Emissions in context

It’s an impressive display of power and engineering to watch an aircraft weighing 80 tons take to the sky. But it takes a lot less energy to fly at 850 kph than most people think. Air travel’s reputation as an environmental “bad boy” is unmerited. There are few other sectors which can point to as comprehensive advances in energy efficiency. Today, emissions per airline passenger are approaching those per train passenger in many countries.

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In 2010, Norwegian emitted on average 97 grams of carbon dioxide (CO_2) per passenger per kilometer, a reduction of 6 percent from the year before. The 737-800s, the only aircraft type Norwegian will operate from mid-year 2012, emitted on average 88 grams per passenger kilometer and consumed 0.026 liters of fuel per seat per kilometer. On longer distances the per passenger emission rate is less than 63 grams per kilometer.

To put the figure in perspective; diesel-powered trains emit 73 grams per passenger per kilometer, an average car more than 107 grams per kilometer with an average of 1.54 passengers. Both cars and trains must typically cover more kilometers to reach the same destination as surface distances are almost always longer than flying distances.

Over longer distances, a passenger traveling alone will emit less by flying on Norwegian’s Boeing 737-800s than driving the most efficient hybrid car available, even without taking into consideration that driving distances are almost always longer.

Over shorter distances fuel consumption is higher per kilometer as take-offs are fuel intensive. Yet, on the 324-kilometer Oslo – Bergen route, one passenger traveling alone will produce more than 90 percent more emissions by driving compared with flying on a Norwegian Boeing 737-800. Given an actual average of 1.54 passengers per car, emissions per passenger are still 26 percent higher compared to a Norwegian passenger on the same route.

Electric trains in Norway are powered by the pan-Nordic electricity grid, which features a mix of primarily renewable energy sources, implying an average carbon footprint of 14 grams of CO_2 per passenger per kilometer. The average train passenger produces 7 kilos of CO_2 from Oslo to Bergen, compared with a Norwegian passenger’s 41 kilos and a car passenger’s 52 kilos. From Oslo to Bodø a train passenger generates 61 kilos of CO_2, while a Norwegian passenger generates 72 kilos.

Interestingly, an extra train departure replacing a Norwegian flight would increase carbon emissions per passenger on most distances. Here is why: one extra (marginal) train departure results in more electricity being consumed. Since renewable energy sources, such hydro power and wind power, are in short supply, any additional electricity consumed must therefore be generated from fossil fuels such as oil, gas and coal which, according to Enova (Norwegian government-owned corporation devoted to the promotion of energy saving), has an emissions factor of 617 grams of CO_2 per kilowatt-hour.

This implies that for every extra train departure between Oslo and Bergen the passengers on board will produce about the same amount of carbon emissions as a Norwegian 737-800 passenger, while on the Oslo – Bodø route a train passenger on an extra departure will produce 37 percent more than the airborne Norwegian passenger.

Sources and definitions

Existing Electricity Mix

Electric trains in Norway draw their power from the public Norwegian grid, which physically and economically is part of an integrated pan-Nordic market. The average production mix within Nord Pool’s market area (Norway, Sweden, Denmark and Finland) gives an emission factor of 100 grams of CO_2 per kilowatt-hour according to various sources, including IEA and Naturvårdsvärket (Swedish Environmental Protection Agency).

Marginal emissions and the Norwegian electricity mix

Global warming is a global challenge. When comparing different modes of transport, the marginal emissions (emissions from one extra trip) should reflect the additional carbon emissions generated by that trip. In terms of electricity, that means the carbon emissions created from generating the marginal (extra) power, and not the average emissions of the power already generated (and already consumed).

In 2010 Norway was a net importer of electricity. Imports and exports are arguably driven by price and not production capacity. However, while Norway’s 1,200 hydropower plants have a maximum installed capacity of approximately 30,000 MW, annual median precipitation allows for a maximum output of approximately 123.4 TWh which is less than the total domestic consumption, according to NVE (Norwegian Water Resources and Energy Directorate. This means that any additional consumption stems from non-renewable domestic sources, or imports. According to Enova (Veileder – kommunal energi- og klimaplanlegging (2-2008)) marginal electricity has a carbon factor of 617 grams of CO_2 per kilowatt-hour.

Certificates of origin

Some organizations, including the Norwegian State Railways, claim their electricity consumption remains carbon neutral as they buy certificates of origin. A certificate of origin is a guarantee whereby the supplier of energy states that they will produce at least an amount of renewable energy equivalent to the buyer's consumption. Yet, for every kilowatt-hour of renewable energy the buyer consumes, there is one less kilowatt-hour of renewable energy available to others. Under the same rationale, airlines could in theory buy certificates of origin for an amount of kilowatt-hours equivalent to the energy contained in the jet fuel consumed, and thus claim to be carbon neutral.

From a global perspective trading in certificates of origin does not reduce carbon emissions but is rather a gimmick which allows power consumers to buy themselves good environmental conscience.

Norwegian State Railways (NSB)

Figures for average electricity consumption per passenger kilometer for electrically propelled trains and average emissions per passenger kilometer from diesel propelled trains are taken from NSB's "Green Audit" and are confirmed by The Norwegian National Rail Administration's (Jernbaneverket) Environmental Report 2009.

Head-on competitor

Average emission figures are taken from the head-on competitor's annual report 2010. Route-specific emission figures are taken from the head-on competitor's online "Emission Calculator", which is widely used by third parties for benchmarking aviation in general. The aircraft type used is the default "most used aircraft"

Norwegian Air Shuttle ASA

Average emissions are based on actual emissions and actual passenger kilometer and passenger kilometers respectively. For the route-specific examples only the Boeing 737-800W is displayed as it provides the most relevant benchmark, given that Norwegian will have a uniform fleet of this aircraft type from 2012. The route-specific emissions are based on actual average fuel consumption and actual average load factors on the routes in question and include all stages of flight including fuel used for taxiing at the airports.

Cars

The average emission of 165 grams of CO_2 per kilometer is taken from The Norwegian Advisory Council for Road Traffic (Opplysningsrådet for Veitrafikken), and reflects the average of all cars sold in Norway between 2002 and 2010. The actual figure is thus higher.

The average occupancy rate of 1.54 is taken from The National Travel Behavior Survey 2005 conducted by The Institute of Transport Economics (TØI).

Bus

According to The Institute of Transport Economics (TØI), the average long-distance bus (coach) in Norway emits 36.60 grams of CO_2 per passenger per kilometer.