AVIATION IN NORWAY. SUSTAINABILITY AND SOCIAL BENEFIT.

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CONTENT

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ABSTRACT

Aviation is vital for human settlement, business, health and tourism in Norway. As air traffic continues to grow, the aviation industry's ambition is to ensure this growth is managed sustainably. This report documents the fact that there are few transport alternatives to aviation, which underscores the importance of implementing emissions reducing measures in the industry.

The 2008 report "Aviation in Norway - Sustainability and Social Benefit" suggested that if the outlined emissions reducing measures were implemented and traffic continued to grow as anticipated, greenhouse gas emissions from domestic aviation would be 10-19 per cent lower in 2020 than they were in 2007. Emissions from flights to and from Norway would increase by 17-32 per cent because greater growth was expected in international aviation than in domestic aviation, and because longer flights would be made from Norwegian airports. Overall, a 1-16 per cent increase in emissions from all aviation fuel sold in Norway was expected.

This is the second industry-wide report published by the Norwegian aviation industry on sustainability and social benefit. More experience and greater knowledge have been gained in the last three years, and some of the assumptions in the 2008 report have changed. The purpose of this report is to provide an updated description of the facts about greenhouse gas emissions from aviation, analyse the effect of the measures that have been implemented in the last three years, and present new measures.

Work on the report was initiated and led by Avinor and carried out in partnership with SAS, Norwegian, Widerøe and the Confederation of Norwegian Enterprise (NHO) Aviation.

The report shows that greenhouse gas emissions from domestic aviation in Norway amounted to 1.1 million tons of CO_2 equivalents in 2009, i.e. 2.1 per cent of Norway's total emissions. Emissions from international aviation - to the first international destination - amounted to 1.2 million tons in 2008[1].

The 2008 report identified a number of emissions reducing measures. These measures are being implemented as planned. The most important short-term measure involves fleet renewal. Airlines are now speeding up the pace of renewal and have brought forward their fleet plans, which means that by the end of 2014 the fleets of the dominant Norwegian airlines, SAS and Norwegian, will consist of only the latest generation of aircraft. The new fleet, consisting of Boeing 737 NGs, will produce around half of the emissions of the aircraft they are replacing, Boeing 737-300s and MD87s. This will result in substantial reductions in emissions before 2020 as well. The emissions reduction estimates for 2020 are also more reliable than before with respect to fleet renewal and technical and operative measures.

One of the important new measures is the introduction of biofuel in aviation. The ability to add sustainable, synthetic biofuel could significantly increase the potential for emissions reductions. Avinor will, together with the aviation industry, conduct a feasibility study to look at different alternatives. The authorities, research institutions and business will be invited to participate in the project.

Based on the expected growth in traffic and flight distances, and assuming that the measures outlined in the report are implemented, the following main conclusions can be drawn:

- Domestic emissions will be lower in 2025 than they were in 2007.
- International emissions will increase in the period up to 2025.
- Overall (bunkers) emissions could stabilise at around the 2007 level in 2025.

Forecasts indicate that air traffic, measured in passenger kilometres, will increase by more than 97 per cent between 2007 and 2025. A large proportion of the emissions caused by the growth in traffic will be compensated for by the measures discussed in this report. Stabilising/reducing emissions from bunkers will require access to biofuel and the availability on the market of a new generation of aircraft with the expected energy efficiency.

[1] Latest official figures.

INTRODUCTION

Aviation plays a greater role in Norway's transport pattern than it does in other European countries because of Norway's topography and geographical location. The Norwegian economy is expected to continue to grow strongly in the next few decades, and at the same time the population will increase, business will become steadily more globalised and people will have greater purchasing power. This will result in greater demand for transport, including transport by air. No form of transport other than aviation can satisfy the same needs for travel over long distances. An analysis by the Norwegian Institute of Transport Economics (TØI) (Figure 1) indicates that an alternative means of travel may exist for 30 per cent of today's flights in and to/from Norway, but this only applies to 8 per cent of passenger kilometres (which also takes distance travelled into account). Aviation is vital with regard to sustaining human settlement and business throughout the country.

At the same time, aviation, like other transport, results in greenhouse gas emissions and other environmental challenges. There is little doubt that man-made emissions of greenhouse gases have caused much of the global rise in temperatures since the middle of the 1900s. If emissions are not reduced, the mean global temperature will continue to rise. Major climate changes in the future could change the living conditions for animals and plants, and the consequences for human settlement, agriculture and business could be far-reaching. This is one of our time's greatest challenges.

The overarching goal of the Norwegian government's transport policy is to offer an efficient, safe and environmentally friendly transport system with good accessibility for everyone. The transport system should meet society's transport needs and promote regional development.

The goals for aviation pull in different directions and different considerations must be balanced against each other. In the public debate, for example, calls have been made for the growth in air traffic to be halted in order to reduce greenhouse gas emissions. At the same time, attention is often focused on how important aviation is to Norwegian society, and that the development desired in many areas make significant air traffic a necessity. Examples of this include the objective of increasing tourist traffic to Norway, public expectations of nationwide access to good health services and emergency preparedness, as well as the reliance on air transport of the oil industry, travel industry and construction industry.

Collectively, the Norwegian aviation industry recognises the climate challenges, and at the same time would like to make a positive contribution to social development. The "Aviation in Norway - Sustainability and Social Benefit" report was published in 2008. Among the things this report documents is that if the outlined emissions reducing measures were implemented, and air traffic continued to grow as expected, greenhouse gas emissions from domestic aviation would be somewhat lower in 2020 than they were in 2007. On the other hand, the emissions from flights to and from Norway would increase somewhat (17-32 per cent) because greater growth in is expected in international traffic than in domestic traffic, and because longer flights would be made from Norwegian airports.

This is the second industry-wide report published by the Norwegian aviation industry on sustainability and social benefit. New experience and greater knowledge have been gained in the last three years, and at the same time some of the assumptions in the 2008 report have changed. The purpose of this report is to provide an updated description of the facts about greenhouse gas emissions from aviation, analyse the effect of the measures that have been implemented in the last three years, present new measures, including the introduction of biofuel in aviation, and update the forecasts for greenhouse gas emissions from civil aviation in and to/from Norway. A calculation error in relation to emissions from feeder transport in the 2008 report has also been corrected. New emissions figures have been calculated for feeder transport.

Work on the report was initiated and led by Avinor, and carried out in partnership with SAS Norway, Norwegian, Widerøe and the Confederation of Norwegian Enterprise (NHO) Aviation. Moss Airport Rygge and Sandefjord Airport Torp contributed to the chapter on airport operations.

CICERO (Centre for International Climate and Environmental Research – Oslo) supplied the data for the chapter on emissions in the upper atmosphere, and the Institute of Transport Economics (TØI) produced the traffic and emissions forecasts and updated figures for ground transport access.

A resource group tasked with contributing to the work was established to ensure broad participation. The resource group included representatives from the Climate and Pollution Agency (CPA), Norwegian Confederation of Trade Unions (LO), Parat/YS, Bellona, Future In Our Hands (FIOH) and

Friends of the Earth Norway. The resource group bears no responsibility for the content of the report or any other written material produced during the process; it has instead acted as a discussion partner in the project.

Friends of the Earth Norway, Bellona and Future In Our Hands would like to make it clear that: "This report shows that the growth in greenhouse gas emissions from air traffic in the period 1990-2025 will be very high. Such growth means that other sectors must reduce their emissions by a correspondingly greater amount. Great uncertainty also exists concerning the environmental and climate effects of factors such as biofuel and air traffic higher up in the atmosphere, which indicates a need for extra caution. In order to achieve the 2 °C target (which is adopted Norwegian policy) and other environmental goals, measures are required to dampen the predicted heavy growth in air traffic. This must be combined with technological measures that reduce the environmental impact of air traffic per person and per ton kilometre."

NORWAY DEPENDENT ON GOOD RANGE OF FLIGHTS

Airport coverage is very good in Norway, and aviation helps to connect the country together. Administration of the country's resources and the political goal of ensuring people can live in the peripheral regions of Norway have steered the building and maintenance of the airport network. Proximity to an airport is of great importance with regard to human settlement, employment and business development in both the peripheral regions of Norway and in central districts. Surveys conducted by Cranfield University and the Institute of Transport Economics show that aviation is more important in Norway than it is in other comparable countries. The social importance of aviation can be summed up as follows:

- **Accessibility:**
  - Two out of three Norwegians have access to an airport within a journey time of one hour.
  - 99.5 per cent of the population can travel to Oslo, spend the day there, and be back the same day.
- **Employment:**
  - Aviation contributes 60,000-65,000 jobs in Norway.
  - The significance of this is particularly high in the regions.
- **Importance to the oil and gas industry:**
  - 13 per cent of all domestic flights are linked to this industry.
  - 550,000 helicopter flights are made each year to installations on the Norwegian continental shelf.
- **Tourism:**
  - 34 per cent of all tourists who visit Norway arrive by air, and this is the form of transport that is growing the most.
  - Tourists who arrive by air spend around NOK 13 billion in Norway.
  - There are 227 routes between Avinor's airports and international destinations (summer 2010).
- **Patient flights:**
  - 400,000 patients are transported on scheduled flights each year. Aviation's importance to the health sector is greatest in Northern Norway.
  - There are 30,000 air ambulance movements each year.
  - Passenger assistance (for passengers such as the elderly, sick people and unaccompanied minors) accounts for more than 250,000 flights each year.
- **Reliability:**
  - Regularity: 97.4 per cent, punctuality: 89 per cent (2010).
- **Aviation makes is possible to hold nationwide cultural and sporting events.**
- **The industry plays a key role in steadily increasing globalisation.**

LIMITED ALTERNATIVES TO AVIATION

When assessing aviation as a means of transport, consideration must be given to alternative means of travel. In general, satisfactory alternatives for relatively short flights may exist, whereas for long journeys no real alternatives exist.

Figure 1: Number of passengers and passenger kilometres as % of in and to/from Norway by possible alternative transport 2009 and 2020.

An analysis by the Norwegian Institute of Transport Economics (TØI)[2] (Figure 1) indicates that an alternative means of travel may have existed for 30 per cent of flights in 2009 in and to/from Norway, while this only applied to 8 per cent of passenger kilometres (which also takes flying distance into account). In practice, there are alternatives internally within Southern Norway and between Norway and Denmark/Sweden. The most important alternative to flying is currently the private car.

Forecasts for the period leading up 2020 indicate that the proportions will to sink to 27 per cent of flights and 6 per cent of air passenger kilometres, respectively. This means that 73 per cent of passengers and 94 per cent of goods transport have no genuine alternative.

Even though a very small percentage of air passenger kilometres would be affected by high speed rail links, they would constitute a good market offer were they to be constructed. Assuming travel times of 2:40 and 3:00 hours from Oslo to Bergen and Oslo to Trondheim respectively, rail would capture around half of air passengers on these routes. Vehicle traffic would also be transferred to high speed rail links and new traffic would be generated. As part of the Norwegian High Speed Rail Study, the Atkins consultancy has calculated that given these travel time assumptions for rail and the full development of the proposed lines[3], the number of passengers using Oslo Airport Gardermoen would fall by 10 per cent (everything else being equal)[4].

On a nationwide basis, the proposed new high speed links would affect around half of air traffic with an alternative means of travel. In other words, high speed rail could become an alternative for around 13-14 per cent of air passengers and 3 per cent of air passenger kilometres. If high speed rail takes 50 per cent of this traffic, the introduction of high speed rail nationwide would result in a reduction of around 7 per cent in air passenger numbers and 1.5 per cent of air passenger kilometres.

Measured in CO_2 emissions, the saving would be 7 per cent of emissions from Norwegian aviation were high speed rail to take the entire point-to-point market, and around 10 per cent in total were rail to also capture all transfer traffic on the affected routes. Were rail to take 70 per cent of the point-to-point market and 50 per cent of transfer traffic, CO_2 emissions (bunkers[5]) from Norwegian aviation would be reduced by 6.5 per cent. However, were rail to take only 50 per cent of the point-to-point market (as the Atkins consultancy assumes), emissions would be reduced by 3.5 per cent.

As previously explained, aviation is vital for social development in Norway. Few alternative means of transport exist, either in the short or long-term. This underscores the importance of emissions reducing measures in aviation.

[2] Cf. update of Lian et al. (2007): Aviation in Norway - Sustainability and Social Benefit. TØI Report 921/2007. No precise criteria have been defined with regard to what constitutes an alternative means of travel, but a rudimentary assessment of which geographical markets have genuine alternatives (with a certain market share) has been made.

AVIATION'S ENVIRONMENTAL IMPACT

Aviation affects both the local and the global environment. Traditionally there has been a heavy focus on aviation's local environmental impact, especially with respect to noise, though local air water and ground pollution have also been focused on. In recent years, increasing attention has been paid to aviation and climate change. This is a complex issue in which the facts are still evolving to some extent. This chapter provides a brief presentation of aviation's environmental impact, while the rest of the report focuses on aviation and the climate.

The status of aviation's local environmental impact is regularly reported on in the environmental reports of Avinor and the airlines. Below follows a brief presentation of the most important challenges.

Discharges to water and the ground: De-icing aircraft and runway systems involves the use of chemicals. Chemicals are also used in fire fighting drills. Their adverse effects depend on the conditions in the area the activities take place in, and such discharges require a permit pursuant to the Pollution Control Act. Only the de-icing agent Formiat, plus sand, is used on Avinor's airport runways. This is an organic salt that contains no environmentally hazardous admixtures. Formiat is used in both sold and liquid form. Formiat is eco-labelled with the Nordic Ecolabel and is the most environmentally friendly runway de-icing chemical on the market. Glycol is used for de-icing aircraft. This decomposes biologically. The fluid also contains small amounts of admixtures that afford the fluid the right properties, which ensures it meets safety requirements. The admixtures in glycol account for less than 1 per cent and are not toxic for the environment around the airport in the quantities in which it is used.

Noise: Aviation generates noise, especially during take-offs and landings. According to the latest update from the Climate and Pollution Agency (2007), aviation's proportion of the national noise annoyance index (SPI) is 4.7 per cent, although this also includes the Norwegian Air Force's activities. The SPI from all included noise sources was 547,686 for 2007, of which aviation noise accounted for 25,900. The total number of people affected by noise in 2007 was calculated to be 1,703,956, of which 57,400 (3.3 per cent) were subjected to aircraft noise. In the future, air traffic will grow at the same time as new engines become less noisy, which means there is reason to believe that the number of people adversely affected by aircraft noise will fall in the next ten years.

Air quality: The dispersion conditions around Norwegian airports are so good that concentrations of air pollutants (airborne particles and NO2) are within the limits laid down by the Pollution Regulations. Concentrations at Oslo Airport can exceed the recommended limits during the winter, but calculations show that the areas around the terminal used by most people are most affected by road traffic.

Land use: Aviation does not occupy great areas of land compared to other means of transport. The amount of land used in Norway by aviation has hardly changed since the mid 1990s and any future expansions would not form contiguous barriers in the landscape.

Biodiversity: Unfertilised hayfields/grazing land used to be common in the agricultural landscape, but the continuous reuse of land for crops and fertiliser have substantially reduced these types of habitat in the last few decades. However, such areas can be found within airport fences and thus today these are important replacement biotopes for these types of habitat. Open area habitats are home to many species, including endangered species. This entails a significant responsibility. Avinor surveys biodiversity at its airports according to a prioritisation list in order to manage and conserve important areas. Surveyed airports implement the necessary management plans according to the findings that are made.

[3] From Oslo to Trondheim, Bergen, Stavanger, Kristiansand, Stockholm and Copenhagen, as well as from Bergen to Stavanger.
[4] Atkins 2011: Contract 6, subject 1, effects on road and aviation sectors. Available from the Norwegian National Rail Administration's website: www.jbv.no.
[5] Bunkers are emissions from all aircraft fuel sold for civilian purposes in Norway, i.e. from all domestic air traffic and all air traffic from Norway to the first international destination.

GREENHOUSE GAS EMISSIONS FROM AVIATION

Aviation and shipping are international industries in which emissions are emitted both inland and between countries. A large proportion of aviation emissions are emitted in international airspace. This has presented challenges in international climate negotiations and the result has been that only greenhouse gas emissions from domestic aviation and shipping are included in the Kyoto Protocol.

The media have presented greenhouse gas emissions from aviation in many different ways. The reason for these different estimates is the use of different calculation methods. One of the main goals of the project is to help ensure that a correct basis exists for discussing the facts surrounding industry emissions.

Domestic aviation

In 2009[6], greenhouse gas emissions from domestic aviation in Norway amounted to 1.1 million tons of CO_2 equivalents, or 2.1 per cent of Norway's total emissions (1.1 million out of 51.3 million tons of CO_2 equivalents). It is these emissions that are regulated by the Kyoto Protocol (Figure 2). Around 10 per cent of these emissions are from helicopter traffic to and from the Norwegian continental shelf. Domestic aviation emissions have increased in the last 30 years, although by significantly less than traffic has grown.

If military aviation is included, greenhouse gas emissions in 2009 totalled around 1.2 million tons. Both civilian and military emissions must be reported to the United Nations Framework Convention on Climate Change (UNFCCC). Military activities are reported in the 'mobile' and 'stationary' categories, but emissions from military aircraft are not reported separately.

Figure 3 illustrates the distribution of inland emissions from mobile sources in 2009. The 'other mobile combustion' category includes emissions from motorised equipment such as tractors and excavators. The total emissions from transport in Norway amounted to 16.4 million tons of CO_2 equivalents in 2009, i.e. 32 per cent of total national emissions.

Demand for transport services is increasing in line with economic and population growth. The project Climate Cure made forecasts about greenhouse gas emissions from the transport sector. They showed, based on a number of assumptions[7], that without new or strengthened measures, emissions can be expected to grow to around 19 million tons in 2020 and 21 million tons in 2030. Road traffic is expected to produce the greatest growth in emissions (Figure 4).

Figure 2: Distribution of national greenhouse gas emissions 2009.

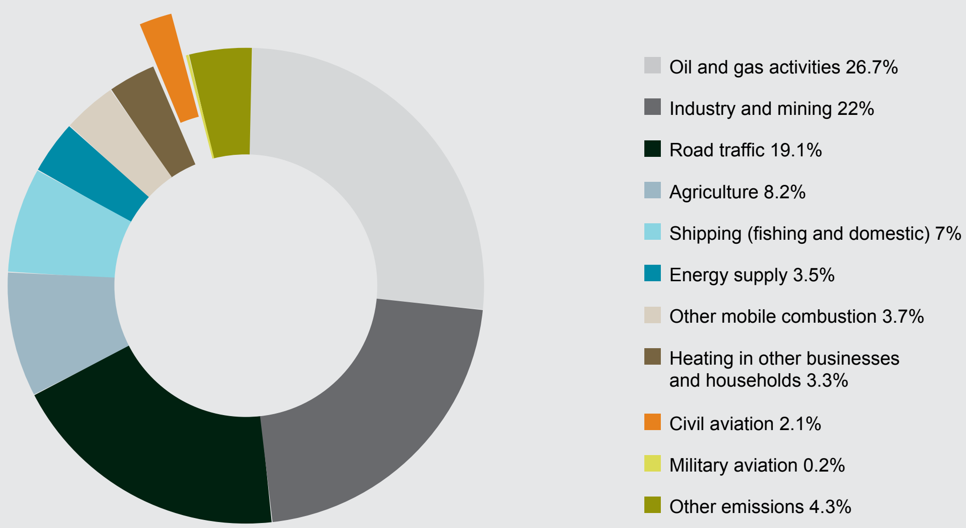
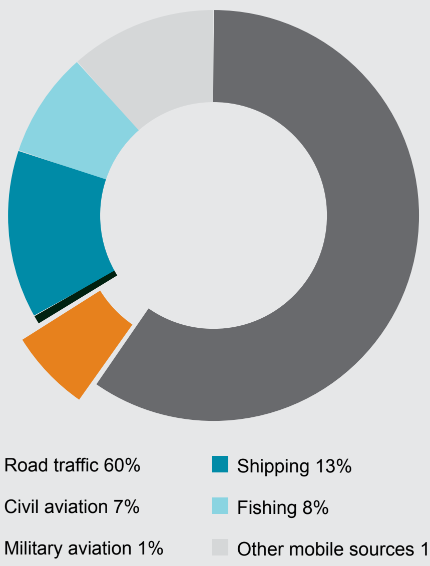


Figure 3: Distribution of greenhouse gas emissions from mobile sources in Norway in 2009 (Statistics Norway's Statistics Bank)



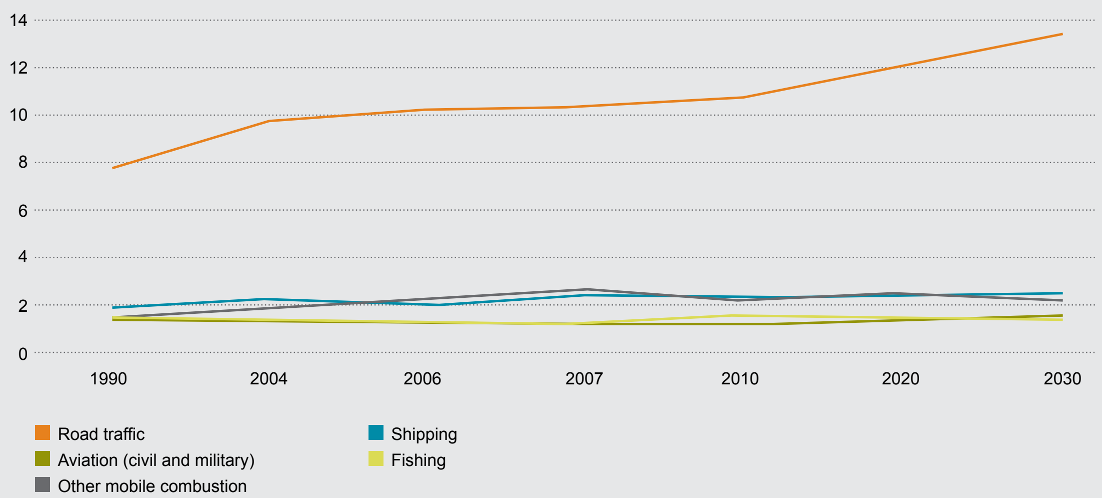
International aviation

International traffic is growing strongly and in 2008 (latest official figures) greenhouse gas emissions from aviation fuel sold in Norway for international purposes, flights to the first international destination, amounted to 1.2 million tons of CO_2 equivalents. This figure includes traffic from one Norwegian airport to an airport abroad, but not international traffic to Norway. Such emissions will appear in the relevant country's emissions accounts. For example, a flight from Amsterdam to Oslo would be recorded in the Netherlands' emissions accounts, while the return flight from Oslo to Amsterdam would be recorded in Norway's emissions accounts. This avoids double registration. However, it has not been possible in the climate negotiations to reach agreement concerning how this can be included in the Kyoto Protocol.

[6] Latest official figures.

[7] For more information about the assumptions, see pages 84-86 of Climate Cure's main report. Klif (2010): Climate Cure 2020 Measures and Instruments for Achieving Norwegian Climate Goals by 2020 Climate and Pollution Agency Rep TA2590/2010

Figure 4: Historical and projected emissions of greenhouse gases from mobile sources 1990-2030 (Statistics Norway and Climate and Pollution Agency 2009). The figure covers both civil and military aviation and higher traffic growth is assumed than in the National Transport Plan 2010-2019. Please note that the intervals on the time axis vary. (Source: Climate Cure, main report, page 86)



Bunkers and global aviation

In total, air traffic from and in Norway accounted for greenhouse gas emissions of the magnitude of 2.3 million tons[8]. This has been calculated on the basis of aviation fuel sales statistics in Norway and is also called 'bunkers'. It is these figures that the Climate and Pollution Agency (Klif) report to the United Nations Framework Convention on Climate Change (UNFCCC). The figures provide the basis for calculations of total global greenhouse gas emissions from aviation. In 2008, total CO_2 emissions from aviation amounted to 628 million tons, or just over 2 per cent of total global man-made greenhouse gas emissions. While the growth in air traffic in Western Europe and the USA is relatively moderate, strong growth is expected in air traffic in Eastern Europe and Asia.

Emissions from Norwegians' flights

International climate negotiations are based on emissions from domestic and international aviation from national states. This is makes sense since it is national states that are supposed to comply with international agreements and which can implement measures and means to achieve emissions reduction targets.

However, many of the international flights Norwegians take involve connecting flights in other countries. Upon reaching the first international destination, journeys continue on foreign airlines, which are subject to various regulatory regimes and consequently have little chance of being influenced by measures implemented by the Norwegian aviation industry or Norwegian authorities.

It is possible to calculate total global emissions from flights taken by Norwegians by analysing travel habit surveys, using emissions calculators, etc. Such calculations try to provide a picture of Norwegians' 'carbon footprint' due to flights by calculating emissions from both domestic and international flights, as well as those between and within third countries. However, it would not be methodologically correct to compare Norwegians' total global emissions from flights with the contribution other sectors make in the national greenhouse gas accounts because some emissions would be registered twice, i.e. the emissions would be counted/recorded in the accounts of both Norway and other countries. If such a proportion were to be calculated, one would have to assess Norwegians' global greenhouse gas emissions from aviation in relation to Norwegians' global greenhouse gas emissions from all consumption, i.e. one would have to include, for example, the import and export of goods. No satisfactory technical basis for arriving at reliable estimates for this exists.

The Institute of Transport Economics (TØI) has previously, on behalf of Avinor, calculated Norwegians' greenhouse gas emissions from flights between foreign airports at around 1.2 million tons of CO_2 equivalents in 2007[9]. TØI has also calculated that the total flights made by Norwegians throughout the world resulted in greenhouse gas emissions of around 3.4 million tons in 2007. This includes Norwegians' domestic flights and flights to their first international destination, while it excludes emissions from foreign citizens' flights in and to/from Norway.

[8] Emissions domestic 2009, international 2008. Latest official figures.
[9] This figure does not include deductions for emissions due to cargo in the belly of aircraft, which can constitute around 30 per cent of payloads on intercontinental flights.

EMISSIONS IN THE UPPER ATMOSPHERE

In addition to CO_2, aircraft emissions also contain other components that affect the climate, either directly or indirectly via chemical and physical processes in the atmosphere. This is not unique to aviation; it also applies to other sectors.

Carbon dioxide (CO_2) and water vapour (H_2O) account for most of the emissions from aircraft. In addition to these come nitrogen oxides (NO_x), sulphuric dioxide (SO_2), carbon monoxide (CO), hydrocarbons (HC) and particles such as organic carbon (OC) and soot. Of these gases it is only CO_2 that is covered by the Kyoto Protocol. In addition to being a greenhouse gas, water vapour (H_2O) is also important as a contrail precursor. Emissions from air traffic can also result in the formation of cirrus clouds. These are thin clouds that primarily consist of ice crystals. Such cloud formation can occur due to contrails dispersing outwards or particles directly emitted or formed due to emissions from aircraft causing the formation of cirrus clouds.

Their influence is complex and complicated; some mechanisms result in cooling, others in warming. Some effects are regional and have an impact on radiative forcing that varies according to location (and time of day)[10]. The various emissions' atmospheric lifetimes also vary greatly and they thus impact the climate for varying lengths of time. Some of the mechanisms that produce climate impacts depend on the chemical and meteorological conditions in the atmosphere. Changes in the areas in which aircraft operate, or the altitudes at which they operate, may thus change their environmental impact. Research is being carried out into the extent to which alternative routes and operating altitude can mitigate aviation's climate impact[11]. In the long-term, it will be necessary to reduce CO_2 emissions from aviation in order to reduce its contribution to global warming since these are responsible for most of the long-lasting warming effect.

Because of the strongly warming, but short-lived, effects of air traffic, the total climate effect in the first few years after the emissions occur will be significantly greater than the effect of the CO_2 alone. So-called 'weighting factors' have been introduced to indicate the magnitude of these 'additional effects'. Based on a calculation method (GWP) and a time horizon (100 years) that are consistent with what are applied in the Kyoto Protocol, the use of a weighting factor of 1.2-1.8 has been proposed (Lian et al. 2007). New studies state a figure of the same magnitude. The weighting factor heavily depends on the time horizon and indicator for evaluating climate impact, and on which components are included. Other approaches can also be used. For example, Global Temperature Potential (GTP) will result in a lower 'weighting factor'[12].

Emissions in the upper atmosphere are looked at and discussed in more detail in a report produced by CICERO in 2011: "Luftfart og klima. En oppdatert oversikt over status for forskning på klimaeffekter av utslipp fra fly" [Aviation and the Climate: an updated overview of the status of research into the climate effects of aircraft emissions], which is available from Avinor's website, among other places.

[10] Radiative forcing is defined as the change in the energy balance at the top of the atmosphere due to the change in the composition of the atmosphere. It is used as a measure of the strength of a disturbance that can cause climate change.
[11] See, for example, REACT4C: www.react4c.eu/. The University of Oslo and CICERO participate in this project.
[12] See, for example, Fuglestvedt J. S., Shine K. P., Berntsen T., Cook J., Lee D. S., Stenke A., Skeie R. B., Velders G. J. M. & Waitz I. A. (2010): Transport impacts on atmosphere and climate: Metrics. Atmospheric Environment. 44(37), 4648-4677 and/or Shine, K., (2010): Radiative forcing and climate change, Encyclopedia of Aerospace Engineering. Edited by Richard Blockley and Wei Shyy. John Wiley & Sons, Ltd.

EMISSIONS REDUCING MEASURES

While air traffic is responsible for the vast majority of aviation emissions (around 94 per cent), emissions from airport operations and travel to and from the airports also play a role. Emissions from Avinor's activities in 2010 are estimated at approximately 23,500 tons (around 1 per cent), while TØI calculates that emissions from feeder transport to Norwegian airports accounted for 120,000 tons (around 5 per cent) in 2010. Emissions from airport operations and ground transport access are not recorded in aviation emissions statistics, but are covered by other national statistics, including in emissions from road transport. Figure 5 provides an overall picture of the emissions from the areas discussed in the project.

The 2008 report outlined a number of measures for reducing greenhouse gas emissions from Norwegian aviation by 2020. The status of the emissions reducing measures outlined in the 2008 report is commented on below.

Aviation technology and fleet renewal

Aviation technology covers engine technology, material use and the aerodynamics of fuselages and wing profiles. It is in the development of these, and the use of other fuels, that the greatest potential for emissions reducing measures lie in aviation.

In the short-term, fleet renewal is the indisputably most important measure that can be implemented to reduce aviation emissions.

The 2008 report presented figures that indicated that aviation technology measures and fleet renewal could provide emissions reductions of approximately 25 to 30 per cent between 2007 and 2020. It assumed that Norwegian would replace its entire fleet of Boeing B737-300s with new B737-800s, and that SAS would start replacing its remaining 'classic' B737s and MD80s once a completely new generation of aircraft with up to 30 per cent lower CO_2 emissions than the 737NGs came onto the market in around 2015. It now appears that a new generation of aircraft for the short and medium-haul market will not enter production before after 2020.

Figure 5: Greenhouse gas emissions from aviation in tons and as a percentage of greenhouse gas emissions from all aviation fuel sold in Norway (domestic 2009 + international 2008, latest official figures), airport operations (Avinor and OSL) in Norway (2010), and ground transport access in Norway (estimated) (2009).

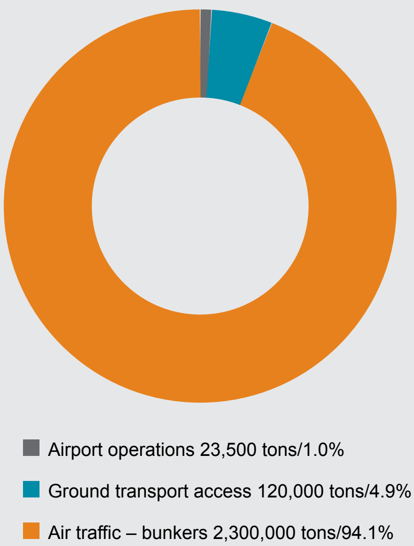
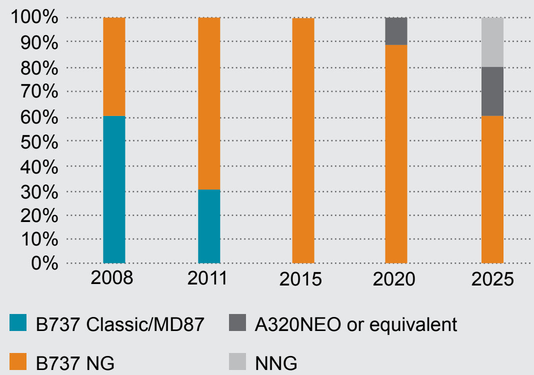


Figure 6: Distribution of aircraft types in the Norwegian fleet (SAS and Norwegian). Assumed distribution in 2020 and 2025. NNG is the designation for the next generation of aircraft.



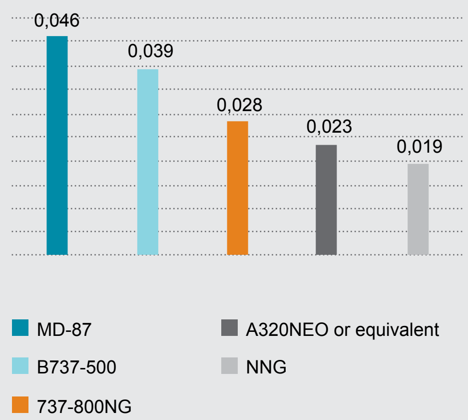
The airlines are now speeding up the pace of renewal. Norwegian is speeding up its renewal so that it will have a full fleet of 737-800s by 2012, and SAS is going to replace all of its older aircraft from the 'classic generation' before 2015, which means that from then on in Norway both SAS and Norwegian will have fleets that consist of only the latest generation of aircraft (Figure 6). Deliveries of the latest versions of existing aircraft types will provide further reductions in total emissions from 2015 up to 2020. For example, Boeing reduced emissions from its Boeing B 737-800 by several percentage points between 2007 and 2010 through constant product improvements, including engines improvements. This trend is continuing. Airbus has launched a new version of its A320 series, the A320-NEO, which has a new engine and other improvements. This will provide reductions of around 15 per cent compared with today's A320 aircraft (Figure 7).

The lowest and 'reliable' alternative is now an emissions reduction of around 25 per cent per seat kilometre in 2020. One can also say with certainty that by 2025 emissions will be reduced by a minimum of a further 5 per cent, meaning that in total there will be a reduction of a minimum of 30 per cent by 2025 compared with 2007.

If the oldest NG Boeing B737s are replaced with the latest version of the NG in the period 2020-2025, this will result in a further reduction of 5-10 per cent. Alternatively, were they to be replaced by Airbus A320-NEOs or its equivalent, this would provide a reduction of around 10-15 per cent in the period 2020 to 2025. Similarly, one could say that if the oldest NG aircraft are replaced even earlier, then the total emissions reductions in 2020 and 2025 would be even greater than with a lower but 'reliable' alternative. Therefore, an optimistic, but technically realistic alternative, is that fleet renewal could reduce emissions by around 30 per cent in 2020 and around 40 per cent in 2025 in relation to 2007. This will to a great extent depend on the availability of a completely new generation of aircraft in 2025 and how much more efficient this new generation is in relation to today's generation of aircraft.

Long-haul flights direct from Norway are becoming increasingly relevant. New long-haul aircraft operated by Norwegian and SAS means that traffic that today uses older aircraft types will move over to newer and far more energy efficient aircraft. When the Norwegian airlines

Figure 7: Fuel consumption litres per seat kilometer from relevant aircraft types (single aisle/narrow-body) in SAS's and Norwegian's fleets. The values in the first three columns were obtained from SAS, but vary somewhat due to different seat configurations. The values for NEO and NNG (new generation of single aisles not yet in production) were provided by Avinor and Boeing, respectively.



offer more direct routes this could, seen in isolation, increase the amount of traffic from and to Norway, although direct routes will simultaneously entail an emissions reduction because total flight time will be considerably reduced when traffic that currently travels via other cities in Europe flies more directly. This applies to both passenger traffic and, not least, cargo, which is currently often flown using older aircraft types. Emissions from today's wide-body aircraft are far lower than they were 15-20 years ago. For example, an Airbus 330-300 consumes 21 per cent less fuel than its predecessor the B767-300. Airbus 350 and B787 Dreamliners will reduce this consumption by a further 25 per cent.

Boeing's new long-haul aircraft the Boeing 787 Dreamliner represents a completely new generation of aircraft with regard to energy consumption. Norwegian will take delivery of their first five Boeing 787 Dreamliners from and including the start of 2013. These will make long-haul flights from Oslo. Norwegian is in negotiations concerning more Dreamliners. SAS's fleet of Airbus 340s and 330s will be replaced by new B787 Dreamliners or A350s by 2020.

Measures being implemented in the existing fleet are also producing effects. Examples of such measures include retrofitting winglets (wing tip extensions), engine flushing, upgrading engines and fuselage measures. As far as winglets are concerned, the Norwegian airlines have retrofitted these on a number of their aircraft, while all new B737s are now delivered from the factory with these already fitted.

The expected development of measures relating to aviation technology and fleet renewal thus appear to be in line with, or slightly better than, what was reported in the 2008 report, even though the manufacturers are not achieving the same progress with respect to the next generation of aircraft. Both SAS and Norwegian will have modern, efficient aircraft fleets by 2020, and they will achieve this faster than previously assumed.

Aircraft operations

The largest emissions reductions are described above and being implemented in the actual aircraft themselves. However, the way in which aircraft are operated, aircraft operations, also provides great potential for emissions reductions. These aircraft operations measures require cooperation and coordination between air traffic control services, airports and airlines. Since the 2008 report, the airlines, Avinor and the Confederation of Norwegian Enterprise (NHO) Aviation have held regular meetings focusing on emissions reductions, and the airlines are also playing a key role in the work of reorganising airspace and other projects.

The 2008 report discussed several emissions reducing measures. A number of measures were scheduled to be introduced between 2008 and 2011. These have largely been implemented and have resulted in emissions reductions in line with the goals of SAS, Norwegian and Widerøe. Emissions reductions of the magnitude of 2-5 per cent in the period 2005-2010, depending on aircraft type, have been achieved in the existing fleet.

The potential for further emissions reductions exists in all phases of a flight. Measures include reorganising airspace, establishing procedures for approaches and departures, and the introduction of new technology. For example, the introduction of electronic flight bags (EFB) by Norwegian resulted in an emissions reduction of 1 per cent. The transition from ground based navigation to the use of satellites (PBN) enables curved approach and departure flight paths, shorter and more direct routes, more energy efficient departures and landings, and tailored approach paths that reduce the impact of noise on the airport's neighbours. Calculations by the Confederation of Norwegian Enterprise (NHO) Aviation show that emissions reductions of up to 2-400 kg can be achieved for the majority of approaches where this is relevant. Accumulated, this means significant reductions per annum. In the space of five years such calculations will be made for all Norwegian airports.

The goal of designing new airspace and procedures is to increase the number of both continuous descents during landings and continuous climbing during departures. However, sometimes during day-to-day operations conflicts can arise that mean one of the methods must be chosen. Continuous climbing during departures, 'continuous climb operations' (CCO), are already offered in most locations, and continuous descents during landing, 'continuous descend operations' (CDO), are offered when the traffic situation permits it at all of Avinor's airports where flight control services are provided. Data from the airlines show that the time spent in 'level flight' during approaches to selected airports has been reduced. This results in fuel savings and emissions reductions, but it is currently not possible to precisely quantify the effect.

The reorganised airspace over Eastern Norway (Oslo ASAP) was implemented in April 2010. An important element of the concept is to increase the number of continuous landings and departures, especially in periods of heavy traffic, to reduce greenhouse gas emissions. It is currently too early to calculate the actual effect of Oslo ASAP, but simulations have shown that the estimated emissions reductions in the 2008 report are still valid, i.e. an emissions reduction of approximately 20,000-30,000 tons of CO_2 equivalents in the year 2020 compared with the old system, given otherwise equal circumstances. The airspace over Eastern Norway will be further developed through the use of modern satellite-based navigation technology. The system has presented some challenges during its implementation, but these are expected to be resolved such that the expected environmental effect in 2020 can be achieved.

A major project is underway in Europe aimed at establishing a common European airspace (Single European Sky - SES). The programme was launched by the European Commission in 1999 to meet capacity and aviation safety requirements in a modern air traffic system for Europe for the next 30 years. One of the goals of this is to cut 8-14 minutes flying time off an average flight and thus save 948-1,575 kg of CO_2. It is estimated that European aviation emissions can be reduced by as much as 10 per cent. This report assumes an emissions reduction of only 3-5 per cent for Norwegian aviation for international traffic because the airspace over Norway is far less busy than that over Central Europe. The work is very demanding and covers both the drawing up of new procedures for air traffic management and the development of new technology. SES provides the guidelines for many of the measures that are being implemented. One concrete example of measures is the establishment of so-called free route airspace (FRA). This concept entails airlines being able to planning direct routes from the point where they leave a departure path from a major airport up to the point where they either leave the free route airspace or to a point where an arrival path for a major airport starts. Models of the effect of free route airspace in a Northern Europe functional airspace block (FAB) indicate potential emissions reductions of between 60,000 and 87,000 tons per year in the period between 2015 and 2020. The models cover the airspace over Iceland, Norway, Sweden, Denmark, Finland, Estonia and Latvia.

Another example is the 'green routes' the so-called 'Santa flights' from the UK to Rovaniemi in Finland have been assigned since 2008. The cooperation between Norway, Finland, Sweden, Denmark and the UK has cleared the way for shorter travel routes into Norwegian airspace and onwards to Finland, with estimated emissions reductions of 15-20 tons of CO_2 equivalents on the busiest days. The routes are also available to other types of traffic from Finland and Sweden to the British Isles, as well as long-haul traffic that enters Norwegian airspace north of Finnmark with destinations in the British Isles.

The airlines have also established optimal cost index regimes for speeds during various phases of flights. The aim of this is to achieve a comprehensive and optimum operational concept in which time and fuel consumption/greenhouse gas emissions are guiding parameters. Harmonising decent speed (260 knots) has also helped to reduce emissions, improve predictability and improve traffic flow into airports.

The world's first satellite-based approach system (SCAT-I) will be introduced primarily to improve safety at the regional airports in Norway. This measure could also reduce fuel consumption on approaches to some airports. However, the future combination with PBN will considerably increase the potential for emissions reductions. Brønnøysund Airport was the first to introduce the system in 2007, and by 2013 around 20 of the airports in Avinor's short runway network will be using SCAT-I.

Aircraft operational measures also cover aircraft movements on the ground. The potential for emissions reductions due to new taxiing procedures and technologies were calculated in the 2008 report at 3-7 per cent, with the upper end of the range lying some years into the future and assuming that an aircraft's' jet engines are not used for propulsion on the ground. Other measures involve the airlines taxiing with one engine after landing where possible. Avinor is considering changes to rapid-exit taxiways from the runway at OSL which also take into account the extension of taxiing systems in connection with the expansion of the terminal. The estimated potential emissions reductions from taxiing are unchanged from the 2008 report.

Apart from a few changes with regard to fleet renewal, the potential for energy efficiency measures that were calculated in the 2008 report remains the same. An overview of the main categories of measures and their effects are presented in the chapter on emissions forecasts. This also projects further effects prior to 2025.

Airport operations

Airport operations cover those measures required to enable aircraft to land and take-off from airports, i.e. keeping runways open, as well as running areas for the general public, parking areas, etc. In addition to Avinor, which owns and operates most of the airports in Norway, there are a number of other players that carry out activities at airports, e.g. handling companies. Greenhouse gas emissions from these activities are not covered by this report.

New in relation to the 2008 version of the report is that airport operations and relevant emissions reducing measures at Moss Airport Rygge and Sandefjord Airport Torp are included. The measures presented in the 2008 report, and some new proposed measures, are reviewed in this document.

OSL and Avinor produce annual greenhouse gas accounts, cf. the Greenhouse Gas Protocol and ISO 14064 series, and the methodology used for reporting has evolved since these were first introduced in 2006. Sandefjord Airport Torp also produces greenhouse gas accounts, but uses a slightly different methodology.

Avinor is investing in emissions rights allowances in projects which achieve emissions reductions equivalent to the climate impact that Avinor/OSL cannot reduce themselves. The purchased emissions allowances are certified through the UN's Clean Development Mechanism (CDM).

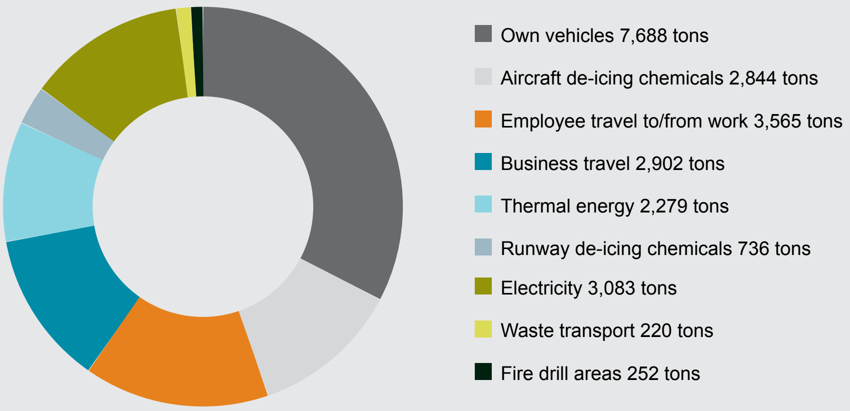
Oslo Airport, Trondheim Airport, and Kristiansand Airport have participated in the European Airport Carbon Accreditation (ACA) scheme since 2009[13]. This means that the airports' greenhouse gas accounts are certified by an independent third party and that binding reduction targets must be set for greenhouse gas emissions from the airport via associated action plans.

The greatest potential for emissions reductions from their own activities can be found in their own vehicles and thermal energy. A number of airports have purchased electric vehicles and arranged eco-driving courses. However, large emissions reductions in vehicle operations require renewable fuel, especially for the large vehicles. To date, today's biodiesel has not been considered reliable enough, particularly because of its poorer low-temperature behaviour than ordinary diesel. Nor has it been possible to establish supplier agreements for biodiesel at airports throughout the Norwegian market.

Work is continuing on reducing stationary energy consumption at Norwegian airports. A pilot project has been conducted to assess the best possible energy management in Avinor, and a project is currently ongoing in which external advisers are conducting energy efficiency analyses at a number of airports. In connection with the plans for the expansion of the terminal at OSL, the heat exchange system involving groundwater will be expanded and thermal snow

[13] www.airportcarbonaccreditation.org

Figure 8: Avinor's greenhouse gas emissions by source (tons) in 2010. (Source: Avinor' Environmental Report 2010)



storage established for cooling energy. A new energy power plant has been built at Stavanger Airport Sola. This is based on wood chip heating. Heat pumps have also been installed at a number of airports. Besides this, both Trondheim and Kristiansand airports have concrete plans for heat exchange via the sea, like the system Alta Airport has established. Biogas for heating boilers has also been assessed at some Avinor airports.

The last few winters have been harsh, and the emissions factor calculated for electricity has increased considerably due to the import of energy into Norway. Reducing electricity consumption is an important goal for Avinor. LED technology has a long working life, provides considerable savings in energy consumption and is being used more often in terminal buildings and parking facilities. LED lighting has previously only been certified for use on taxiways. Moss Airport Rygge will be the first airport in Europe to use such low energy lighting on a runway. The LED lamps will replace the energy demanding halogen lamps.

Sandefjord Airport, Torp is the first airport operator in the Nordic region to have been certified pursuant to the ISO 14001 standard for environmental management. Certification means the airport has a continuous process for minimising pollution, established systematic procedures for monitoring and improving the external environment, and is able to document the employees' competence with regard to the proper handling of environmental factors.

The thermal snow storage planned in connection with the expansion of the terminal at Oslo Airport entails pure snow from ploughing being placed in a big heap before being covered. In the summer a heat exchanger will use this cold store to cool the terminal building. This will be the first system in Norway based on this principle. A very strict energy reduction requirement has been stipulated for the new terminal; a 50 per cent reduction in relation to energy consumption in the present day terminal. This has been a challenge in the pilot project, but with a number of building-related measures, including the roof design (tortoise shell), the controlled use of glazed surfaces and sun screening, it would appear it is feasible.

In other words, a number of emissions reducing measures are being implemented at the airports, but in order to reduce the emissions from the dominant fractions, especially vehicle operation, there must be a switch to an alternative, climate neutral fuel. It is assumed that such fuel will be available in 2020. Achieving the potential 25 per cent reduction in electricity consumption by 2020, as stated in Table 1, will also be very demanding.

Table 1: Estimated potential for emissions reductions from airport operations in 2020 compared with 2007. (Assumes access to sustainable second generation biofuel in 2020)

MEASURES	EMISSIONS REDUCTION
District heating and renewable sources of energy in own heat production	80-90%
Reduction in electricity consumption in Avinor	25%
Reduction in fuel consumption in own vehicles	20-30%
Carbon neutral fuel in own vehicles	80-90%
Technological developments and misc. initiatives taken in business trips and employee's journey's to/from work	25-30%
Carbon neutral fuel in standby power	80-90%
Potential for collective emission reductions	25-35%

Ground transport access

Ground transport access to airports produces substantial emissions of greenhouse gases. Responsibility for good, eco-friendly ground transport access primarily lies with local and central government authorities, and the relevant transport companies. As part of the fulfilment of its social responsibilities, Avinor has set a goal that public transport should provide an increasing share of transport to airports by 2020. In addition to meeting environmental challenges, a high proportion of public transport will also reduce capacity strains on road networks. Avinor will contribute to this within its constraints and the means at its disposal.

A mathematical error was discovered in the calculations of emissions from ground transport access in the 2008 report. Furthermore, transport distance calculations for each means of transport are now based on the 2009 Travel Habits Survey. This has resulted in significantly longer transport distances than those in the 2008 report. This means the calculated emissions in the 2008 report were too low. It is now calculated that total emissions from ground transport access in 2009 were around 120,000 tons of CO_2 equivalents, but this figure is not comparable with the calculations in the January 2008 report due to the differing calculation methods. The largest source of emissions is the private car. Of the major airports, the proportion of public transport is highest at Oslo Airport and lowest at Stavanger Airport and Bergen Airport. The proportion of public transport at Oslo Airport is the highest in Europe.

Table 2 shows the distribution of means of transport in per cent to the largest airports in 2007 and 2009.

Public transport's share of ground transport access increased from 2007 to 2009 at the airports in Oslo, Stavanger and Bergen. They all saw a four percentage point increase in public transport. Trondheim, which has a relatively high proportion of public transport, saw little movement, minus one percentage point. Apart from in Oslo, transport by private car/taxi accounts for the largest share of feeder transport. Airports that are close to cities generally have a high taxi percentage and low public transport percentage, while the opposite is true for airports located far from cities. The new concession for Oslo Airport now also includes a requirement that public transport's share of ground transport access shall be kept at "the same level as today", which for 2009 means around 65 per cent (Table 2).

Separate studies have been carried out concerning ground transport access to Oslo Airport, Stavanger Airport and Bergen Airport. Trondheim Airport has also systematically striven to increase public transport's share of ground transport access. The surveys show that it is possible to guarantee good surface access to all the airports in the longer term, and that public transport's share can be increased.

The airports in Oslo, Bergen, Stavanger and Trondheim have set targets for public transport's share of 70, 32, 30 and 60 per cent by 2020, respectively. Table 3 shows CO_2 emissions in 2009 without special measures and CO_2 emissions in 2020 when the public transport and vehicle efficiency targets have been achieved.

Even with an increase in public transport's share by 2020, CO_2 emissions will increase somewhat. Without an increase in public

Table 2: Means of travel to airport 2007 and 2009. Per cent. Source: TØI

	TAXI		**PRIVATE CAR**		**OTHER**		**PUBLIC TRANSPORT**		
	2007	2009	2007	2009	2007	2009	2007	2009	Target 2020
Oslo	6	5	31	28	2	2	61	65	70
Stavanger	35	30	53	54	2	3	10	14	30
Bergen	34	25	40	46	3	3	22	26	32
Trondheim	15	12	39	44	1	2	43	42	60

Table 3: Calculated CO_2 emissions in tons from ground transport access to OSL, Bergen, Stavanger and Trondheim in 2009 and 2020, if the public transport targets of 70, 32, 30 and 60 per cent, respectively, are met.

CO_2 emissions 2009*					**With the public transport targets met CO_2 emissions 2020**				
Oslo	Bergen	Stavanger	Trondheim	Total	Oslo	Bergen	Stavanger	Trondheim	Total
57219	12535	10234	15252	95240	68272	14614	11285	15243	109414

* Assuming CO_2 emissions in 2009 of 170 g/km for private cars and 1,350 g/km for buses.

transport's share and greater vehicle efficiency, CO_2 emissions in 2020 would total 117,578 tons at the four largest airports, i.e. 8,200 tons or 7.5 per cent higher than the total would be were the public transport target achieved (Table 3).

Avinor wants to strengthen its initiatives and cooperation with local authorities in order to consider further measures for increasing public transport's share beyond the current targets, such that total emissions do not increase.

The most important short-term initiatives in Bergen and Stavanger are better bus services (including new routes and greater frequency). These are measures for which local and central authorities, and transport companies, are responsible. If the proportion of public transport is to increase significantly, road improvements, bus lanes, new bus routes and light rail systems will have to be realised.

At Oslo Airport, good, reliable rail services with competitive prices are absolutely crucial to achieving the public transport target.

The respective airports have decided to establish forums to increase public transport's share of ground transport access. Avinor also wants to improve its facilities for buses, provide better traffic information, and improve marketing at the airport. It may also be of relevance to help ensure a range of public transport services is available at the major airports for late arriving flights.

Together with business and the local authorities, Avinor will also review potential measures at other major airports before 2020.

BIOFUEL

Biofuel has been identified as the most likely alternative energy carrier for aviation in the short and medium-term. The development of aviation biofuel has evolved very quickly in the last few years. Synthetic biofuel has been approved for testing, a number of test flights have taken place, and a new specification that permits the mixture of up to 50 per cent biofuel with conventional jet fuel is expected to be certified in 2011. After this production will probably also take off.

However, aviation's interest organisations, both national and international, are adamant that greenhouse gas emissions from, and the climate effects of, biofuel must be significantly less than those due to today's fossil energy carrier in order to make a significant contribution to emissions reductions in aviation. Strict criteria must almost be stipulated throughout the entire production chain. Drinking water resources must not be required and only biomass that does not encroach on land used for food production is acceptable.

Norway started its own development and production of biofuel late. In the industry's opinion too little is happening in this area in Norway. Therefore, the Norwegian aviation industry is taking the initiative and conducting an extensive study of alternatives for the production of sustainable biofuel for aviation purposes in Norway.

Driving forces

The increasing attention being paid to, and knowledge about, man-made climate impact has focused attention on the use of fossil energy and increasing greenhouse gas emissions. Strong global growth is expected in air traffic. Historically, aviation can point to technology-based efficiency increases of around 2 per cent per annum. However, given the expected growth in traffic of more than 2 per cent, total emissions will increase unless other emissions reducing measures are introduced.

Fossil energy is a limited resource. It is probable that the prices of oil and refined oil products will rise due to greater demand and increasing production costs. More expensive fossil fuel will make alternatives more competitive. The 2011 National Budget, for example, forecasts an oil price of just over NOK 400 (or around USD 70) a barrel in the period up to 2030[14]. In addition, reliability of supply is important for many countries and an important driving force in the work on developing biofuel in the military sector, including in the USA.

Most sectors have already developed alternative energy solutions that might be more or less commercially realistic under certain general conditions. Aviation has entered the game late with regard to the development of alternatives to fossil energy carriers. This means the industry is vulnerable to oil price fluctuations and political regulatory environments.

The alternatives

The phasing in of an alternative energy carrier for aviation could in principle follow two main paths. It could involve a totally new fuel/propulsion system that would entail the phasing in of new technology and new infrastructure, or it could involve an alternative sustainable fuel that is mixed with, or fully replaces, conventional aviation fuel.

Hydrogen is a relevant alternative as a totally new fuel/fuel system, but its energy density is low and would, given today's technology, require large fuel tanks on aircraft. Once the technological challenges have been resolved, commercialisation will depend on acceptable hydrogen prices and thus the political will to introduce the 'hydrogen society'.

In the longer term, the electrification of aircraft, where, for example, one uses hydrogen fuel cells or solar cell panels (photovoltaic (PV) may become relevant. NASA has been working on prototypes for a long time. Airbus has flown its 'eGenius', and the Swiss consortium SolarImpulse[15] has produced a prototype solar cell fuelled aircraft. In the summer of 2010, SolarImpulse conducted a flight that lasted for more than 24 hours. The fact that an aircraft exclusively fuelled by solar energy was flown at night was regarded as a breakthrough. In the long-term the project intends to circumnavigate the globe in a single flight.

However, it would appear that synthetic fuels based on biomass are the most promising sustainable path to alternative aviation fuel in the short and medium-term. Such fuel can be mixed with, or completely replace, conventional jet fuel (Jet A/A-1). The assumption is

[14] Page 41 of Report to the Storting No. 1 (2010-2011) National Budget 2011. Ref. price of oil assumption from the Perspective Report, which is equivalent to NOK 416 per barrel in 2011 money.
[15] www.solarimpulse.com

that a synthetic fuel must satisfy the technical requirements for the certification of conventional aviation fuel. The important elements of this are a low freezing point, thermostability, energy density and low particle emission. This means that only so-called second and third generation biofuels are relevant alternatives for aviation. Furthermore, strict sustainability requirements must be stipulated for both the new biofuels and the raw materials that are used.

Fischer-Tropsch and 'hydrogeneration' are two principal methods/technologies for producing aviation biofuel. The end product will be almost identical. Fischer-Tropsch synthesis is a familiar process that has been used since the interwar period. The raw materials resource (coal, natural gas or biomass) is first converted into a synthesis gas and then, via the Fischer-Tropsch process, used to produce hydrocarbon chains that can be refined into the desired products, e.g. aviation fuel. Aviation fuel has been produced from coal (South Africa) and natural gas (Malaysia and Qatar) in this way for many years. However, mixing fuel with synthesised products from coal and natural gas provides no reduction in greenhouse gas emissions compared with conventional fuel. The use of biomass as the raw material enables the use of all kinds of biomass (including waste fractions) and permits a choice between pure biomass (e.g. timber or fast growing plants) and leftovers/waste (forestry leftovers, agricultural leftovers and organic fractions from waste). Resources for this type of fuel possess great potential with regard to sustainable production/procurement, but the conversion process is at an early (near commercial) stage.

Hydrogeneration methods construct the carbon chains using added hydrogen to produce the desired hydrocarbon chains (e.g. like Jet A/A-1). In this case, the raw materials are oils from oilseed crops that are used for today's (first generation) biodiesel, which is produced using a different method. This is the principal method used to produce the fuel used in test flights. The challenge with this type of fuel involves the raw material. One must be able to produce enough oilseed crops sustainably.

[16] www.astm.org

[17] ASTM D-7566 /Standard Specification for Aviation Fuel Containing Synthesised Hydrocarbons

A possible third method may be genetically modified organisms (GMO) where, for example, yeast cultures are used to synthesise biofuels. However, this is controversial for many reasons and can be regarded as unrealistic in the short-term.

Testing

Since February 2008, various consortia of airlines, aircraft manufacturers, engine manufacturers and fuel producers have tested different mixtures of synthetic biofuels and Jet A-1 in laboratories, on test benches and in test flights. Most of the test flights have involved one engine on a two or four engine aeroplane being fuelled by mixtures containing different amounts alternative fuel (up to 50/50). The alternative fuels have proven to have certain desired properties in relation to full miscibility with fossil fuel, and lie well within the specification requirements for certification in relation to their freezing point, thermostability and energy density.

Certification

Only certified fuel can be used in commercial aviation. The key to implementing synthetic fuel is thus certification. One important step in the process towards certification was that the international certification body for aviation fuel, ASTM International[16], approved a standard specification for mixing conventional and synthetic components[17] on 1 September 2009. ASTM is expected to certify a standard for a 50/50 mixture for use in commercial civil aviation in 2011. It is anticipated that once this is available, rapid development will be seen with regard to methods and the commercialisation of processes for manufacturing synthetic aviation fuel that can be mixed with conventional fuel.

Current projects and key technology players

Airlines will start using synthetic biofuel as soon as it is available and certified. In order to achieve the International Air Transport Association's (IATA) goal of 'carbon neutral growth' in global aviation by 2020, the industry must have access to sufficient volumes of biofuel on acceptable commercial terms.

A number of leading airlines and technology suppliers have formed the Sustainable Aviation Fuel Users Group (SAFUG)[18], and a number of projects are being carried out by cooperating groups of airlines, aircraft and engine manufacturers, government bodies and research communities across the world. Projects have been established in the USA, Brazil, Australia and New Zealand, the Arabian Peninsula, and Europe[19].

Major technology companies, such as Honeywell UOP in the USA, Choren in Germany, Solena in the USA, Neste Oil in Finland, and Alge-Link in the Netherlands, have made great strides in the development of technology, and are collaborating with airlines and aircraft and engine manufacturers on the development and production of aviation biofuel based on various technologies and raw materials. For example, Solena is carrying out concrete collaboration projects with airlines such as British Airways, Qantas and Alitalia.

Raw materials, land use and ethics issues

Even if the technological challenges can be resolved and the costs of producing biofuel reduced to a level at which biofuel becomes commercially available, a number of ethical challenges exist in relation to the production of biofuel. These include debates on land use, climate effects, and the amount of biomass that can actually be made available for the production of biofuels for transport purposes. Meanwhile, there are very many types of biofuel on the market.

Traditional 'first generation' biofuels, which other transport modes have been using for many years, contain too little energy and their freezing properties are too poor for use in aviation. First generation biofuels include biodiesel and bioethanol based on raw materials such as plant oils (rape and soya) and the fermentation of biomass that contains carbohydrates in the form of sugar, starch or cellulose. From a purely technical perspective these have, with minor or no modification, functioned well in today's diesel and petrol engines, but have been criticised, including because the raw materials are grown on agricultural land that could be used for food production and because the net emissions reducing effects have in some cases been very low.

As far as biofuel for use in aviation is concerned, in the short and medium-term it is synthetic biofuel that is relevant. This is fuel produced from sustainably produced biomass resources. To date plants such as Jatropha, Halophytes, Camelina and various algae have been used as raw materials in aviation fuel production. Jatropha is grown in dry steppe regions and requires a lot of manual harvesting, and could in many places create new economic activity. Halophytes are grown in brackish water, while Camelina[20] can also be grown without encroaching on food production. Oil containing algae can be grown in both freshwater and salt water under controlled conditions. There are high expectations concerning algae because they grow very quickly and because they will not encroach upon agricultural or forestry land. However, in principle any biomass can be used as raw materials for biofuel produced using the Fischer-Tropsch method, and the use of agricultural waste, forestry waste and household waste[21] that would otherwise end up in landfill sites is also being tested.

Life cycle analyses of biofuel production show that the actual emissions reduction depends on the type of biomass used, and where and how it is produced. Land use is of particular significance with regard to the magnitude of the net emissions reductions that can be achieved[22], but is also important with regard to biodiversity and the degree to which biomass production encroaches on food production. Water consumption is also an important factor with regard to being able to produce the raw materials for biofuel sustainably. These issues are closely associated with local conditions and in the future one can expect different types of biomass to be produced depending on location and other conditions.

Access to energy is crucial for economic development and thus also to resolving the problems of poverty in the world. At the same time, it is likely that there will be a prolonged scarcity of energy in the future. This is one of the reasons why an important discussion is taking place concerning the amount of biomass that actually can or should be 'spared' for transport purposes, including aviation, in the future. The EU, International Energy Agency (IEA) and many others have analysed how much biomass can be produced in various scenarios. Such estimates vary a lot depending on the assumptions on which they based. The goal is to increase the extraction of land-based biomass in Norway[23] from the current 14 TWh to 28 TWh by 2020. 14 TWh of biomass can provide 360 million litres (290,000 tons) of aviation fuel[24], which is equivalent to around half of all the aviation fuel sold at Oslo Airport Gardermoen in 2010.

In addition to this comes any future production of biofuel algae.

The aviation industry will stipulate very strict criteria for future synthetic fuel. It also expects the authorities to stipulate certification requirements for future biofuel with standardised life cycle analyses (LCA) as documentation, such that these can be used as a basis.

If it is produced in the right way, biofuel could make a very important contribution to reducing greenhouse gas emissions from the transport industry. Climate Cure 2020 shows, for example, that the introduction of a larger share of biofuel in the transport industry could make a very large contribution to ensuring that Norway achieves its emissions target. The basic alternative in Climate Cure[25] assumed that 10 per cent of fuel requirements for aviation could be met by biofuel in 2020 and 20 per cent in 2030. Therefore, the emissions forecasts in this report assume that emissions from aviation in Norway will be reduced by 10 per cent in 2020 and 15 per cent in 2025 due to the phasing in of biofuel.

The biofuel initiative

The Norwegian aviation industry is heavily focused on continuing its work on improving energy efficiency. However, given current traffic growth, increasing energy efficiency will be insufficient to achieve net emissions reductions in the industry, and the mixing of biofuel will therefore be an important element of future sustainable aviation. The production of biofuel for transport in Norway is very limited today, and most of the fuel that is used is imported. In the near future, it is likely that demand for fuel will exceed supply both in Norway and the rest of Europe. The infrastructure (from ports to airports, etc) is well suited for deliveries of biofuel and does not require modification. At the same time, by adding biofuel at the four largest airports in Norway one can effectively reach the majority of air traffic in Norway. Climate Cure 2020 calculated[26] that the net socio-economic costs per ton of reduced CO_2 emissions for biofuel within the transport industry were lowest for aviation, both in the calculations for 2020 and in the calculations for 2030.

The entire Norwegian aviation industry wants to start using sustainable biofuel as quickly as possible and is therefore taking the initiative and focusing on the production of aviation biofuel in Norway.

The following measures will be initiated:

- An extensive pilot project will be established which will look at alternatives for biofuel production in Norway. The project will be established no later than 1 October 2011 and its report presented by the end of 2012.
- The airlines are prepared to conclude long-term agreements for purchasing biofuel from suppliers. The airlines will contribute competence to the projects and carry out test flights when relevant products are available.
- Avinor will be able to make financial contributions to development measures that support these aims.

Internationally recognised sustainability criteria must be complied with and the biofuel must not be produced at the expense of drinking water or in competition with food production.

The Norwegian aviation industry will invite the relevant authorities, research communities, environmental organisations, and business to participate in the work, and seek proposals and possible cooperative solutions.

The authorities will play an important role in achieving the production of second generation biofuel for aviation purposes in Norway by helping ensure the general conditions are favourable for relevant research and development, and stimulating the commercialisation of biofuel.

[18] http://www.safug.org/

[19] See e.g. http://www.enviro.aero/Biofuels-case-studies.aspx for some examples.

[20] Camelina sativa (also known in Norway as dodder oil or false flax) is an annual weed which is 30-60 cm tall with yellow flowers.

[21] See a press release from British Airways here: http://press.ba.com/?p=904

[22] The international debate is related to "Indirect land use change impacts of biofuels (ILUC)".

[23] Ref. for example, the Ministry of Petroleum and Energy (2008): Strategi for økt utbygging av bioenergi [Strategy for the increased expansion of bioenergy]

[24] Calculated by SINTEF based on the same assumptions as in Ekbom, Tomas, Hjerpe C., Hagström M. and Hermann F. (2009): Förstudie för biobaserat flygbränsle för Stockholm-Arlanda Flygplats. [Pilot study for bio-based aviation fuel for Stockholm Arlanda Airport] Värmeforsk (Swedish Thermal Engineering Research Association), Systems Technology. Report 1125, SYS08-831. Paraffin oil, heavy diesel and heat can also be produced.

[25] Page 88 of Klif (2010): Climate Cure 2020 Measures and Instruments for Achieving Norwegian Climate Goals by 2020 Climate and Pollution Agency Rep TA2590/2010

[26] Page 91 of Klif (2010): Climate Cure 2020 Measures and Instruments for Achieving Norwegian Climate Goals by 2020 Climate and Pollution Agency Rep TA2590/2010

POLITICAL MEANS

Norway introduced a CO_2 excise duty for domestic aviation in 1999. International aviation is exempt from the excise duty because this would conflict with international regulations. The excise duty has gradually increased and in 2011 it amounted to NOK 0.69 per litre of aviation fuel, equivalent to around NOK 270 per ton CO_2. The excise duty is higher for jet A-1 than the ordinary excise duty, i.e. higher than, for example, diesel and light heating oil, but lower than for petrol. The total proceeds from the CO_2 excise duty in Norwegian aviation amount, at their current level, to around NOK 300 million per annum.

From 1 January 2012, the EU system for trading emissions rights (EU ETS) will be incorporated into European aviation. This will also apply to Norwegian aviation. All domestic flights and flights to/from the EU/EEA area will be covered. The Norwegian airlines, Avinor and the Confederation of Norwegian Enterprise (NHO) have long supported this initiative. A specific ceiling has been set for the number of quotas assigned to aviation, and a proportion of the quotas will be auctioned. The European quota price has, due to the financial crisis, been relatively stable in the last few years at between NOK 110-120 (EUR 14-15/ton), but since the start of 2011 this has risen to around NOK 140 (EUR 17) per ton. The quota price is expected to rise in the future. Climate Cure 2020 assumes that the quota price for a ton of CO_2 equivalents will be EUR 26 in 2015, EUR 40 in 2020, and EUR 100 in 2030. Norwegian aviation wants the proceeds from sales of quotas to be earmarked for environmental improvement measures in the industry.

A NOx excise duty was introduced in Norway, with some exceptions, including international shipping and aviation, in 2007. The excise duty in 2011 amounts to NOK 16.43 per kg of NOx emissions[27]. Meanwhile, a NOx fund was established in May 2008 and will be continued between 2011 and 2017. All Norwegian airlines and helicopter companies that are currently members of the Confederation of Norwegian Enterprise (NHO) Aviation are members. Becoming a member of the fund means that instead of paying the excise duty, NOK 4 per kg of NOx is paid (the petroleum industry pays a higher rate) to the fund. The fund's income finances emissions reducing measures. The fund has undertaken to reduce annual NOx emissions by its member companies by 30,000 tons per annum. Aviation paid around NOK 5 million into the fund in 2010.

[27] Excise duty on emissions of NOx 2011, Circular no. 14/2011 S, Norwegian Directorate of Customs and Excise, Oslo, 7 January 2011.

TRAFFIC FORECASTS

Strong forces will drive the continued growth of air traffic in Norway. The driving forces are related to demographics, economics, production, globalisation, business development and trade. Demographic driving forces such as population growth and centralisation are important development trends that affect air traffic. Future population growth will be strong. Norway's population is expected to grow from 4.9 million in 2010 to 6.2 million inhabitants by 2040 (Statistics Norway). This will in itself result in increased air traffic, but there will also be effects from its interaction with other driving forces such as income growth. Population growth can primarily be explained by heavy immigration, although higher birth rates and life expectancy are also factors.

Economic growth, globalisation and changes to the structure of business affect demand for air travel. The world has seen strong economic growth in the last few decades, driven by continuous productivity improvements. This has laid the groundwork for very strong growth in prosperity, including growth in tourism. Continued economic growth is expected over time, which together with steady improvements in the routes on offer will contribute to higher demand for air travel in the future.

A growing economy results in increased international trade and increased production, both in Norway and the rest of the world. Disposable real income per inhabitant is expected to increase by 1.6 per cent per annum up to 2040. There is a clear correlation between GDP growth and transport levels. Higher incomes result in more travel activity, longer journeys and strong growth in leisure travel. Given high global income growth, new types of aircraft and better route provision to other continents, the scope of long journeys will in particular grow. At the same time flights that today fly via hubs in Europe will fly directly to other continents.

The Institute of Transport Economics (TØI) prepares traffic forecasts for Avinor, partly based on the above assumptions.

High, low and benchmark alternatives[28] have been calculated for the latest traffic forecasts. In the benchmark alternative inland traffic will increase by 29 per cent from 2007 to 2020, and 38 per cent by 2025. This corresponds to around 1.8 per cent per annum. The growth in international traffic from 2007 will be 73 per cent by 2020 and 101 per cent by 2025, which corresponds to growth of 4 per cent per annum.

It is also assumed that the average distance flown by international passengers to their first destination will increase by 15 per cent and that this will affect fuel consumption per departing passenger correspondingly. One interpretation of this is that around 600,000 more air passengers than today (in excess of normal traffic growth) will be travelling directly by intercontinental flights instead of flying to/via European airports by 2020. The increase in the average distance corresponds to, for example, 6-7 daily intercontinental departures from Norwegian airports, journeys that today fly via other European airports, possibly combined with an increase in direct routes from Norway to the Mediterranean region. Thus the number of air passenger kilometres will increase by 98 per cent by 2020 and 131 per cent by 2025.

TØI estimates that the increase in emissions in Norway due to this increase in distance will be in the order of 200,000 tons of CO_2 in 2020. The increase will partly be due to the general growth in traffic and partly due to emissions being assigned to their 'home country'. Emissions that were previously recorded in, for example, German, British or Dutch emissions accounts will now be recorded in Norway's accounts because the fuel is filled in Norway. This also has a positive effect on total emissions in that one 'saves' one start and one landing, and parts of the distance flown.

[28] The growth rates in TØI's Avinor forecasts are used for all Norwegian civil aviation in the emissions calculations.

TRAFFIC AND EMISSIONS PROJECTIONS

The emissions forecasts for the periods leading up to 2020 and 2025 divided by domestic traffic, international traffic and all traffic in and from Norway (i.e. emissions from all fuel sold in Norway - bunkers) were arrived at by comparing traffic forecasts and the analysed potential for emissions reductions in aviation.

The growth without energy efficiency measures would in practice parallel the traffic growth measured in passenger kilometres. This is illustrated by the orange graph.

Three different scenarios have also been assumed for emissions reductions:

The low potential alternative for emissions reductions (LOW) assumes greater efficiency per passenger kilometre of 29 per cent domestically and 31.2 per cent internationally from 2007 to 2020. In this the lowest (and most reliable) estimate of the effects of fleet renewal (25 per cent) has been assumed, as has a relatively modest effect from the Single European Sky (which is primarily assumed to affect international traffic). A low alternative has also been assumed for taxiing. For the period 2020-2025 a further effect from fleet renewal is assumed of 6.7 per cent (from a 25 per cent reduction in 2020 to 30 per cent in 2025).

The high potential alternative for emissions reductions (HIGH) includes an assumption that includes the full effect of fleet renewal, -30 per cent in 2020. The high and most optimistic alternative for more energy efficient taxiing is also included, and the effect of SES is set at 5 per cent for international traffic. This means one could achieve efficiency gains per passenger kilometre of 37.6 per cent domestically and 40.8 per cent internationally between 2007 and 2020. In the period leading up to 2025 a further effect from fleet renewal of 14.2 per cent (from 30 percent in 2020 to 40 percent in 2025) is assumed, but this will depend to a large extent on the availability of a totally new generation of aircraft in 2025 and how much more energy efficient the new generation is in relation to today's generation of aircraft.

An alternative in which biofuel is included has also been outlined (HIGH + BIO). This has been added to the high estimate for energy efficiency. In this a further emissions reducing effect of 10 per cent has been assumed in 2020 and 15 per cent in 2025, which is in line with the analysis in Climate Cure.

The different estimates are presented in Table 4.

Table 4: Emissions reducing measures in the various alternatives.

	LOW		**HIGH**		**HIGH+BIO**	
	Domestic	**International**	**Domestic**	**International**	**Domestic**	**International**
Measures 2007-20:						
Fleet renewal	-25 %	-25%	-30 %	-30 %	-30 %	-30 %
Misc. technical aircraft measures	-0,3 %	-0,3%	-0,5 %	-0,5 %	-0,5 %	-0,5 %
Misc. aircraft operations measures	-2,2 %	-2,2%	-3,8 %	-3,8 %	-3,8 %	-3,8 %
Taxiing	-3 %	-3%	-7 %	-7 %	-7 %	-7 %
Single Eur. Sky		-3%		-5 %		-5 %
Effect of biofuel					-10 %	-10 %
Total measures 2007-20:	**-29 %**	**-31,2%**	**-37,6 %**	**-40,8 %**	**-43,6 %**	**-46,7 %**
Further measures 2020-25:						
Fleet renewal 2020-25 (as % of 2020 level) (Total respectively -30% and -40%)	-6,7 %	-6,7%	-14,2 %	-14,2 %	-14,2 %	-14,2 %
Further effect of biofuel (total -15%)					-5,5 %	-5,5 %

The emissions reductions per passenger kilometre will probably lie somewhere between the low alternative and the high alternative. This is illustrated by the shaded field in the figure.

However, the increases in the average distance and fuel sales are not expected to be linear in the periods leading up to 2020 and 2025. For example, a substantial increase in fuel sales at Norwegian airports was observed from 2009 to 2010. This was due to stronger growth in international traffic than the expected average annual growth, and longer internationally flown distances per flight due to more direct routes. TØI's forecasts do not indicate that the same growth will occur each year going forward.

Based on the above assumptions, the forecasts for domestic traffic (Figure 9) show that emissions will be between 9 and 27 per cent lower in 2020 than they were in 2007. In 2025, the emissions reductions will have levelled out out in the low alternative because a conservative estimate is assumed for the effect of fleet renewal. Emissions will according to the forecast be 9 per cent lower than they were in 2007. In the case of high energy efficiency, plus the emissions reducing effect of 15 percent due to the mixture of biofuel, it is estimated that the emissions could be up to 36 per cent lower than they were in 2007. Emissions reductions for domestic aviation are principally explained by the fact that traffic growth is expected to be quite modest and the flying distances will not increase.

On the other hand, if one looks at international traffic in isolation, the forecasts indicate that emissions will increase in the periods leading up to 2020 and 2025 (Figure 10) for all alternatives without access to biofuel[29]. In 2020, emissions will be 6-37 per cent higher than they were in 2007, while they will be 0-49 per cent higher in 2025 than they were in 2007. This is primarily explained by significantly higher international traffic growth plus a simultaneous increase in average flying distance from Norway being assumed, including more direct intercontinental flights.

[29] It is assumed that foreign airlines will implement measures equivalent to those Norwegian and SAS will implement.

Figure 9: Traffic growth and various estimates for emissions reductions from domestic aviation up to 2025 (indexed).

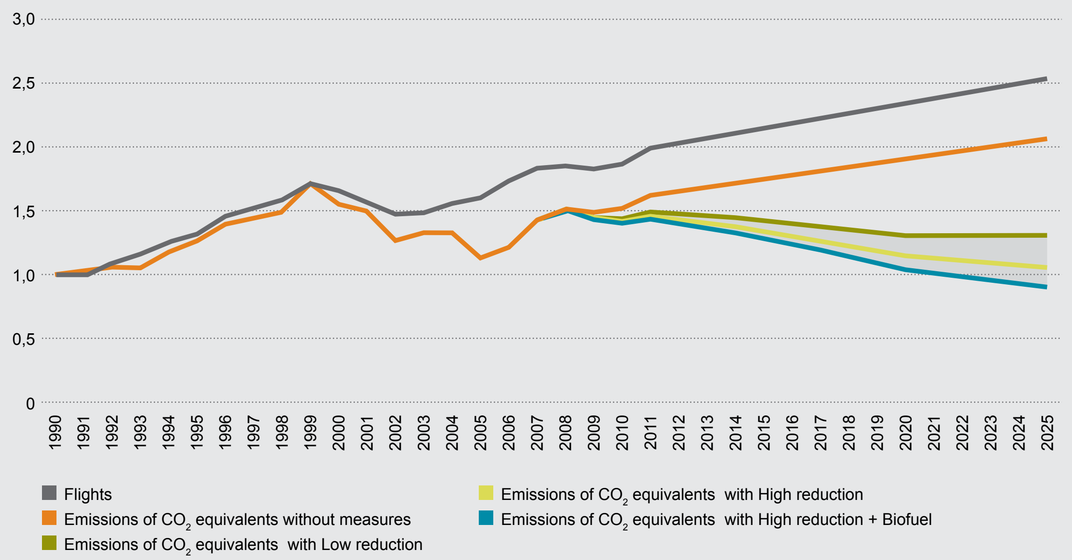
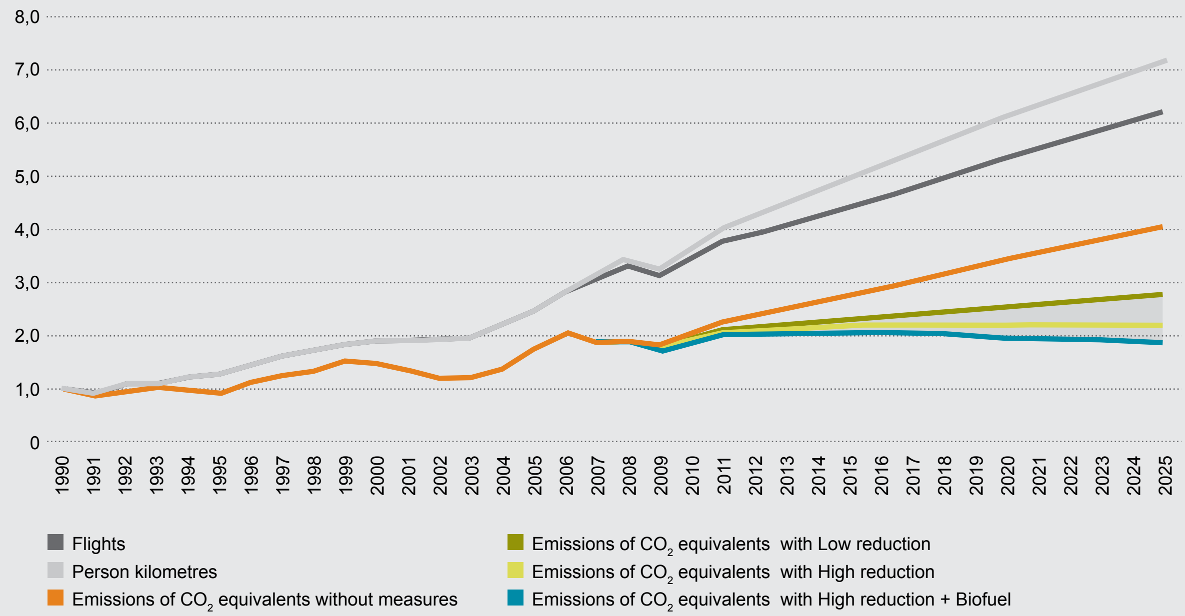
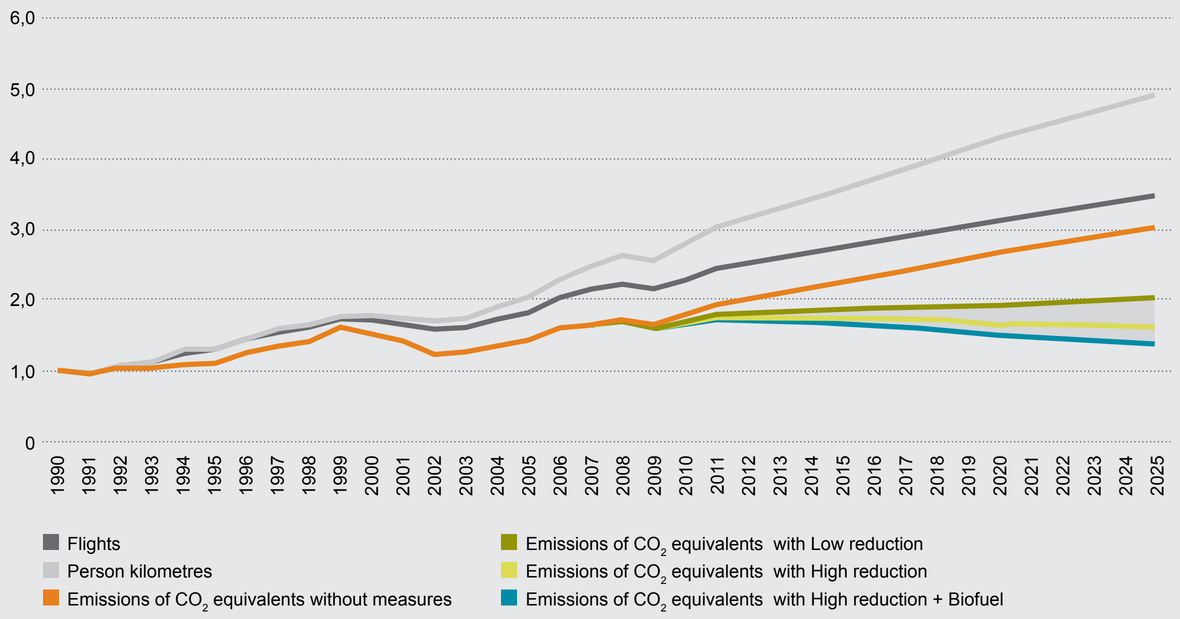


Figure 10: Traffic growth and various estimates for emissions reductions from international aviation up to 2025 (indexed).



Finally, forecasts were made for all air traffic in and from Norway - bunkers (Figure 11). A potential change in emissions of -9 to +17 per cent in 2020 has been calculated. In other words, it is possible to achieve zero growth in emissions compared with 2007, although this assumes that the potential inherent in all the analysed energy efficiency measures will be realised. In 2025, the range will be from -16 to +24 per cent. In order to achieve zero growth in emissions, a certain level of biofuel will probably have to be mixed in and/or a new generation of aircraft with the expected energy efficiency gains will have to be available on the market.

Figure 11: Traffic growth and various estimates for emissions reductions from all traffic in and from Norway (bunkers) up to 2025 (indexed).



CONCLUSIONS

The social benefits of aviation are substantial in Norway. Social development will stimulate, and require, continued growth in traffic. The aviation industry's aim is to manage this growth in a sustainable manner. Few alternatives to aviation exist. This underscores the importance of implementing emissions reducing measures in the industry.

In 2009, greenhouse gas emissions from domestic aviation in Norway amounted to 1.1 million tons of CO_2 equivalents, i.e. 2.1 per cent of Norway's total emissions as regulated by the Kyoto Protocol. Emissions from international aviation (to the first international destination) amounted to 1.2 million tons in 2008[30].

The industry has identified a number of emissions reducing measures. These measures are being implemented as planned. The most important short-term measure involves fleet renewal. Airlines are now speeding up the pace of renewal and have brought forward their fleet plans, which means that by the end of 2014 the fleets of the dominant Norwegian airlines, SAS and Norwegian, will consist of only the latest generation of aircraft. The new fleet, consisting of Boeing 737 NGs, will produce around half of the emissions of the aircraft they are replacing, Boeing 737-300s and MD87s. For example, 737-800NGs will emit 0.027-0.028 g of CO_2 per seat kilometre. This will result in substantial reductions in emissions before 2020 as well. The emissions reduction estimates for 2020 are also more reliable than before with respect to fleet renewal and technical and operative measures. At the same time, the ability to mix in sustainable biofuel has increased the potential for emissions reductions, meaning that the ranges for emissions changes are greater in this report than they are in the 2008 report.

Based on the expected traffic growth and flying distances, the following main conclusions may be drawn:

- Domestic emissions will be 9-27 per cent lower in 2020 than they were in 2007, and in 2025 emissions will be 9-36 per cent lower than they were in 2007.
- Internationally, the forecasts indicate that emissions will increase by 6-37 per cent by 2020 and by 0-49 per cent in 2025 compared with 2007.
- Overall (bunkers) emissions could stabilise at around the 2007 level in 2020 (calculated emissions change of -9 to +17 per cent). In 2025, the range will be from -16 to +24 per cent.

Forecasts indicate that air traffic, measured in passenger kilometres, will increase by more than 97 per cent between 2007 and 2025. A large proportion of the emissions caused by the growth in traffic will be compensated for by the measures discussed in this report. Stabilising/reducing emissions from bunkers will require access to biofuel and the availability on the market of a new generation of aircraft with the expected energy efficiency.

The Norwegian aviation industry will conduct a feasibility study to look at the future production of sustainable biofuel in Norway. The project will assess various alternatives and the aim is to carry out the project in partnership with the authorities, research institutions and business.

[30] Latest official figures.

Work on the report was initiated and led by Avinor, and carried out in partnership with SAS, Norwegian, Widerøe and the Confederation of Norwegian Enterprise (NHO) Aviation. The following sat on the steering group:

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