive recycling program and hopes to divert 50% of its waste by 2012. Presently, Virgin has an in-flight recycling rate of around 47%. While many airlines have yet to add any environmental or ethically sourced food options, Virgin has risen to the challenge and serves only fair trade coffee and also has some local or organic options. Virgin offers passengers the ability to offset their carbon footprint when flying and the projects they source are good mostly revolving around green energy generation. Lastly, Virgin's headquarters is LEED certified and that its new terminal*

210 http://www.statista.com/statistics/270986/airlines-by-passenger-kilometers-flown/
211 http://www.statista.com/statistics/246347/the-largest-airline-worldwide-by-revenue/
212 http://www.statista.com/statistics/269617/top-10-airlines-worldwide-by-number-of-passengers/
213 http://www.theaviationwriter.com/2013/05/top-50-low-cost-carriers-world.html
214 http://76.74.159.164/LO/airline_listing.aspx?ID=1&input=Name-or-product&Listpage=0&section=Description

at San Francisco Airport has received LEED Gold status..

Issues:
Although Virgin does very well in all of our categories, there are a few airline chains that have been more successful with their in-flight recycling programs (in terms of recycling rate). Also, Virgin has not released an updated sustainability report for some time, which is very surprising given how much effort they put in their original reports.

Greenopia Verdict:
In spite of some outdated environmental reporting, Virgin is still our greenest overall airline for the fourth straight year."

And, about Air France – KLM[215]:

"Efforts:
First off, Air France has tremendous environmental reporting. It sports the best carbon efficiency of any airline in this study that readily reported this value. Its fleet is somewhat young, coming in at just under 10 years, and Air France has been a leader in biofuel research. Almost half of Air France's ground vehicles are electric and it has been very progressive in various fuel-saving measures such as aircraft lightweighting. There is also a strong focus on recycling and its strong internal metrics reflect this. Air France is also one of the few major airlines with a solid number of sustainable food options and it is looking to extend its green offerings as well. Finally, Air France has been an industry leader in regards to the construction of green facilities and offers a high quality carbon offset program for its passengers.

Issues:
There is really very little of which we can be critical. Air France makes a strong effort in every area that we studied.

Greenopia Verdict:
Air France is our overall top performer for Non-US Airlines and is clearly one of the greenest airlines in the world."

Another ranking confirming the environmental position of Air France – KLM is the DJSI – Dow Jones Sustainability Index[216]. In September 2013, Air France – KLM was for the ninth successive year ranked as the number 1 airline in sustainability. In the last 5 years, the company is the number 1 in the ranking of the whole transport sector[217].

2. About SAS, the researchers conclude[218]:
"**Efforts:** SAS has decent environmental reporting and practices a variety of efficiency measures including engine washing, using electric ground vehicles, as well as other initiatives. SAS is in the process of researching biofuels and offers high quality carbon offsets to its passengers.

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[215] http://76.74.159.164/LO/airlineNonUS_listing.aspx?ID=3&input=Name+or+product&Listpage=0
[216] http://www.sustainability-indices.com/review/industry-group-leaders-2013.jsp
[217] http://news.klm.com/air-france-klm-ranked-world-leader-in-the-transport-category-by-the-djsi-2013-en/
[218] http://76.74.159.164/LO/airlineNonUS_listing.aspx?ID=8&input=Name+or+product&Listpage=0

Issues:
We do wish SAS would report more environmental metrics such as carbon efficiency and recycling rates. We also noticed very few green food or drink options available on its flights. Finally, its fleet is one of the oldest out of the airlines in our study."

Greenopia Verdict:
SAS has some solid green initiatives, but needs to do more to stand up to some of their competitors environmentally".

3. The economic performance of Air France – KLM is reported to be: "In terms of dollars lost, Air France/KLM was the biggest loser at negative $553 million; Alitalia lost $395 million; Malaysia Airlines lost $300 million; Jet Airways lost $284 million; and Air Berlin lost $266 million."[219]

That raises the question whether the profitability of Air France – KLM was weak for only that year, or whether the financial performance is structurally weak. After research , I argue that the profitability of Air France –KLM is structurally weak: "*The group has reported losses in four out of the past five years, during which time its cumulative net loss has been EUR3.8 billion"*[220] and: *'The group has reported a cumulative net loss of EUR439 million for the period of its post-merger existence. It seems that there was no step change in profitability and that the merger synergies were mainly revenue-related, all but evaporating as soon as the revenue environment became difficult"*[221]. The holding company Air France – KLM was created by the merger of Air France and KLM in 2004.[222]

All in all, I argue that Air France – KLM has a strong sustainability ranking but, on the other hand, a weak financial performance.

When checking applicable theories, I start with the SWOT analyze, BCG matrix and 3 theories created by Porter:

1. SWOT analyze
2. BCG matrix
3. Porter's 5 forces theory.

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[219] http://www.deseretnews.com/article/865601066/Delta-tops-list-of-most-profitable-airlines-in-2013.html?pg=all
[220] http://centreforaviation.com/analysis/air-france-klm-why-it-must-transform-as-medium-haul-and-cargo-operations-hurt-the-bottom-line-98885
[221] http://centreforaviation.com/analysis/air-france-klm-why-it-must-transform-as-medium-haul-and-cargo-operations-hurt-the-bottom-line-98885
[222] http://www.klm.com/corporate/en/about-klm/profile/

4. Porter’s theory about generic strategies.
5. Porter and van der Lindes theory about environmental regulations and profitability.

SWOT analyze:

The SWOT – Strengths Weaknesses, Opportunities and Threats analyze is used to determine a company’s Strengths and Weaknesses (internal, related to the organization) and Opportunities and Threats (external, related to the environment).

When I tried to make a SWOT-analyze to explain the strong sustainability performance and the weak financial performance of Air France - KLM, I realized that it was not possible to make a good SWOT analyze based on objective data and that I was not able to directly connect the SWOT analyze to the profitability of the company. I therefore argue that a SWOT analyze is not the appropriate analyze to analyze the problem statement.

BCG – matrix:

Because of the growth of low cost carriers in the last decade, substantially increasing their market shares in Europe and the USA, I considered to use the BCG - Boston Consulting Group matrix for my research. I argue that the matrix can be used for the airline industry. However, in relation to my research question, I have to conclude that it is not the most appropriate research tool. The reason is that it does not, in sufficient way, provide information directly linked to the relationship between commercial opportunities/profitability and sustainability.

Porters five force strategy:

I have briefly discussed the 5-force theory in the paragraph “economic framework” (paragraph 3.1). During my research, I found out that the five force strategy is a useful tool to discover the relationship between the created value, the supply chain (tells us how the company created the value, in this thesis sustainable aviation) and what the result is (performance expressed in profit/loss). By crosschecking the relationships, as the ratings of profitability and sustainability, a company is able to get insight in its own performance and to compare the performance with other companies in the same industry (airlines). Analyzing the outcome helps a company to create a competitive advantage. In order to create a competitive advantage, a company needs a clear strategy. Margretta (2012) argues: “*Porter’s point, an* *important one, is that strategy requires analytic thinking*"[223] and *"Strategy explains how an organization, faced with competition, will achieve superior performance.*[224]*"*

Having a clear strategy, the company is able to create competitive success, also referred to as having the ability to create unique value. In this case, I check whether a CO2-policy, as a part of the corporate strategy, creates commercial opportunities.

On order to get insight in the possibility to create superior performance, an airline needs to know the industries structure. On the other hand, the company has to be aware of its relative position in the industry (e.g. place on the sustainability index). The forces working in the industry structure and the relative position in the industry are illustrated in figure 7.

Figur 7, Source: Michael E. Porter, « The Five Competitive Forces That Shape Strategy», Harvard Business Review, January 2008

An additional advantage when referring to the five-force theory of Porter is that Porter has, on behalf of IATA, explained how the 5 forces in the airline industry work. Porters' explanation is published in IATA's Vision 2050 which was published in 2011. Porter argues that "*Profitability is a function of the collective strength of the Five Forces as well as the interaction among them. These forces shape the behavior of the actors and determine both the overall value created in the industry and the way in which this value is divided among them.*

The Five Forces framework identifies the underlying drivers of industry profitability. However, though the underlying economics of an industry limit the set of possible industry outcomes, the actual outcome depends to some degree on the decisions made by rivals and

[223] Joan Magretta, Understanding Michael Porter, 2012, page 13
[224] Joan Magretta, Understanding Michael Porter, 2012, page 20

other industry actors. In a low-profitability industry like airlines, a key question is thus whether the fundamentals would be consistent with a different set of company choices resulting in a more sustainable level of profitability."[225]

Figure 8 illustrates Porters explanation of the 5 forces in the airline industry:

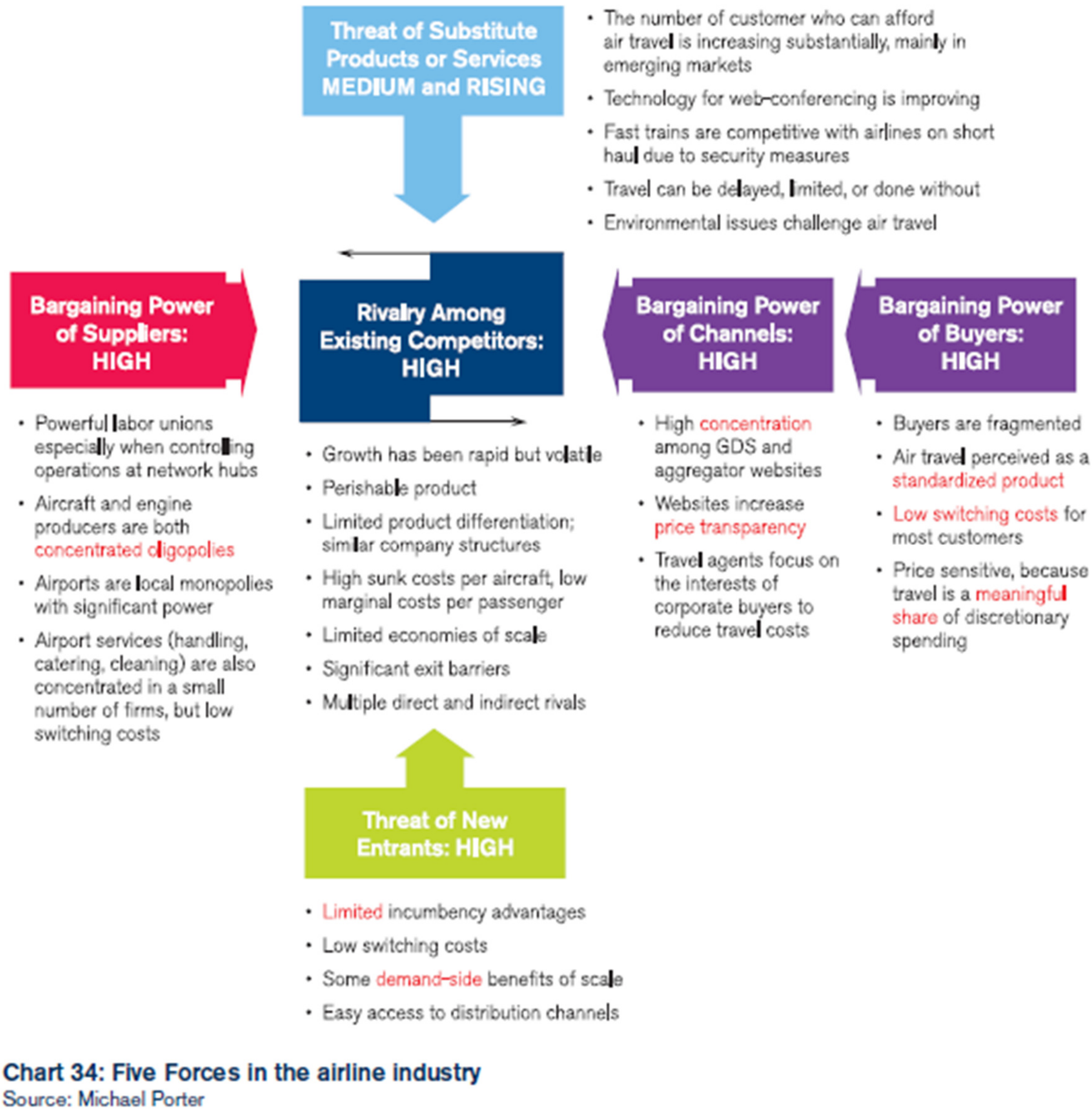

Figure 8, Porters' 5 forces in the airline industry. Source: IATA Vision 2050

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[225] IATA, Vision 2050, 2011, page 30

Porters five forces in relation to the research question:

When trying to find specific answers on the problem statement? "W*hich commercial opportunities are created for the Norwegian airline industry by new CO_2-regulations*?", I consider it useful to reflect Porters illustration to the airline market situation in Norway.

In chapter 3 (background information), we found elements which can be used as a tool to specify/complete Porters illustration for the Norwegian airlines.

I comment the 5 forces, based on my research.

- *High Bargain power of Suppliers*: I found no relevant information to adjust Porters point of view.
- *Threat of substitutes*: VC is a potential threat as the Norwegian government actively promotes the use of VC instead of actual travelling for its employees. The Norwegian policy has been discussed in 3.1 (economic framework). HSR is not considered a threat for Norwegian airlines on their domestic markets as HSR has shown not to be profitable in the coming years (as discussed in 3.1 economic framework). On the other hand, HSR might take over a part of the market share abroad. That can be considered as a potential threat as Norwegian and SAS have hubs abroad. I consider the overall threat as limited.
- *Bargain Power of Channels and Bargaining Power of Buyers*: I found no relevant information to adjust Porters point of view for the Norwegian market.
- *Threat of New Entrants:* I estimate that the threat of new entrants is limited as several Norwegian airports have capacity limitations, especially the main airports Oslo, Bergen, Stavanger and Trondheim. Detailed research of that subject, is however not performed for this thesis.
- *Rivalry Among Existing Competitors:* I estimate that, amongst others based on the fact that 13 out of 17 bases of Norwegian are located outside Norway[226], Norwegian is less affected buy "significant exit barriers" than SAS. Researching that subject in detail, is beyond the scope of this thesis.

[226] Norwegian Air Shuttle, Corporate fact sheet, June 2014; http://www.mynewsdesk.com/no/norwegian/documents/corporate-fact-sheet-2014-36943

Margretta (2012) illustrates how the 5 forces influence profitability (figure 9 and 10):

THE FORCE		IMPACT		WHY
IF threat of entry ↑	Profitability ↓	because	(Prices ↓ Costs ↑)
IF supplier power ↑	Profitability ↓	because	(Costs ↑)
IF buyer power ↑	Profitability ↓	because	(Prices ↓ Costs ↑)
IF substitutes ↑	Profitability ↓	because	(Prices ↓ Costs ↑)
IF rivalry ↑	Profitability ↓	because	(Prices ↓ Costs ↑)

Figure 9, How the 5 forces influence profitability, source: Joan Magretta, Understanding Michael Porter, Page 41

Figure 10, How the 5 forces impact profitability, source: Joan Magretta, Understanding Michael Porter, Page 54

<u>Porter's theory about generic strategies:</u>

The forth theory which I reflect my problem statement to is Michael Porters theory about generic strategies. Porter identified 3 generic strategies[227]:

- Focus, refers to the breath or narrowness of the customers and needs a company serves.
- Differentiation, allows a company to command a premium price.
- Cost leadership, allows the company to offer a low relative price.

Magretta (2012) argues that there are 3 preconditions required to correctly implement the corporate strategy:

- Creation of a unique value proposition.
- Correct linkage between value proposition (external on the customer) and value chain (internal on operation) creates a competitive advantage. If the value proposition is not correctly linked with the value chain, it is not possible to create a competitive advantage.

[227] Joan Magretta(2012) Understanding Porter

- The company has to make unique choices. That includes making choices of tradeoffs (choosing unique market segments).

During my research, in my attempts to find a linkage between "profitability" and "sustainability", I realized that it would become complicated to use Porters generic strategies as a tool to find an answer to my problem statement. As discussed in the introduction in this chapter, the 3 largest low cost carriers in the world (cost leadership companies) are all represented in the rating of most sustainable airlines. Ryanair, "Ryanair is Europe's favourite low fares airline".[228]

I do not argue that cost leaders cannot achieve sustainable performance. It is possible that low CO2-emissions by the low cost carriers is caused by the fact that they buy the most fuel efficient aircraft (cost leadership), what results in low emissions. If that is the case, then the environmental performance is a result of commercial choices and not the other way. Magretta (2012) argues that not making clear choices of generic strategies, causes a situation of being "stuck in the middle" in relation to Porters generic strategies: The company is outflanked by cost leaders and differentiators.

All in all, I consider the Porters theory about generic strategies as not suitable to find an answer for my problem statement.

5. Porter and van der Lindes theory about environmental regulation and profitability

In the article "Toward a New Conception of the Environment-Competitiveness Relationship", Porter and van der Linde argue that: "Companies must start to recognize the environment as a competitive opportunity-not as an annoying cost or a postponable threat. Yet many companies are ill-prepared to carry out a strategy of environmental innovation that produces sizable compensating offsets"[229].
The quoted statement offers me a good platform to initiate a discussion about the relationship between CO_2 regulations and profitability (chapter 7).

I recognize that I maybe could have evaluated more management theories before starting the discussion. There are several theories about sustainability and profitability, like Orsato (2006) "When does it pay to be green?"

228 http://corporate.ryanair.com/
229 Porter and van der Linde, Toward a New Conception of the Environment-Competitiveness Relationship, The Journal of Economic Perspectives, Vol. 9, No. 4 (Autumn, 1995), page 114

I will use those theories in the discussion and reflect them with Porters five forces and Porter and van der Lindes' statement about environmental regulation and profitability.

5. Methodology

In order to work out/ prepare the aim and objectives of the thesis, I will use a combination of a theoretical and an empirically study as well as report about a concrete challenge which the Norwegian airline industry is facing.

When choosing the research methodology of this paper, I have roughly 2 choices; Qualitative and quantitative methodology.

A qualitative methodology is mainly used in order to answer research questions which start with "how" and have open ends with room for interpretation. Qualitative methodology is mainly used when trying to, amongst others, developing strategic directions, to understand the context of data, to understand perceptions, understand values and feelings, researching marketing strategy and many other research areas which can be investigated by asking open questions. A qualitative research offers flexibility to adjust the research when data gives new insights in the research topic.

A quantitative methodology is mainly used on order to answer research questions which try to find answers which can be given in figures. Examples are the relation between decreasing a price in relation to increase in demand (price elasticity) , measure public opinion, or researching the relation between behavior (for instance smoking and/or lack of physical exercise) and the risk of a specific disease (for instance cancer).

The main purpose of this paper is to research the possibilities for the airline industry to use CO_2-policy as a commercial tool. In other words: Finding a way for airlines to use CO_2-policy as a mean of increasing revenue and/or reducing costs. The data analysis is based on findings which I collect by primary and secondary data. The primary data is mainly received by interviews of stakeholders. The secondary data is mainly received by desk research (published articles, websites, reports, legislation etcetera).

Before answering the question which type of research I choose, it is important to have a clear mental picture of what I am actually researching. In my opinion, the best way to find the answer to that question is by describing the key-elements in of my research. I describe them as 10 questions.

1. I want to know how Norwegian airlines can benefit from CO_2-reduction.
2. I need to know how CO_2-emissions can be reduced without reducing capacity, even increasing capacity, in the coming years.
3. I try to understand the importance of CO_2-emissions from the aviation industry and put it into the context of global emissions.
4. I want to understand what the background is of different opinions/visions on CO2emissions between stakeholders.
5. I try to find out what the importance is of biofuels in order to reduce CO_2-emissions.
6. I want to understand the political process behind the global difficulties to introduce a CO_2 policy for the aviation industry.
7. I want to know what the vision of the Norwegian authorities is and how the Norwegian authorities think they can achieve their goals.
8. I want to know if there are any financial threats when an airline starts to introduce or improve a CO_2-policy.
9. I want to know what the industry already has achieved in reducing CO_2-emissions.
10. I want to know how and where the aviation industry will grow in the coming decades (until approximately 2050).

In order to find answers to these questions, I need to keep the following requirements in mind:

1. I need to observe, document and compare amongst others opinions, facts, technological development, customer needs, marked developments, influence of stakeholders etcetera.
2. I need to respond to available data which becomes available through interviews and desk research.
3. I order to get usable questions, I need to be flexible in amongst other having empathic understanding of the persons I interview and of the desk research. Why do they have the opinion they have, what is their drive?
4. In order to find answers I need to decode the data and transform the data into information which can be used in the thesis.
5. The data I use describe quality/characteristics of what I research.
6. I need a flexible research methodology.

Thoughts:

1. My research relies mainly on the interpretation from people and/or organizations.
2. The research-questions are more or less open-ended.
3. I try to identify norms, trends, possibilities, threads, opinions, views, challenges.
4. I want to describe and explain the answers to the problem statement.
5. I will interview stakeholders on an in-depth 1on1 basis.
6. I use descriptions from the perspective of the research participants as a means of examining specific issues and problems.

Taking the key-elements, requirements and thoughts into consideration, the qualitative research method will, in my opinion, suit this thesis better than a quantitative research method.

Validity:

In order to increase the quality, credibility and trustworthiness of my research, I will make use of triangulation, saturation and reflexivity.

Triangulation:

Triangulation is achieved by using multiple data sources. I compare, amongst other, legislation, data collected from interviews and policies with scientific reports and research.

Saturation:

Saturation might be more or less subjective as I am the person who decides whether I have collected enough data or not. Saturation is therefore also a delimitation of my research. A researcher has to be able judge at which point additional data does not create significant added value in relation to the research questions. I have to take my resources and limitations (amongst other available time) into consideration in order find my own comfort level to find out whether I need more information or not.

Reflexivity:

I am fully aware that I am not capable to put aside my own beliefs, opinions and feelings about aviation and environment. In order to increase the validity of my research, I will compare the outcome of the research with external data. I will use a chapter in order to share my limitations (reflections).

Reliability:

In a qualitative research, it is a big challenge to demonstrate a high level of reliability. Qualitative research is characterized by observations and interpretations. Remaining fully objective during an observation and/or an interview can only be achieved when the researcher acts if every piece of data is completely new for him/her. It cannot be avoided that a qualitative research has subjective elements. I distinguish internal and external reliability. Internal reliability refers to the reliability of the researcher. The outcomes of the research can be distorted by my own background, knowledge, beliefs and opinions. Internal reliability can be increased by making use of more than one researcher. The fact that I am the only researcher is a limitation of my thesis. External reliability refers to the replicability of the research. This means: Would another researcher, with the same approach of the research, have the same conclusion? In order to increase the external reliability, I have saved by research "step by step" and use a transparent approach of my research. My research can be reconstructed and compared to outcomes of future research. The reliability is increased by making use of triangulation which is also used to demonstrate the validity of the research. By triangulation, with the purpose to increase reliability, an item is studied from different perspectives. I study the collected data from different starting points. In this paper, I research the emission question from an economic, environmental and political starting point. What does "aviation is accountable for 3% of global CO_2-emissions" mean for the industry, NGO's and policy makers? What are their respective frames of reference? In this example, I observe the 3% and collect relevant data. The collected data has as much as possible a scientific source. From there, I start interviewing representatives of the industry, NGO's and/or selected government agencies. By crosschecking the interviews with the collected data, I am able to increase the reliability of the outcome of my research.

Limitation:

I realize that the validity and reliability in every research has limitations. The main question for me to answer is: Are the limitations openly communicated and do the limitations influence the validity and reliability in such a way that the main results of the research are significantly influenced by the limitations?

The main limitations in my research are:

- For practical reasons, it was not possible to find a fellow-student to share this research with. By taking the steps as discussed in the chapter's validity and reliability, I am convinced that I have minimized the negative factors of not having a co-student.
- Time and available resources are limited. By clearly delimitating the research to concrete aim and objectives, I decrease the risk of negatively influencing the validity and reliability.
- Research methodology. Contrary to quantitative research, qualitative research is more likely to be influenced by the researcher's views/opinions. I have reduced the risk of this limitation by making use of triangulation and reflexivity.

As I take concrete steps to reduce possible negative consequences, share these limitations and have a transparent approach of my research, I am convinced that the limitations do not significantly influence the outcome of my research. I encourage others to share views/thoughts for improvement of my paper.

6. Overview and results of interviews and questionnaires

- On 28. March 2014, I had an interview with Hilde Høiem. Mrs. Høiem started as the environmental coordinator for “Luftfartstilsynet” -the Norwegian Civil Aviation Authority. Mrs. Høiem started a few months before the interview and her primary task at the administration is noise-related. From this year, she will also be involved in CO_2-policy. Mrs. Høiem and I discussed several CO_2-related issues. However, as Mrs. Høiem just started with her CO_2-related tasks, the scope of the interview was limited. We both agree that the technical development of the industry is impressive and expect that further progress will be made. Details about the aviation authorities’ emission responsibilities are not yet fully clear.
- I sent out 2 questionnaires to stakeholders of other Norwegian organizations. Unfortunately, I did not receive them.
- I consider the effect on reliability of the thesis as limited. As I have crosschecked my data form several sources, I expect that the answers given in the questionnaires would not significantly affect the outcome of my research.

7 Discussion

The previous chapters are the basis for the discussion which I share in this chapter.

In chapter 1, I explained my motivation to choose the subject of the thesis and defined the problem statement, aim and objectives.

In chapter 2, I explained the structure of the thesis in order to guide the reader through the topics and explain what I address where and why.

Chapter 3 contains an in-depth study of the economic, environmental, legal, commercial and technological framework. The main purpose of that chapter is to share as many relevant facts as possible for the discussion, conclusions and final reflections. The chapter is primarily meant as a "fact finding chapter".

Chapter 4 describes the evaluation of theoretical selections. 5 theoretical models were discussed. Of the 5 theories discussed, I consider 2 useful as a basis for the discussion and conclusions: Porters 5 force strategy and Porter and van der Lindes theory about environmental regulation and profitablility.

In chapter 5, I share my motivation for the choice of methodology.

In chapter 6, the outcomes of the interview and questionnaire were evaluated.

In this chapter, I evaluate the research findings and discuss them in relation to scientific theory and scientific research. The main purpose of this chapter is to prove that I have answered the question used as problem statement and that the aim and objectives have been achieved in manner which is scientific responsible.

The discussion is structured by discussing the problem statement and the aim and objectives of the thesis. By using that approach, all relevant issues in relation to the problem statement will be discussed in a structured manner.

The problem statement of the paper is:
"Which commercial opportunities are created for the Norwegian airline industry by new CO_2-regulations?"

The starting point of the discussion to answer the problem statement is the theory of Porter about the five competitive forces that shape strategy[230] and the theory of Porter et al about environmental competitiveness[231].

In Vision 2050[232], Porter explains why airline profitability is so poor by applying his Five Forces framework. Details about the Five Forces framework have been discussed in the economic framework (paragraph 3.1) and the chapter 4 (theory).

In the latter theory, Porter and van der Linde argue that competitiveness is created by superior productivity. The required competiveness is not achieved by lowest possible costs. It is a requirement that the company has the capacity to continuously improve and innovate. Environmental regulations can trigger innovations and improve competitiveness. Based on case studies, Porter and van der Linde argue that the benefits for a company can become so big that the business can become more competitive than competitors from other countries, applying less strict environmental regulations. It is however a prerequisite that the environmental regulations are properly designed. Porter and van der Linde argue that "Pollution is the emission or discharge of a (harmful) substance or energy form into the environment. Fundamentally, it is a manifestation of economic waste and involves unnecessary, inefficient or incomplete utilization or resources, or resources not used to generate their highest value." [233] The theory of Porter and van der Linde that strict environmental regulation can increase profitability is often referred to as PH - Porter Hypothesis.

[230] Porter, The Five Competitive Forces That Shape Strategy, Harvard Business Review, January 2008
[231] Porter and van der Linde, Toward a New Conception of the Environment-Competitiveness Relationship, Journal of Economic Perspectives, Volume 9, Number 4, Fall 1995, Pages 97-118
[232] IATA Vision 2050, 2011
[233] Porter and van der Linde, Toward a New Conception of the Environment-Competitiveness Relationship, Journal of Economic Perspectives, Volume 9, Number 4, Fall 1995, Page 105

Palmer et al (1995)[234] criticize Porter and van der Linde and conclude that environmental regulation is expensive and argue "Porter and van der Linde suggest the cost of environmental regulation may be negligible or even nonexistent"[235] Palmer et al also criticize Porter et al as "the major empirical evidence that they advance in support of their position is a series of case studies. With literally hundreds of thousands of firms subject to environmental regulation in the United States alone, it would be hard *not* to find instances where regulation has seemingly worked to a polluting firm's advantage. But collecting cases where this has happened in no way establishes a general presumption in favor of this outcome."[236]

Ambec et al (2011) argue that the PH "does *not* say that all regulation leads to innovation – only the well-designed regulations do." and the PH "does *not* state that this innovation necessarily offsets the cost of regulation".[237] Ambec et al conclude that "First, on the theoretical side, it turns out that the theoretical arguments that could justify the PH are now more solid than they appeared at first in the heated debate that took place in 1995 in the *Journal of Economic Perspectives* (Palmer et al. 1995) On the empirical side, on one hand, the evidence about the "weak" version of the hypothesis (stricter regulation leads to more innovation) is also fairly well established. On the other hand, the empirical evidence on the strong version (stricter regulation enhances business performance) is mixed, with more recent studies providing more supportive results".

The theory of Porter and van der Linde that environmental performance can create revenue is partly supported by Lanoie et al (2007)[238]. Anoie et al refer to a survey of OECD. The outcome amongst 4.000 organizations was that 43% of them assess the environmental performance of their supplier. That conclusion also illustrates the buyers' power in Porters 5 Forces Framework. In fact, we see that if regulators do not introduce environmental regulations, the market can force a supplier to implement environmental standards through their buying power. From one side, environmental regulations might force companies to

[234] K Palmer et al, Tightening Environmental Standards: The Benefit-Cost or the No-Cost Paradigm? The Journal of Economic Perspectives, Vol. 9, No 4 (Autumn, 1995) page 119-132
[235] K Palmer et al, Tightening Environmental Standards: The Benefit-Cost or the No-Cost Paradigm? The Journal of Economic Perspectives, Vol. 9, No 4 (Autumn, 1995) page 120
[236] K Palmer et al, Tightening Environmental Standards: The Benefit-Cost or the No-Cost Paradigm? The Journal of Economic Perspectives, Vol. 9, No 4 (Autumn, 1995) page 120
[237] Ambec et al, The Porter Hypothesis at 20: Can Environmental Regulation Enhance Innovation and Competitiveness? Resources for the future, Jnauary 2011, RFF DP 11-01
[238] Lanoie et al, When and Why Does it Pay to be Green? November 2007

reduce emissions. But that does not say anything about commercial opportunities. On the other hand, if regulators do not adapt new regulations, companies can be forced to reduce emissions by the buying power of their customers.
Anoie et al explain a limitation regarding the PH: “The main limitation regarding the Porter Hypothesis is that it goes against the grain of current thinking. Profit maximizing firms, it is widely held, will not ignore profitable investments in innovation, regardless of the level of regulation, in an economy with the perfect markets.”[239]

King et al (2001) conclude that there is an association between pollution reduction and financial performance, but they are unable to prove the direction of the causality. [240] The researchers explain: “Our research provides both additional supports for the “pays to be green” hypothesis and suggests caution in interpreting its implications. Much of the variance in our study is attributed to firm-level differences. Better understanding of these differences might provide a richer understanding of profitable environmental improvement It may be that it pays to reduce pollution by certain means and not others. Alternatively, it may be that only firms with certain attributes can profitably reduce their pollutions. Additional research is needed to explore how underlying firm characteristics affect the relationship between relative environmental performance and financial performance”. The relationship between underlying capabilities and environmental management is likely to be complex and contingent”.[241]
Scientists, who were involved in the literature I have consulted, do not agree whether legislation targeting reduction of emissions will, or will not, positively influence the company’s financial result, let alone answer the research question “Which commercial opportunities are created for the Norwegian airline industry by new CO_2-regulations?”
I consider the relationship argued in several researches not strong enough to justify the conclusion that I can, in affirmative, answer the question “Are commercial opportunities created by introducing new CO_2-regulation?” Based on the research, I am not able to prove the direct relationship between legislation, aiming for a reduction in CO-2emissions, and creating commercial opportunities for airlines.

[239] Lanoie et al, When and Why Does it Pay to be Green? November 2007, page 16
[240] King et al, Does It Really Pay to Be Green? An Empirical Study of Firm Environmental and Financial Performance, Journal of Industrial Ecology, Volume 5, Number 1, Massachusetts Institute of Technology and Yale University
[241] King et al, Does It Really Pay to Be Green? An Empirical Study of Firm Environmental and Financial Performance, Journal of Industrial Ecology, Volume 5, Number 1, Massachusetts Institute of Technology and Yale University, page 113

On the other hand, the researches prove that there is a positive relationship between environmental demands from the customers and the company policy. Not meeting the demand will, in the worst case, cause a decrease of passengers. As a consequence, the financial performance of the airline comes under pressure if it does not picks up that element. In other words: Commercial opportunities created by a policy to reduce CO_2-emissions are triggered by the market and not by the regulator through legislation.

Porters 5 Forces framework can be used to explain the bargaining power of buyers. The effect of the buyers' power position towards the airline (supplier) is confirmed by Nidumolu et al (2009).[242] Nidumolu et al (2009) conclude that: "Our research shows that sustainability is a mother lode of organizational and technological innovations that yield both bottom-line and top-line returns. Becoming environment-friendly lowers costs because companies end up reducing the inputs they use. In addition, the process generates additional revenues from better products or enables companies to create new businesses[243]. In other words: A market orientated approach to reduce CO_2-emissions, creates commercial opportunities for the airline. Nidumolu et al (2009) encourage businesses to comply with the most limiting environmental rules before they are enforced. By doing so, it is argued, that the company is fully ready when the legislation is enforced what creates a competitive advantage as the company has more time than the competitors to experiment with materials, technologies and power.[244] Nidumolu et al conclude that an additional competitive advantage is that "companies in the vanguard of compliance naturally spot business opportunities first."[245]

The opportunities created by the market mechanism can be found in measures focused on reducing fuel consumption resulting in reduction of CO_2-emissions. As explained in the economic and technical framework, reduced fuel consumption creates lower operational costs. For the Air Transport Industry, fuel costs represent a significant part of the total costs. In 2013, fuel costs represented 24,5%% of the SAS Group's operating expenses[246]. The fuel costs for Norwegian represented 32% of the operating costs[247].

[242] Nidumolu et al, Why Sustainability Is Now the Key Driver of Innovation, Harvard Business Review, September 2009

[243] Nidumolu et al, Why Sustainability Is Now the Key Driver of Innovation, Harvard Business Review, September 2009, page 3-4

[244] Nidumolu et al, Why Sustainability Is Now the Key Driver of Innovation, Harvard Business Review, September 2009

[245] Nidumolu et al, Why Sustainability Is Now the Key Driver of Innovation, Harvard Business Review, September 2009, page 5

[246] SAS annual report 2013, page 33

[247] Norwegian annual report 2013, http://annualreport.norwegian.com/2013/operating-costs

The aim of the thesis is:
To develop an understanding of commercial opportunities for Norwegian airlines when introducing CO_2-policy resulting in a decrease of CO_2-emissions without decreasing capacity.

When discussing "the threat of substitues" in IATA Vision 2050, Porter argues that "the most powerful substitute to aircraft travel is not alternative mode of transport, but the decision not to travel".[248]

On the other hand, the conclusions are not in line with the estimations of Eurocontrol[249] as discussed in 3.1.2.7 and IATA's estimation in "Vision 2050".

Denstadli (2004)[250] concludes that VC has a limited effect on business air travel in Norway. The substitution rate is estimated to be between 2,5-3,5%. The primary area of use for VC is reported to be intra-company contacts. Lian et al (2004)[251], argue that no evidence has been found that the substitution effect of VC has affected intra-company travel in Norway. More recent research by TØI[252], conclude that there might be limited substitution in the Norwegian market but the research does not specify the substitution quantitatively. That conclusion is in line with the DfT forecast[253] as discussed in chapter 3.
On the other hand, the conclusions are not in line with the estimations of Eurocontrol[254] as discussed in in the same chapter and IATA's estimation in "Vision 2050". It cannot be ruled out that the market situation has changed since the Norwegian researches have been carried out. A new generation of employees, grown up with ICT, has entered the labor market and the quality of VC has improved significantly between 2004 and 2014[255]. Due to decrease of costs, VC has become available for more organizations. Additional research is required to confirm whether the findings and conclusion of Denstadli and Lian et al in 2004 and TØI in 2011 are still valid or not. In case it is concluded that VC indeed has become a substitute of importance

[248] IATA Vision 2050, page 42
[249] Challenges of growth 2013, Task 7: European Air Traffic 2050
[250] J.M. Denstadli/Journal of Air Transport Management 10 (2004) 371-376
[251] J.I. Lian, J.M. Denstadli/Journal of Air Transport Management 10 (2004) page 109-118
[252] TØI – Luftfartens betydning i en global verden/The significance of aviation in a globalised world 2011
[253] UK Aviation Forecasts, Department of Transport, 2013
[254] Challenges of growth 2013, Task 7: European Air Traffic 2050
[255] IATA Vision 2050

for business trips, airlines are challenged with the question "how to compensate for that loss of revenue?" Further research is required to find out whether airlines can benefit commercially of the use of VC. It cannot be ruled out that airlines and telecom providers are able to create a win-win situation by considering each other's products as being supplementary and are therefore able to create a win-win situation.

Before evaluating the fact finding, theory and discussion to the problem statement, I share the views of some scientists who have researched some of the topics addressed in more detail.

Olsthoorn (2001)[256] argues that, for international aviation, the price elasticity of fuel is low. As a result of the low price elasticity, Olsthoorn estimates that a tax which is not greater than the marginal external costs of CO_2 emissions will result in a minor to negligible reduction in CO_2 emissions.

Forsyth (2011)[257] argues that environmental sustainability is consistent with financial sustainability. Maximum environmental benefits can be achieved consistent with an acceptable level of economic and financial performance.

Macintosh and Wallace (2009)[258] argue that it will be extremely difficult to meet IATA's climate targets to stabilize CO_2 emissions in 2025 at 2005 levels, without restricting demand. The conclusion is mainly based on the calculation that, in order to achieve that ambition, CO_2 emissions have to decrease with 5,2% annually from 2009 until 2025. Their conclusion is supported by Chèze et al. (2013)[259]. Chèze et al. estimate that, after researching several scenarios, none of the scenarios suggest a stabilization, let alone decrease, of CO_2 emissions by 2025. In the scenario's, strong progress in energy efficiency gains are taken into the calculations. The result is illustrated by the calculation that, if CO_2 emissions are stabilized at 2013-levels (no demand constraints), an annual energy efficiency gain of 4,0% is required in order to achieve the emission targets of 2015. That is approximately twice as much as in the benchmark scenario. The findings are of importance for Norwegian airlines as a backup plan might be necessary in case the industry aims (stabilizing CO_2 emissions in 2025 and 50%

[256] Olsthoorn/Journal of Air Transport Management 7 (2001) page 87-93
[257] R. Forsyth/ Journal of Air Transport Management 12 (2011) page 27-32
[258] A. Mackintosh, L.Wallance / Energy Policy 37 (2009) page 264-273
[259] Chèze et al./Transportation Research Part D 18 (2013) page 91-96

reduction 2050 in relation to 2005 CO_2 emissions) turn out to have been too optimistic. In that case, it will become necessary to focus on the questions “how and how much is it realistic possible to reduce emissions and within which framework and timeframe?” before the question “how an airline can benefit commercially from reductions in CO_2 emissions?” can be answered.

Denstadli (2004)[260] argues that VC has a limited effect on business air travel. The substitution rate is estimated to be between 2,5-3,5%. The primary area of use for VC is reported to be intra-company contacts. Lian et al (2004)[261], argue that no evidence has been found that the substitution effect of VC (video conferencing) has affected intra-company travel in Norway. More recent research by TØI[262], conclude that there might be limited substitution but the research does not specify the substitution quantitatively. Lian et al (2004)[263], argue that no evidence has been found that the substitution effect of VC (video conferencing) has affected intra-company travel in Norway. That conclusion is in line with the DfT forecast discussed in chapter 3 but contrary to the estimation of Eurocontrol as discussed in chapter 3 and IATA’s estimation in “Vision 2050”. It cannot be ruled out that the market situation has changed since the Norwegian researches have been carried out. A new generation of employees, grown up with ICT, has entered the labor market and the quality of VC has improved significantly between 2004 and 2014[264]. Due to decrease of costs, VC has become available for more organizations. Additional research is required to confirm whether the findings and conclusion of Denstadli and Lian et al in 2004 and TØI in 2011 are still valid or not. In case it is concluded that VC indeed has become a substitute of importance for business trips, airlines are challenged with the question “how to compensate for that loss of revenue?” Further research is required to find out whether airlines can benefit commercially of the use of VC. It cannot be ruled out that airlines and telecom providers are able to create a win-win situation by considering each other’s products as being supplementary and are therefore able to create a win-win situation.

[260] J.M. Denstadli/Journal of Air Transport Management 10 (2004) 371-376
[261] J.I. Lian, J.M. Denstadli/Journal of Air Transport Management 10 (2004) page 109-118
[262] TØI – Luftfartens betydning i en global verden/The significance of aviation in a globalised world 2011
[263] J.I. Lian, J.M. Denstadli/Journal of Air Transport Management 10 (2004) page 109-118
[264] IATA Vision 2050

Morrell (2009) argues a strong linear relationship between fuel efficiency and size for airliners[265]. Single aisle aircraft have a higher size-related coefficient than twin aisled aircraft. The efficiency gains are further strengthened on short to medium range operations, offering an optimal operational environment for LCC's. Pai (2010)[266] confirms the relationship but argues that certain preconditions have to be fulfilled before an airline will be able to benefit from increasing aircraft size. Factors positively influencing the decision to upscale the aircraft size are e.g. available runway length, LCC, hub airports, increase in cancellations and airport congestions. Further research is required before it can be concluded whether Norwegian airlines can commercially benefit from the technical advantages of increasing aircraft size as discussed in chapter 3 in relation their efforts to reduce CO_2 emissions.

Givoni et al (2006)[267] argue that railways will play a more and more important role in the future of air transport. The researchers recommend to expand the definition of air transport infrastructure to include railways. They focus on the possibility to transfer a part of new demand to railways and not only meet new demand by new runways. Their conclusions are supported by Chiambaretto et al (2012)[268] who argue strong commercial and environmental benefits associated with air-rail intermodal agreements. Jiang and Zhang (2014)[269] argue significant commercial opportunities for hub and spoke airlines and HST-companies when they start cooperating at hub airports facing constraints. Although opportunities arise for Norwegian airlines, they are not limited to the geographic area of Norway. In Norway, Oslo airport and Værnes airport are directly linked with the railway infrastructure. Norwegian airlines however fly to several European airports which are connected with the railway infrastructure including HST-lines. A commercial corporation between the Finnish airline Finnair and train companies in Switzerland, illustrate that possible corporations are not limited to the home market. Further research has to answer the questions "how, where and who?" offers the best commercial opportunist for corporation with Norwegian airlines.

Van Birgelen et al (2011)[270]conclude that customers have a strong and positive "willingness to compensate" for CO_2-emissions. For the research, the scientists made use of the theories

[265] P. Morrell/Journal of Air Transport Management 15 (2009) page 151-157
[266] V. Pai/Journal of Air Transport Management 16 (2010) page 169-177
[267] M.Givoni and D.Banister/Transport Policy 13 (2006) page 386-397
[268] P.Chiambaretto and C.Decker/Journal of Air Transport Management 23 (2012) page 36-40
[269] C.Jiang and A.Zhang/Transportation Research Part B 60 (2014) page 33-39
[270]

TPB – Theory of Planned Behavior and PCE – Perceived Consumer Effectiveness. Before a customer is willing to compensate for CO_2-emissions, it is necessary that some preconditions are met. First of all, the customers' perception of the contribution of the air trip to global climate change is strongly correlated to the willingness to compensate. In the second place, the researchers concluded that there is a strong relationship between self-perception (people who have an environmental conscious lifestyle) and willingness to compensate. In the third place, the perceived consumer effectiveness can be considered as a direct predictor of the likelihood to compensate for CO_2-emissions. Airlines can benefit from the willingness to compensate by increasing revenues. The revenues generated by the travelers who are willing to compensate for CO_2-emissions can be used for costs related the sustainability policy of the airline which are now paid by other revenues. By investing these revenues, created by passenger who on a voluntary basis are willing to pay a fare increase, in the environmental program, capital generated elsewhere can be used for other investments or profit optimization. Additional research is required to find out how this model can be implemented in the Norwegian airline industry.

My conclusion in relation to the problem statement "Which commercial opportunities are created for the Norwegian airline industry by new CO_2-regulations*?"* is in line with the conclusion of King et al: Based on my research, I notice a correlation between organizational performance and sustainability but I am not able to prove the direction of the causality.

I will now discuss my research in relation to aim and objectives.

In relation to the aim of the thesis (to develop an understanding of commercial opportunities for Norwegian airlines when introducing CO_2-policy resulting in a decrease of CO_2-emissions without decreasing capacity), I conclude that I have not been able to develop an understanding of commercial opportunities **as a result of** a CO_2-policy as the direction of the casualty is unknown. I do however conclude that there is a positive correlation between sustainability and commercial opportunities and profitability. That conclusion is amongst other based on the observation that most airlines represented in the sustainability ranking have a strong economic performance. I do not know how to interpret the combination of structural good performance on sustainability and structural bad performance commercially of the number 1 in sustainability (Air France – KLM). I consider additional research focused on that specific company beneficial in order to create a broader understanding of the complexity in the relationship profitability and sustainability.

The first objective of the thesis is to identify the importance of reducing CO_2-emissions, including the contribution of CO_2-emissions from the aviation industry.

In my opinion, I have been able to explain the importance by amongst other addressing future legislation. A positive effect of an active CO_2-reduction policy is that the only way to achieve that goal is burning less fuel. Reduction of CO_2-emissions creates in my opinion, in general terms, a win – win situation for the environment and for the airline

The second objective of the thesis is to identify and validate ways to reduce CO_2-emissions, including the introduction of biofuels.
In my opinion; I have been able to identify and validate ways to reduce CO_2-emissions. Several technical tools were discussed in the paragraph "technological framework". In that chapter, I discussed the importance of weight reduction of an aircraft in order to save fuel and so reduce CO_2-emissions. In the environmental framework, I discussed recent breakthroughs in the development of biofuels, including the ambition to build a biofuel facility in Norway.

The third objective of the thesis is to develop an understanding of the technical challenges and possibilities to reduce CO_2-emissions.
This objective was mainly discussed in the paragraph "technological framework". We noticed that the fuel efficiency of airliners had improved significantly since the 1960's. We have also noticed that the efficiency is not increasing in the same rate as in the early years of jet aircraft.

The fourth objective of the thesis is to develop an understanding of political process behind the legal framework of CO_2-reduction, including the influence of NGO's.
In the paragraph "legal framework", I discussed the complexity to introduce a global MBM. This is mainly a political problem. The airline industry, represented by IATA, has proposed to introduce a global MBM system in 2013. The global political leaders were not able to reach an agreement in spite of the initiative of the industry.

The fifth objective of the thesis is to develop an understanding of the vision and policy of the airline industry in order to reduce CO_2-emissions.

In order to achieve the fifth objective, I discussed the global roadmap for achieving 50% reduction of CO_2-emissions in 2050 in relation to the reference year 2005. I have also addressed that scientists are not convinced that the goal is realistic.

<u>The sixth objective of the thesis</u> is to develop an understanding of demographic and economic challenges creating an increase of air traffic.

This objective was discussed in the paragraph “economic framework”. I shared information from several sources (amongst other Boeing, Airbus, FAA and Eurocontrol). All sources confirmed that the demand for air travel is strongly correlated to GDP and demographic developments. Airport constraints are expected to increase in several parts of the world. The strongest growth of air traffic is expected in the Asia-Pacific area. All in all, I conclude that I have been able to address the sixth objective in a satisfactory manner.

<u>The seventh objective of the thesis</u> is to develop an understanding of the policy of the Norwegian authorities in relation to CO_2-emissions from the aviation industry.
We have seen that the Norwegian public sectors has the ambition to reduce business trips in favor for VC. I have also discussed “klimameldingen” addressing the ambitions of the Norwegian government in relation to fight the consequences of CO_2-emissions. On the other hand, we have seen that the Norwegian government does not mention one word about reducing CO_2-emissions in the aviation paragraph of Sundvollen-erklæringen. Contrary to the authorities in Sweden, Denmark and Finland, Norwegian authorities are not participating in the nordic biofuel project NISA (discussed in the environmental framework). On general terms, I conclude that the Norway has clear general CO_2-ambitions. On the other hand, Norway does does specify an ambition for the airline industry. That fact raises some questions as we have seen that Norway is more or less dependent on a well-functioning domestic air transport system. In my opinion, it is beneficial to further research the ambitions of government in relation to sustainable aviation.

8. Conclusions

- Additional research is required to determine the exact relation between cause and effect of a sustainability policy and the profitability in the airline sector.
- Airlines might benefit from the willingness to pay for sustainable air transport.
- The Norwegian authorities adopt a restrictive policy for their employees in relation to air travel and encourage the use video conferencing. Video conferencing might (partly) become a substitute for air travel.
- Scientists are not convinced that the CO_2-roadmap of the airline industry is realistic.
- HSR – High Speed Rail is not expected to become a rival for the airlines offering domestic services in Norway.
- Outside Norway, corporation between rail operators and airlines become more and more common (example: Finnair cooperating with rail operators in Switzerland)
- The fact that no global MBM – agreement has been reached is primarily a political problem. The aviation industry is prepared to introduce a global MBM.
- Biofuels are playing a significant role in mitigating CO_2-emissions.

9. Suggestions for future research

I consider it beneficial to initiate further research on:

- The relationship sustainability and profitability in the airline industry, focusing on the situation of Air France - KLM.
- The role of the Norwegian state in relation to sustainable aviation.
- Research “the willingness to pay” for sustainable aviation of customers of Norwegian airlines.
- The role of VC as possible substitute for air travel.
- Possibilities for corporation between rail operators and Norwegian airlines.

10. Final reflections

Despite the fact that I was not able to fully prove that an airline policy aiming to reduce CO_2-emissions is translated into commercial opportunities, I do not regret the choice of the research-topic, on the contrary. I have showed that several commercially well performing airlines, are able to combine that performance with a high sustainability ranking. I hope these airlines are an eye-opener for other actors in the air transport industry.

We have seen that Norwegian and SAS are both actively participating in several experiments aiming to find ways to mitigate their emissions as much as possible. They both corporate with other industries in order to speed up the production of biofuels in Norway. Both airlines are also willing to participate in experiments aiming to introduce more effective ATM-systems.

It can be questioned what the real motivations of commercial organizations are to show a “green identity”. While there always is room of improvement, I became more and convinced that these 2 companies have the sincere attitude to create a win-win situation for the airline and for the environment.

I hope that this thesis encourages other students to pick up research in the area of sustainable aviation.

IX - Bibliography

1. A. Mackintosh, L.Wallance / Energy Policy 37 (2009) page 264-273
2. Aeronautics Research Mission Directorate/NASA Facts; IPPC 1999; Vista Analyse AS Rapport 2011/05, Utslippskutt I luftfart? Tor Homleid og Ingeborg Rasmussen, Vista Analyse AS, ISBN 978-82-8126-018-4
3. Aeronautics Research Mission Directorate/NASA Facts; The global impact of the transport sectors on atmospheric aerosol: Simulations for year 2000 emissions/ European Geosciences Union; The climate impact of aviation aerosols/ Geophysical Research Letters, Vol. 40, 1-5, doi:10.1002/grl.50520, 2013; Vista Analyse AS Rapport 2011/05, Utslippskutt I luftfart? Tor Homleid og Ingeborg Rasmussen, Vista Analyse AS, ISBN 978-82-8126-018-4; Intergovernmental Panel on Climate Change (IPCC). Aviation and the Global Atmosphere, Cambridge University Press, Cambridge, 1999.
4. Aeronautics Research Mission Directorate/NASA Facts; Vista Analyse AS Rapport 2011/06, Biodrivstoff: hva er netto klimaeffekt? – en oversikt over nyere forskning, Karin Ibenholt, Vista Analyse 9. mars 2011, ISBN 978-82-8126-019-1
5. Ambec et al, The Porter Hypothesis at 20: Can Environmental Regulation Enhance Innovation and Competitiveness? Resources for the future, Jnauary 2011, RFF DP 11-01
6. American Institute of Aeronautics and Astronautics, "Reducing Aviation's Environmental Impact Through Large Aircraft For Short Range
7. American Institute of Aeronautics and Astronautics, "Reducing Aviation's Environmental Impact Through Large Aircraft For Short Range"
8. Annual reports Norwegian and SAS 2010 – 2013
9. Aviation and the European Union's Emission Trading Scheme, Congressional Research Service, August 2, 2012
10. Aviation and the Global Atmosphere, IPPC 1999
11. Aviation, benefits beyond borders, ATAG 2013
12. Avinor Samfunnsrapport 2013
13. Avtale om klimameldingen, 17.January 2008
14. Beginner's guide to Aviation Biofuels. Air Transport Action Group 2009
15. Biofuels 2020, A policy driven logistics and business challenge, Research and Innovation, Position paper 02 – 2010
16. Boeing current market outlook 2013 – 2032
17. Bombardier commercial market forecast 2012-2031

18. C.Jiang and A.Zhang/Transportation Research Part B 60 (2014) page 33-39
19. Challenges of growth 2013, Task 4: European Air Traffic 2035
20. Challenges of growth 2013, Task 7: European Air Traffic 2050
21. Chèze et al./Transportation Research Part D 18 (2013) page 91-96
22. Comparing the environmental impact from using large and small passenger aircraft on short haul routes.
23. Deloitte, 2014 Global Aerospace and Defense Industry outlook
24. Economic Benefits from air transport in Norway – Oxford economics 2011
25. Economic contribution of Civil Aviation – Ripples of prosperity, ICAO, 2004
26. EU Transport in figures, statistical pocketbook 2013
27. Eurocontrol Seven – Year forecast February 2014
28. Fact sheet; Industry statistics, IATA, March 2014
29. Fuel and air transport, A report for the European Commission prepared by Air Transport Department, Cranfield University
30. Global Market Forecast Airbus
31. High speed rail strategic plan, Federal Railroad Administration, April 2009
32. High-Speed Railway Lines in Norway. Concept Evaluation, Cost Estimate and Uncertainty Analysis, October 2007
33. http://76.74.159.164/LO/airline_listing.aspx?ID=1&input=Name-or-product&Listpage=0&section=Description
34. http://76.74.159.164/LO/airline_search.aspx?category=Airline&Listpage=0&input=Name-or-product&subcategory=None
35. http://76.74.159.164/LO/airlineNonUS_listing.aspx?ID=3&input=Name+or+product&Listpage=0
36. http://boarding.no/art.asp?id=54904
37. http://centreforaviation.com/analysis/air-france-klm-why-it-must-transform-as-medium-haul-and-cargo-operations-hurt-the-bottom-line-98885
38. http://corporate.easyjet.com/corporate-responsibility/our-environment/easyJets-carbon-emissions.aspx?sc_lang=en
39. http://corporate.ryanair.com/
40. http://ec.europa.eu/clima/policies/transport/aviation/index_en.htm
41. http://ec.europa.eu/energy/technology/initiatives/doc/20110622_biofuels_flight_path_launch.pdf

42. http://ecenergy/renewables/biofuels/biofuels_en.htm.europa.eu/
43. http://eex.gov.au.technologies/transport-technologies/opportunities/#Aerodynamic_aeroplanes
44. http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/File:Labour_costs_per_hour_in_EUR,_2008-2013_whole_economy_excluding_agriculture_and_public_administration.png
45. http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32003L0030
46. http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32009L0028
47. http://news.cision.com/sas/r/sas-signs-with-airbus--total-renewal-of-long-haul-fleet,c9433660
48. http://news.klm.com/air-france-klm-ranked-world-leader-in-the-transport-category-by-the-djsi-2013-en/
49. http://sbrc.labs.masdar.ac.ae/
50. http://total.com/en/energies-expertise/renewable-energies/biomass/projects-achievements/biotfuel
51. http://www.afdc.energy.gov/fuels/emerging_dropin_biofuels.html
52. http://www.afm.aero/magazine/trading-legal-and-finance/item/570-aircraft-economic-life-is-age-just-a-number
53. http://www.aftenposten.no/okonomi/Nordmenn-flyr-mest-i-Europa-7050587.html#.U3kRzvl_voE
54. http://www.airportwatch.org.uk/?p=1230
55. http://www.atag.org/our-publications/latest.html
56. http://www.aviator.edu/129/section.aspx/59/post/principles-of-flying-understanding-jet-streams
57. http://www.bioqueroseno.es/nav/en/iniciativa_en.aspx
58. http://www.bls.gov/fls/country.htm
59. http://www.boeing.com/commercial/aeromagazine/articles/qtr_03_09/article_03_1.html
60. http://www.boeing.com/commercial/aeromagazine/articles/qtr_03_09/article_02_1.html
61. http://www.boeing.com/commercial/aeromagazine/articles/qtr_03_09/article_05_1.html
62. http://www.caafi.org/about/caafi.html
63. http://www.cleansky.eu/?arbo_id=35
64. http://www.cleansky.eu/content/homepage/about-us
65. http://www.cphcleantech.com/home/services/matchmaking--sector-networks/nisa---nordic-initiative-for-sustainable-aviation

66. http://www.deseretnews.com/article/865601066/Delta-tops-list-of-most-profitable-airlines-in-2013.html?pg=all
67. http://www.dn.no/nyheter/naringsliv/2012/11/21/nordmenn-flyr-mest-i-europa
68. http://www.environmentalleader.com/2013/05/08/ups-aircraft-fleet-saves-fuel-reduces-emissions-with-winglets/
69. http://www.eurocontrol.int/articles/stakeholders#internationalorganisations
70. http://www.faa.gov/news/press_releases/news_story.cfm?newsId=13254
71. http://www.flysas.com/
72. http://www.greenaironline.com/news.php?viewStory=1568
73. http://www.greenaironline.com/news.php?viewStory=1699
74. http://www.greenaironline.com/news.php?viewStory=1769
75. http://www.greenaironline.com/news.php?viewStory=1769
76. http://www.hemispheremagazine.com/2014/04/01/dont-burn-this/
77. http://www.iata.org/about/sp/areas/Documents/Environment.pdf
78. http://www.iata.org/policy/environment/Pages/climate-change.aspx
79. http://www.iata.org/publications/economics/fuel-monitor/Pages/price-analysis.aspx
80. http://www.icao.int/environmental-protection/GFAAF/Pages/Project.aspx?ProjectID=29
81. http://www.icao.int/environmental-protection/Pages/AlternativeFuels-QuestionsAnswers.aspx
82. http://www.icao.int/Meetings/a38/Documents/WP/wp288_en.pdf
83. http://www.icao.int/Meetings/wrdss2011/Documents/JointWorkshop2005/ATAG_SocialBenefitsAirTransport.pdf
84. http://www.icao.int/Newsroom/Pages/ICAO-environmental-protection-committee-delivers-progress-on-new-aircraft-CO2-and-noise-standards.aspx
85. http://www.icelandair.co.uk/destinations/
86. http://www.icenews.is/2012/03/08/keflavik-international-airport-expects-passenger-traffic-increase-for-2012/
87. http://www.iea.org/topics/biofuels/
88. http://www.itaka-project.eu/nav/pages/about.aspx
89. http://www.jadc.or.jp/outline_jadc_e.htm
90. http://www.klm.com/corporate/en/about-klm/profile/
91. http://www.miljostatus.no/Tema/Klima/Klimanorge/Tiltak-og-virkemidler/CO2-avgift/
92. http://www.norwegian.com/uk/about-norwegian/corporate-responsibility/environment/

93. http://www.nrk.no/norge/statsansatte-flyr-stadig-mer-1.8090607
94. http://www.oecd-library.org
95. http://www.ons.gov.uk/ons/rel/census/2011-census/population-and-household-estimates-for-the-united-kingdom/stb-2011-census--population-estimates-for-the-united-kingdom.html
96. http://www.regjeringen.no/nb/dep/smk/dok/rapporter_planer/rapporter/2013/politisk-plattform.html?id=743014
97. http://www.safranmbd.com/IMG/pdf/MBD_737NGbrake.pdf
98. http://www.safug.org/
99. http://www.safug.org/members
100. http://www.scb.se/sv_/Hitta-statistik/Statistik-efter-amne/Befolkning/Befolkningens-sammansattning/Befolkningsstatistik/25788/25795/Behallare-for-Press/Befolkningsstatistik-2011---folkokning/
101. http://www.ssb.no/
102. http://www.statcan.gc.ca/pub/57-601-x/2010004/appendix-appendice1-eng.htm
103. http://www.statice.is
104. http://www.statista.com/statistics/246347/the-largest-airline-worldwide-by-revenue/
105. http://www.statista.com/statistics/269617/top-10-airlines-worldwide-by-number-of-passengers/
106. http://www.statista.com/statistics/270986/airlines-by-passenger-kilometers-flown
107. http://www.statista.com/statistics/275944/brand-value-of-airlines/
108. http://www.sustainability-indices.com/review/industry-group-leaders-2013.jsp
109. http://www.theaviationwriter.com/2013/05/top-50-low-cost-carriers-world.html
110. http://www.theicct.org/sites/default/files/publications/ICCTupdate_ICAO_CO2cert_aug2013a.pdf
111. http://www.thenational.ae/news/uae-news/plant-fuel-test-for-jets-nears-take-off
112. http://www.un.org/documents/ga/res/42/ares42-187.htm
113. https://unfccc.int/essential_background/items/6031.php
114. https://www.eurocontrol.int/articles/eurocontrol-economics-and-business-cases
115. https://www.eurocontrol.int/articles/member-states
116. IATA Technology roadmap 4th edition June 2013
117. IATA, Vision 2050, 2011
118. ICAO Fact sheet, Aircraft CO_2-Emissions Standard Metric System
119. ICAO, Environmental Report 2013

120. IMF - Marked –Based Instruments for International Aviation and Shipping as a source of Climate Finance, November 2011, page 19
121. IPPC 1999; Luftfart og klima – En oppdatert oversikt over status for forskning på klimaeffekter an utslipp fra fly, CIENS-rapport 3-2011, ISBN 978-82-92935-08-8
122. J.I. Lian, J.M. Denstadli/Journal of Air Transport Management 10 (2004) page 109-118
123. J.M. Denstadli/Journal of Air Transport Management 10 (2004) 371-376
124. K Palmer et al, Tightening Environmental Standards: The Benefit-Cost or the No-Cost Paradigm? The Journal of Economic Perspectives, Vol. 9, No 4 (Autumn, 1995)
125. King et al, Does It Really Pay to Be Green? An Empirical Study of Firm Environmental and Financial Performance, Journal of Industrial Ecology, Volume 5, Number 1, Massachusetts Institute of Technology and Yale University
126. Konkurranseutsatte næringer i Norge, SSB rapport 58/2013
127. Kyoto Protocol to The United Nations Framework Convention on Climate Change, United Nations, 1998, page 2
128. Lanoie et al, When and Why Does it Pay to be Green? November 2007
129. Luftfart og klima – En oppdatert oversikt over status for forskning på klimaeffekter an utslipp fra fly, CIENS-rapport 3-2011, ISBN 978-82-92935-08-8
130. Luftfartens betydning i en global verden, TØI 2011
131. M.Givoni and D.Banister/Transport Policy 13 (2006) page 386-397
132. Market-Based Instruments for International Aviation and Shipping as a source of Climate Finance, International Monetary Fund, November 2011, page 19
133. Mathematically Modelling Aircraft Fuel Consumption, Kevin Pyatt and Jacqueline Coomes, Eastern Washington University, Cheney, WA, USA
134. Meld. St.21 (2011-2012), Melding til Stortinget, Norsk klimapolitikk; http://www.regjeringen.no/nb/dep/kld/dok/regpubl/stmeld/2011-2012/meld-st-21-2011-2012.html?id=679374
135. Nidumolu et al, Why Sustainability Is Now the Key Driver of Innovation, Harvard Business Review, September 2009
136. Norwegian Air Shuttle, Corporate fact sheet, June 2014; http://www.mynewsdesk.com/no/norwegian/documents/corporate-fact-sheet-2014-36943
137. Nytte-kostnadsanalyse av høyhastighetstog I Norge, Econ-roppport nr. 2008-154, ISBN 978-82-8232-033-7
138. Olsthoorn/Journal of Air Transport Management 7 (2001) page 87-93

139. Operational flightplans KLM – Royal Dutch Airlines

140. P. Morrell/Journal of Air Transport Management 15 (2009) page 151-157

141. P.Chiambaretto and C.Decker/Journal of Air Transport Management 23 (2012) page 36-40

142. Performance Review Report Eurocontrol, 2011

143. Porter and van der Linde, Toward a New Conception of the Environment-Competitiveness Relationship

144. Porter, The Five Competitive Forces That Shape Strategy, Harvard Business Review, January 2008

145. Presentation "Best practices for Fuel Economy" during ICAO Measures Workshop / Montreal, 20/21 September 2006. Published by Airbus

146. Presentation "Saving fuel, it's a team sport". IATA Maintenance Cost Conference - October 2012. Published by Airbus

147. R. Forsyth/ Journal of Air Transport Management 12 (2011) page 27-32

148. Rapport 2009-082, IKT og klimagassutslipp; http://www.regjeringen.no/upload/FAD/Vedlegg/IKT-politikk/IKT_klimagassutslipp.pdf#search=videokonferanse erstatte flyreise&regj_oss=1

149. SAS Sustainability Report November 2012 – October 2013

150. Strategi for norsk luftfart, Samferdelsdepartementet, 2008

151. Sundvolden-erklæringen, English version, page 67

152. The climate impact of aviation aerosols/ Geophysical Research Letters, Vol. 40, 1-5, doi:10.1002/grl.50520, 2013; Barrett et al. (2010)

153. The future of climate-friendly aviation: Ten percent alternative aviation fuels by 2025

154. The future of aviation: Ten percent, alternative fuels 2050. climate-friendly

155. The Journal of Economic Perspectives, Vol. 9, No. 4 (Autumn, 1995), page 114

156. TØI – Luftfartens betydning i en global verden/The significance of aviation in a globalised world 2011

157. UK Aviation Forecasts, Department of Transport, 2013

158. Understanding Michael Porter, Joan Magretta, 2012

159. Utredning bærekraftig biodrivstoff for luftfart, Rambøll, 1/2013

160. V. Pai/Journal of Air Transport Management 16 (2010) page 169-177

161. Winning the Oil Endgame: Innovation for Profits, Jobs, and Security. Rocky Mountain Institute, Snowmass, Colorado, USA – 2004

162. World Bank, Second-Generation Biofuels, Economics and Policies, Policy Working Paper 5406
163. www.flysas.com/fleet
164. www.luftfartstilsynet.no/luftfartøyregister
165. www.miljøstatus.no
166. www.nho-luftfart.no
167. www.norwegian.no