

## Decarbonizing aviation: comparing nine policies

Delft, 7 August 2020

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### Assessing policy options

Aviation needs to bring its CO<sub>2</sub> emissions down to zero not far beyond 2050. To achieve this, a wide range of technologies and policies is considered. Among these are taxes, ban on short flights, faster trains, electric planes, zero-carbon fuel and enhanced energy efficiency of aircraft and operations. For policy development and for investment decisions, it is useful to have insight into the impact of alternative approaches. The table below assesses the three most important consequences of different policies: CO<sub>2</sub> emissions, ticket price and travel volume. This gives a first comparative overview. The data are estimates, based on uncertain assumptions (see below). This assessment is not intended as final answer, instead as a kick-off for discussion and improvements. Despite its limitations, the overview shows that sustainable fuels will have a large role in decarbonizing aviation.

Policy options	Illustration of impact on:	CO <sub>2</sub> emissions	Ticket price	Travel volume
<b>Reference = 100</b>	Fossil kerosene 0.50 €/l, No taxes	100	100	100
<b>Modal shift Air2Rail</b>	HSR between all major cities Europe, Airport capacity restricted	87	100	92
<b>Expected pricing policy aviation</b>	Ticket taxes 5%, ETS price 50 €/tonne CO <sub>2</sub>	87	109	93
<b>No CO<sub>2</sub> flights &lt; 500 km</b>	Half flights avoided, half zero CO <sub>2</sub> , Airport capacity restricted	87	104	97
<b>10% blending of green kerosene</b>	Green kerosene 3.00 €/l, 10% CO <sub>2</sub> compared to fossil	67	108	94
<b>Taxing aviation</b>	0.33 €/l kerosene, VAT 25%	66	138	77
<b>25% blending of bio or blue kerosene</b>	Bio or blue kerosene 1.50 €/l 10% CO <sub>2</sub> compared to fossil	64	108	94
<b>50% blending of green kerosene</b>	Green kerosene 2.50 €/l 5% CO <sub>2</sub> compared to fossil	31	129	82
<b>50% green kerosene and taxing aviation</b>	Green 2.50 €/l, 5% CO <sub>2</sub> VAT 25%, ETS 100 €/tonne CO <sub>2</sub>	25	165	67
<b>80% green kerosene</b>	Green kerosene 2.00 €/l 0% CO <sub>2</sub> compared to fossil	10	143	75

### Modal shift Air2Rail

The estimates are from my [study Air2Rail](#). It is assumed that all rail links in Europe have the same quality as the contemporary best High-Speed Rail links. This reduces air travel by 48 billion passenger-kilometres, corresponding with 8% of total intra-European aviation. CO<sub>2</sub> is reduced by 7.4 Mt or 13%. Furthermore, it is assumed that the freed-up airport capacity will not be used for new flights. If short flights are replaced by long-haul, total aviation emissions might even go up.

### Pricing

International aviation is currently hardly taxed. It is exempt from VAT and fuel taxes. The European Commission published [an overview of existing aviation taxes](#). The 'expected pricing' policy assumes an average ticket tax of 5% and a price of 50 euro per tonne CO<sub>2</sub> for ETS-allowances purchased by



airlines. The ‘taxing’ policy, as advocated by environmental NGO’s, includes 25% VAT on tickets and 0.33 euro per litre fuel tax on fossil kerosene (corresponding with the minimum diesel tax in the EU). Fuel tax has a larger impact on CO<sub>2</sub> than VAT, because a fuel tax of 0.33 €/l improves the energy efficiency of aviation by an estimated 5%. VAT only increases the ticket price, and therefore has a stronger impact on travel volume.

### **No CO<sub>2</sub> flights <500 km**

This policy ends all flights shorter than 500 km, except for carbon-free flights. This can be electric aircraft or using green kerosene in a conventional plane. In both cases the energy used needs to be entirely without emissions of CO<sub>2</sub>. This policy gives a strong incentive to develop and deploy carbon-free aviation. The estimates in the table assume that half of the current flights below 500 km will be skipped, and the other half will be replaced by carbon-free flights. Next, it is assumed that the ticket price for carbon-free flying will initially double. The price increase in the table is the average of all intra-European flights. Finally, it is assumed that the freed-up airport capacity will not be used for new flights. If short flights are replaced by long-haul, total aviation emissions might even go up.

### **Blending sustainable fuels**

It is technical feasible to blend sustainable fuels with fossil kerosene and to use this mix in a conventional aircraft. Big advantage is that no new planes and engines have to be developed and introduced in the fleet. This would last several decades. Sustainable aviation fuels can be bio or synthetic kerosene. Bio kerosene is produced from agricultural or other wastes. Because its limited supply, synthetic kerosene is needed as well. Synthetic kerosene can be ‘blue’ or ‘green’ and is produced from hydrogen. Blue kerosene is made from natural gas in combination with carbon capture and storage. Green kerosene is made from solar and wind power.

Sustainable aviation fuels are more expensive than fossil kerosene. Their future price levels are still uncertain. Bio and blue kerosene will probably cost the same, while green kerosene will be more expensive. Therefore, bio and blue are considered transition fuels, while green kerosene is the ultimate technology. The estimates in the table use a variety of price levels for sustainable fuels, reflecting the uncertainties. Different values for the remaining CO<sub>2</sub> emissions from sustainable fuels are also used.

The increased fuel price is an incentive for further improvements in the energy efficiency of aircraft and operations. This generates an additional reduction in emissions. To illustrate this with the policy ‘50% blending of green kerosene’: the 69% reduction in CO<sub>2</sub> is partly caused by a 10% improvement in energy efficiency and a 18% reduction in travel volume. [Blending mandates](#) for sustainable aviation fuels are an effective lever to decarbonize aviation.

### **Non-CO<sub>2</sub> impact**

The contribution from aviation to climate change is not limited to its CO<sub>2</sub> emissions. Climate relevant emissions include nitrogen oxides (NO<sub>x</sub>), sulphur oxide (SO<sub>2</sub>), water vapor (H<sub>2</sub>O), aerosols, contrails and contrail cirrus. The total climate impact of aviation is estimated to be two to four times higher than the effect of CO<sub>2</sub> emissions alone. Contrails formed by high flying aircraft have roughly an equal impact on global warming as the emitted CO<sub>2</sub>. [Recent research](#) indicates that the contribution of contrails can be reduced by 90% through a shift to cleaner engines and changes in the flying altitude of only 2% of the flights.

### **Technical assumptions**

- Fuel costs as percentage of total operating costs: 25%
- Fuel price elasticity on energy consumption: - 0.3
- Fuel price elasticity on energy efficiency: - 0.1
- Ticket price elasticity on travel volume: - 0.8

These are estimates for average values. These parameters show a wide variety for specific routes, aircraft types and carriers.

