Global Journals LaTeX JournalKaleidoscope™

Artificial Intelligence formulated this projection for compatibility purposes from the original article published at Global Journals. However, this technology is currently in beta. *Therefore, kindly ignore odd layouts, missed formulae, text, tables, or figures.*

Air Transport and Sustainable Development: What Complementarities and Compatibility for the Future?

N. P. Mootien[1] and N. P. Mootien[2]

[1] University of Technology, Mauritius

Received: 11 December 2011 Accepted: 6 January 2012 Published: 16 January 2012

Abstract

History is replete of its own repetitions and contradictions and domestic and international air transport are no exceptions. It has now become necessary for several reasons to assess how limited resources could be more wisely used for further welfare and economic growth without threatening the very existence of mankind. In other words we need to stop ?shooting ourselves in the foot? by playing a game of duplicity when it comes to ecology and environmental protection the paradox of economic development and industrialization. The 20th century has seen the rapid and swift development of both international and domestic air transport worldwide. Emphases then were on efficiency, speed, comfort, cabin and cargo space and load factor. In the 2nd half of the last century, more specifically in the early 70s up to the end of the century and as a result of energy crises, oil peaks and price hikes of cartels, more attention was given to fuel efficiency. Air transport being an essential service has forced most aircraft manufacturers to devote more energy, investment and time to designing better equipment. In so doing, aircraft manufacturers, airline operators and governments have all overlooked the issue of sustainability. This oversight has now become a major concern for all. Because of the global but fragmented nature of air transport, it is difficult to regulate the industry in order to establish standard policies and procedures. Attempts made by the European Union have so far produced mitigated results. In this paper, we look at the contradictions and paradoxes when nations have to make a choice between the?now? and the ?future?, between the options of further economic growth and sustainability and between welfare and wealth.

Index terms— International and domestic air transport, sustainability, policies, carbon emissions.

1 INTRODUCTION

his paper questions the complementarities and compatibility of civil aviation with sustainability. Climate change is today recognized as one of the most serious challenges to the global community, potentially affecting almost all aspects across the planet. This century will pose some serious challenges to several sectors of the international economy. How will governments reconcile economic growth and development with the environmental impacts of such an industry like the transport industry in general and air transport in particular.

Author : University of Technology, Mauritius E-mail : nmootien@umail.utm.ac.mu Air transport as an essential service will continue to play a very important role in industrialization and economic growth. Airlines will continue to transport tourists and freight on long and short distances. However, principles of airline management will have to be revisited if the industry is to be sustainable both environmentally and economically. This paper will establish that there are ways to make it sustainable provided there is political will and the industry is viewed in its global perspective rather in a piecemeal way or within an attempt to apportion responsibilities to airline operators and owners or countries where the airlines fly from.

It is necessary for all stakeholders (operators, airline owners and governments) to adopt new methods of management and look in to cost effective means in terms of energy consumption and effects on the environment in general. Admittedly, at this stage our approach is rather fragmented and it is imperative that organizations like IATA, ICAO and the UN establish the required bases for more consolidation and globalization of airline operations worldwide.

2 LITERATURE REVIEW a) Strategies

Consumers are now more conscious and conscientious about environment friendliness and the necessity to consume 'smart'. The preferred strategy to achieve sustainability is to consume more efficiently (Sorrel, 2010) which implies reducing the environmental impacts associated with each good or service. But the success of this approach will definitely depend on the size of the rebounding effects. A related and complementary strategy is to consume differently (Sorell, 2010) which implies shifting to alternative modes of transport with a lower environmental impact. In a review, Heiskanen and Jalas ??2003) concluded that the environmental benefits of product-to-service arrangements are modest at best while ??uh (2006) estimates that a shift to serviceoriented economy could actually increase carbon emissions owing to the heavy reliance of services on manufactured goods. However, Sorell (2010) points out that developed countries are outsourcing the manufactured goods from developing countries confining the impacts on environment to the latter. emissions between 1990 and 2004, but this changes to a 15% increase when the emissions embodied in international trade are accounted for. Nonetheless, given the potential limitations of consuming efficiently and differently, it seems logical to examine the potential of a third option: simply consuming less (Sanne, 2000; ??chor, 1999;Princen, 2005). The key idea here is sufficiency, defined by Princen (2005) as a social organizing principle that builds upon established notions such as restraints and moderation to provide rules for guiding collective behavior. The primary objective is to respect ecological constraints, although most authors also emphasize the social and psychological benefits to be obtained from consuming less.

While Princen (2005) cites examples of sufficiency being put to practice by communities and organizations, most authors focus on the implications for individuals. They argue that 'downshifting' can both lower environmental impacts and improve quality of life, notably by reducing stress and allowing more leisure time.

3 III. SUSTAINABILITY IS INCOMPATIBLE WITH CONTINUED ECONOMIC GROWTH IN RICH COUNTRIES

There is a direct correlation between energy consumption and carbon emission. Unless clean, alternative sources of energy are found very quickly, we will not be able to reduce global warming. However, in the developed countries, increase in economic growth has been associated with over consumption and hence, a negation of the principles of sustainability.

The preceding arguments highlight a conflict between reducing energy consumption and carbon emissions in absolute terms while at the same time continuing to grow the economy. Recognizing the importance of rebound effects and the role of energy in driving economic growth therefore re-opens the debate about limits to growth. This debate is longstanding and multifaceted, but a key point is that the goal of economic development should not be to maximize GDP but to improve human well-being and quality of life. Material consumption is merely a means to that end and GDP is merely a measure of that means. GDP measures the costs rather than the benefits of economic activity and is only a proxy for welfare under very restrictive conditions (Weitzman 1976). It is likely that, beyond a certain level increased material consumption will reduce well-being, since the (typically unmeasured) social and environmental costs will exceed the benefits. As Ekins (1992) argues, human well-being is not determined solely by the consumption of goods and services but also by human capital (e.g., health, knowledge), social capital (e.g., family, friends and social networks) and natural capital (i.e., ecosystems and the services they provide), none of which are necessarily correlated with GDP. Attempts to value these contributions through the use of alternative measures of economic progress typically find that well-being is not improving or even declining in rich countries, despite increases in GDP ??Noury 2008 ?? Victor 2008). Hence, while growth in per capita income is likely to improve well-being in developing countries, the same may not be true for developed countries.

4 IV. THE CASE OF INTERNATIONAL AND DOMESTIC AIR TRANSPORT

The 20 th century has seen the rapid and swift development of both international and domestic air transport worldwide. Emphases then were on efficiency, flight duration, stopovers, speed, cabin and cargo space and load factor. In the 2 nd half of the last century, more specifically in the early 70s up to the end of the century and as a result of various energy crises, oil peaks and price hikes of cartels, more attention was given to fuel efficiency. Air transport being an essential service has forced most aircraft manufacturers to devote more energy, investment and time designing better equipment. In so doing, aircraft manufacturers, airline operators and governments have overlooked the issue of sustainability. This oversight has now become a major concern for all.

Because of the global but fragmented nature of air transport, it is difficult to regulate the industry in order to establish standard policies and procedures. Attempts made by the European Union have so far produced mitigated results.

One of the major issues regarding international and domestic air transport today is the sustainability of the industry in an era where the world is having a different approach to its ecological future and survival. This paper will endeavour to show whether the world can reduce its dependence on this form of transportation in order to curb the negative effects on the environment or should the air transport operators devise new ways and means to fly while reducing all the adverse effects such as air and noise pollution. Already in Europe and the US, more and more travelers are finding alternatives to air transport. This paper will look at several proposals and recommendations with a view to make the industry more sustainable. This approach will require the involvement of all stakeholders namely airlines, airports, craft manufacturers, legislators and air traffic management.

V.

5 CLIMATE CHANGE

It is now widely recognized that there is an urgent need for the world community to address the challenge of climate change. Sustainable development Aircraft engines, particulates and gases which contribute to climate change (ICAO 2008) and global dimming. Despite emission reductions from automobiles and more fuel efficient and less polluting turbofan and turboprop engines, the rapid growth of air travel in recent years contributes to an increase in total pollution attributable to aviation. In the EU, greenhouse gas emissions from aviation increased by 87% between 1990 and 2006. There is an ongoing debate about possible taxation of air travel and the inclusion of aviation in an emission trading scheme, with a view to ensuring that the total external costs of aviation is taken into account ??EU 2006).

VI.

6 MECHANISMS

According to IPCC (Intergovernmental Panel on Climate Change), subsonic aircraft-in-flight contribute to climate change in four ways: CO_2 emissions from in flight aircraft are the best and most significant element of aviation's total contribution to climate change ??Sausen et al 2007). The level and effects of CO_2 emissions are currently believed to be broadly the same regardless of altitude (i.e. they have the same atmospheric effects as ground based emissions). In 1992, emissions of CO_2 , from aircraft were estimated at around 2% of all such anthropogenic emissions, and that year the atmospheric concentration of CO_2 attributable to aviation was only around 1% of the total anthropogenic increase since the industrial revolution, having accumulated primarily over just the last 50 years (IPPC 199). De Haan (2009) argues that CO_2 is emitted "at such an altitude that it will not easily be removed from the atmosphere and thus, will continue to have an impact on climate change for a relatively longer period of time". He also points out that "CO_2 has a strong relation with fuel consumption. There is a strong economic incentive to reduce fuel consumption in aviation. As a result of that aircraft have become very efficient in their fuel consumption. Flying one aircraft seat costs roughly the same as, or even less than, driving a car, only aircraft have ten times the speed of a car. However, people drive cars for relatively small distances, whereas they fly planes over long distances. Therefore in absolute terms, flights require a lot of fuel, and the result, thus, is a lot of CO_2 emission".

7 Carbon dioxide (CO_2)

At the high altitudes flown by large jet airliners around the tropopause, emissions of NOx are particularly effective in forming ozone (O_3) in the upper troposphere. High altitude (8-13 km) NOx emissions result in greater concentration of O_3 than surface NOx emissions and these in turn have a greater global warming effect. The effects of O_3 concentrations are regional and local as opposed to CO_2 emissions which are global (IPPC 1999).

8 Oxides of Nitrogen (NOx)

One of the products of burning hydrocarbons in oxygen is the water vapour, a greenhouse gas. Water vapour produced by aircraft engines at high altitudes, under certain atmospheric conditions, condenses into droplets to form concentration trails also known as contrails. Cirrus clouds have been observed to develop after the persistent formation of contrails and have been found to have a global warming effect over and above that of contrail Water Vapour (H_2O) should remain safe and affordable in order to ensure mobility on an equitable basis to all elements of society. The international community has a shared interest in ensuring that civil aviation can continue to deliver vital social and economic benefits, while addressing its impacts on the global climate (Sustainable Aviation, 2010). Like all human activities involving combustion, most forms of aviation release carbon dioxide (CO_2) and other green gases into the earth's atmosphere, contributing to the acceleration of global warming (Anderson 2008) and ocean acidification (McNeil and Matear 2008). In addition to the CO_2 released by most aircraft in flight through the burning of fuels such as Jet-A (turbine aircraft) or Avgas (piston aircraft), the aviation industry also contributes to greenhouse gas emissions generated by the production of energy used in airport buildings, the manufacture of aircraft and the construction of airport infrastructure

(Hovarth and Chester 2008). While the principal greenhouse gas emission from powered aircraft in flight is CO_2 , other emissions may include nitric oxide and nitrogen dioxide, also sometimes referred to oxides of nitrogen or NOx, water vapour and particulates (soot and sulfate particles), sulfur oxides, carbon monoxide, partly burned hydrocarbons, tetra-ethyl lead and radicals such as hydroxyl. The contribution of civil aircraft-in-flight to global CO_2 emissions has been estimated at around 2%. However, in the case of highaltitude airliners which frequently fly near or in the stratosphere, non-CO_2 altitude-sensitive effects may increase the total impact on anthropogenic (manmade) climate change significantly (IPCC 1999). formation alone. However, there is a degree of scientific uncertainty about the contribution of contrail 2012 ebruary F worldwide also relies on access to aviation which and cirrus cloud formation to global warming and attempts to estimate aviation's overall climate change do not tend to include its effects on cirrus cloud enhancement ??Sausen et al 2008).

Least significant is the release of soot and sulfate particles. Soot absorbs heat and has a warming effect; sulfate particles reflect radiation and have a small cooling effect. In addition, they can influence the formation and properties of clouds ??EU 2005). All aircraft powered by combustion will release some amount of soot.

9 Particulates

10 VII. CO 2 EMISSIONS PER PASSENGER KILOMETRE

Emissions of passenger aircraft per passenger kilometre vary extensively, according to variables such as the size of the aircraft, the number of passengers on board, and the altitude and the distance of the journey as the practical effect of emissions at high altitudes may be greater than those emissions at low altitudes. In 2009, the LIPASTO survey in Finland provided some figures for CO_2 and CO_2 equivalent per passenger kilometre:

-Domestic, short haul distances, less than 463 km: 257 g/km CO_2 or 259 g/km CO_2 e -Domestic, long haul distances, greater than 463 km: 177 g/km CO_2 or 178 g/km CO_2 e -Long haul flights: 113 g/km CO_2 or 114 g/km CO_2 e For perspective, per passenger a typical economy-class New York to Los Angeles round trip produces about 715 kg of CO_2 but is equivalent to 1,917 kg of CO_2 when the high altitude "climatic forcing" effect is taken in to account (Nevins 2010). Within the categories of flights above, emissions from scheduled jet flights are substantially higher than chartered jet flights. The emissions above are similar to a four-seat car with one person on board (LIPASTO 2009). However, flying trips often cover longer distances than cars, so the total emissions are much higher. About 60% of aviation emissions arise form international flights and these flights are not covered by the Kyoto Protocol and its emissions reduction targets (Owen et al. 2010). Per passenger kilometre, figures from British Airways suggest CO_2 emissions of 0.1 kg for large jet airliners -a figure that does not account for the production of other pollutants or condensation trails (Goodall 2007).

11 VIII.

12 TOTAL CLIMATE EFFECTS

In attempting to aggregate and quantify the total climate impact of aircraft emissions, the IPCC has estimated that aviation's total climate impact is some 2 to 4 times that of its direct CO_2 emissions alone excluding the impact of cirrus cloud enhancement ??IPCC 1999). This is measured as radiative forcing. While there is uncertainty about the exact level of impact of NOx and water vapour, governments have accepted the broad scientific view that they do have an effect. Globally in 2005, aviation contributed possibly as much as 4.9% of radiative forcing (Owen et al 2010). UK government policy statements have stressed the need for aviation to address its total climate change impacts not simply the impact of CO_2 (HMSO White Paper 2003).

The IPCC has estimated that aviation is responsible for around 3.5% of anthropogenic climate change, a figure which includes both CO_2 and non-CO_2 induced effects. The IPCC gas produced scenarios estimating what this figure will be in 2050. The focus point of the estimate is that aviation's contribution could grow to 5% of the total contribution by 2050 if action is not taken to tackle these emissions, though the highest scenario is 15%! (IPCC 1999). Moreover, if other industries achieve significant cuts in their own greenhouse gas emissions, aviation's share as a proportion of the remaining emissions could also rise.

13 IX.

14 FUTURE EMISSIONS LEVELS: IMPROVED EFFICIENCIES VS. THE TREND IN INCREASED TRAVEL AND FREIGHT

Admittedly, there have been significant improvements in fuel efficiency through aircraft technology and operational management but these improvements are being overshadowed by the increase in traffic volumes. From 1992 to 2005 and in spite of 09/11 and two significant wars, passenger kilometers increased by 5.2% annually. During the first three quarters of 2010, air travel markets expanded at an annualized rate approaching 10% (IATA 2010).

15 X.

16 INCREASING EFFICIENCIES OF AIRCRAFT AND THEIR OPERATIONS

Modern jet aircraft are significantly more fuel efficient and thus emit less CO 2 than 30 years ago. Aircraft fuel efficiency has improved by some 50% over the past 30 years (IATA/ATAG 1999). Moreover, manufacturers have forecast and are committed to achieving reductions in both CO 2 and NOx emissions each new generation of design and engine **??**ACARE 2002). Therefore, the accelerated introduction of more modern aircraft represents an opportunity to reduce emissions per passenger kilometre flown. However, aircraft are major investments that are endured for decades and the replacement of international fleet is therefore a long term proposition which will greatly delay realizing the climate benefits of these improvements in aircraft design and engine. Engines can be changed at some point but nevertheless 2012 ebruary F airframes have a long life (ICAO 2001). It is also to bear in mind that in real situations, such aircrafts once depreciated are never phased out immediately. Because of high costs of equipment, they are either resold to private operators or developing countries where rules are either more relaxed or flexible than in the US and the EU. Moreover such equipment are often leased on a wet or dry lease basis.

Other opportunities arise from the optimization of airline timetables, route networks flight frequencies to increase load factors (ICAO 2001) together with the optimization of air space. Another possible reduction of the climate-change impact is the limitation of cruise altitude of aircraft. This would lead to a significant reduction in high-altitude contrails for a marginal trade off increased flight time and an estimated 4% increase in CO 2 emissions. Drawbacks of this solution include very limited airspace capacity to do this, especially in Europe and North America and increased fuel burned because jet aircraft are less fuel efficient at lower cruise altitudes (Williams et al 2002). On a more positive note, turboprop aircraft are known to bring two major benefits: they burn less fuel per passenger mile and they fly at lower altitudes, well inside the tropopause, where there are no major concerns about the ozone or contrail production.

17 XI.

18 ALTERNATE FUELS

Some research organisations have been experiencing on the following biofuels: ethanol, combination of coconut and babassu oils and jatropha oil. However there are major concerns from pressure groups that production of organic oils would lead to deforestation and a large increase in greenhouse gas emissions. The vast amount of land needed is more of a deterrent to produce biofuels for both civil and military aviation (Rapier 2011). However the latest research shows that Jatropha can thrive on marginal agricultural land where many trees and crops do not grow or would produce only slow growth yields (Oxburgh 2008). Other researches are now being carried out with components of algae and jatropha.

19 XII.

20 REDUCING AIR TRAVEL

Aviation has been growing faster than any other source of green house gases. In the UK alone between 1990 and 2004, the number of people using airports rose by 120% and the energy the planes consumed increased by 79%. Their CO 2 emissions almost doubled in that period -from 20.1 to 39.5 megatonnes or 5% of all emissions produced in the country (Monbiot 2006). However, attempts to discourage air travels have not been very successful. Flying is still associated with glamour and social status. With most international conferences having hundreds if not thousands of participants, and the bulk of these usually travel by plane, conference travel is an area where significant reductions in air-travel-related CGH emissions could be made and as Reay (2004) argues, this does not mean non-attendance. Teleconferencing and other forms of technology could be used if we want to reduce unnecessary air travel. But Marshall (2009) is persuaded that many travelers still find it hard to believe that air travel could be replaced by alternative modes of transport.

21 XIII.

22 ENDING INCENTIVES TO TRAVEL AND FREQUENT FLYER PROGRAMMES

Over 130 airlines have frequent flyer programmes based at least in part on miles, kilometers, points or segments of flights taken. In 2005, globally such programmes included some 163 million people. These programmes benefit airlines by habituating people to air travel and through the mechanics of partnership with credit card companies and other businesses [?] The only part of United Airlines that was making money when the company filed for bankruptcy was its frequent flyer programme (The Economist Dec 2005). Concerning business travel, the ease of international travel and the fact that, for most of us, the costs are met by our employers, means that globe trotting conference travel is often regarded as a perk of the job (Reay 2004). However, the perk usually is not only the business trip itself, but also the frequent flyer points which the individual accrues by taking the trip, and which can be redeemed later for personal air travel. Thus a conflict of interest is established whereby bottom-up pressure may be created within a firm or government agency for travel that is really not necessary. Even when such conflict is not a motivation, the perk of frequent flyer miles can be expected to lead in any cases to personal trips that would not be taken if a ticket had to be paid out of personal funds (UNEP DTIE 2009). In some countries, by just using an airline-sponsored credit card to pay for ones household or other such expenses or even personal bills paid by an employee and claimed from an employer , frequent flyer points can be racked quickly (The Economist Dec 2005). Thus, free travelfor which the individual has to pay nothing extra -becomes a reality. Across society, this too can be expected to lead to much air travel -and green gas emissions -that otherwise would not occur. Several studies have contemplated the elimination of FFPs, on the grounds of anticompetitiveness (Storm 1999), ethics, conflict with society's overall well-being , or climate effects. Some countries even went to the extent of banning such programmes. Denmark did not allow the programmes until 1992, then changing its policy because its airlines were disadvantaged (Storm 1999). In 2002, Norway banned FFPs in order to promote competition among its airlines **??**Berglund 2002). In 1989, some US airlines were of the opinion that governments should consider putting an end to the FFPs as they encourage unfair competition **??**Michael 1989).

XIV.

23 DECREASING DEMAND FOR AIR TRAVEL

One means of reducing impact of aviation is to constrain demand for air travel, through increased fares in place of expanded airport capacity.

24 KYOTO PROTOCOL

Greenhouse gas emissions from fuel consumption in international aviation, in contrast to those from domestic aviation and from energy use by airports, are not assigned under the firs round of the Kyoto Protocol, neither are the non-CO 2 climate effects. In place of an agreement , governments agreed to work through the ICAO to limit or reduce emissions to find solutions to the allocation of emissions from international aviation in time for the 2 nd round of Kyoto in 2009 in Copenhagen; however, the conference failed to reach an agreement on these emissions (GreenAirOnline 2009).

25 XVI.

26 EMISSIONS TRADING

As part of that process the ICAO has endorsed the adoption of an open emissions trading system to meet CO 2 emissions reduction objectives. Guidelines for the adoption and implementation of a global scheme have been developed and presented at the ICAO assembly in 2007, although the prospects of a comprehensive intergovernmental agreement on the adoption of these guidelines are still uncertain. Within the EU, however, the European Commission has resolved to incorporate aviation in the EU Emissions Trading Scheme (ETS) (EC 2005). A new directive has been adopted by the European Parliament in July 2008 and it is expected to be effective from January 2012 (EC 2008). Emissions trading ensures that aggressive emission cuts are achieved, either through cutting emissions further within the aviation sector or paying other sectors that are able to reduce emissions at lower cost. Through trading, the abatement efforts are shared between sectors of the economy in the most cost-effective manner. The idea that all sectors must make the same absolute contribution misses the point of using emissions trading emissions trading to find the most cost-effective share of effort (Manifesto for Copenhagen 2009) XVII.

27 PROPOSALS AND RECOMMENDATIONS a)

It necessary for each organisation to have a policy statement on its ambition to reduce environment impact by reducing travel and making travel more efficient.

28 A reduction in travel b)

The combination of several missions or sectors on a single ticket instead of several journeys. Each landing and takeoff increases the carbon footprint of any aircraft.

29 Consolidation of long haul travel instead of multiple travels for the same purposes c)

Recruitment of expatriates is to be limited to the necessary personnel really indispensable for the purpose of the organization.

Encourage the recruitment of local staff instead of expatriates wherever possible d)

Organizations to limit the number of participants to the bare minimum Reduce the number of participants and staff attending official missions and conferences e) Many meetings could be conducted via ICT (Information and

Communication Technology) such as telephone, e-mail, video conferencing, virtual meeting rooms or personalized (PC to PC) video links.

30 Use of alternative means of communication such as virtual technology for meetings, seminars and conferences f)

The carbon footprint of any travel depends not only on the distance travelled but also on the form of travel used. Travel usually has a much smaller footprint than travel by car. Travel by car usually has a smaller carbon footprint than travel by air. Air travel in economy Encourage more efficient and alternative modes of transport: train and road travels for short haul distances 2012 ebruary F class has a smaller carbon footprint than travel in business class and business class has a smaller carbon foot print than travel in first class. The lower the class, the smaller share of the aircraft and associated emissions does the ticket represent. Normally a business seat accounts for twice the emissions of an economy seat and a first class seat three times the emissions of an economy.

31 g)

Travel by modern aircraft has normally a smaller footprint than older aircraft. Governments in their bilateral and multilateral agreements should give preference to routings and airlines minimizing the number of landings and takeoffs and using more modern aircraft.

32 Governments to purchase modern low emission aircrafts h)

One of the proposals being considered now is to create economies of scale by making aircraft larger. The currently largest available aircraft, the Airbus A380, can host 550 passengers in a 3-class configuration and up to 800 passengers if all seats would be shortpitch economy class (de Haan 2009). A preliminary design study (Blok et al. 2001) of a larger aircraft flying 1000 passengers showed advantages in terms of costs and fuel consumption (and thus CO2 emission) of roughly 10% per flown seat kilometre. However, disadvantages were also found, ranging from psychological resistance by both potential passengers and crew to fly with so many people together in one plane.

Aircraft Technological Development XVIII.

33 CONCLUSION

This paper has attempted to show that energy consumption will have to live side by side with sustainability unless clean, alternative sources of energy are found and used more than fossil fuels. We have also shown that economic growth is to some extent incompatible with sustainability and will not be complementary with each other until there is a change in people's mindset and in the approach towards industrial development, consumption and basic economic parameters. Economic growth just for the sake of greater wealth and comfort is no longer a panacea for social advancement. Society will have to make choices in terms of forgone alternatives. [1]

Figure 1: TKeywords:

[Blok ()] , G Blok . 2001. 2006. London: Delft British House of Commons Publications. 3. Faculty of Aerospace Engineering, Delft University of Technology

[Manifesto For Copenhagen ()] *2009) We still don't believe in climate change*, Manifesto For Copenhagen . climatedenial.org. 2009. UK Marshall, G. (Sustainable Aviation)

[Ekins ()] 'A Four-Capital Model of Wealth Creation'. P Ekins . *In Real-Life Economics: Understanding World Creation* Ekins, P., Max-Neef, M., Eds., Routledge (eds.) 1992.

[Unep Dtie ()] *A Guide to Greenhouse Gas Emission Reduction in UN Organisations, Sustainable Consumption & Production Branch 26. Victor, P. Managing Without Growth: Slower by Design, Not Disaster*, Unep Dtie . 2009. 2008. Aldershot, UK.

[Lipasto ()] *Average passenger aircraft emissions and energy consumption per passenger kilometre in finland*, Lipasto . 2009. 2008.

[Aviation and the Global Atmosphere: A Special Report of the Intergovernmental Panel on climate Change IPCC ()] 'Aviation and the Global Atmosphere: A Special Report of the Intergovernmental Panel on climate Change'. *IPCC* 1999. 2007. Cambridge University Press. 11. (IPCC (2007a) Summary for Policy Makers, Climate Change)

[Sausen and Isaksen ()] *Aviation Radiative Forcing in 2000: an Update on IPCC Schor, J. The Overspent American: Upscaling, Downshifting, and the New Consumer*, R Sausen , I Isaksen . 2005. 1999. Basic Books; New York, NY, USA.

[Goodall ()] 'Can services lead to radical eco-efficiency improvements?-A review of the debate and evidence'. C Goodall . *ISBN 1844074269 Heiskanen, E.; Jalas, M*, 2007. 2003. Earthscan Publications Ltd. 10 p. . (How to Live a Low-carbon Life: The Individual's Guide to Stopping Climate Change)

[Climate change: Commission proposes bringing air transport into EU Emissions Trading Scheme ()] *Climate change: Commission proposes bringing air transport into EU Emissions Trading Scheme*, 20. 2006. EU Press Release. 12.

[Sanne ()] 'Dealing with environmental savings in a dynamical economy-How to stop chasing your tail in the pursuit of sustainability'. C Sanne . *Energ. Policy* 2000. 28 p. .

[Sorrell ()] 'Energy, Economic Growth and Environmental Sustainability: Five Propositions, Sustainability, Sussex Suh, S. Are services better for climate change?'. S Sorrell . *Environ. Sci. Technol* 2010. 2006. 40 p. .

[Hmso ()] 'Environmental Life-cycle Assessment of Passenger Transportation: An Energy, Greenhouse Gas and Criteria Pollutant Inventory of Rail and Air Transportation'. Hmso . *The Future of Air Transport White Paper Hovarth, A. and Chester, M*, 2003. 2008. 2010. University of California Transportation Centre (Air Transport Market analysis, Geneva IATA/ATAG (1999) Aviation and Environment: aircraft fuel efficiency has improved by 50% over the past 30 Years)

[Michael ()] 'Kicking the Habit: air Travel in the Time of Climate Change, Yes Magazine Nourry, M. Measuring sustainable development: Empirical evidence for France from eight alternative indicators'. K Michael . 13.12.2010. *The Guardian*, (Orlando Sentinel, Florida, USA Monbiot, G; UK Nevins, J) 2006. 2008. 67 p. . (On the Flight Path to Global Meltdown)

[Rapier ()] 'New Directions : Flying in the face of the climate change convention'. R Rapier . *Atmospheric Environment* Reay, D. S. (ed.) 2011. 2004. 38 p. . (Marginal Land Produces Marginal Biomass, consumer Energy Report)

[Weitzman ()] 'On the welfare significance of the national product in a dynamic economy'. M L Weitzman . *Q. J. Econ* 1976. 90 p. .

[Icao ()] *Operational Opportunities to Minimize fuel Use and Reduce Emissions*, Icao . 2001.

[Williams ()] 'Reducing the Climate Change Impacts of Aviation by Restricting Cruise altitudes, 29'. V Williams . *Transportation Research Part D: Transport and Environment* 2002. 7 (6) p. .

[Anderson ()] 'Reframing Climate Change: From Long-term Targets to Emission Pathways'. K Anderson . 17. 06. *N. (19.03.2002) Sterling polishes plans for new routes*, (Aftenpost, Norway) 2008. Tyndall Centre for Climate Change Research, University of Manchester Berglund,

[Mcneil and Matear ()] 'Southern Ocean Acidification: A tipping point at 450-ppm atmospheric CO2'. B I Mcneil , R J Matear . 105:48:18860. *National Academy of Sciences* 2008.

[Strategic Research Agenda Airports and Travel Trade Journal of Air Transport Management ()] 'Strategic Research Agenda Airports and Travel Trade'. *Journal of Air Transport Management* 2002. 12 (1) p. . (ACARE)

[Storm ()] 'Sustainable Aviation (2005) A Strategy towards sustainable development of UK aviation The Economist (20.12.2005) Frequent-Flyer Miles -Funny Money Travis'. S Storm . *Contrails reduce daily temperature range*, 1999. 2002. 24. (Nature)

[De Haan et al. ()] 'The carbon footprint of UK households 1990-2004: A socio-economically disaggregated, quasi-multi-regional input-output model'. A R De Haan , A C ; Druckman , T Jackson . *Aerlines Environmental Report* 2009. 2009. 68 p. . (Ecol. Econ)

[Princen ()] *The Logic of Sufficiency*, T Princen . 2005. Boston, MA, USA: MIT Press.

[Oxburgh et al. ()] *Through Biofuels we can reap the fruits of our labours, The guardian*, R Oxburgh , B Owen , D S Lee , Lim . 28.02. 2008. 2010. Uk. (Flying in to the Future: Aviation Emissions Scenarios to 2050, 17. Environmental Science and Technology (44:7:2255-260)