Hochschule für Angewandte Wissenschaften Hamburg
Hamburg University of Applied Sciences

AERO – AIRCRAFT DESIGN AND SYSTEMS GROUP

Eco-Efficiency in Aviation – Flying Off Course?

Dieter Scholz

Hamburg University of Applied Sciences

resilience

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Deutscher Luft- und Raumfahrtkongress 2012

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Contents

- Introduction
- Growth and Goals for Innovation
- Learning from History Looking into the Future
- Some Ideas (Air Travel Evaluator)
- Summary

Contents

Introduction

Definition: **Eco-efficiency** (Ökoeffizienz)

Eco-efficiency is based on the concept of creating more goods and services while using fewer resources and creating less waste and pollution.

World Business Council for Sustainable Development (WBCSD): "Changing Course“, 1992

The term has become synonymous with a management philosophy geared towards *sustainability*.

The **eco-efficiency strategy** has the following characteristics:

- Technological innovation the main solution
- Business as the principal actor of transformation
- Trust in markets (if they are functioning well)
- “cradle-to-cradle” (essentially waste free) growth is conducive.

Boulanger, P.M. (2010) “Three strategies for sustainable consumption”. S.A.P.I.EN.S. 3 (2)

Introduction

Definition: **Sustainability** (Nachhaltigkeit)

A sustainable development is a development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

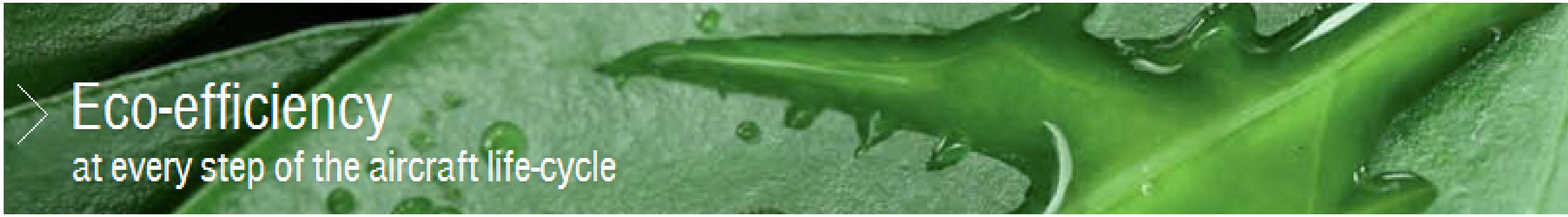
United Nations General Assembly: "Report of the World Commission on Environment and Development: Our Common Future; Transmitted to the General Assembly as an Annex to document A/42/427 – Development and International Co-operation: Environment; Our Common Future, Chapter 2: Towards Sustainable Development; Paragraph 1“. March 20, 1987. - http://www.un-documents.net/ocf-02.htm

Since the 1980s sustainability has been used especially in the sense of human sustainability on planet earth.

Translation: **off course = vom Kurs abgewichen**

Introduction

Introduction



Airbus develops eco-efficient solutions at every stage of the aircraft life-cycle:

- Optimized performance by design
- Dissemination of best environment practices within the supply chain
- Greener manufacturing processes
- Supporting efficient aircraft operations
- Recycling and re-use at end-of-life

In addition, the company assumes a leading role in improving the overall air transport system by

- contributing to the modernization of Air Traffic Management (ATM) and
- promoting low-emission alternative fuels.

Introduction

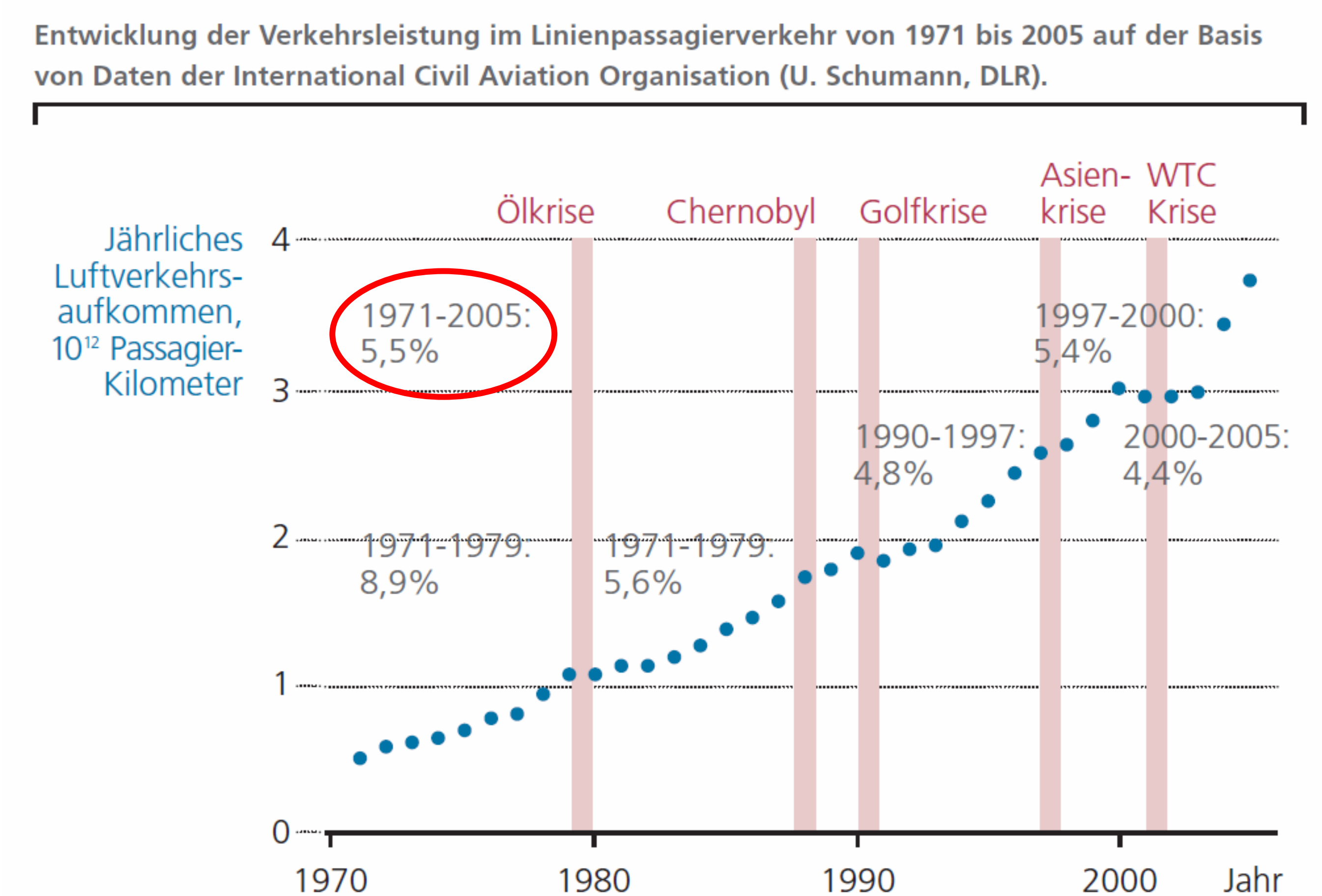
Introduction

some
have
a different
view …

Contents

- Introduction
- **Growth and Goals for Innovation**
- Learning from History Looking into the Future
- Some Ideas (Air Travel Evaluator)
- Summary

Growth and Goals for Innovation



DLR: *Klimawirkung des Luftverkehrs*. Köln, DLR, 2007

Growth and Goals for Innovation

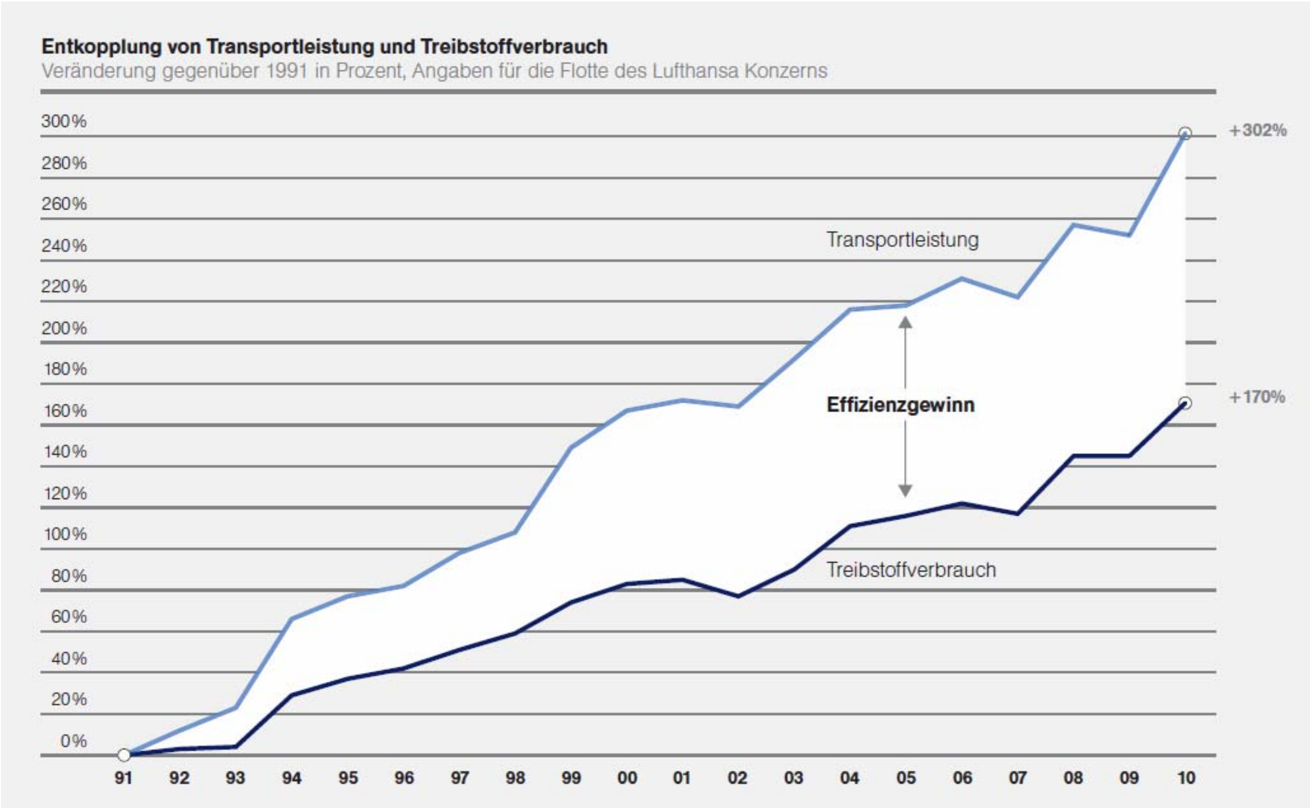
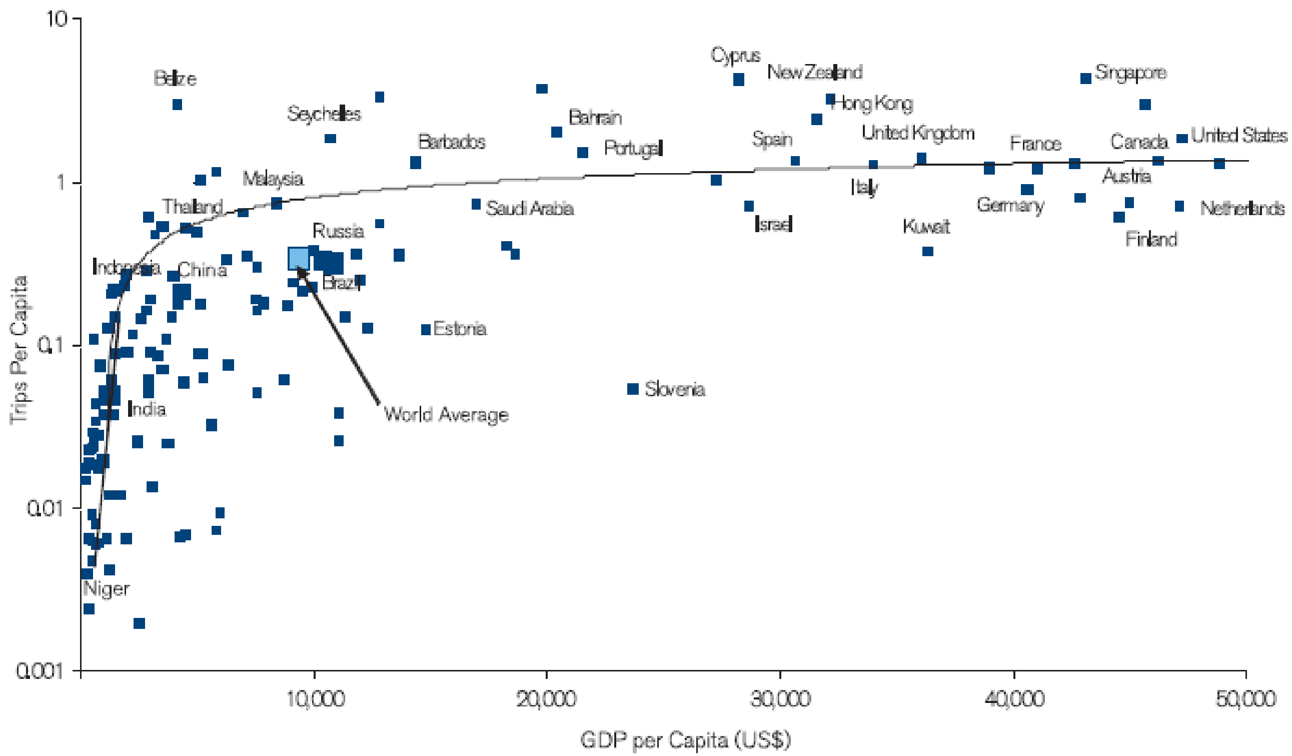


Fig.: Growth of Transport Capacity and Fuel Consumption at Lufthansa

Lufthansa: Balance – Das wichtigste zum Thema Nachhaltigkeit im Lufthansakonzert. 2011

Growth and Goals for Innovation



Only a few people fly more than one time a year. So there is still a hughe growth potential for aviation as less developed countries develop and the number of people on earth increases.

IATA: *Vision 2050*. Singapore, IATA, Report, 2011

Growth and Goals for Innovation

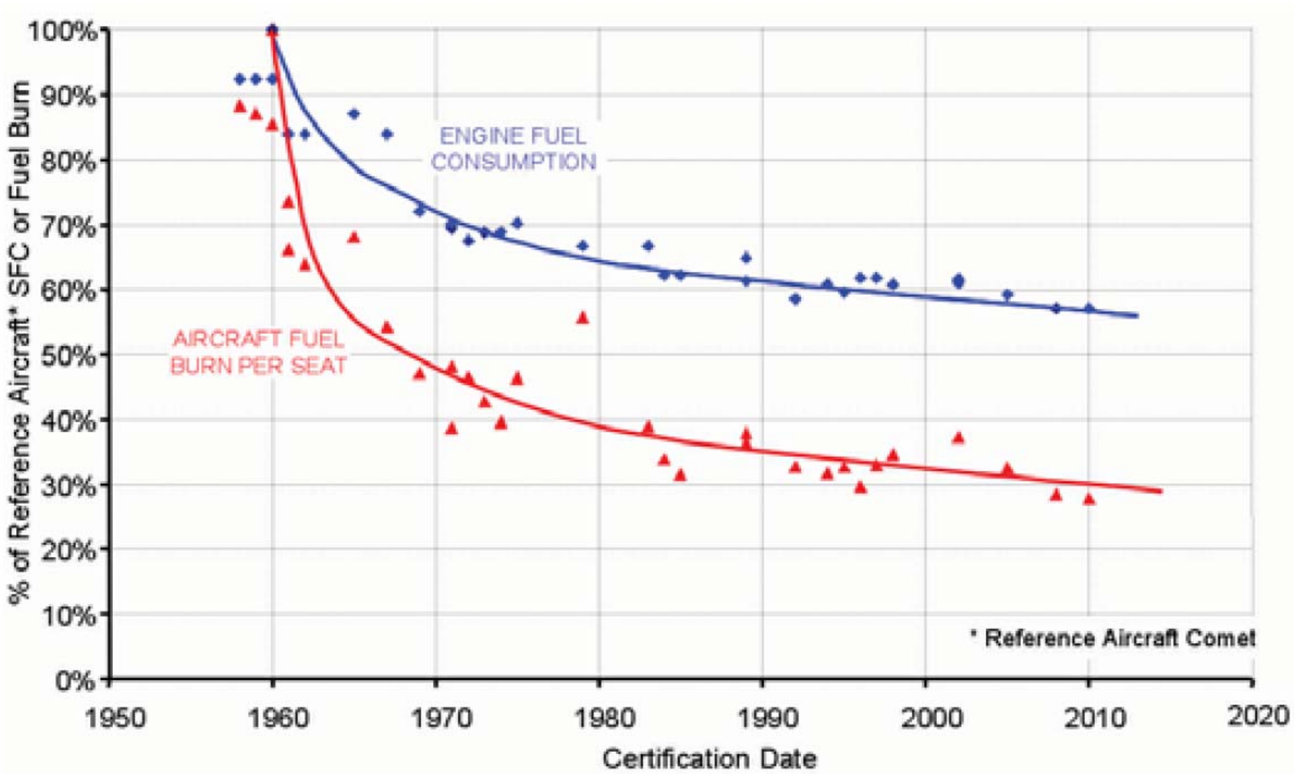
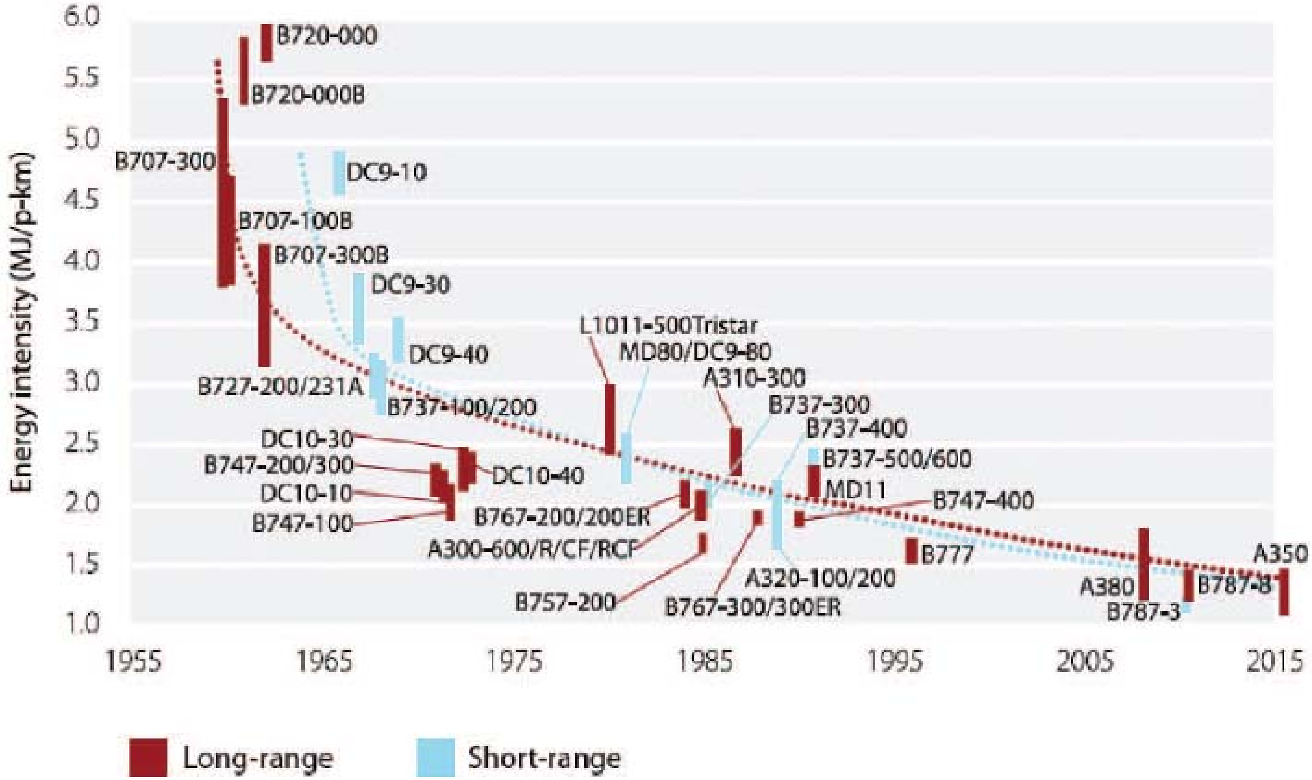


Fig.: Fuel efficiency improvements of long range transport aircraft

RAeS: *Greener by Design: Mitigating the Environmental Impact of Aviation: Opportunities and Priorities*. Royal Aeronautical Society, Report, 2005

Growth and Goals for Innovation



Fuel efficiency improvements of transport aircraft

IATA: *Vision 2050*. Singapore, IATA, Report, 2011

Growth and Goals for Innovation

ATAG Goals for the Reduction of Fuel Burn or CO2

ATAG
AIR TRANSPORT ACTION GROUP

Our climate targets:

1.5%

We will improve our fleet fuel efficiency by 1.5% per annum between now and 2020.

Stabilise

From 2020, net carbon emissions from aviation will be capped through carbon neutral growth.

50%

By 2050, net aviation carbon emissions will be half of what they were in 2005.

An Old IATA Goal for the Reduction of Fuel Burn or CO2

Home » Pressroom » Press Releases » IATA Calls for a Zero Emissions Future

No.: 21
Date: 4 June 2007

IATA Calls for a Zero Emissions Future

VANCOUVER - The International Air Transport Association (IATA) issued four challenges to drive the air transport industry towards its vision of zero emissions.

"The environmental track record of the industry is good: over the last four decades we have reduced noise by 75%, eliminated soot and improved fuel efficiency by 70%. And the billions being invested in new aircraft will make our fleet 25% more fuel efficient by 2020. This will limit the growth of our carbon footprint from today's 2% to 3% in 2050," said Giovanni Bisignani, IATA Director General and CEO.

"But a growing carbon footprint is no longer politically acceptable—for any industry. Climate change will limit our future unless we change our approach from technical to strategic. Air transport must aim to become an industry that does not pollute—zero emissions," said Bisignani.

Growth and Goals for Innovation

A New IATA Goal for the Reduction of Fuel Burn or CO2

IATA Fuel Efficiency Goal

IATA airlines have adopted a voluntary fuel efficiency goal. This is to reduce fuel consumption and CO2 emissions (per revenue tonne kilometer) by at least 25% by 2020, compared to 2005 levels.

www.iata.org (12-09-10)

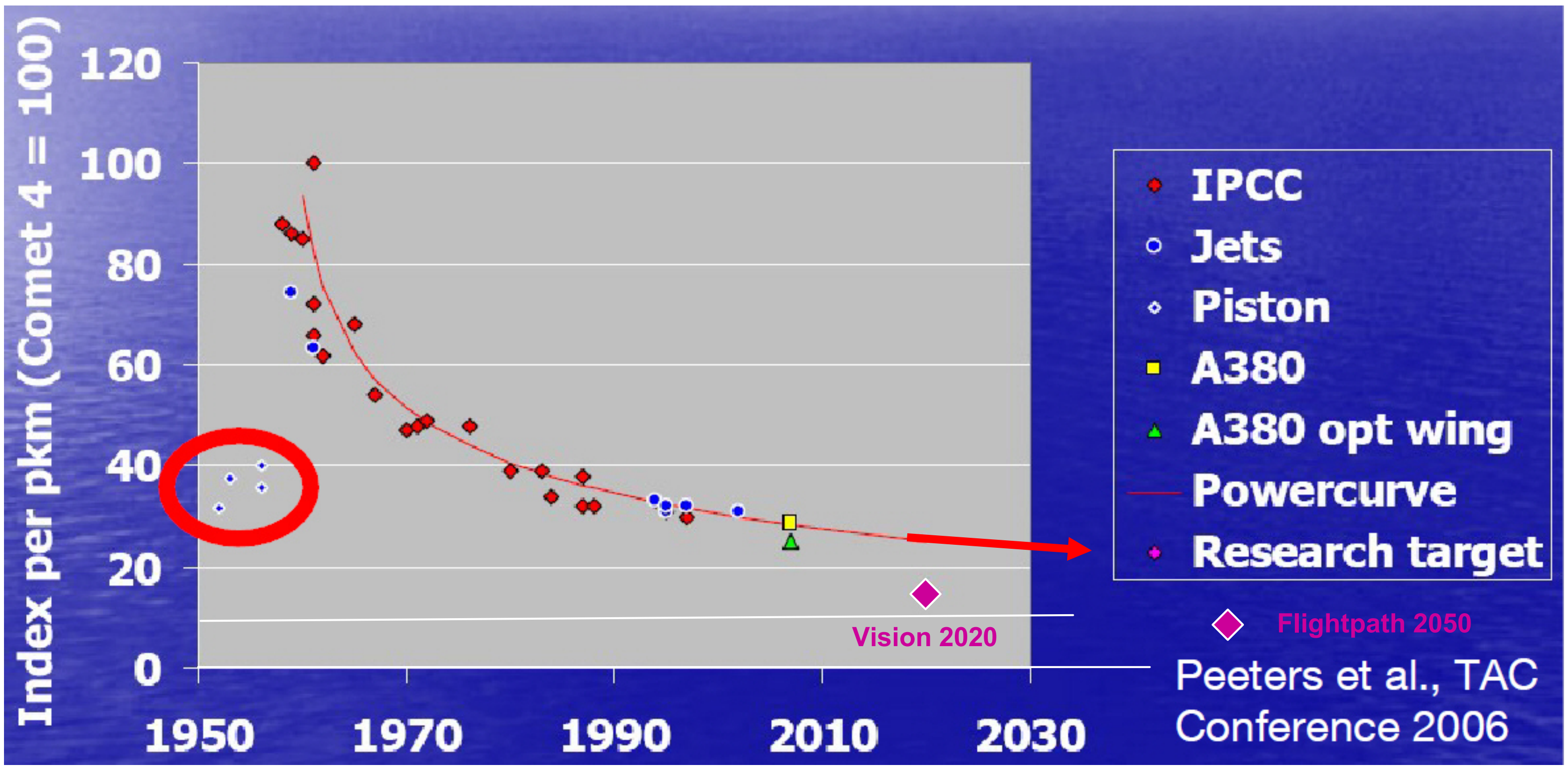
Summary of Goals for the Reduction of Fuel Burn or CO2

organization	goal	from	to	per year	level	source
ACARE	50,0%	2000	2020	2,05%	A/C	ACARE: *Vision 2020*. Luxembourg, EU, 2001 (deleted from www)
ACARE	75,0%	2000	2050	1,13%	A/C	ACARE: *Flightpath 2050*. Luxembourg, EU, 2011
ATAG	19,6%	2008	2020	1,50%	A/C	ATAG: *Towards sustainable Aviation. Summit Declaration*. Geneva, ATAG, 2012
ATAG/Airbus	0,0%	2020			fleet	ATAG: *Towards sustainable Aviation. Summit Declaration*. Geneva, ATAG, 2012
ATAG/Airbus	50,0%	2020	2050	1,36%	fleet	ATAG: *Towards sustainable Aviation. Summit Declaration*. Geneva, ATAG, 2012
IATA	zero emmission	2007	2050	1,63%	fleet	Bisignani, Vancouver, 2007. - www.iata.org (2012-09-10) (not valid anymore)
IATA	build A/C zero emission	---	2062	---	---	www.iata.org (2012-09-10)
IATA	25,0%	2005	2020	1,50%	fleet	www.iata.org (2012-09-10)
historic data	70,0%	1960	2010	1,07%		www.atag.org (2012-09-10)

- Goals are quite diverse
- Goals have been withdrawn over the years (ACARE, IATA)
- Some goals are not well defined
- Some goals may not be reached …

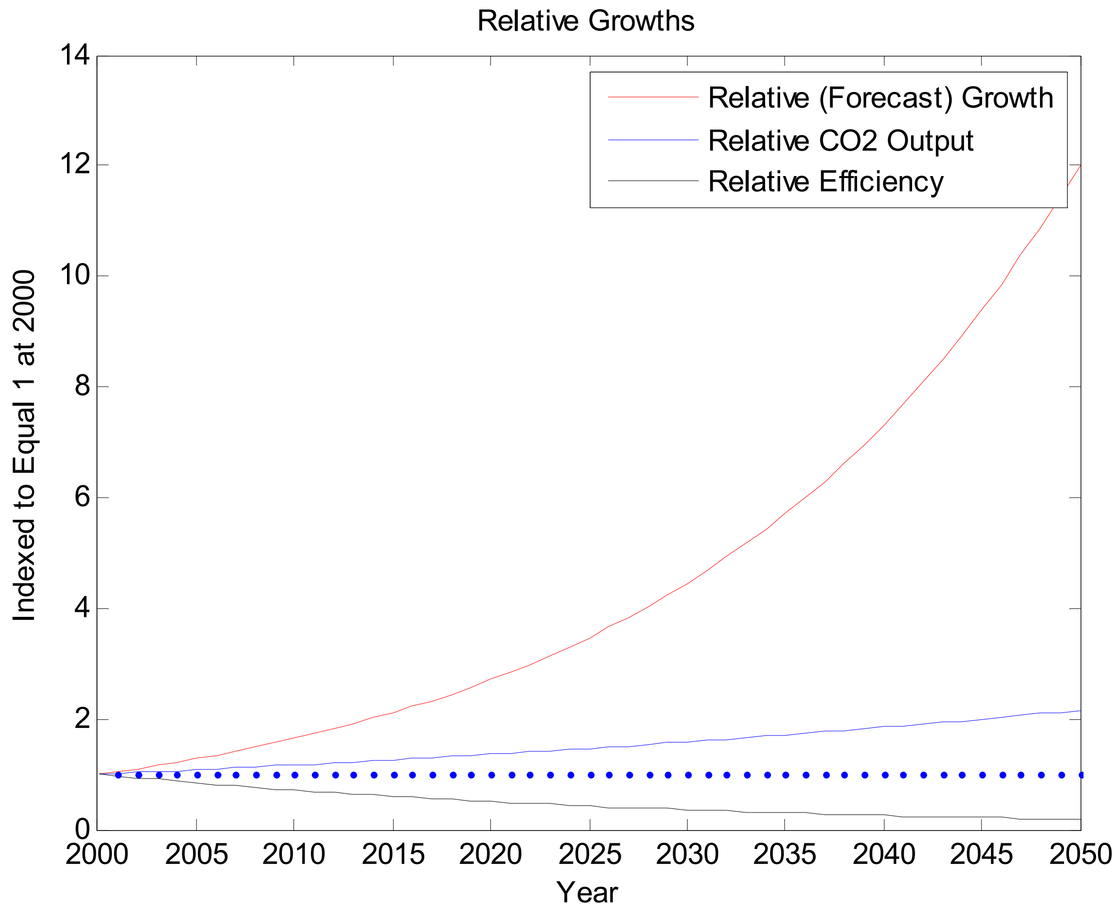
Growth and Goals for Innovation

Fuel Efficiency Improvements of Transport Aircraft Compared with ACARE Goals



Growth and Goals for Innovation

Working with Growth and Fuel Efficiency increases: Exponential Growth



Example

5,1 % Growth (p.a.)
3,6 % Effciency Increase (p.a.)

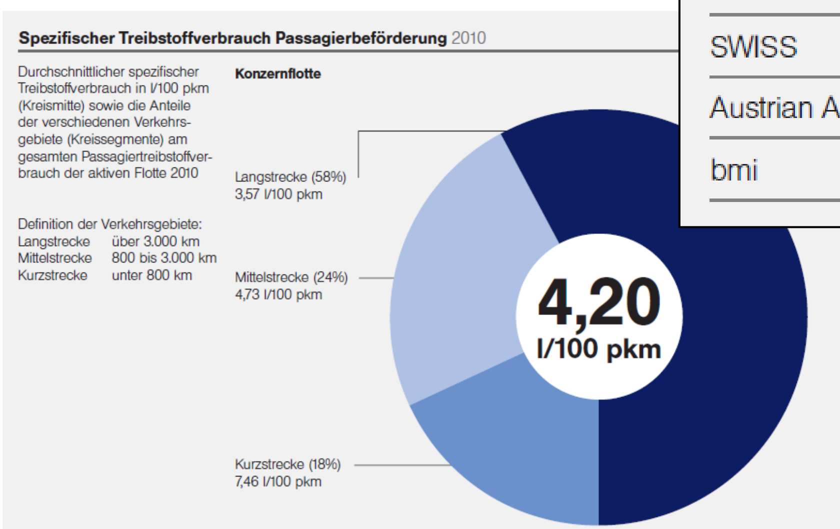
Resulting in:
1,5 % Net Growth (p.a.)

Growth and Goals for Innovation

Comparing Lufthansa Achievements with ACARE/ATAG/IATA Goals

Spezifischer Treibstoffverbrauch Passagierbeförderung
Veränderung in Prozent

	2010	2009	Veränderung
Konzernflotte	4,20	4,30	– 2,4
Lufthansa Passage	4,25	4,38	– 3,0
SWISS	3,73	3,88	– 3,9
Austrian Airlines	4,21	4,14	+1,5
bmi	5,09	4,70	+ 8,4



Lufthansa: Balance – Das wichtigste zum Thema Nachhaltigkeit im Lufthansakonzert. 2011

From 2009 to 2010 Lufthansa achieved 2,4% efficiency improvement on fuel burn. This is higher than goals by ACARE, ATAG and IATA setting 1 % …2 %.

Growth and Goals for Innovation

ACARE Goals Progress Evaluation (AGAPE) Public Summary

Whilst the AGAPE analysis has shown that significant progress has been achieved and is underway for all of the Goals, it also outlined that more efforts are required for the Goals to be fully reached at a uniform pace.

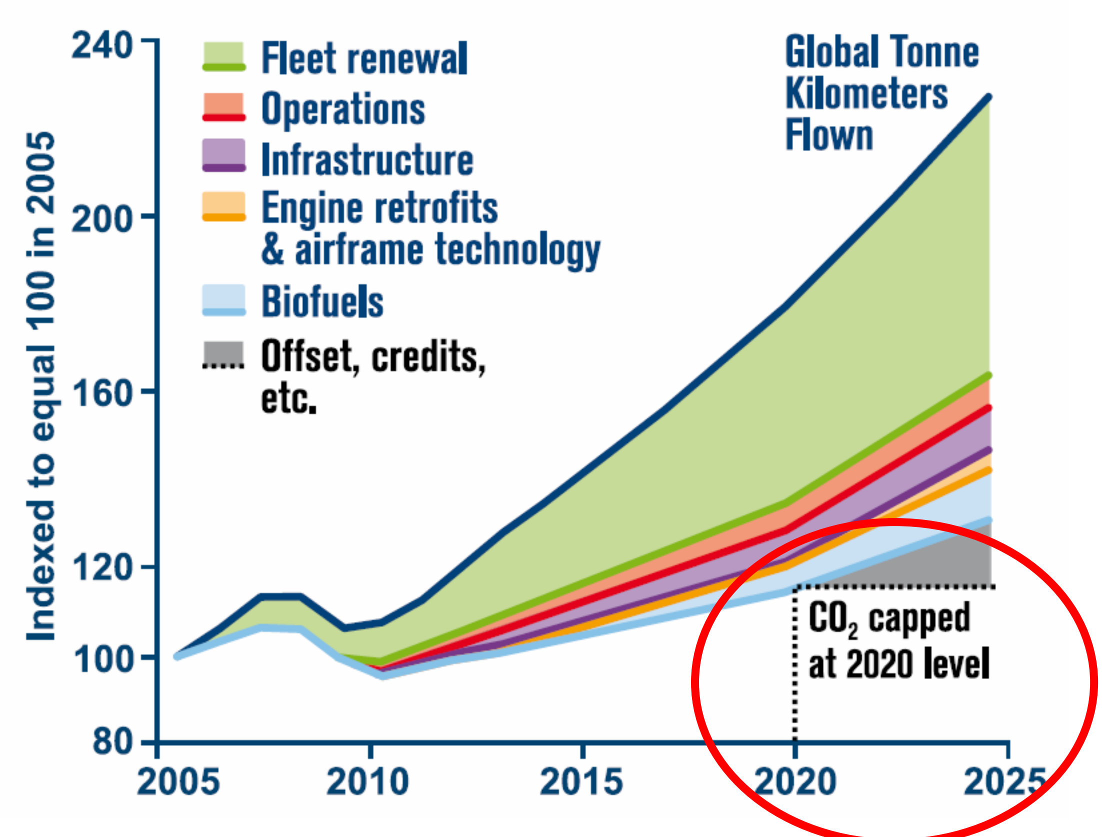
Furthermore, the transition from technology availability to technology uptake in product or system is influenced by many factors and amongst factors of a non-technological nature such as market expectations, new products or improvements being developed. Other factors …

Romain Muller: *ACARE Goals Progress Evaluation*. AeroSpace and Defence Industries Association of Europe,2010

Not all ACARE goals from Vision 2020 will be met. This has no consequence, because the goal post has shifted to 2050 with the new Flight Path 2050. Therefore the Vision 2020 is no longer needed.

Growth and Goals for Innovation

Making up for what is Missing: Introducing Compensation Schemes



There is no real reason to start with compensation in 2020. Compensation could as well start today. If the level of CO2 concentration in the atmosphere is not considered high enough jet, it may not warrant to start with compensation now.

www.iata.org (12-09-10)

IATA (and ATAG) want to achieve zero emission growth from 2020 onwards. This is only possible with carbon offset schemes.

Carbon Offsets / Carbon Compensation

1.) 

Using atmosfair as an example.

www.atmosfair.de

Emission Calculation is sufficiently accurate.

2.) **Compensation rate**: 24 € for each t of CO_2

3.) **Application**: „**In indischen Tempelküchen** wird das gesamte Warmwasser über Dieselbrenner erhitzt. Dies ist emissionsintensiv und zudem teuer. atmosfair hat daher mit einem Projektbetreiber in Indien die Installation von Solarspiegeln vereinbart, welche die bisher verwendeten Dieselbrenner ersetzen. Für die Realisierung der Anlage bekommt der **Betreiber die benötigten 21.000 EUR** von atmosfair. **In zehn Jahren vertraglicher Laufzeit sollen damit jährlich 40.000 Liter Diesel** und dem Klima so insgesamt 1.000 Tonnen Kohlendioxid (CO_2) **erspart werden**. atmosfair hat mit dem Projektbetreiber einen Vertrag geschlossen, wonach dieser für eine nachweislich **eingesparte Tonne CO_2 einen Betrag von 23 EUR** von atmosfair bekommt.

Some Comments on ETS and Carbon Compensation

Emission Trading Scheme (ETS)

- The EU charges with ETS for something they do not own! (It's Gods nature!)
- But: ETS could also be called charge or tax.

Carbon compensation

- Only activities count that would otherwise not be done => activities in „third world countries"
- Activities do not ask for an economic equivalent contribution
- if they would, profit could be made => compensation costs were zero
- What happens to the "Diesel burners"? Still in use?
- Planting (new!) forests only works as long as land is available!
- My impression: Too much CO2 is compensated for too little activity (the wood stove).
- If you own an eco investment that makes a profit, it does not count.
- Compensation is compared to indulgences (Ablasshandel) (R.E. Goodin)
- Compensation is morally problematic: "If you pay it's ok".
- Someone in Africa stops (flying) for you to continue.
- Big (IATA) compensation problematic: Who is so big as to compensate aviation (partially)?
- How many wood stove do you need to give to Africa to compensate for all aviation?
- But it could be cheaper to compensate (on the ground) than spend big money in the air.

Contents

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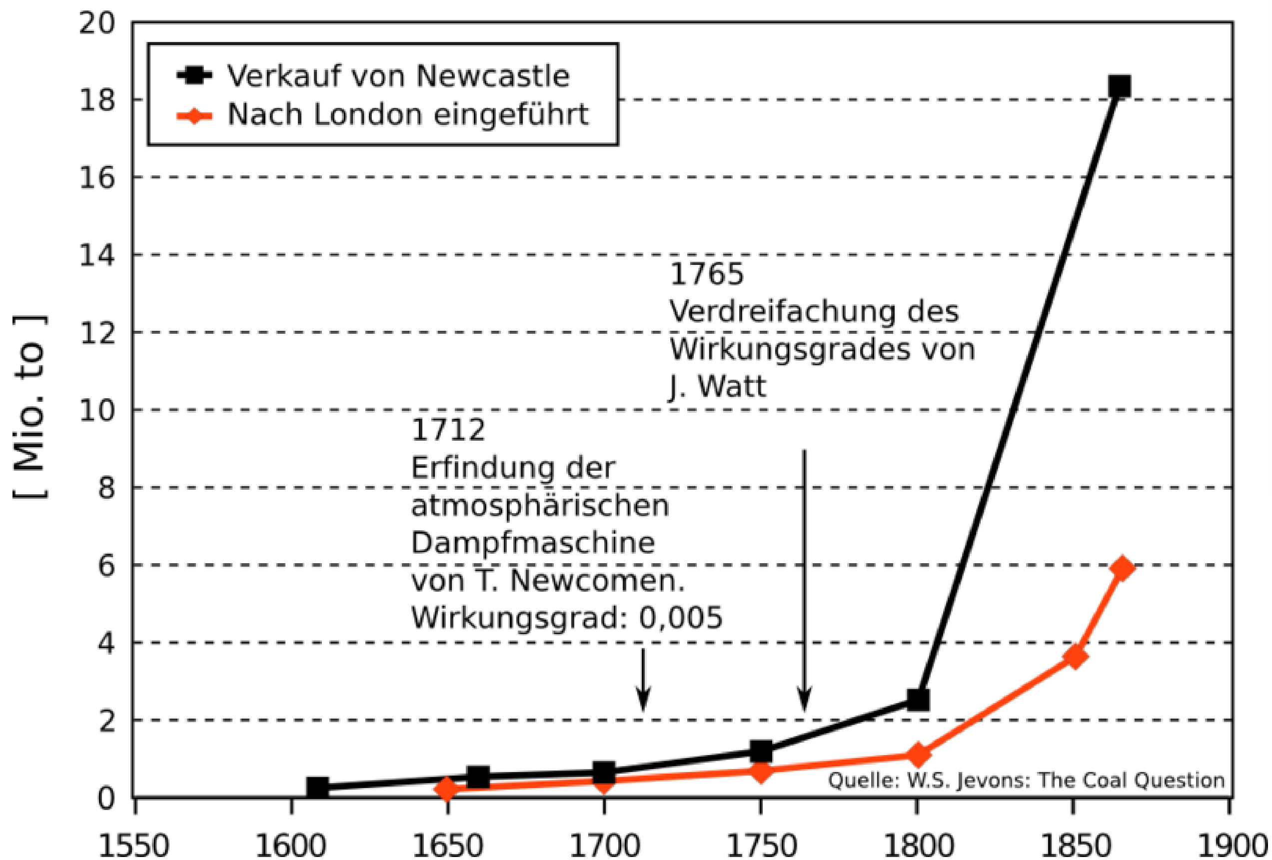
Learning from History

1. Bust of the American whale oil industry. 1859, Edwin Drake struck oil at Titusville, Pennsylvania. In a few days, Drake extracted as many barrels of oil as a whaling ship could gather on a four-year voyage.
2. British excessive coal usage after the invention of the efficient steam engine by James Watt. William Jevson analyses the mechanism.

Jevsons Paradox: Why Fuel Can Not Be Saved from Efficiency Increase



William Jevson
around 1885

de.wikipedia.org
(12-09-10)

Jevsons Paradox: Why Fuel Can Not Be Saved from Efficiency Increase

Technological progress that increases the efficiency with which a resource is used tends to increase (rather than decrease) the rate of consumption of that resource.

Increased energy efficiency tends to increase energy consumption by two means:

1. Increased energy efficiency makes the use of energy relatively cheaper, thus encouraging increased use (the direct rebound effect).
2. Increased energy efficiency leads to increased economic growth, which pulls up energy use for the whole economy (indirect rebound effect).

To ensure that efficiency enhancing technological improvements reduce fuel use, efficiency gains must be paired with government intervention that reduces demand (e.g., green taxes, a cap and trade program, or higher fuel taxes.

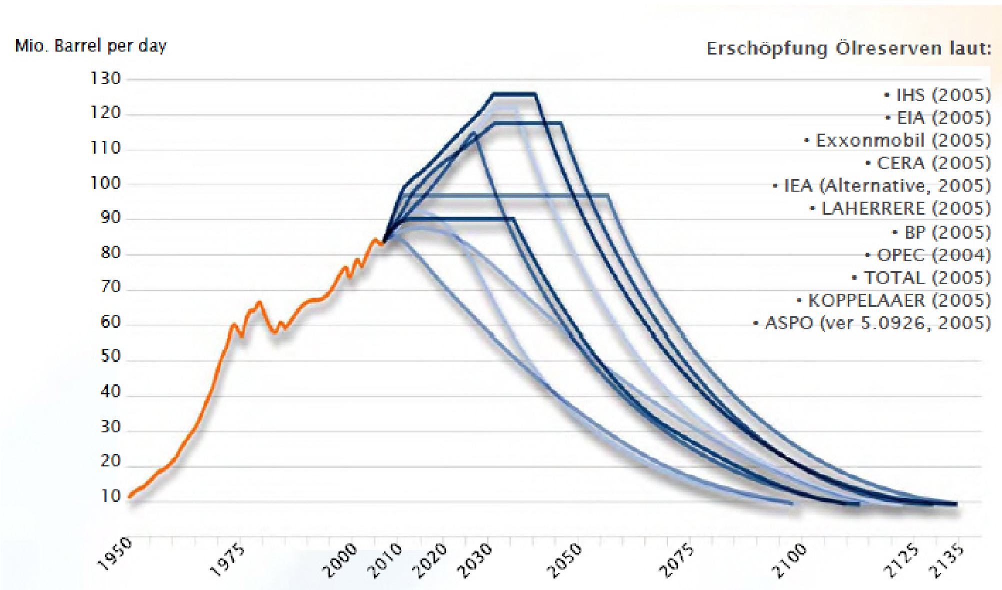
William Jevson
around 1885

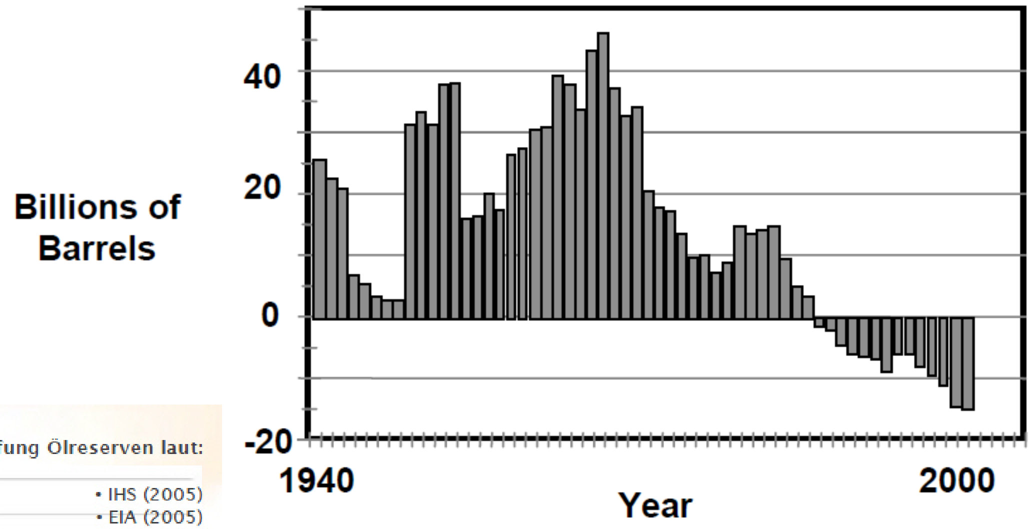
Learning from History Looking into the Future

M. King Hubbert (1956): Peak Oil

Different assumptions for Peak Oil.

Kuhlmann, A.: *Luftfahrt und Klimawandel.* Bauhaus Luftfahrt, 2009



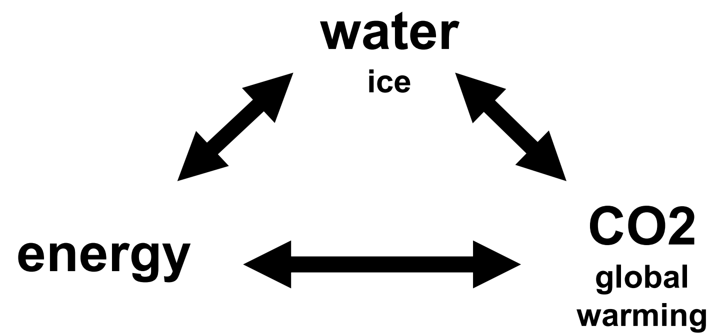


Net difference between annual world oil reserves additions and annual consumption.

Hirsch, R. L.: *Peaking of World Oil Production – Impact, Mitigation and Risk Management*. SAIC, 2005

Learning from History Looking into the Future

We will have not One but Three Issues!



E => CO2 :	Burning Energy produces CO2
CO2 => E :	Splitting CO2 with sunlight gives kerosine (some day): STL
E => W:	Sea water is converted to drinking water with help of energy
W => E:	Water ist needed for BTL (exception: algae)
CO2 => W:	global worming means melting of glaciers the drinking water storage
W => CO2:	melting of glaciers and polar caps means more global worming

So what is of importance?

1.) **water**
2.) **energy**
3.) **CO2**

What is needed?

1.) drinking water protection (from pollution)
2.) reservoirs (saving water from melting glaciers)
3.) wells
4.) energy efficient salt water treatment plants

Looking into the Future

- Past: **climate models**. Future: **world models**!
- Today things could be simulated much better than in the 70s (Dennis Meadows)

- **Challenge all assumptions** (like those from eco efficiency):
  - Technological innovation the main solution
  - Business as the principal actor of transformation
  - Trust in markets (if they are functioning well – no they are not)
  - (waste free) growth is conducive.

- We may need new guidance - maybe from a new buzz word?

Definition: **Resilience** (Widerstandsfähigkeit)
Resilience is the ability of an organization, resource, or structure to sustain the impact of an interruption, recover and resume its operations to continue to provide at least minimum services. One way to achieve resilience is by using redundancy.

Contents

- Introduction
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Selecting Research Ideas

How to select and prioritize technologies / ideas with always limited financial resources?

- Time is running up - Get things done today!
- Consider possible "show stoppers" for ideas and eliminate these ideas first!
- Quantify potential savings first (and set them in relation to entry into service)!
- Is the (implementation) strategy sound?

...

Get things done! This is what we could easily do:

- Get more openness in data and **information sharing** for aircraft and engine data [1]
- Reach general acceptance towards a **metric for fuel efficiency of aircraft**
- Provide on the Internet an “**Air Travel Evaluator**” (Avoid detours!)

[1] *Simos*, Dimitri: Transparency in Aviation Emissions - An Open Letter, 2010. - URL: http://www.piano.aero (12-02-20)

Some Ideas

“Air Travel Evaluator”

Carbon compensation should only be a way with which to mitigate the damage of unavoidable emission release.

There is often no relationship between environmental impact (fuel burn) and ticket price. On the contrary, in many cases flight options with large detours would often be the cheapest travel option.

Atmosfair: *Airline Assessment Index* serves to differentiate between airlines.

Compensator’s online emission calculators give equivalent CO2 for each flight. No software support is given for the selection of the best flight. A flight evaluation tool the ‘Flight Evaluator’ is needed.

Some Ideas

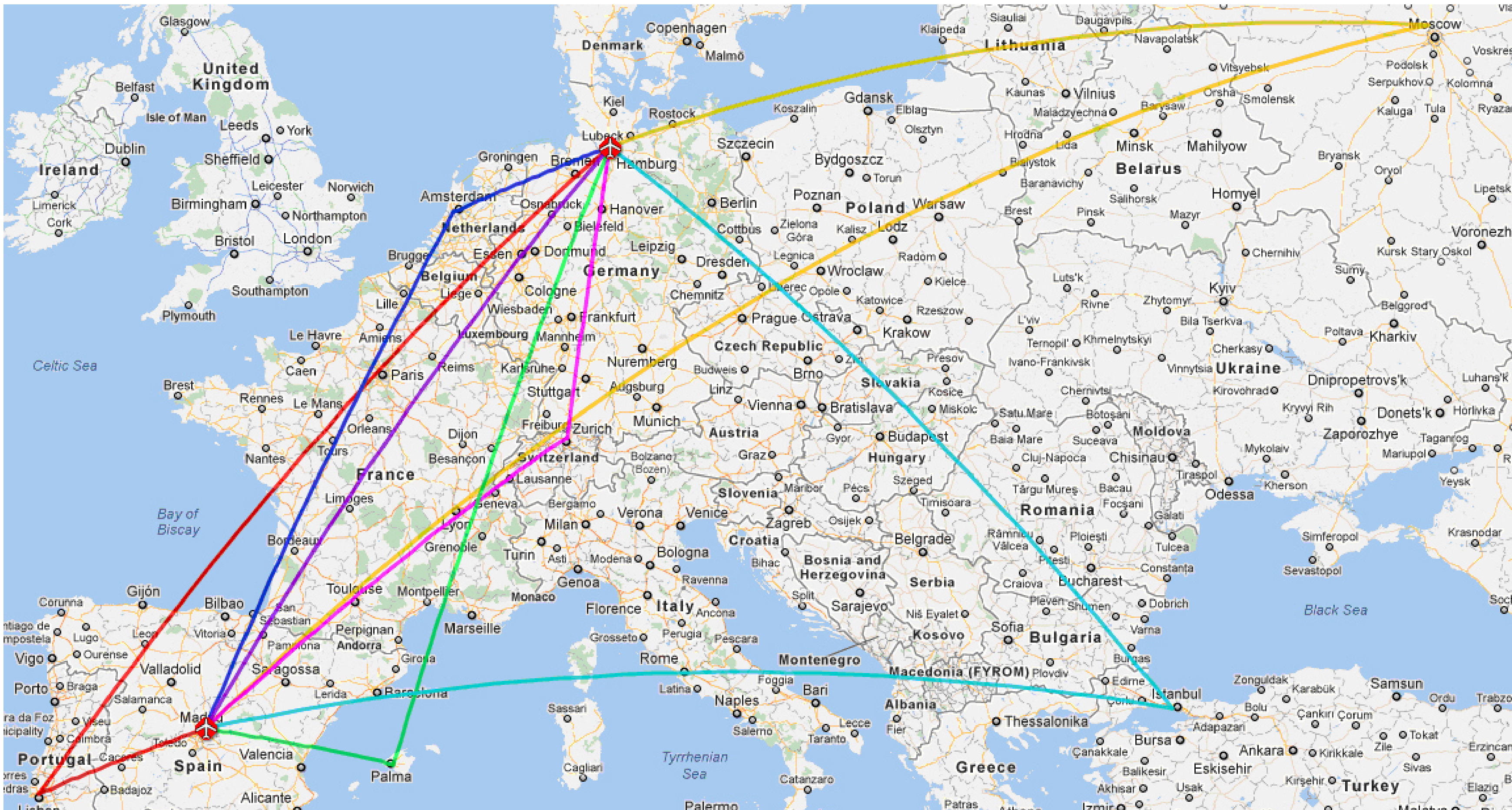
"Air Travel Evaluator"

Airline	Stage 1 A/C	Via	Airport Code	Stage 2 A/C	GCR Distance (km)	Price (€)	m_F (kg)
TAP Portugal	A319	Lisbon	LIS	A319	2709	303	68.79
Aeroflot	A320	Moscow	SVO	A320	5181	453	143.09
Swiss Air	A319	Zurich	ZRH	A319	1931	516	47.62
Air Berlin	A320	Palma	PMI	A321	2203	517	53.81
Turkish Airlines	B737-800	Istanbul	IST	A321	4697	528	122.05
KLM	B737-800	Amsterdam	AMS	B737-800	1837	682	47.97
Lufthansa	B737-300	Direct	n/a	n/a	1778	717	47.17

per pax

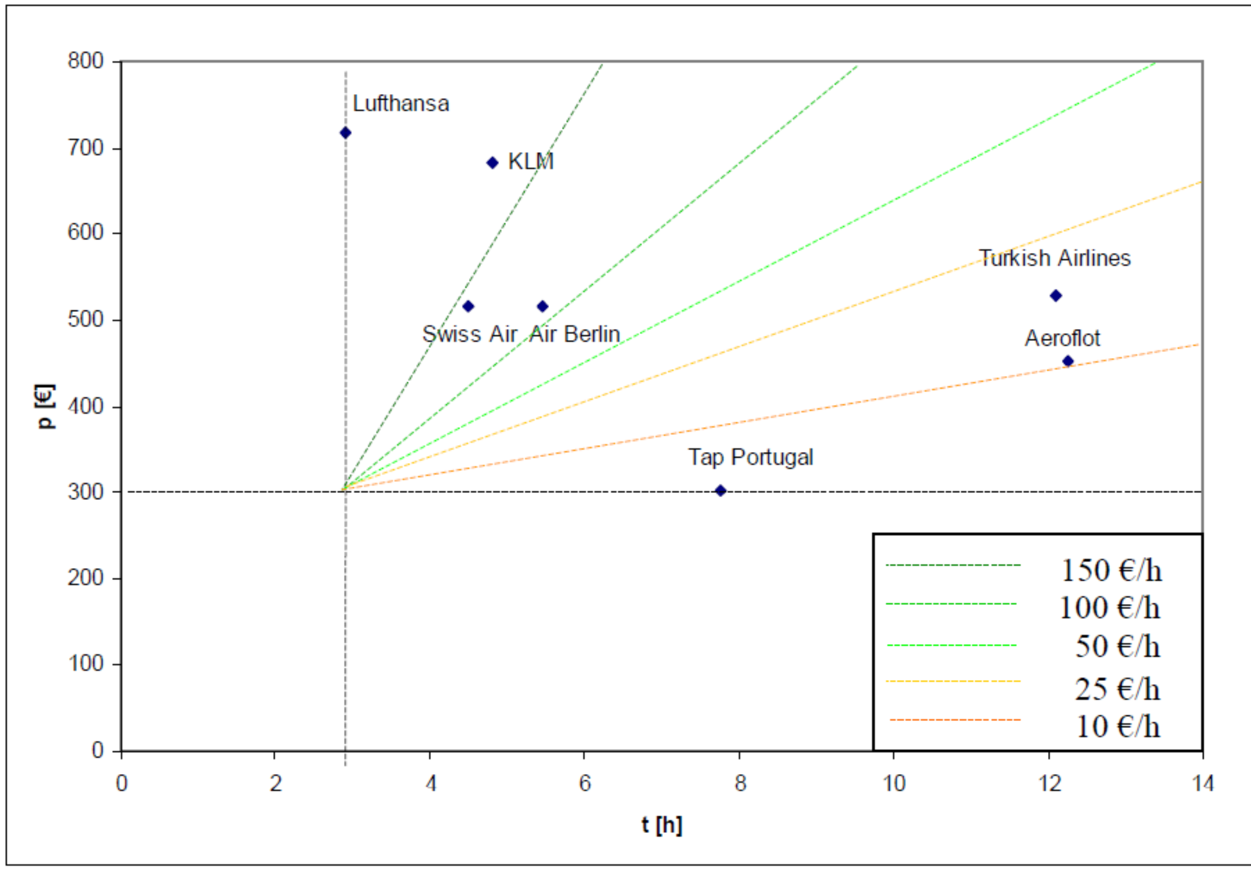
Some Ideas

“Air Travel Evaluator”



Some Ideas

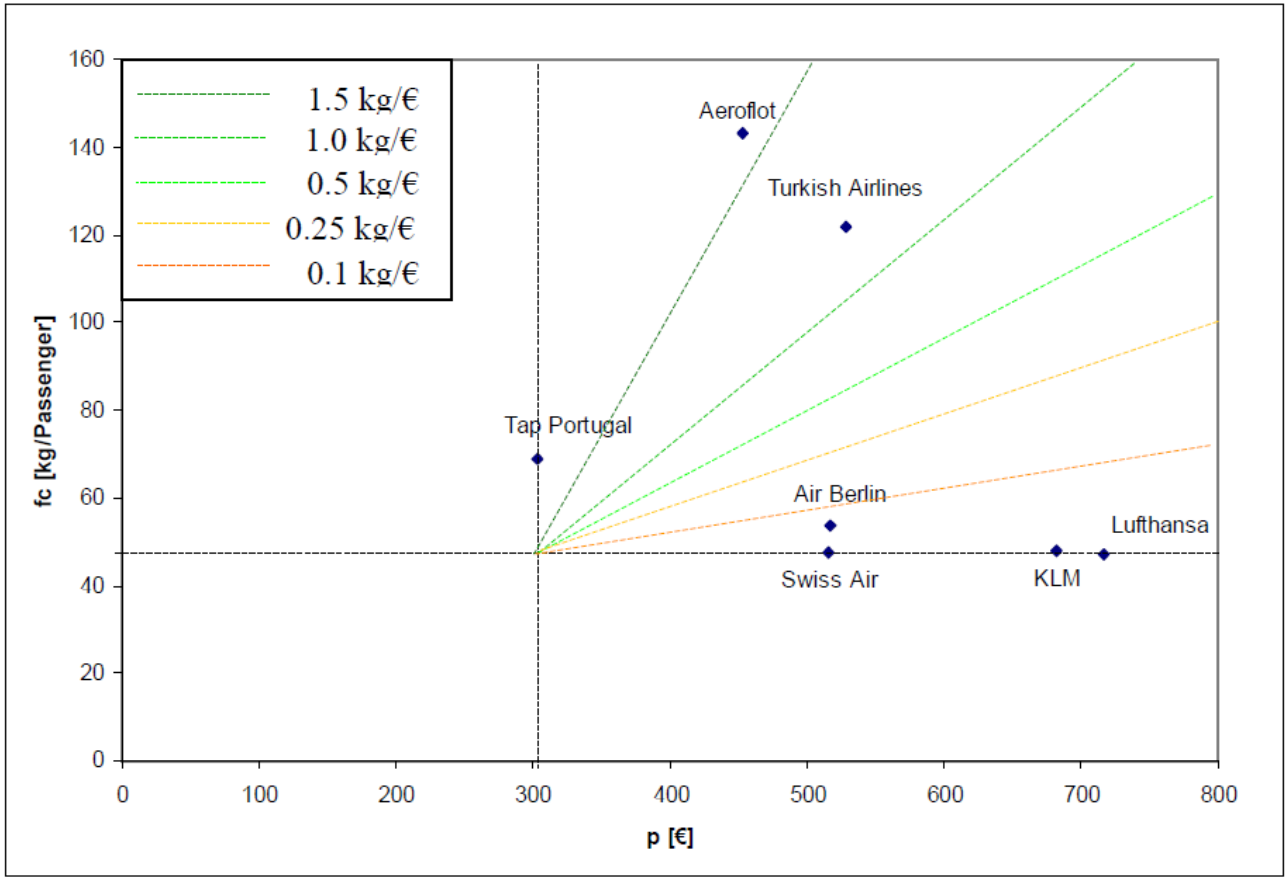
"Air Travel Evaluator"



Spread of ticket price vs. trip time for flights - Madrid (MAD) and Hamburg (HAM)

Some Ideas

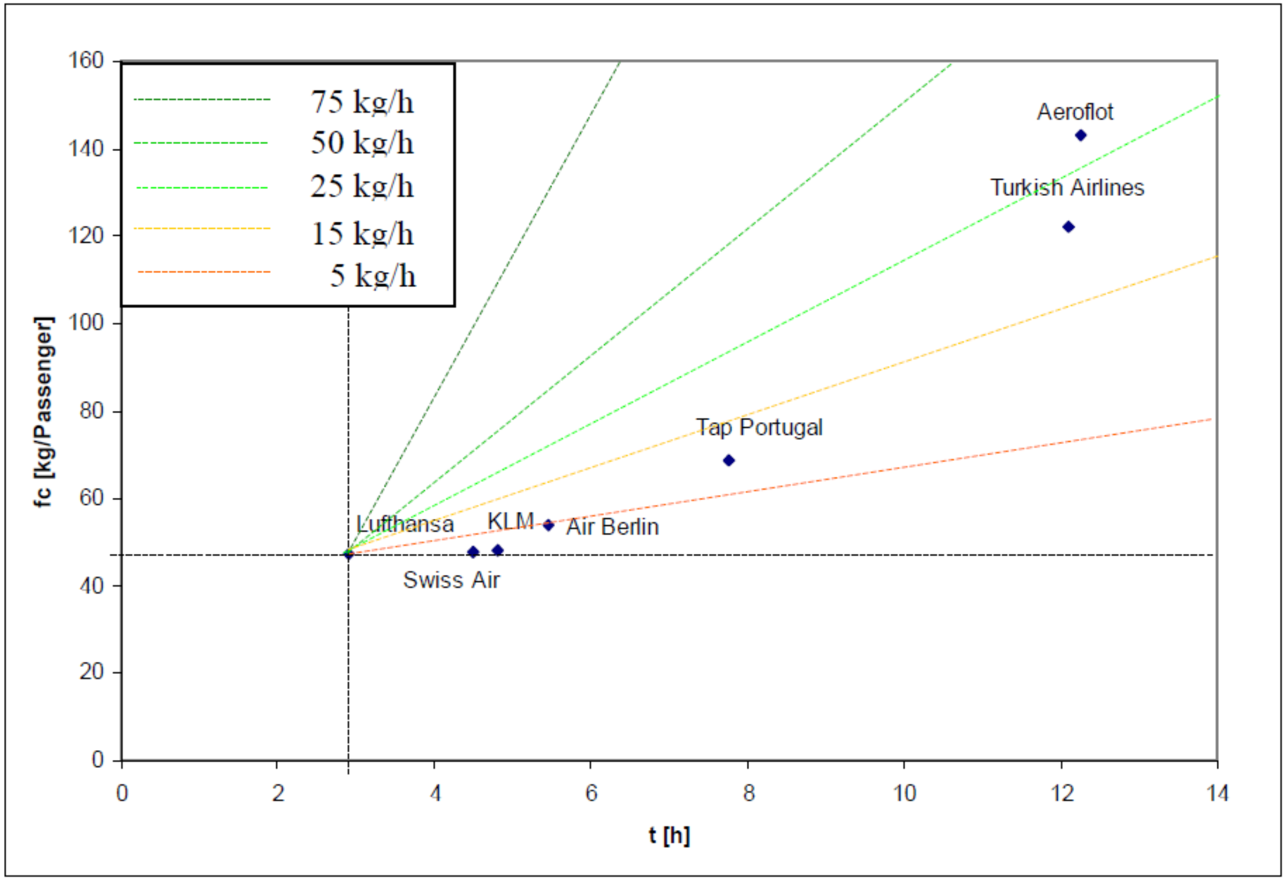
"Air Travel Evaluator"



Spread of fuel consumption vs. ticket price for flights - Madrid (MAD) and Hamburg (HAM)

Some Ideas

“Air Travel Evaluator”



Spread of fuel consumption vs. total trip time for flights - Madrid (MAD) and Hamburg (HAM)

Some Ideas

"Air Travel Evaluator"

$$X_p = 1 - \frac{P_x - P_{Min}}{P_{Max} - P_{Min}}$$

$$X_t = 1 - \frac{t_x - t_{Min}}{t_{Max} - t_{Min}}$$

$$X_{m_F} = 1 - \frac{m_{F,x} - m_{F,Min}}{m_{F,Max} - m_{F,Min}}$$

Some Ideas

"Air Travel Evaluator"

Relative ranking output from Flight Evaluator

	X_p	
TAP Portugal	100	A
Aeroflot	64	D
Swiss Air	49	E
Air Berlin	48	E
Turkish Airlines	46	E
KLM	8	G
Lufthansa	0	G

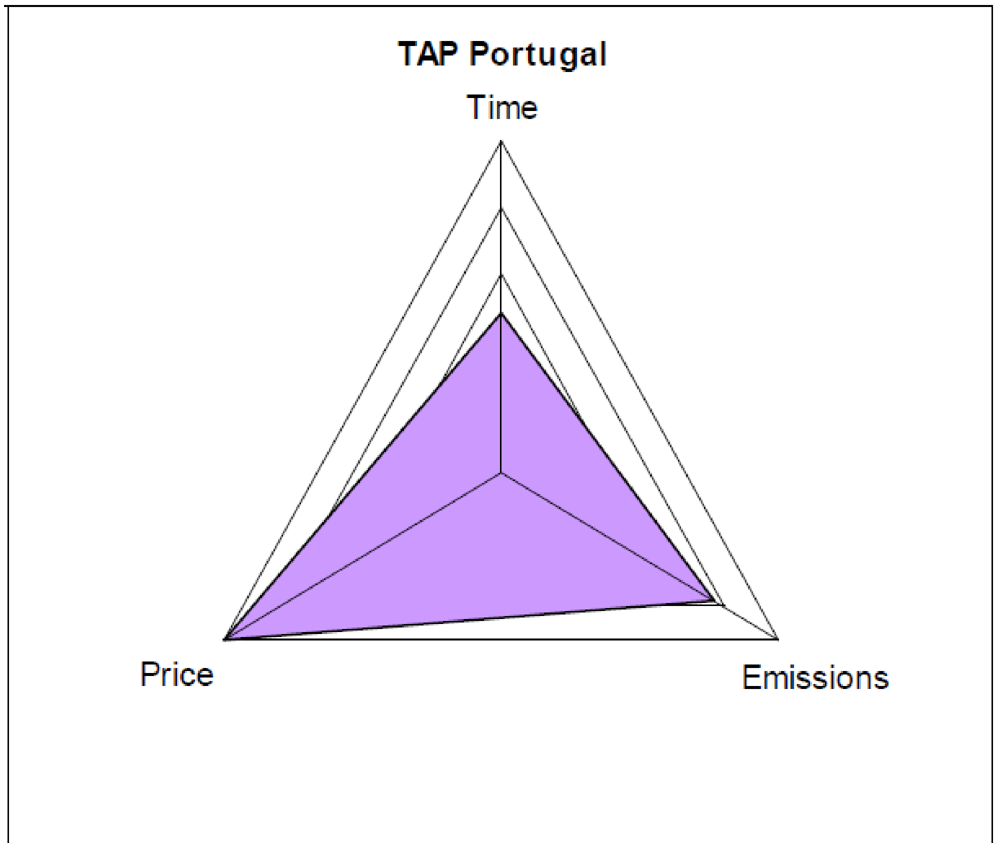
	X_t	
Lufthansa	100	A
Swiss Air	83	B
KLM	80	B
Air Berlin	73	C
TAP Portugal	48	E
Turkish Airlines	2	G
Aeroflot	0	G

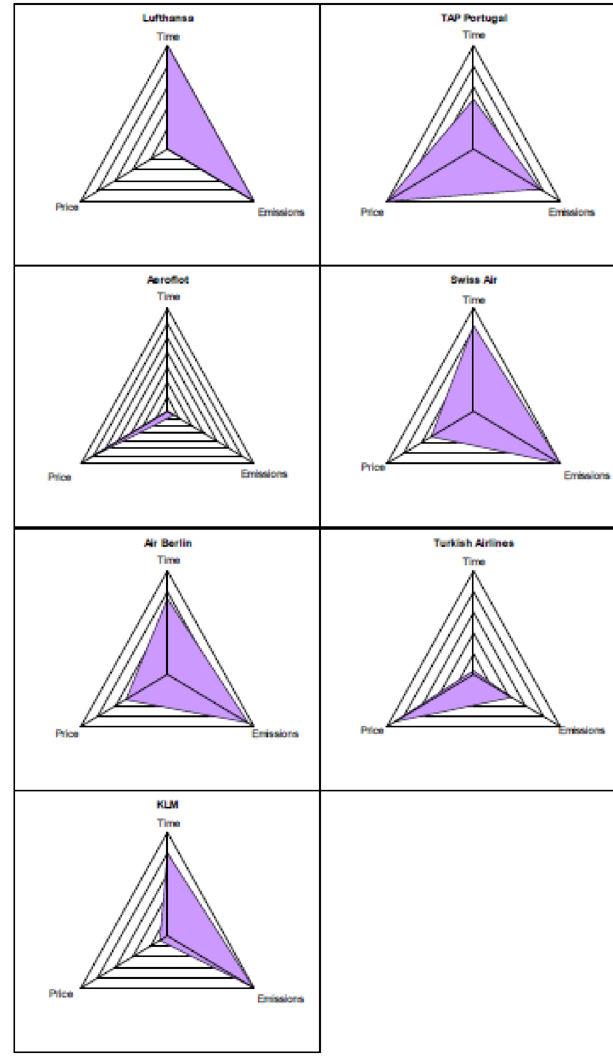
	X_{mf}	
Lufthansa	100	A
Swiss Air	100	A
KLM	99	A
Air Berlin	93	A
TAP Portugal	77	C
Turkish Airlines	22	F
Aeroflot	1	G

[4] EU Directive 2006/32/EC is applicable to 'Energy End-use Efficiency and Energy Services'. To ensure complete suitability, the introduction of an aviation specific directive would be advised

Some Ideas

"Air Travel Evaluator"





Spider diagrams generated using the Flight Evaluator

Some Ideas

$$P_{eff} = P + L(t_x - t_{Min}) + C(m_{F,Pax,x} - m_{F,Pax,Min})$$

$$X_{P_{eff}} = 1 - \frac{P_{eff,x}}{P_{eff,Max}}$$

To provide illustration of the system, predefined rates for *L* and *C* of 6 €//h leisure, 20 €//h business, and 0 €/tCO_2 indifferent, 25 €/tCO_2 green, respectively, are used in the analysis.

Some Ideas

"Air Travel Evaluator"

Flight Evaluator Leisure traveller Green and Indifferent customised ranking

Leisure					
Green			**Indifferent**		
Airline	**Ranking**		**Airline**	**Ranking**	
TAP Portugal	100	A	TAP Portugal	100	A
Swiss Air	58	E	Aeroflot	54	D
Air Berlin	52	E	Swiss Air	50	E
Aeroflot	9	E	Air Berlin	48	E
KLM	6	F	Turkish Airlines	35	E
Lufthansa	4	G	KLM	6	G
Turkish Airlines	0	G	Lufthansa	0	G

Some Ideas

"Air Travel Evaluator"

Flight Evaluator Business traveller Green and Indifferent customised ranking

Business					
Green			**Indifferent**		
Airline	**Ranking**		**Airline**	**Ranking**	
TAP Portugal	100	A	TAP Portugal	100	A
Swiss Air	75	D	Swiss Air	54	D
Air Berlin	67	E	Air Berlin	48	E
Lufthansa	35	F	Aeroflot	25	F
KLM	33	F	Turkish Airlines	3	G
Aeroflot	7	G	Lufthansa	1	G
Turkish Airlines	0	G	KLM	0	G

Some Ideas

"Air Travel Evaluator"

Tools for Political Influence

Fiscal Policy
- Charges
- Subsidies
- Capital Investments

Administrative Policy
- Traffic Regulations
- Administrative Regulations
- Technical Regulations
- Personnel Certification

Regulatory Policy
- Market Authorisation
- Capacity Control
- Price Regulation
- Monopoly Prevention,
- Code-share & Co-operation

Contents

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My very personal Summary and Outlook

- **The aircraft is mature**, whatever will come, will not change the game

- With ever more people on this planet, life will get more difficult
- Primary concern in the future is **water**, if water runs out, a war can start in days

- Fossil fuels will come to an end – probably later than we now believe
- Something totally different will be coming after this energy aera – we need to work on it
- The change will not be smooth so we need **resilience**

- We spend our resources on too many things that do not matter in the big picture
- We could be advancing at a faster pace if we **get focused on what really matters**

Contact

info@ProfScholz.de

http://www.ProfScholz.de