Life cycle assessment of current and future passenger air transport in Switzerland

Master Thesis

February – December 2015

Conducted at

Technology Assessment Group, Laboratory for Energy System Analysis

Paul Scherrer Institut (PSI), Switzerland

For the Programme

Master of Science in Energy Management

University of Nordland, Bodø, Norway

Graduating Student

Wojciech Jemioło

Main Supervisor

Brian Cox[1]

Tutor

Gisle Solvoll[2]

---

[1] Technology Assessment Group, Laboratory for Energy Systems Analysis, Paul Scherrer Institut (PSI), Switzerland

[2] Bodø Graduate School of Business, University of Nordland, Norway

Abstract

The aviation sector strongly facilitates the growth of modern economies. Around 10% of all passenger-kilometers are travelled by aircraft. The demand for this means of transport is projected to grow in the years to come. Air transportation emits globally about 600 million tons of carbon dioxide yearly to the atmosphere. Its contribution is estimated to be 2% of total global CO_2 emissions and 12% if we look at the share in the transportation sector only.

The goal of this study is to examine the current environmental impacts of air transport in Switzerland and to assess how future developments and technology improvements may influence the results in year 2050. Furthermore, the results are examined with respect to the change in the variables such as aircraft weight, fuel consumption, flight length or assumption about filling up the baggage hold that is used for passenger luggage (practice known as belly cargo). Life Cycle Assessment (LCA) methodology is used in this thesis to assess the environmental impacts of passenger air transport in Switzerland for aircraft with construction year 2015 and 2050. Five different generic models of passenger aircraft (regional; small and large narrow body; small and large wide-body) are developed and further examined.

Presented results show that the cruise phase is responsible for the majority of the greenhouse gas emissions (GHG). Much smaller, but still significant contributions come from the landing and take-off cycles and fuel production. They differ considerably due to the underlying assumption of average flight distance that is related to plane size. Regional aircraft are found to emit 157 g of CO_2 equivalent per passenger-kilometer (PKM), while the large wide-body one 71 g of CO_2 equivalent per PKM assuming the fill-up rate of 100% and average flight distances.

Belly Cargo in the case of low seat load factor was found to have crucial impact on the results. Sensitivity analysis shows that without applying this practice, GHG emissions may rise even up to 50% depending on the plane category. Two other crucial developments that influence the environmental impacts of future aircraft are fuel efficiency and exhaust emissions improvement rates and light-weighting of the aircraft structure.

This work implies that the most effective way to address the environmental impacts from air transport is to reduce fuel consumption while at the same time increasing the number of passengers on board or use the spare volume to carry additional freight.