Hochschule für Angewandte Wissenschaften Hamburg
Hamburg University of Applied Sciences

AIRCRAFT DESIGN AND SYSTEMS GROUP (AERO)

Ein kritischer Blick auf die Luftfahrt

– Kontaminierte Kabinenluft

– Corona und Fliegen

– Grünes Fliegen

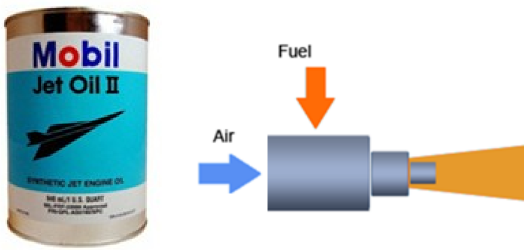
– Elektrisches Fliegen ?

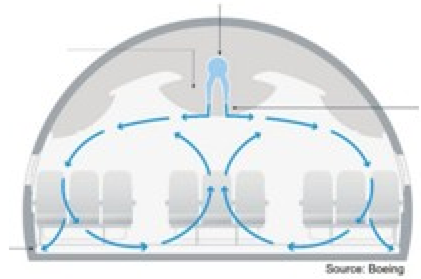
Dieter Scholz Hamburg University of Applied Sciences

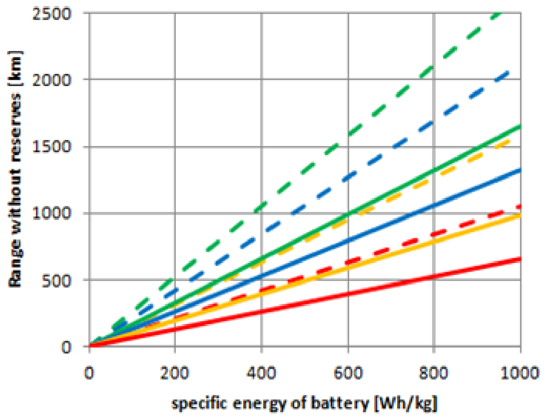
2. Webinar der BAG MoVe, BÜNDNIS 90/DIE GRÜNEN

Online, 12.06.2020, 19:30

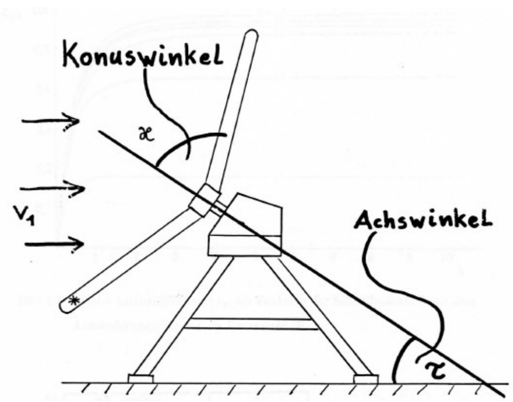
Diese Datei: https://purl.org/AERO/PRE2020-06-12

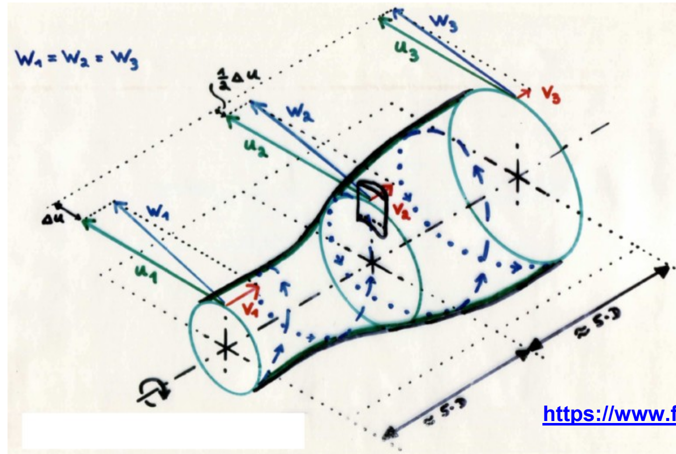






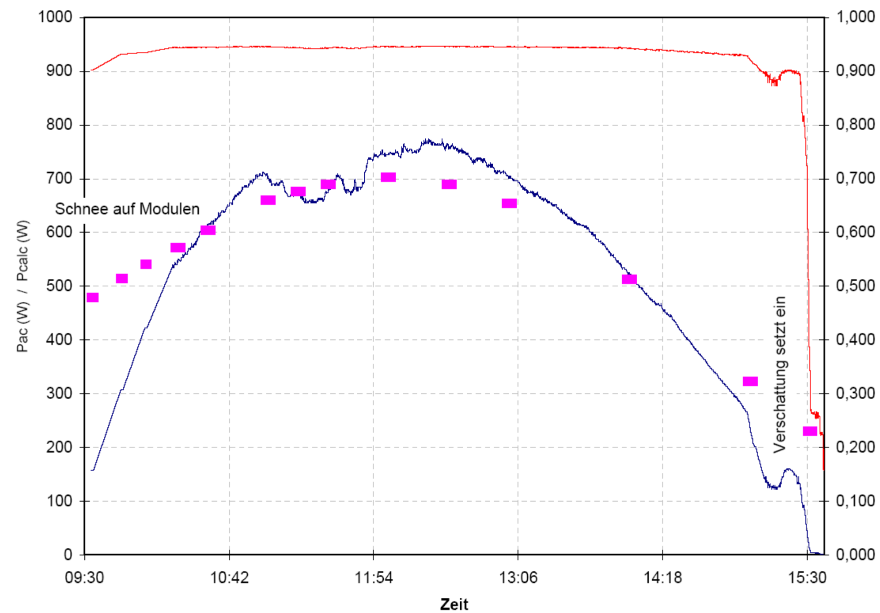
Aus meinem Leben





$$(\vec{V}\cdot\nabla)\vec{V}\cdot d\vec{s} = \frac{1}{2}\nabla(\vec{V}\cdot\vec{V})\cdot d\vec{s} \qquad (l\ddot{a}ngs\ s)$$
$$= \frac{1}{2}\left[\vec{i}\frac{\partial V^2}{\partial x} + \vec{j}\frac{\partial V^2}{\partial y} + \vec{k}\frac{\partial V^2}{\partial z}\right]\cdot\left[dx\vec{i} + dy\vec{j} + dz\vec{k}\right]$$
$$= \frac{1}{2}\left[\frac{\partial V^2}{\partial x}dx + \frac{\partial V^2}{\partial y}dy + \frac{\partial V^2}{\partial z}dz\right]$$
$$(\vec{V}\cdot\nabla)\vec{V}\cdot d\vec{s} = \frac{1}{2}d(V^2) \qquad (l\ddot{a}ngs\ s)$$

https://www.fzt.haw-hamburg.de/pers/Scholz/Paper.html#Uni-Hannover



EINLADUNG

Bundesarbeitsgemeinschaft Mobilität und Verkehr (BAG MoVe) von BÜNDNIS 90/DIE GRÜNEN
https://www.gruene-bag-verkehr.de

Webinar Nr. 2: Kontaminierte Kabinenluft, Corona und Fliegen, Grünes Fliegen, Elektrisches Fliegen?

Am 12. Juni 2020, 19:30 Uhr (online).
Referent: **Prof. Dr. Scholz**
Hochschule für Angewandte Wissenschaften Hamburg
Department Fahrzeugtechnik und Flugzeugbau

Die Fragen der Elektromobilität beim Fliegen sind in den letzten Tagen durch andere aktuelle Ereignisse überlagert worden: Die Lufthansa musste gerettet werden, wobei unser Referent sich bei den technischen Inhalten in die Expert*innengruppe eingebracht hat.

Wir haben an diesem Abend die einmalige Chance, uns gleich mehreren Aspekten zur Flugzeugwirtschaft zu widmen:
- Was ist mit Auflagen für die Lufthansa?
- Welche Rolle spielen das BMVI und die EASA?
- Unter die Lupe genommen werden die „Sorglos-Aussagen" der Luftfahrtindustrie in der Corona-Pandemie:
  https://purl.org/corona/PR2020-06-05
- Können Nicht-CO2-Effekte durch Fliegen in geringen Höhen reduziert werden?
- Sind neue Flugzeugtypen notwendig?
- Welche positiven Umweltwirkungen könnten wir bereits jetzt erzielen?
- Und ganz bestimmt fliegen wir bald elektrisch - oder?

Susanne Menge, MdL Niedersachsen (Sprecherin, BAG MoVe)
(https://de.wikipedia.org/wiki/Susanne_Menge)

Die Antworten, die
Ihnen versprochen wurden ...
... liefere ich als erstes

Was ist mit Auflagen für die Lufthansa?
Offene E-Mail an Katharina Dröge , Christian Kindler und Markus Tressel: Maßnahmen gegen kontaminierte Kabinenluft (Ölaustritt aus dem Triebwerk).
Siehe: https://purl.org/CabinAir/E2020-05-13

Welche Rolle spielen das BMVI und die EASA in Corona-Zeiten?
Das BMVI verweist an die EASA. EASA und ICAO liefern nur Empfehlungen.
Airlines und Flughäfen machen was Sie wollen.

Die Luftfahrtindustrie fährt eine „Rundum-Sorglos-Kampagne"
Details hier: https://purl.org/corona/PR2020-06-05

Können Nicht-CO2-Effekte durch Fliegen in geringen Höhen reduziert werden?
Ja, stark!

Sind neue Flugzeugtypen notwendig?
Ein großes Propellerflugzeug könnte helfen.
Eine Neuentwicklung eines Passagierflugzeugs ist derzeit finanziell aber nicht darstellbar.
Mit dem neuen Airbus A220 (ehemals Bombardier CSeries, CS300) hat Airbus bereits ein neues Flugzeug mit bester Aerodynamik.

Und ganz bestimmt fliegen wir bald elektrisch - oder?
Nein!

Was Sie aus diesem Abend mitnehmen sollen!

Die "Corona-Rundum-Soglos-Kampagne" geht an der Wahrheit vorbei!
Luft pro Person statt Luftwechselrate
Belüftung statt "HEPA-Filter darum OP-Luft"
Virenverteilung in der ganzen Kabine statt "keine horizontale Strömung"

Wir haben kein CO2-Problem in der Luftfahrt, sondern ein Wasser-Problem!
Daher: Tiefer fliegen

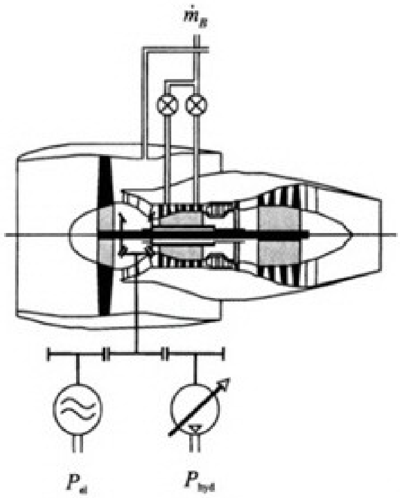
Was ist schlimmer Recourcenverbrauch oder Erderwärmung bei der Verbrennung fossiler Rohstoffe?
Am Boden: beides gleich
In Flug: die Erderwärmung

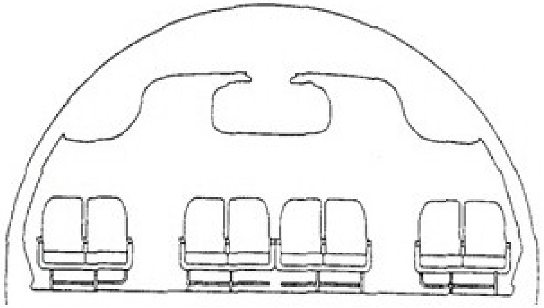
Die regenerative Luftfahrt fliegt mit sythetischem Kraftstoff aus erneuerbaren Energien.
Schnelle Durchdringung der existierenden Flotte.

Wasserstoff ist für das Flugzeug nicht die Lösung (Erderwärmung)

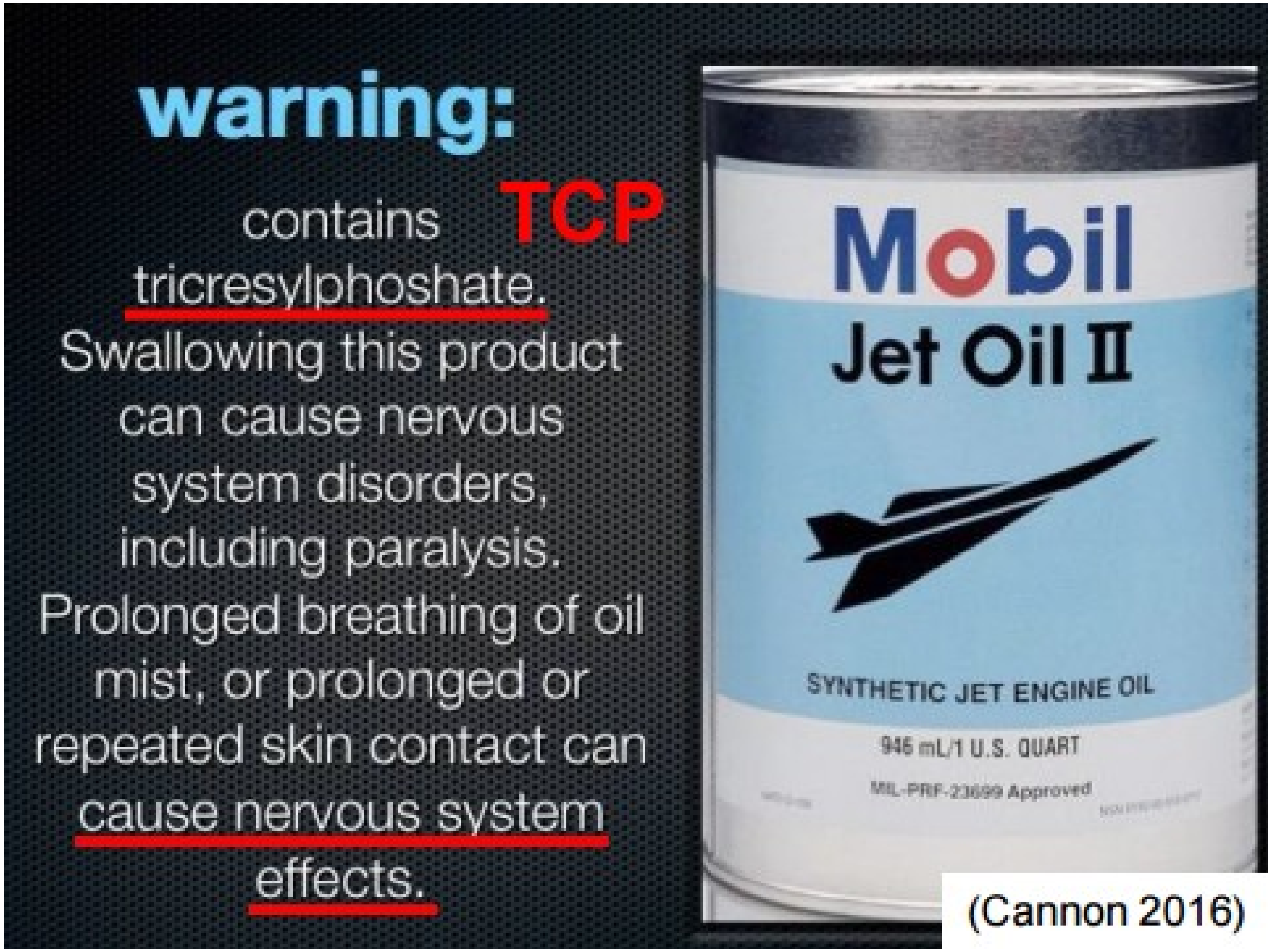
Elektroflug ist keine Lösung:
Zu schwer. Keine Reichweiten möglich. Unwirtschaftlich. In der Stadt nur für Super-Reiche.

Kontaminierte Kabinenluft

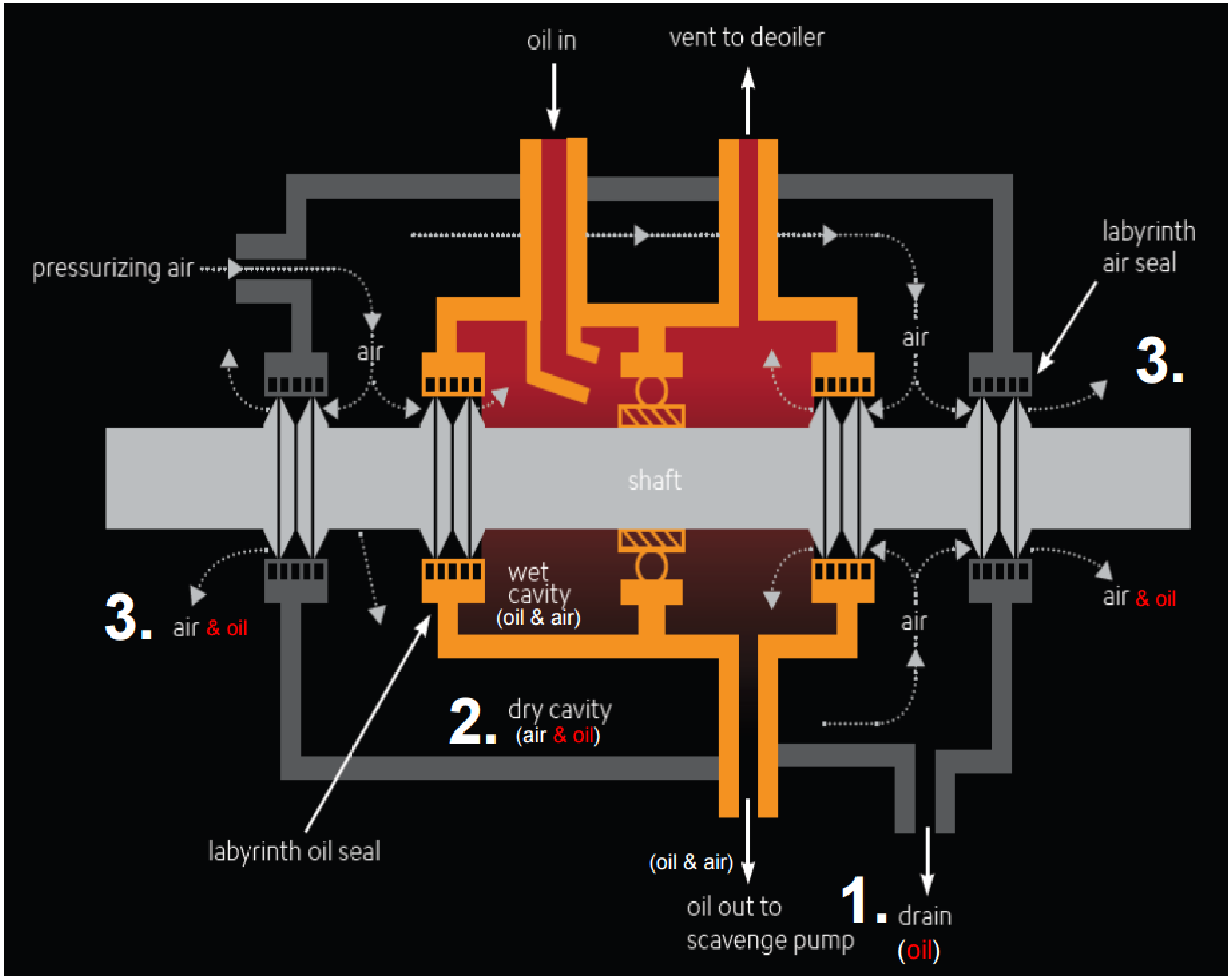




http://CabinAir.ProfScholz.de

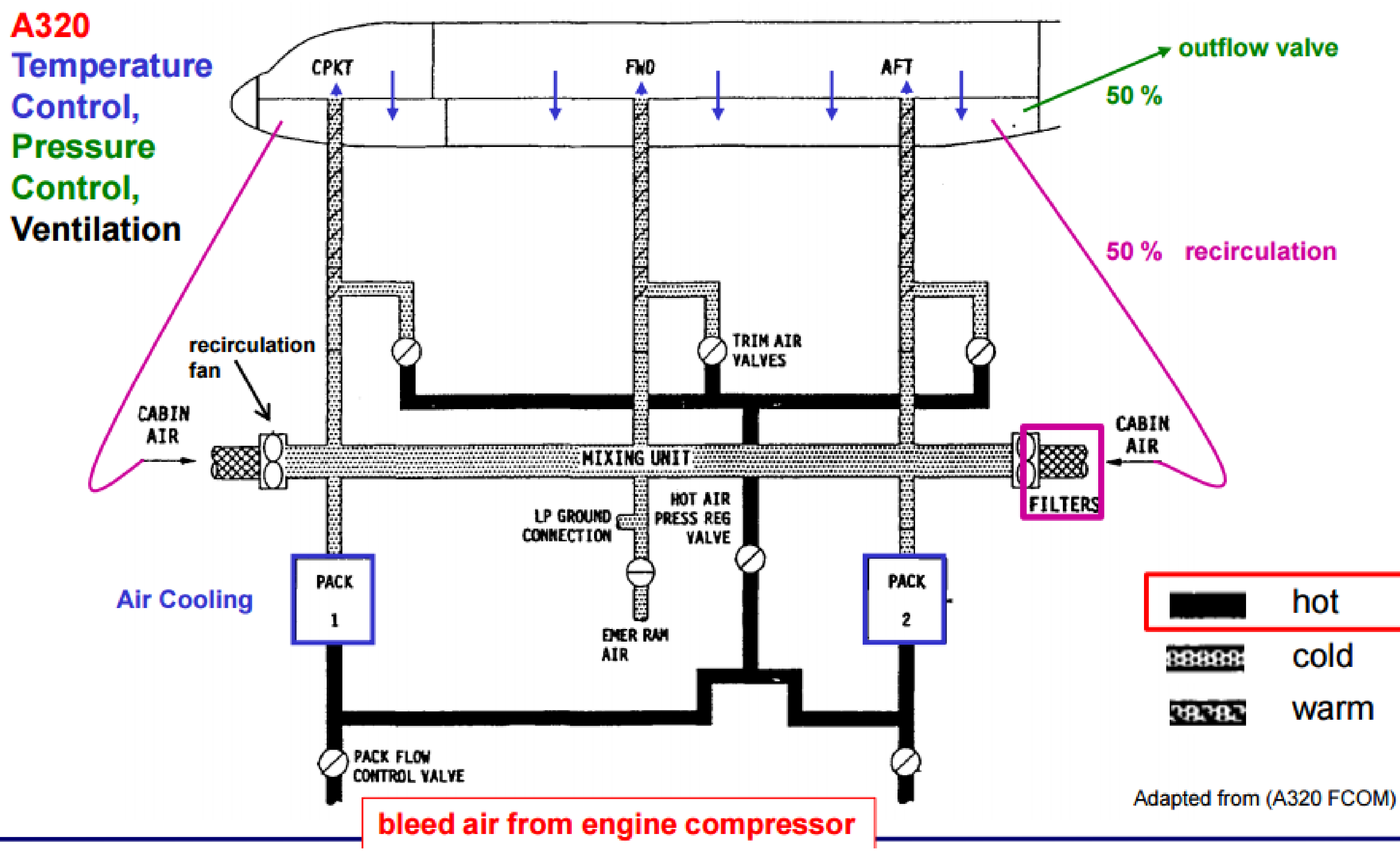

warning:
contains TCP
tricresylphoshate.
Swallowing this product can cause nervous system disorders, including paralysis. Prolonged breathing of oil mist, or prolonged or repeated skin contact can cause nervous system effects.
Mobil
Jet Oil II
SYNTHETIC JET ENGINE OIL
946 mL/1 U.S. QUART
MIL-PRF-23699 Approved

(Cannon 2016)


oil in
vent to deoiler
pressurizing air
air
labyrinth
air seal
3.
air
shaft
wet
cavity
(oil & air)
3.
air & oil
air & oil
air
2.
dry cavity
(air & oil)
labyrinth oil seal
(oil & air)
oil out to
scavenge pump
1.
drain
(oil)

Air Conditioning Technology

A320



Adapted from (A320 FCOM)

Corona und Fliegen

Aero

Dieter Scholz

Sommer 2020, COVID-19, Fliegen: ja oder nein? Vorsicht: Gesundheitsrisiko und unklare Rechtslage!

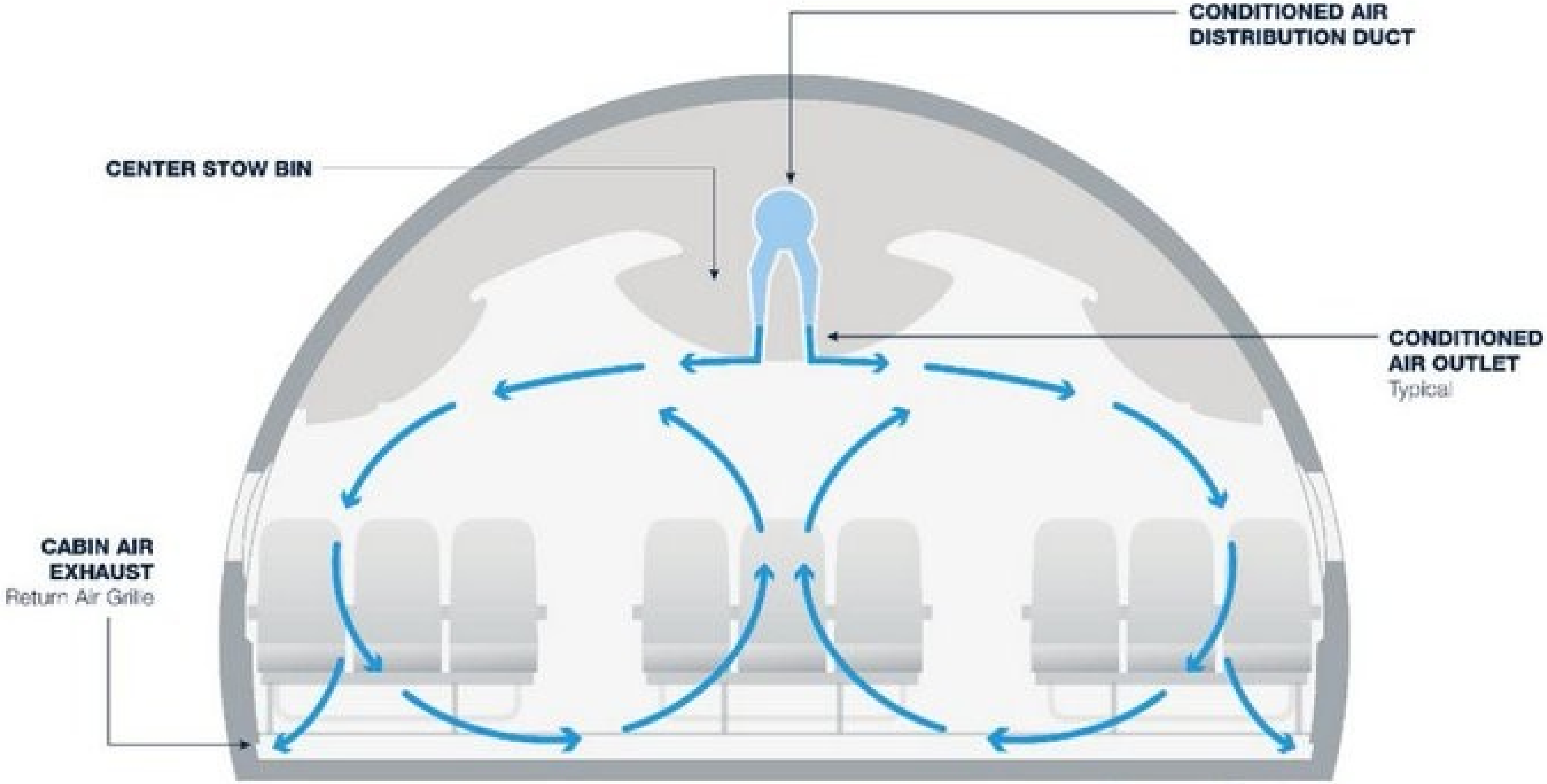
(PresseBox) (Hamburg, 05.06.20) Die Sonne scheint. Die beliebten Strände in Südeuropa sind noch leer. Flugtickets zu den Urlaubsorten werden bereits angeboten und das Auswärtige Amt stellt die Aufhebung der weltweiten Reisewarnung wegen COVID-19 in Aussicht. Die Verlockung ist groß, aus dem Corona-Alltag auszubrechen. Aber Vorsicht. Die Gefahr sich im Flugzeug mit SARS-CoV-2 anzustecken ist real gegeben, denn an kaum einem anderen Ort sind Personen so dicht nebeneinander untergebracht wie im Flugzeug. Nicht husten am Flughafen, dadurch könnte der Zutritt zum Flugzeug verweigert werden. Vor dem Rückflug wird evtl. die Körpertemperatur gemessen – mit ungewissem Ausgang. Frisch gerettete Fluggesellschaften beteuern, dass keine Gefahr einer Ansteckung im Flugzeug bestehen würde. Die Luft wäre im Flugzeug so gut wie im Operationssaal. Mit der Wahrheit wird es bei solchen Aussagen nicht so genau genommen, denn es geht um viel Geld. Die Verantwortlichen schauen weg, schließlich kann eine Lufthansa nicht jedes Vierteljahr erneut gerettet werden. Hier eine detaillierte Darstellung der Hintergründe aus ingenieurwissenschaftlicher Sicht.

...

https://purl.org/corona/PR2020-06-05

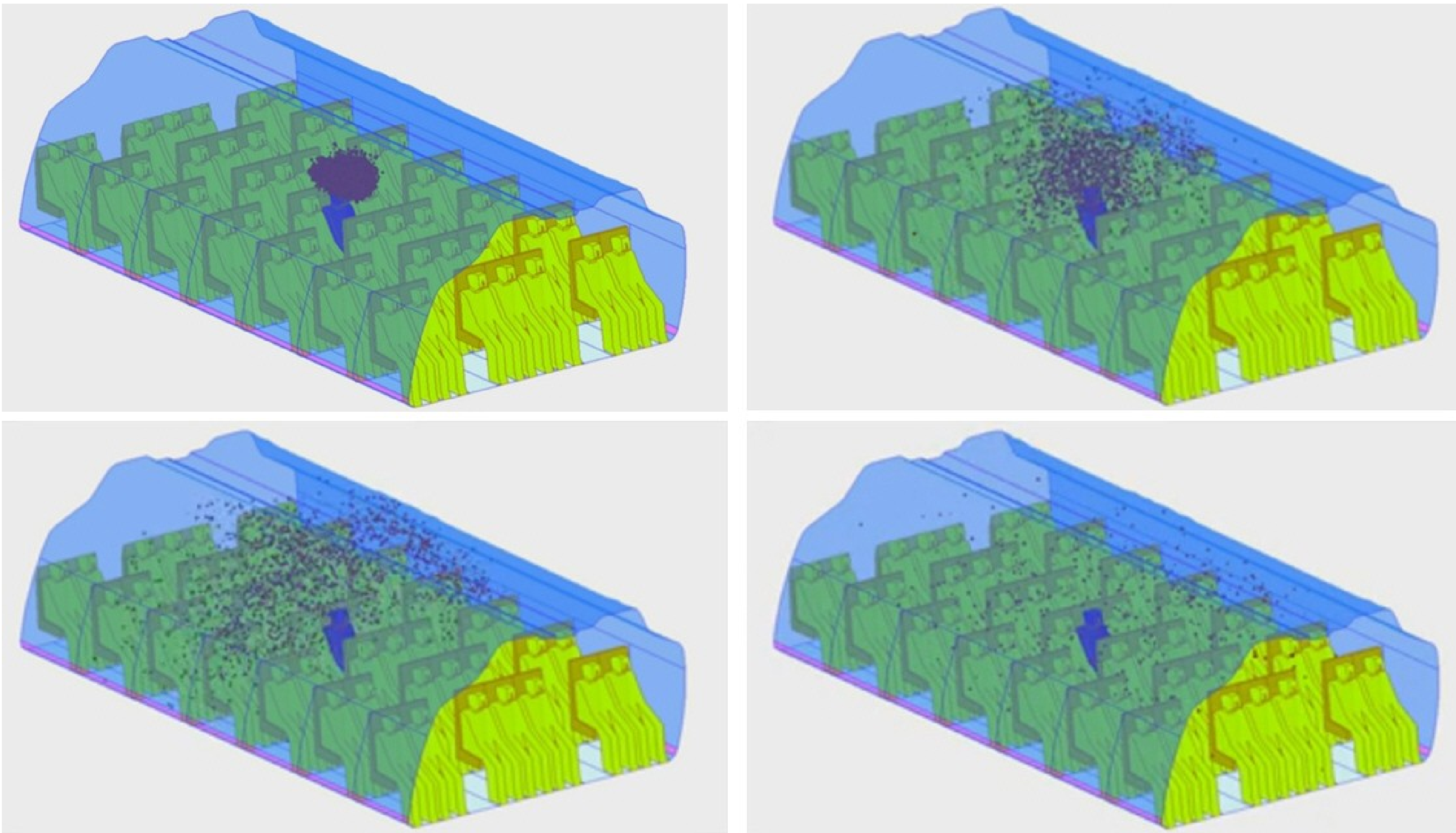
(PDF, 1.6 MB, 24 Seiten)

Strömung im Querschnitt der Passagierkabine – Austausch innerhalb weniger Sitzreihen durch die Klimaanlage



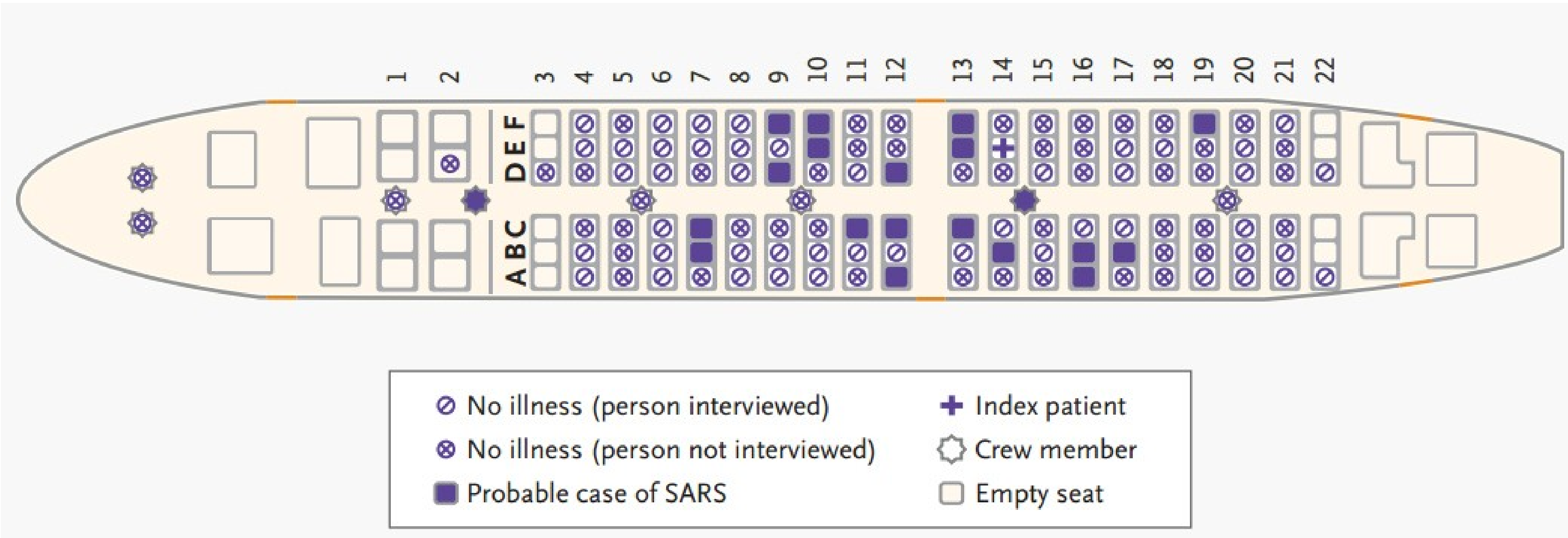
Source: Boeing

Verteilung von Aerosolen in der ganzen Kabine

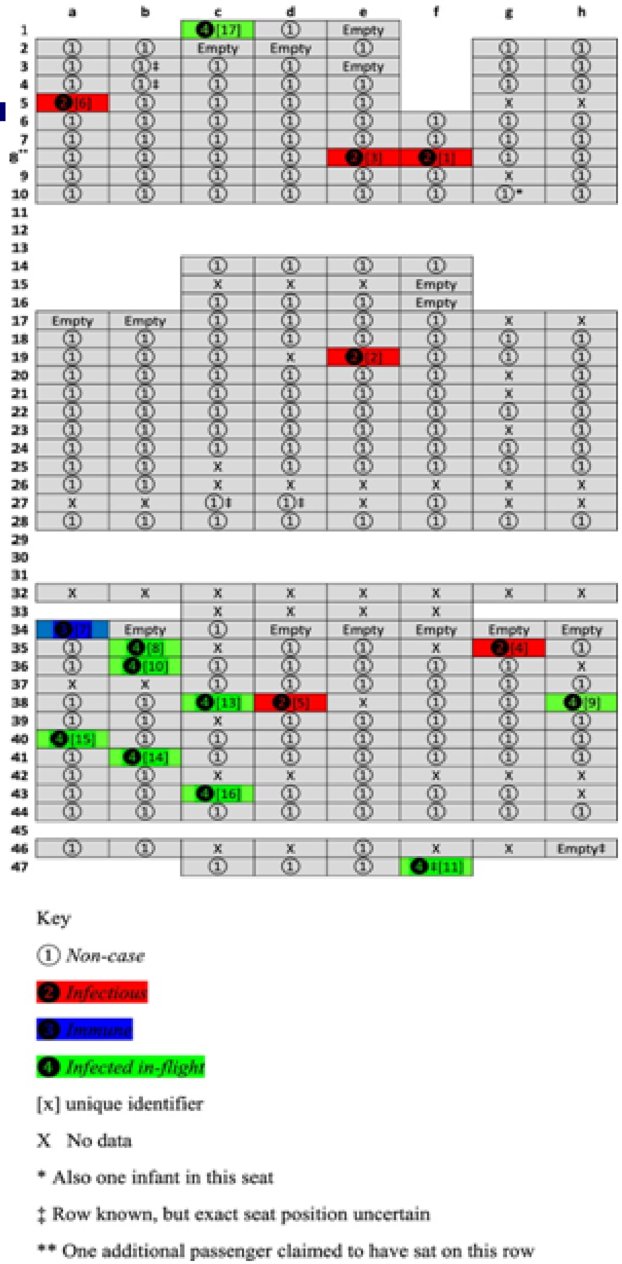


Verteilung der Aerosole einer hustenden Person (Prof. Chen, Purdue University)

Ansteckung ist in der ganzen Kabine möglich



Boeing 737-300 auf dem Flug von Hong Kong nach Peking über 3 Stunden.
"Index patient" ist die erkrankte Person auf Sitz 14E.
https://doi.org/10.1056/NEJMoa031349

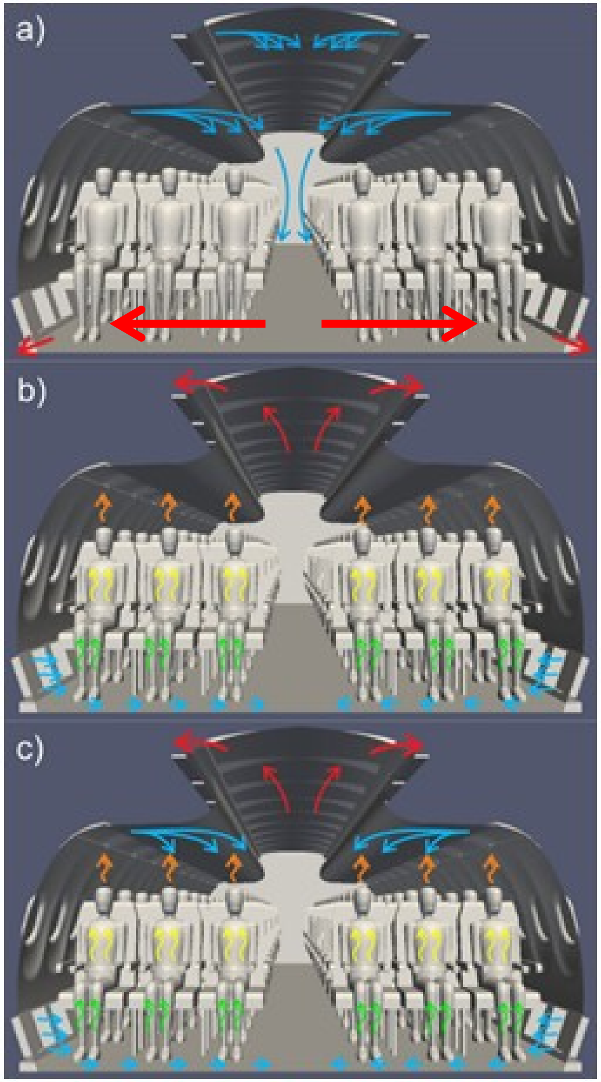


Ansteckung ist in der ganzen Kabine möglich

Boeing 767 auf dem Flug von Mexiko in das Vereinigte Königreich über 9,5 Stunden.

Eine weitere infizierte Person ist im Sitzplan nicht eingezeichnet.

https://doi.org/10.1111/irv.12181



Luftströmung besser von unten nach oben!

a) Das System von heute hat
höhere Turbulenz durch
Luftströmung von oben nach unten

b) und insbesondere c)

Klimaanlage (blau) und Konvektion am Passagier (grün, geld, orange):
beide haben die gleiche Strömungsrichtung: von unten nach oben! Kein "Kampf der Strömungen". Daher:

geringere Turbulenz .

Geringere Verteilung der Viren über die ganze Kabine.

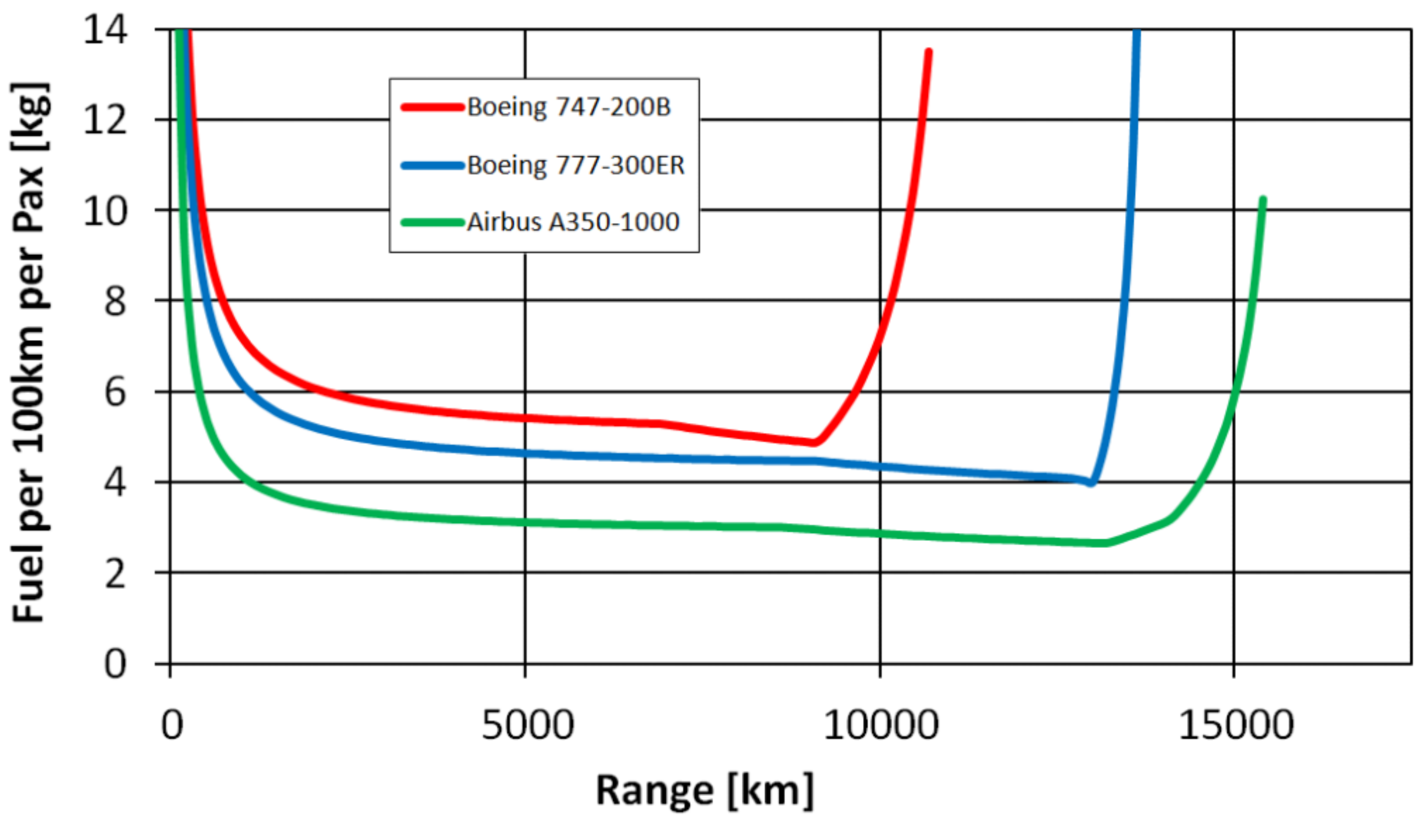
Hohes Risiko der Ansteckung:

	im Flugzeug?
Viele Menschen zusammen	**ja**
Menschen dicht zusammen	**ja**
Über lange Zeit zusammen	**ja**
Geringe Belüftung des Raumes	**nein**

Grünes Fliegen

Grundlagen

Der Kraftstoffverbrauch pro 100 km und Person hängt von der Flugdistanz ab!



https://nbn-resolving.org/urn:nbn:de:gbv:18302-aero2017-12-13.019

Tiefer Fliegen!

		Mach number								
		0,4	0,45	0,5	0,55	0,6	0,65	0,7	0,75	0,8
Altitude (m)	3000	0,053	0,023	0,012	0,011	0,018	0,035	0,058	0,092	0,155
	3500	0,062	0,027	0,012	0,008	0,013	0,026	0,047	0,078	0,135
	4000	0,072	0,032	0,013	0,006	0,008	0,019	0,037	0,064	0,117
	4500	0,083	0,038	0,015	0,005	0,005	0,013	0,028	0,052	0,100
	5000	0,097	0,046	0,018	0,006	0,002	0,008	0,020	0,042	0,085
	5500	0,114	0,057	0,025	0,009	0,003	0,006	0,016	0,035	0,074
	6000	0,133	0,068	0,032	0,012	0,003	0,004	0,012	0,028	0,065
	6500	0,155	0,083	0,041	0,018	0,006	0,004	0,009	0,023	0,057
	7000	0,192	0,110	0,062	0,035	0,020	0,015	0,018	0,030	0,061
	7500	0,231	0,140	0,087	0,054	0,036	0,029	0,030	0,039	0,066
	8000	0,282	0,180	0,119	0,082	0,060	0,050	0,048	0,055	0,079
	8500	0,349	0,233	0,164	0,121	0,095	0,082	0,077	0,082	0,103
	9000	0,425	0,294	0,215	0,166	0,135	0,118	0,111	0,112	0,131
	9500	0,502	0,354	0,265	0,209	0,173	0,153	0,142	0,141	0,157
	10000	0,589	0,422	0,320	0,256	0,215	0,190	0,176	0,172	0,184
	10500	0,675	0,481	0,364	0,289	0,241	0,211	0,193	0,186	0,196
	11000	0,685	0,483	0,361	0,284	0,234	0,203	0,185	0,178	0,189
	11500	0,769	0,535	0,394	0,305	0,247	0,211	0,188	0,178	0,186
	12000	0,867	0,591	0,426	0,322	0,255	0,211	0,184	0,170	0,175
	12500	1,000	0,677	0,485	0,364	0,285	0,234	0,201	0,183	0,184

Results environmental impact (normalized between 0 and 1)

https://nbn-resolving.org/urn:nbn:de:gbv:18302-aero2019-07-28.013

- Entscheidungen werden in der Luftfahrtindustrie allein nach wirtschaftlichen Überlegungen gefällt. Auf der Kurz- und Mittelstrecke ist der Kostenanteil durch den Kraftstoffverbrauch mit ca. 9 % gering. Eine Verbesserung in der Umweltwirkung ist durch Marktkräfte daher nicht unbedingt zu erwarten.

- Im üblichen Reiseflug spielt CO2 mit nur ca. 20 % an den äquivalenten CO2 eine untergeordnete Rolle. Wir haben kein CO2-Problem, sondern ein H2O-Problem (contrails / AIC). Viele Aktivitäten in der Luftfahrtindustrie verlieren vor diesem Hintergrund ihre Berechtigung.

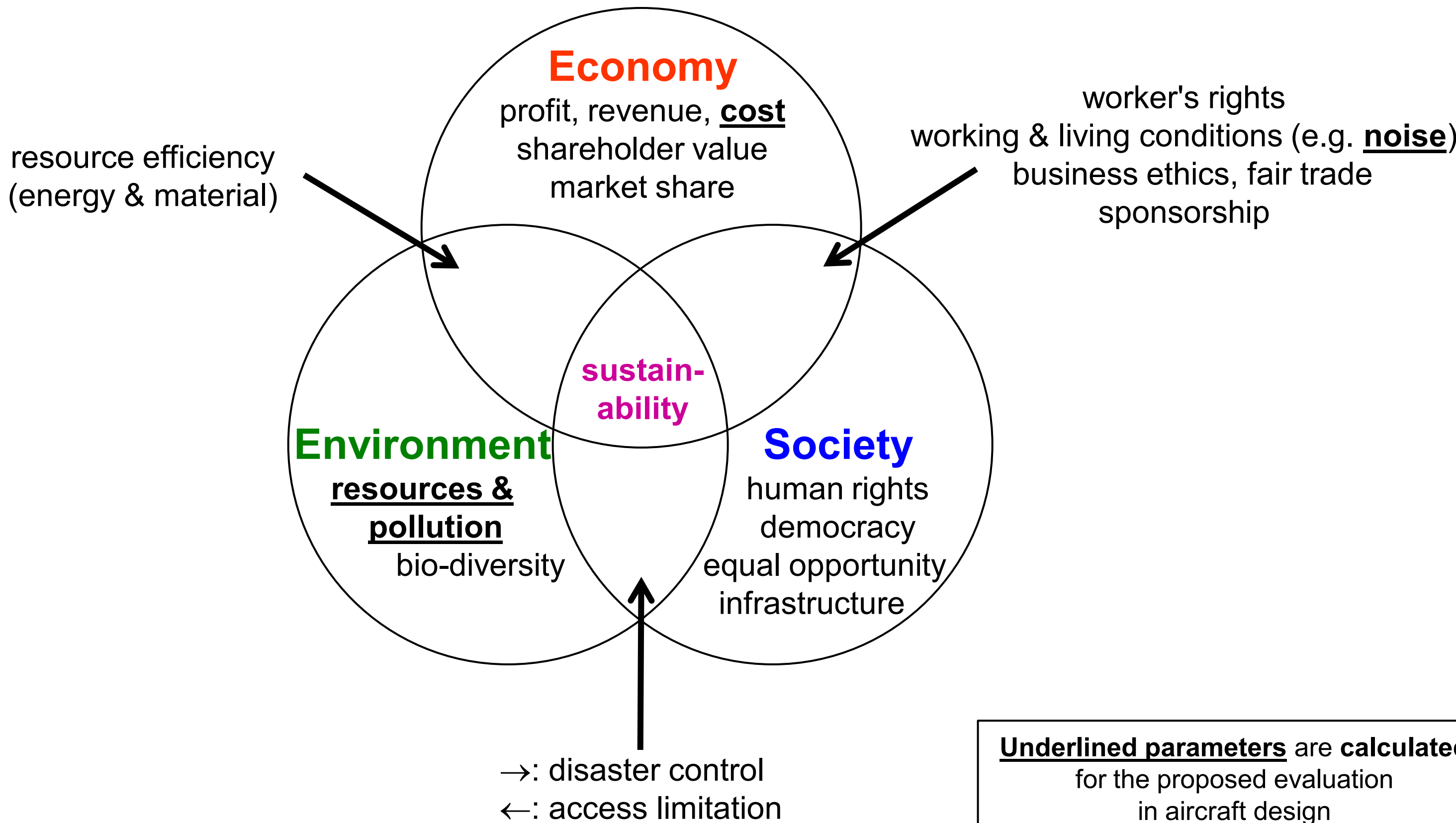
- Warten auf neue Flugzeuge ist nicht erforderlich. Schon heute könnte die Umweltwirkung bei einem Flug in 6500 m Höhe um 70 % reduziert werden. Dabei würde der Kraftstoffverbrauch um knapp 6 % ansteigen, was die Kosten (DOC) nur um ca. 0,6 % erhöhen würde. Bei einer vollständigen ökonomischen Ausrichtung ist das aber keine Handlungsoption und wird daher nicht von allein passieren.

- Einsparungen können auch mit den Methoden des Flugzeugentwurfs erreicht werden. Wenn man die erheblichen Reduktionsmöglichkeiten in der Umweltwirkung ernst nimmt, dann könnte man evtl. auch zu einer anderen vorteilhaften Festlegung der Anforderungen an die Flugzeuge bereit sein (Stichwort: längere Landestrecke vorsehen).

Bewertung im Flugzeugentwurf

Enthalten in: https://doi.org/10.15488/3986

The 3 Dimensions of Sustainability



Underlined parameters are **calculated** for the proposed evaluation in aircraft design

Sustainability Venn Diagram

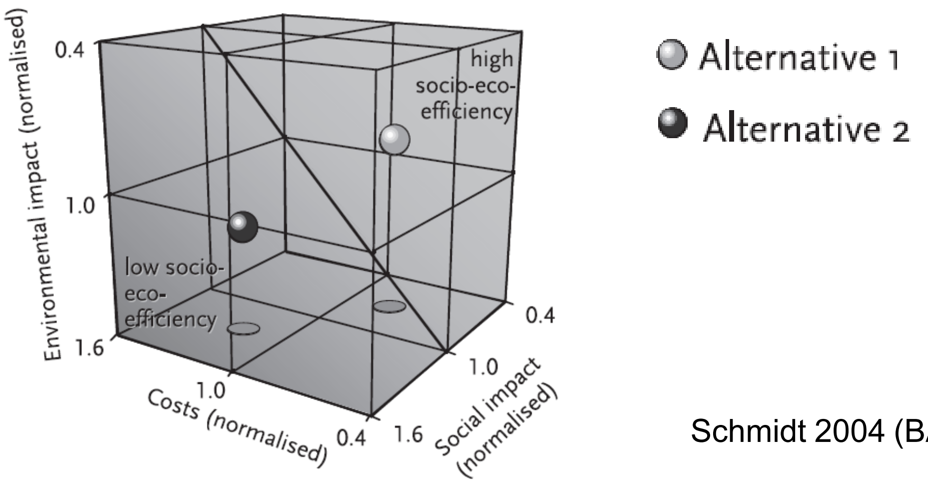
Evaluation: Purpose

- evaluation of the aircraft for **optimum design** (definition of an objective function)
- **technology evaluation** (on an assumed aircraft platform)
- evaluation for **aircraft selection** (for aircraft purchase by an airline)

Evaluation in the 3 Dimensions of Sustainability: Measuring Socio-Eco-Efficiency

- Economic Evaluation
- Environmental Evaluation
- Social Evaluation

Economic + Environmental → Eco-Efficiency; Eco-Efficiency + Social → Socio-Eco-Efficiency (SEE)



Type of Evaluation	Method
Economic	DOC
Environmental	LCA
Social	S-LCA

Schmidt 2004 (BASF SEE)

Environmental Evaluation

Kerosene Versus Battery in Flight

Type of Comparison	Kerosene	Battery
Energy (wrong)	$E = m_F \; H_L$	$E = E_{bat} / \eta_{charge}$
Max. Exergy (not good)	$B_{max} = \eta_C \; H_L \; m_F$	$B_{max} = E$
Exergy (ok)	$B = \eta_{GT} \; H_L \; m_F$	$B = \eta_{EM} \; E$
Primary Energy (better)	$E_{prim} = 1.1 \, H_L \; m_F$	$E_{prim} = k_{PEF} \; E$
CO2 (without altitude effect)	$m_{CO2} = 3.15 \cdot 1.1 \, m_F$	$m_{CO2} = 3.15 \, x_{ff} \; E_{prim} / H_L$
Equivalent CO2 (good, simple)	$m_{CO2,eq} = m_{CO2} (k_{RFI} + 0.1)$	$m_{CO2,eq} = m_{CO2}$

$H_L = 43$ MJ/kg

$\eta_{charge} = 0.9$

$\eta_{GT} = 0.35$ $\qquad \eta_{EM} = 0.9$

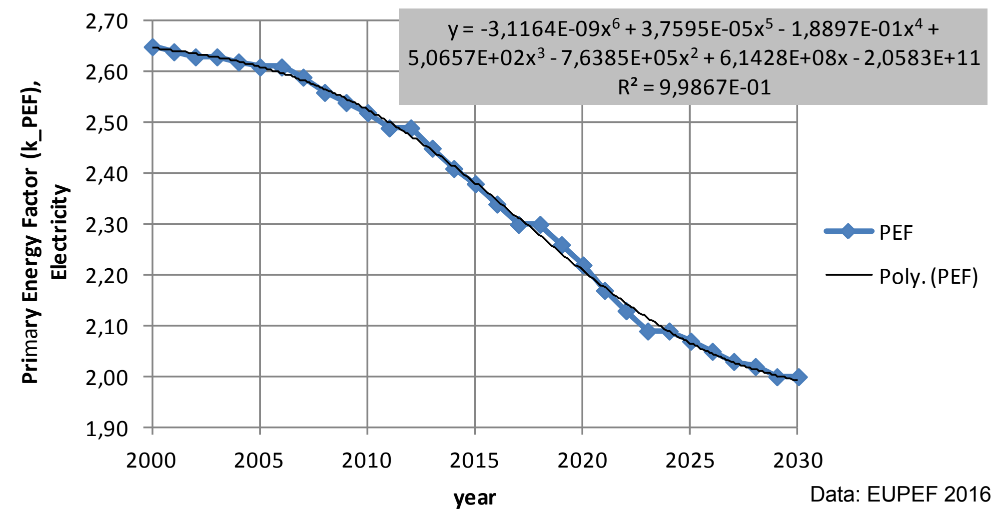
Carnot Efficiency:

$\eta_C = 1 - T(h) / T_{TET} = 1 - 216.65/1440 = 0.85$

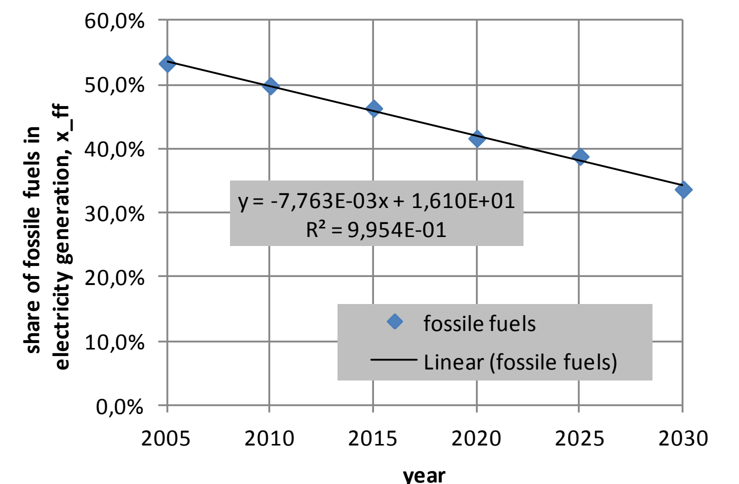
Radiative Forcing Index:

$k_{RFI} = 2.7 \quad (1.9 \ldots 4.7)$

Due to flight at altitude plus energy mix with renewables & nuclear power: $m_{CO2,eq,kerosene} \approx 2.5 \cdot m_{CO2,eq,battery}$



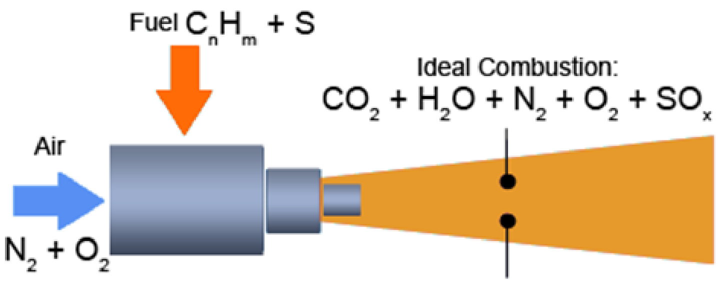
Data: EUPEF 2016



Data: EUPEF 2016

Environmental Evaluation

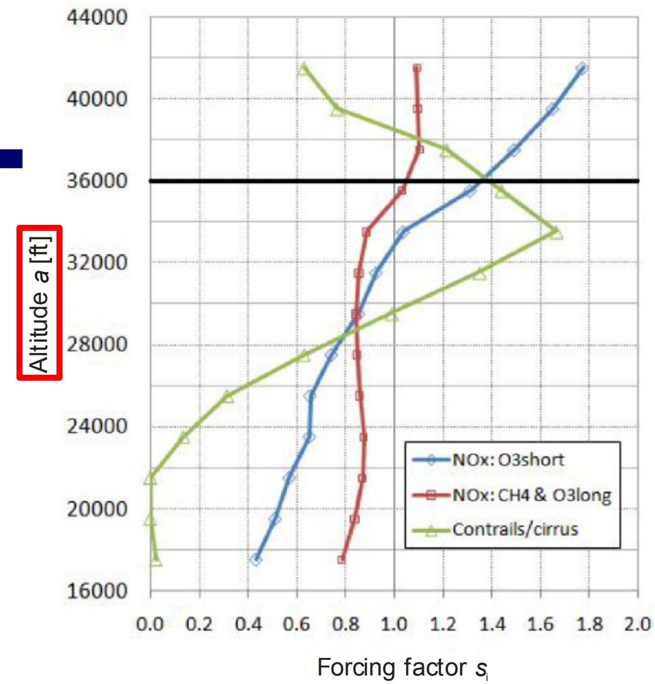
Altitude Dependent Equivalent CO2



Real Combustion: $CO_2 + H_2O + N_2 + O_2 + SO_x + UHC + CO + C_{Soot} + \underbrace{NO + NO_2}_{NO_x}$

EI_{NOx} ↑ **EMEP/EEA Guidebook** http://www.eea.europa.eu

m_F ↑ **Own Fuel Calculation**



$$m_{CO2,eq} = \frac{EI_{CO2}}{SAR \cdot n_{seat}} \cdot 1 + \frac{EI_{NOx}}{SAR \cdot n_{seat}} \cdot CF_{midpoint,NOx} + \frac{L_{flight}}{L_{flight} \cdot n_{seat}} \cdot CF_{midpoint,clouds}$$

$$s_{O_3,L}(h) = s_{CH_4}(h)$$

$$s_{contrails}(h) = s_{cirrus}(h) = s_{AIC}(h)$$

Species	Emission Index, EI (kg/kg fuel)
CO_2	3,15
H_2O	1,23
SO_2	$2{,}00 \cdot 10^{-4}$
Soot	$4{,}00 \cdot 10^{-5}$

Sustained Global Temperature Potential, SGTP (similar to GWP):

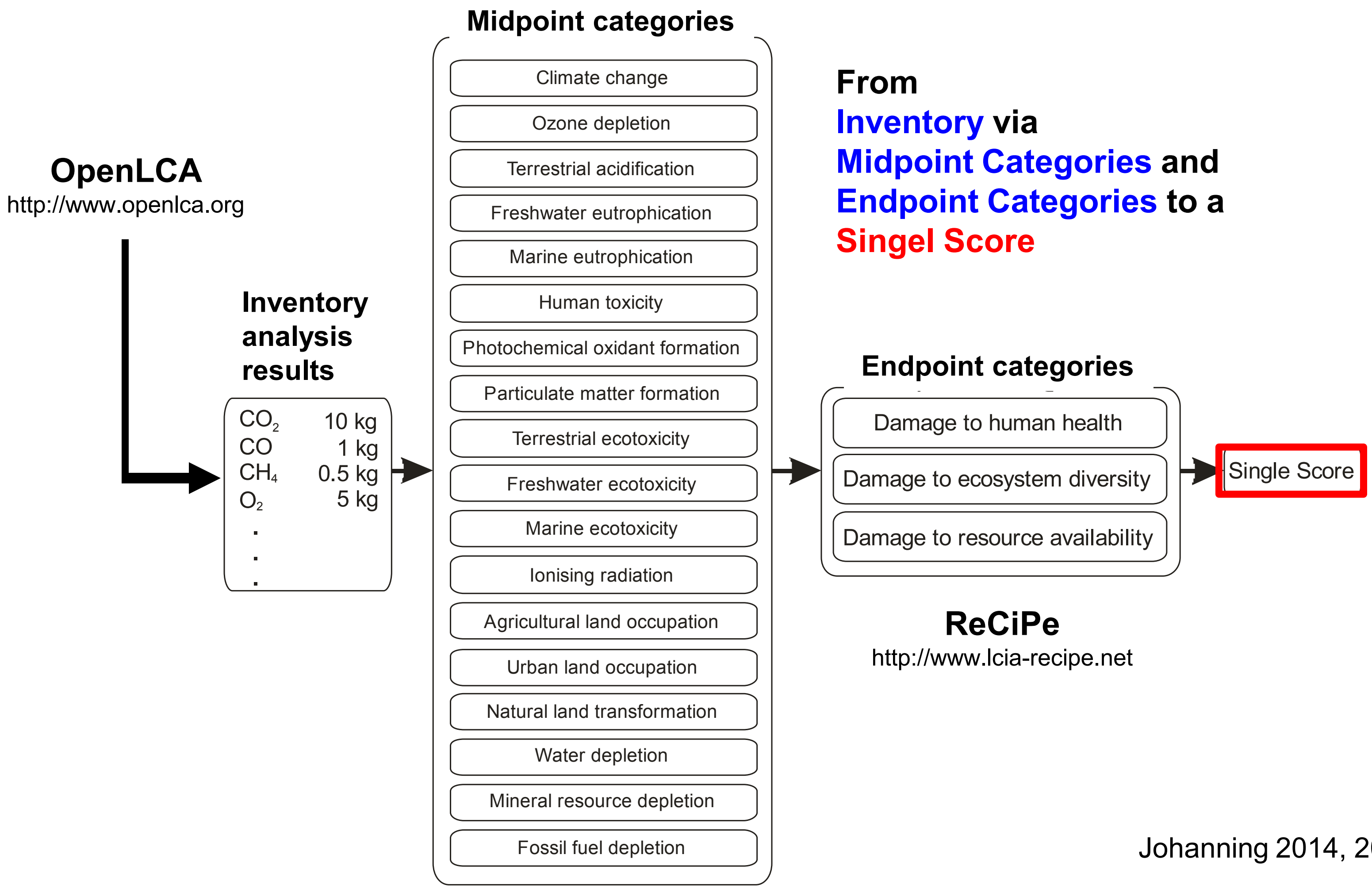
$$CF_{midpoint,NOx}(h) = \frac{SGTP_{O_{3s},100}}{SGTP_{CO_2,100}} \cdot s_{O_3,S}(h) + \frac{SGTP_{O_{3L},100}}{SGTP_{CO_2,100}} \cdot s_{O_3,L}(h) + \frac{SGTP_{CH_4,100}}{SGTP_{CO_2,100}} \cdot s_{CH_4}(h)$$

$$CF_{midpoint,cloudiness}(h) = \frac{SGTP_{contrails,100}}{SGTP_{CO_2,100}} \cdot s_{contrails}(h) + \frac{SGTP_{cirrus,100}}{SGTP_{CO_2,100}} \cdot s_{cirrus}(h)$$

Species	$SGTP_{i,100}$
CO_2 (K/kg CO_2)	$3{,}58 \cdot 10^{-14}$
Short O_3 (K/kg NO_x)	$7{,}97 \cdot 10^{-12}$
Long O_3 (K/NO_x)	$-9{,}14 \cdot 10^{-13}$
CH_4 (K/kg NO_x)	$-3{,}90 \cdot 10^{-12}$
Contrails (K/NM)	$2{,}54 \cdot 10^{-13}$
Cirrus (K/NM)	$7{,}63 \cdot 10^{-13}$

An Excel-Based Life Cycle Tool

From
Inventory via
Midpoint Categories and
Endpoint Categories to a
Singel Score



Johanning 2014, 2016, 2017

Elektrisches Fliegen ?

Enthalten in:
https://doi.org/10.15488/3986 bzw. http://EHA2018.ProfScholz.de

und /oder:
https://doi.org/10.5281/zenodo.3265211
https://www.fzt.haw-hamburg.de/pers/Scholz/Aero/AERO_PRE_DLRK2019_LimitsToElectricFlight_19-09-30.pdf

Erste Überlegungen

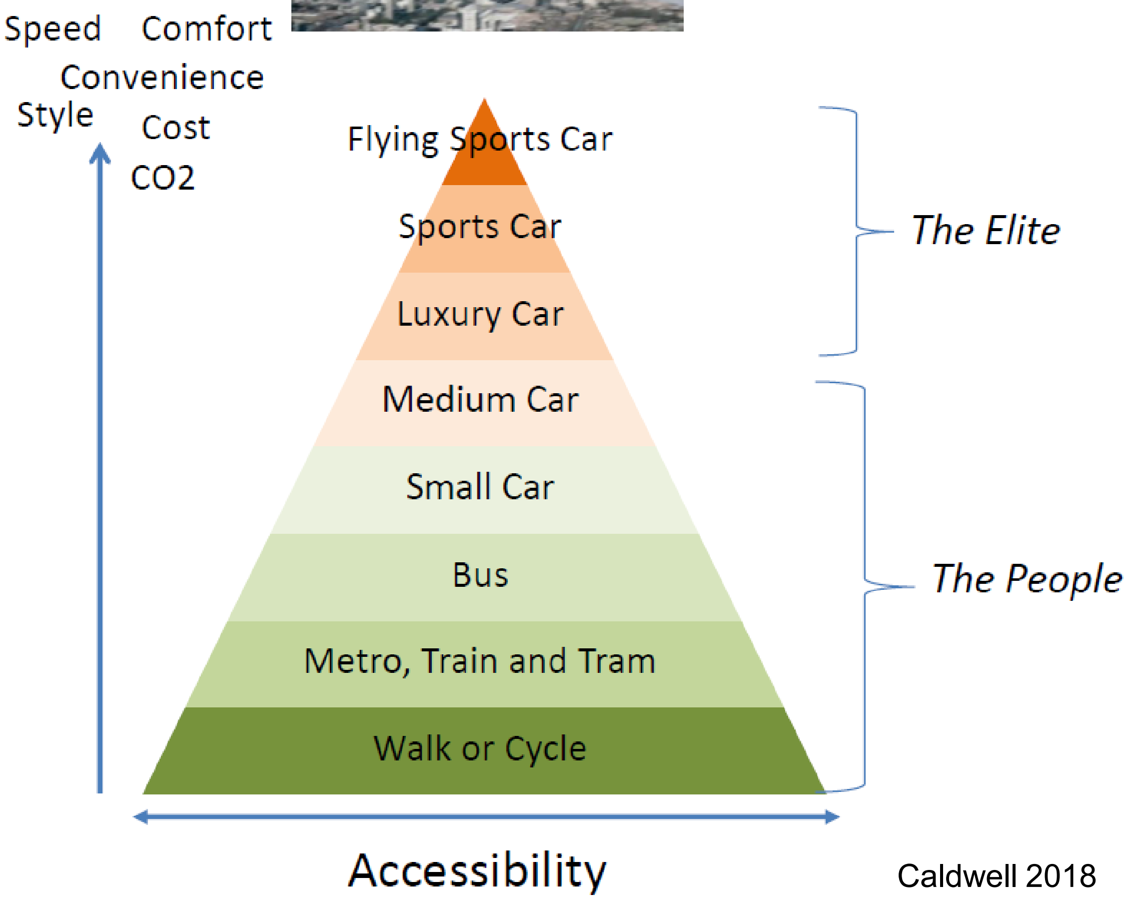
Initial Thoughts

Modes of Transportation and Income

City Airbus, 4 passengers,
endurance: 15 min. (Airbus 2017a)

Max Pixel, CC0

Waiting for the City Airbus?



Caldwell 2018

Initial Thoughts

based on Caldwell 2018

Modes of Transportation and CO2

"Flying Taxi"? ......or "Flying Sports Car"?

Ehang184
Carbon fibre monocoque
360kg
106kW
= 0.29 kW/kg

CO_2=1000g/km (in Dubai)

Lamborghini LP700
Carbon fibre monocoque
1575kg
515kW peak
= 0.33 kW/kg

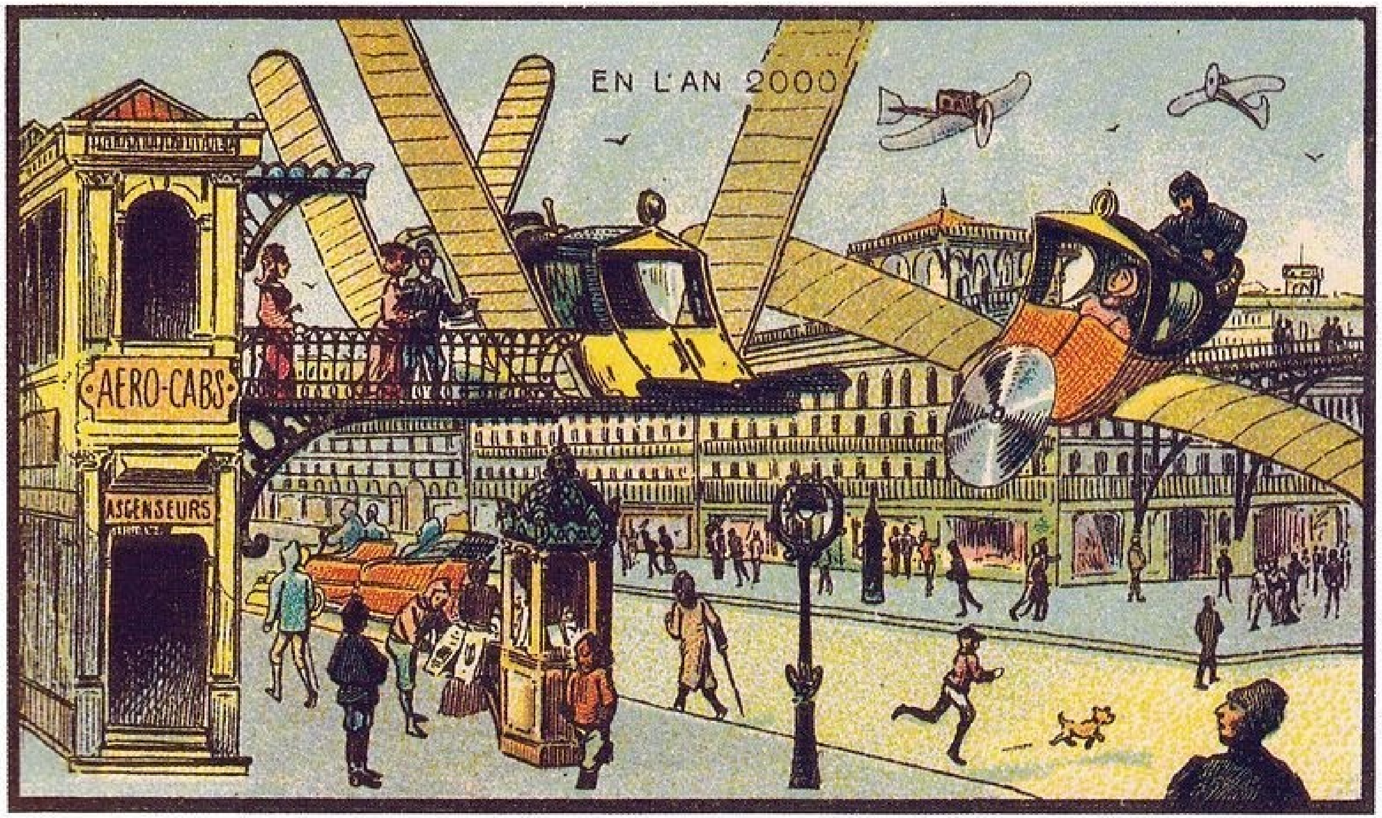
CO_2=370g/km

VW Golf TDI
4.2 l/100 km
1440 kg
118 kW
= 0.082 kW/kg

CO_2 = 106 g/km

Initial Thoughts

Predicting the Future



Aero-Cab Station

A french 1899 forecast of "AERO-CABS" in the year 2000 (courtesy of Prof. Zhuravlev)

Validation – Are we Doing the Right Thing?

Electric (Air) Mobility with/without Grid Connection?

"I am also much in favor of Electric Propulsion in aviation – once the problem with the Aerial Contact Line is solved!"

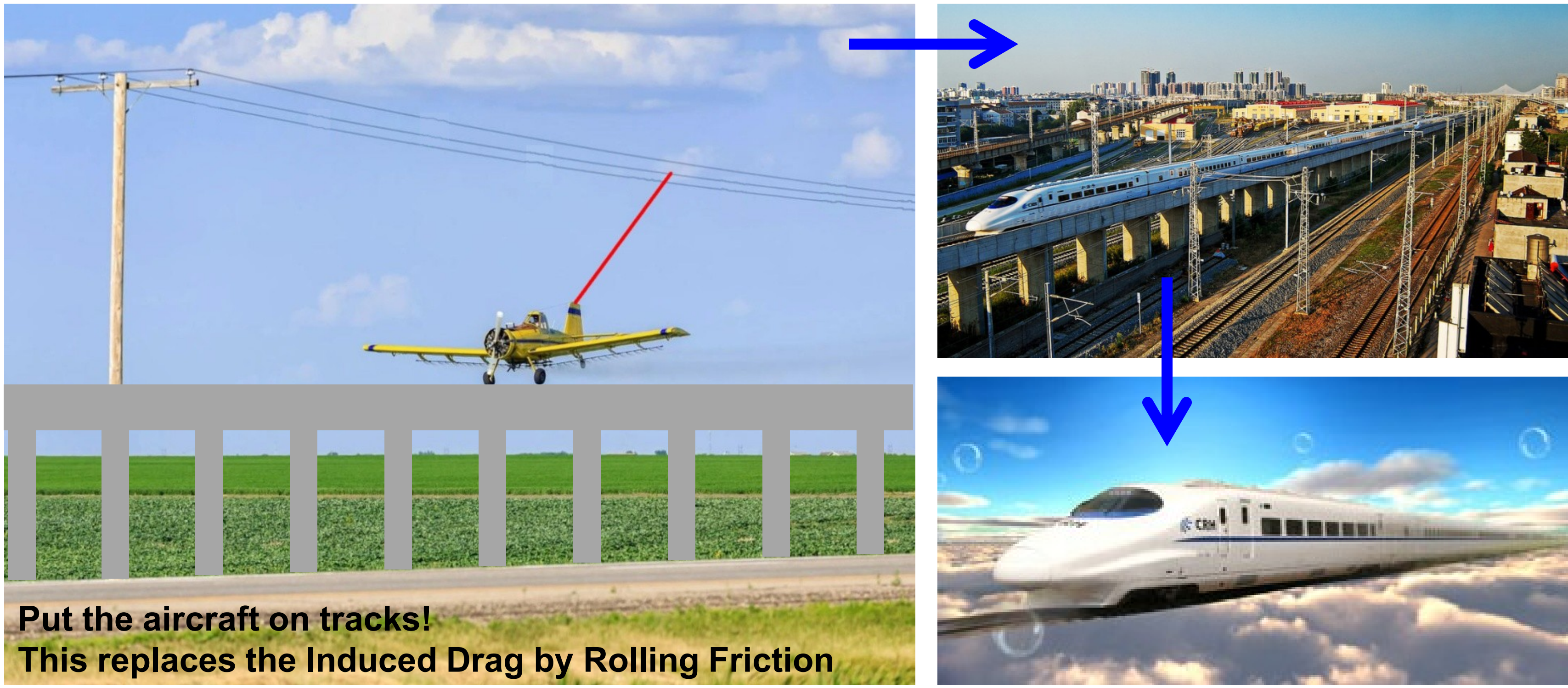
(one of my engineering friends)

We know:

- Electric propulsion suffers from large battery weight / low specific energy.
- Hybrid electric propulsion makes use of fuel with high specific energy, but leads to rather complicated, heavy and expensive systems.

Validation – Are we Doing the Right Thing?

Grid Connected Electric Mobility Operates Successfully on Tracks!



- Aircraft: *Induced drag* is drag due to Lift = Weight. Train: *Rolling Friction* is also drag due to Weight.
- Aircraft: For minimum drag, *induced drag* is 50% of total drag.
- For the same weight, rolling friction of a train is 5% of the induced drag of an aircraft!
- This means: For the same weight, drag of an aircraft is reduced by ≈ 47.5% if put on rails!

Aircraft Design for Electric Propulsion

Maximum Relative Battery Mass

$$m_{MTO} = m_{OE} + m_{bat} + m_{PL}$$

$$\frac{m_{bat}}{m_{MTO}} = 1 - \frac{m_{OE}}{m_{MTO}} - \frac{m_{PL}}{m_{MTO}}$$

$$\frac{m_{OE}}{m_{MTO}} \approx 0.50$$ **technology parameter**

m_{MTO} : Maximum Take-Off mass
m_{bat} : battery mass
m_{OE} : Operating Empty mass
m_{PL} : PayLoad

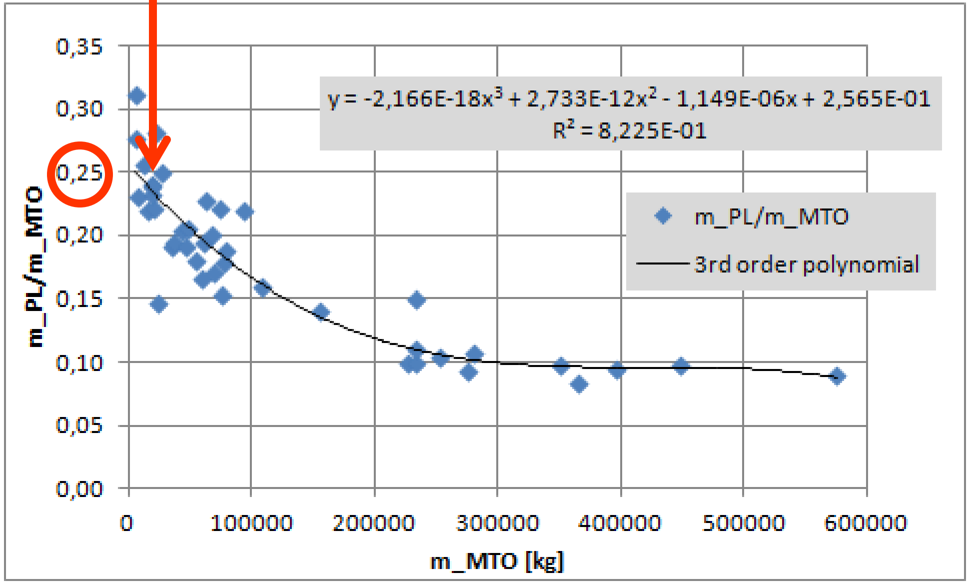
small A/C; short range

$$\frac{m_{PL}}{m_{MTO}} = 0.25 : \quad \frac{m_{bat}}{m_{MTO}} = 0.25$$

$$\frac{m_{PL}}{m_{MTO}} = 0.10 : \quad \frac{m_{bat}}{m_{MTO}} = 0.40$$

$$0.25 \leq \frac{m_{bat}}{m_{MTO}} \leq 0.40$$

this is equivalent to
revenue / expenses



Payload, m_PL calculated from "typical number of seats" from manufacturers seat layout and 93 kg/seat. Data points represent passenger aircraft most frequently in use with 19 seats or more. Note: Although the regression is quite good, physically m_PL/m_MTO is a function of range.

Aircraft Design for Electric Propulsion

Maximum Range for Electrical Propulsion

e_{bat} : specific energy
E_{bat} : energy in battery
E : glide ratio (aerodynamic efficiency)
L : lift
D : drag
W : weight
V : flight speed
R : range
t : time
g : earth acceleration
P : power
η : efficiency (prop: propeller)

$$e_{bat} = \frac{E_{bat}}{m_{bat}} \qquad L = W = m_{MTO}\, g \qquad E = \frac{L}{D} \qquad D = \frac{m_{MTO}\, g}{E}$$

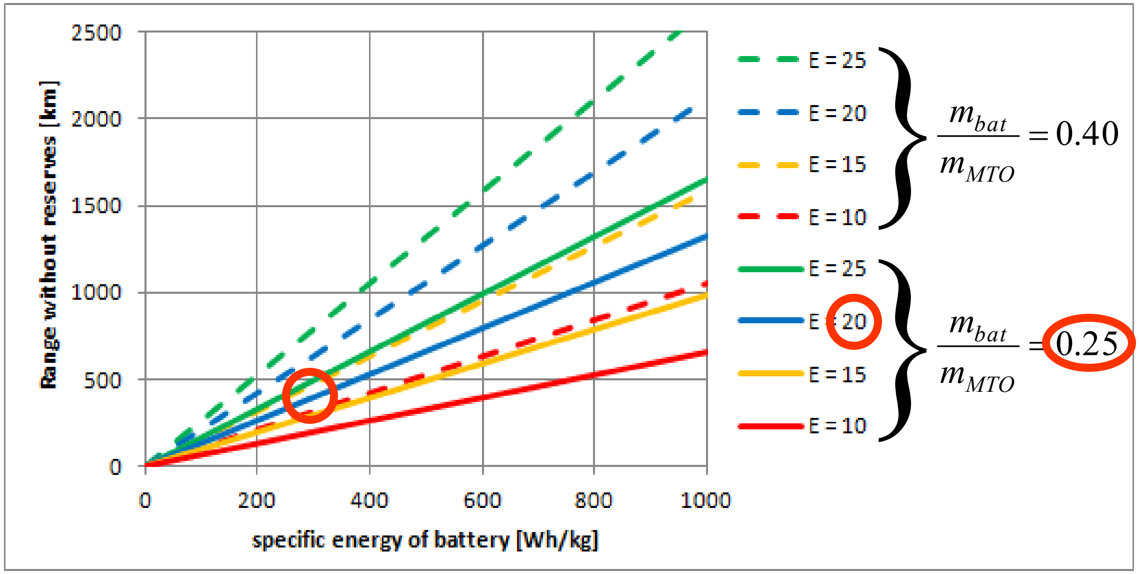
$$P_D = D V = \frac{m_{MTO}\, g}{E} V = P_T = P_{bat}\, \eta_{prop}\, \eta_{elec} \qquad V = \frac{R}{t}$$

$$P_{bat} = \frac{E_{bat}}{t} = m_{bat}\, e_{bat} \frac{V}{R}$$

$$m_{bat}\, e_{bat} \frac{V}{R} \eta_{elec}\, \eta_{prop} = \frac{m_{MTO}\, g}{E} V$$

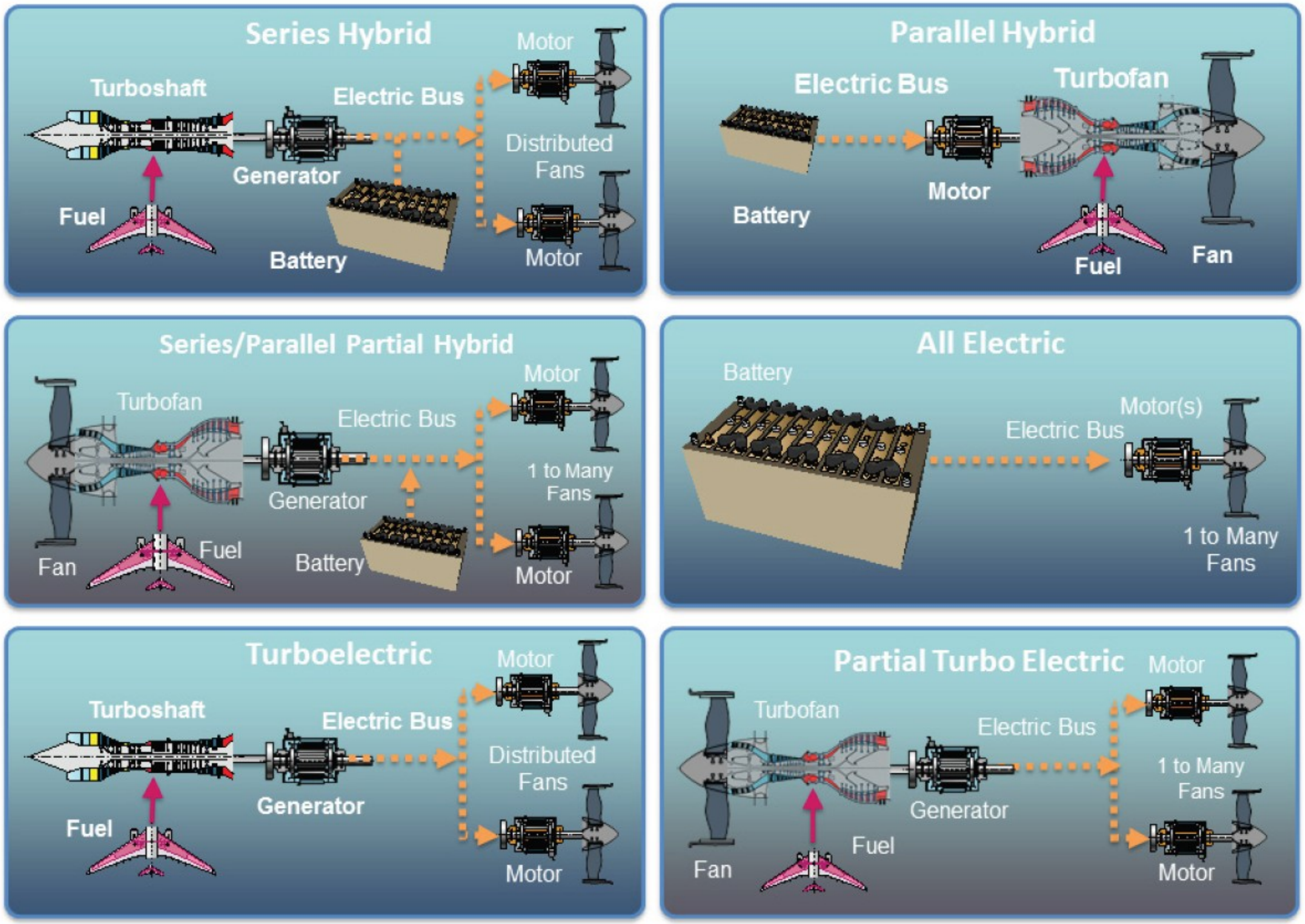
$$\boxed{R = \frac{m_{bat}}{m_{MTO}} \frac{1}{g} e_{bat}\, \eta_{elec}\, \eta_{prop}\, E}$$

$$\eta_{elec} = 0.9; \qquad \eta_{prop} = 0.8$$



○ : realistic parameters

The Major 6 Turbo / Electric / Hybrid Architectures



NAS 2016

Ausgewählte Projekte – Media Hype?

Selected Projects Evaluated – Media Hype?

Media Hype or Media Circus and Greenwashing

Media Hype

Definition:
A news event for which the level of media coverage is perceived to be excessive or out of proportion to the event being covered.
(https://en.wikipedia.org/wiki/Media_circus)

Greenwashing

Definition:
A form of spin in which green PR or green marketing is deceptively used to promote the perception that an organization's products, aims or policies are environmentally friendly
(https://en.wikipedia.org/wiki/Greenwashing)

Criteria (translated):
Missing acts, borrowed plumes, hidden goal conflicts, lack of evidence, vague statements, wrong labels, irrelevant statements, lesser evil, untruths, Deep Greenwash
(https://de.wikipedia.org/wiki/Greenwashing)

Selected Projects Evaluated – Media Hype?

A320 Successor ?

Bloomberg

Hyperdrive

Airbus May Make the Next Version of Its Top-Selling Jet an Electric Hybrid

By Benjamin D Katz

13. Juni 2019, 16:50 MESZ *Updated on 14. Juni 2019, 16:01 MESZ*

- Successor to A320 workhorse could also be conventional model
- Decision depends on technology progress, Boeing competition

Katz 2019

The launch of a hybrid model, while the biggest advance in the industry for decades, would bring its own challenges, not least convincing airlines to back technology that might initially offer only limited range and capacity. ?

The aircraft would operate at slightly lower speeds !, adding, for example, about 30 minutes to a typical flight within Europe.

Airbus is ultimately working toward a zero-emissions aircraft ?, though given the relative immaturity of the technology it's likely to have to develop a hybrid model first, head of engineering Jean-Brice Dumont said at the May briefing.

May 22 interview at the planemaker's headquarters in Toulouse, France.

HAW HAMBURG

Selected Projects Evaluated – Media Hype?

E-Fan X Hybrid-Electric Flight Demonstrator (based on Avro RJ100 / BAe 146)

Airbus 2018

Airbus 2018

Airbus 2018

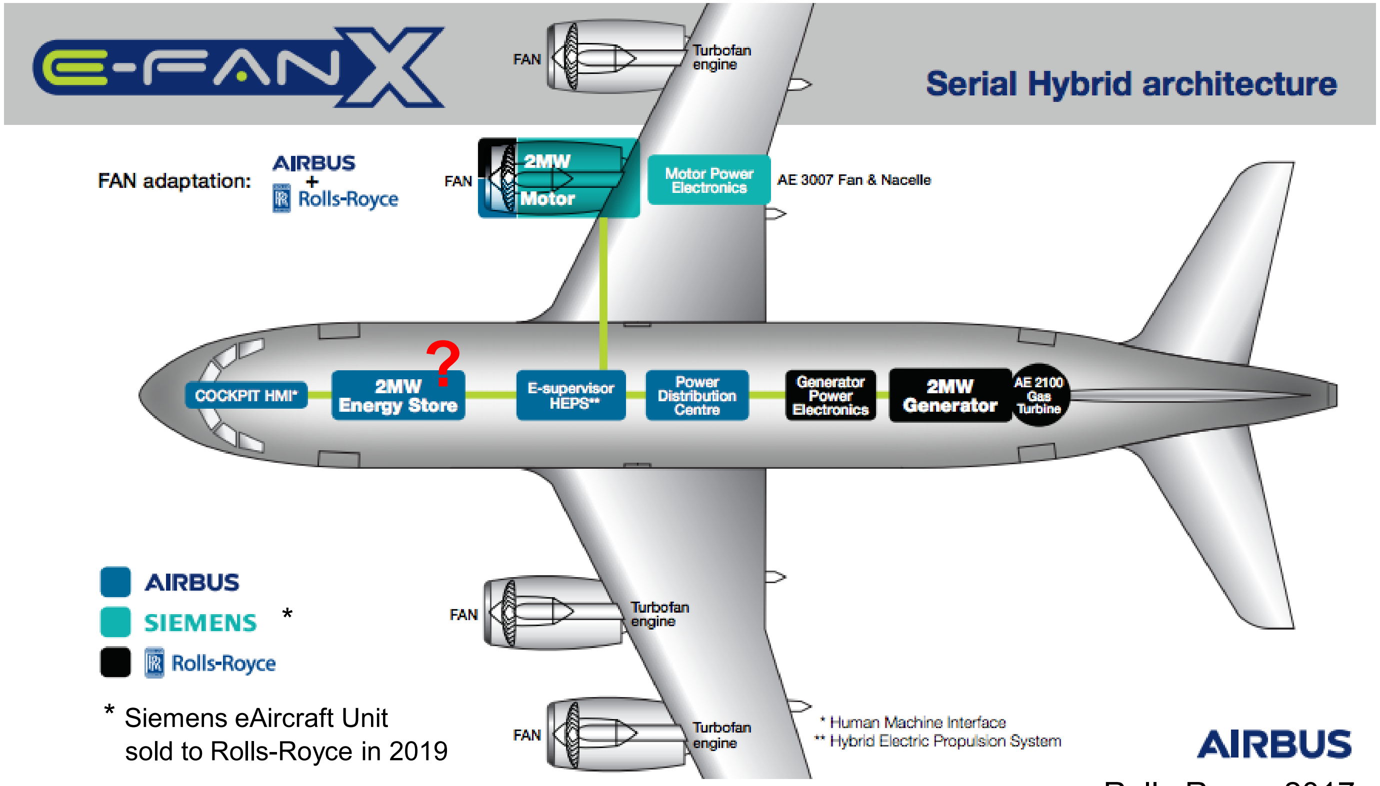
The project was announced on 2017-11-28 (Airbus 2017b/c).

"Airbus will involve BAE Systems Regional Aircraft in the design of the modification ... to work together with the other partners to approve the modification and release the aircraft for flight under their Design Organisation Approval [DOA]." (E-Fan X project lead Olivier Maillard, Airbus 2018)

Note: Airbus as aircraft manufacturer only adds a few electronic componets to the project. Batteries are bought.

Selected Projects Evaluated – Media Hype?

E-Fan X Hybrid-Electric Flight Demonstrator



* Siemens eAircraft Unit sold to Rolls-Royce in 2019

Rolls-Royce 2017

More at RAeS: Robinson 2017

- Electric engines have at best the same mass as an aviation gas turbine.
- The new propulsion system (gas turbine, generator, electric motor) has at least 3 times the mass of the original propulsion system, which could do with only the gas turbine.

E-Fan X Hybrid-Electric Flight Demonstrator

Evaluation Results:

- Given aircraft => Wing area, maximum loads, mass (MTOW, MZFW) relevant for certification is fixed!
- E-Fan X: Three Lycoming ALF 502 engines (old), one AE2100A turboshaft (new)
- New AE2100A gas turbine is slightly more efficient
- Take-off requires less than 2.5 MW => no batteries required (therefore eliminated here to improve design)
- Operating empty weight (OEW) increases => payload (MPL) decreases

  => number of passengers npax decreases to 73 (from 82)
- Direct Operating Costs (DOC) per passenger seat mile increase by about 10%

	OEW (kg)	$m_{F,TOTAL}$ (kg)	MPL (kg)	n_{pax}
Bae 146-100	23820	5667	8612	82
E-FAN X	24722	5608	7667	73
Increase	902	-59	-945	-9
Percentage difference (%)	3.787	-1.042	-10.97	-10.97

Caluclations by Benegas 2019, **HAW Hamburg**

Selected Projects Evaluated – Media Hype?

E-Fan X Hybrid-Electric Flight Demonstrator

Greenwashing

Airbus is giving false impression:

"Among the top challenges for today's aviation sector is to move towards a means of transport with improved environmental performance, that is more efficient and less reliant on fossil fuels. The partners are committed to meeting the EU technical environmental goals of the European Commission's Flightpath 2050 Vision for Aviation (reduction of CO2 by 75%, reduction of NOx by 90% and noise reduction by 65%). These cannot be achieved with the technologies existing today. Therefore, Airbus, Rolls-Royce and Siemens are investing in and focusing research work in different technology areas including electrification. Electric and hybrid-electric propulsion are seen today as among the most promising technologies for addressing these challenges."

Airbus 2017b

Translated from German: "The hybrid drive offers advantages above all with regard to noise emissions and consumption. Incidentally, the e-turbine, which draws its power from a fossil fueled generator rather than a battery, is expected to consume a good 25 percent less."

Focus 2017

Selected Projects Evaluated – Media Hype?

easyJet Full Electric Aircraft (9-seat demonstrator: 2019)

Greenwashing

Wright 2019

- Design for an easyJet-sized aircraft London - Amsterdam, Europe's second busiest route, is seen as a strong contender for full electric flying in the future.
- easyJet ... confirmed progress ... towards its strategy to operate ... more sustainably and reduce noise from aviation.
- US start-up company, Wright Electric, has commenced work on an electric engine that will power a nine seater aircraft.
- Wright Electric partner Axter Aerospace already has a two seater aircraft flying, and the larger [nine seater] aircraft is expected to start flying in 2019.
- Work will commence on an easyJet-sized aircraft by aircraft designer Darold Cummings [Aerospace Consultant].

(EasyJet 2018)

More on Darold B. Cummings see under: CSULB 2016.

Selected Projects Evaluated – Media Hype?

easyJet Full Electric Aircraft (9-seat demonstrator: 2019)

Greenwashing

AXTER AEROSPACE *

Axter 2019

→ ? →

Seats:	2	9	> 100
Year:	2018 (2016)	2019	< 2038? **

Source: Easy Jet 2018

* Axter does not mention the EasyJet project on its website!
* Wright Electric's goal is for every short flight to be zero-emissions within 20 years (Wright 2019).

Selected Projects Evaluated – Media Hype?

won't meet spec

Eviation Aircraft: Alice All-Electric Business and Commuter Aircraft

- One main pusher propeller at the tail and two pusher propellers at the wingtips to improve efficiency
- 9 passengers (plus 2 pilots) up to 650 sm (1000 km) at a cruise speed of 240 kt
- Li-Ion battery: 900 kWh
- MTOW: 6350 kg

(https://www.eviation.co/alice as of 2019)

- Battery mass is 65% of total aircraft mass (without payload)
- Specific energy of battery is 400 Wh/kg [much too high]

(https://www.eviation.co/alice as of 2017)

EVIATION

Sarsfield 2019

- Service entry is expected in 2022
- Maximum payload: 1250 kg (including pilots). This is only 13.7% of MTOW (low due to batteries).
- 183 kg cargo (with assumed 97 kg per person)
- Direct Operating Costs (DOC): 200 USD per flight hour with 11 person at 240 kt

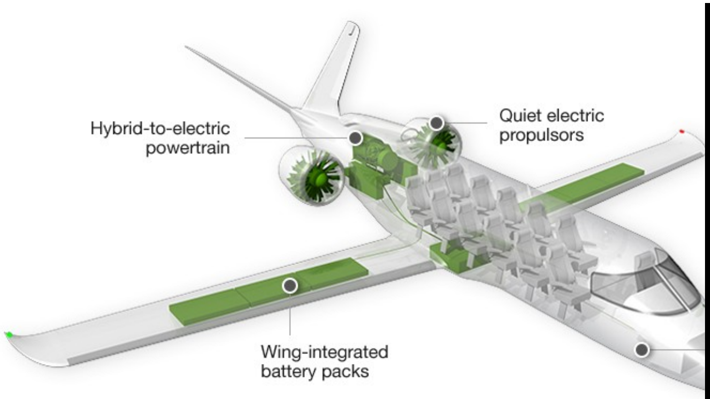
(Hemmerdinger 2019)

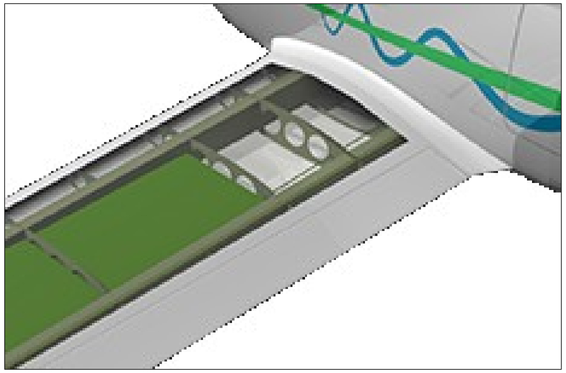
Own calculations based on given data:

- OEW: 2043 kg
- battery mass: 3434 kg
- OEW/MTOW = 0.32 (too low)
- Specific energy of battery calc.: 285 Wh/kg (high)
- L/D in cruise: 17.5 (based on 400 Wh/kg)
- L/D in cruise: 24.5 (based on 285 Wh/kg) (too high)

Selected Projects Evaluated – Media Hype?

ZUNUM Aero: Commuter Aircraft – Series Hybrid with Range Extender





Zunum 2019

Selected Projects Evaluated – Media Hype?

ZUNUM Aero: Commuter Aircraft – Series Hybrid with Range Extender

Greenwashing

Zunum's 2022 Aircraft by the Numbers

Weights (lb.)

Max. takeoff	<12,500	Zunum 2019: 11500 lbs = 5216 kg
Max. payload	2,470	Zunum 2019: 2500 lbs = 1134 kg
Standard fuel	800	= 363 kg (will give range of about 1250 km = 780 SM as specified)
Battery weight	<20% of MTOW	very low for battery electric flight

Performance

Max. cruise speed	340 mph	= 295 kt this gives M = 0,49 in 25000 ft
Max. range	>700 mi.	meant are 700 SM = 608 NM = 1126 km guaranteed by fuel !!!
Max. altitude	25,000 ft.	
Takeoff distance	2,200 ft.	
Landing distance	2,500 ft.	
Time to 25,000 ft.	18 min.	
Stall speed	73 kt.	
Max. power	1-megawatt class	
Emissions	<0.3 lb. CO_2/ASM	
Sideline noise	65 EPNdB	

Source: Zunum Aero

Warwick 2017

Zunum 2019:
12 pax => 94.5 kg / pax (low)
battery mass (@ 20% MTOW): 2300 lbs = 1043 kg
OEW = 5900 lbs = 2676 kg
OEW/MTOW = 0,51 (realistic)
With 250 Wh/kg, L/D=18: battery range = 238 km = 148 SM

Aircraft flies only 21% of its range on batteries!

Selected Projects Evaluated – Media Hype?

Diamond Aircraft Multi-Engine Hybrid Electric Aircraft (based on DA40)

Diamond 2018

- First flight: 31st of October 2018 at Diamond Aircraft's headquarters in Wiener Neustadt, Austria.
- Two electric engines have been added on a forward canard, which combined can generate 150kW of take-off power.
- The diesel generator is located in the nose of the aircraft and can provide up to 110kW of power.
- Two batteries with 12 kWh each are mounted in the rear passenger compartment [taking two of the four seats!], and act as an energy storage buffer.
- Pure electric, the aircraft has an endurance of approximately 30 minutes. The hybrid system extends this to 5 hours.
- The objective of future flight tests will be to determine the exact efficiency increase achieved in comparison to similar non-electric aircraft.

Remark: Direct Operating Costs (DOC) per passenger seat will roughly double with only 2 seats instead of 4!

Own Example

Environmental Evaluation

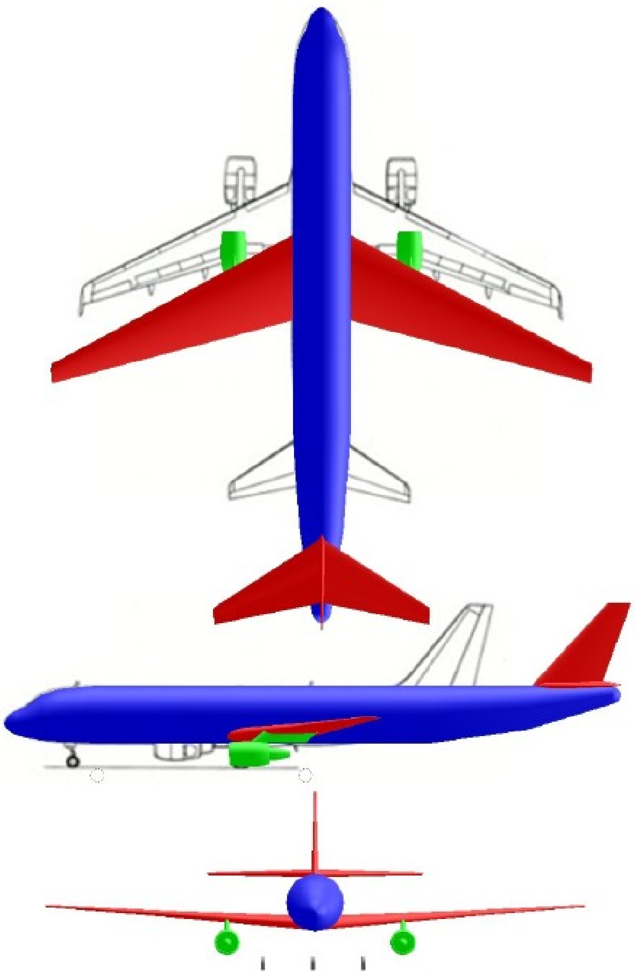
Battery Powered A320

- Only design solution with Range reduced by 50%
  => not a fair trade-off <=

- Specific Energy: 1.87 kWh/kg
- Energy density: 938 kWh/m³
- Batteries in LD3-45 container
- 2 container in cargo compartment
- 13 container forward and aft of cabin
- Fuselage streched by 9 m to house batteries

- MTOW plus 38%
- Battery mass plus 79% (compared with fuel mass)
- On study mission (294 NM) environmental burden (SS) down by 45% (EU electrical power mix)

Parameter	Value	Deviation from A320
Requirements		
m_{MPL}	19256 kg	0%
R_{MPL}	755 NM	-50%
M_{CR}	0.76	0%
max(s_{TOFL} , s_{LFL})	1770 m	0%
n_{PAX} (1-cl HD)	180	0%
m_{PAX}	93 kg	0%
SP	29 in	0%
Main aircraft parameters		
m_{MTO}	95600 kg	30%
m_{OE}	54300 kg	32%
m_F	22100 kg	70%
S_W	159 m²	30%
$b_{W,geo}$	36.0 m	6%
$A_{W,eff}$	9.50	0%
E_{max}	18.20	≈ + 3%
T_TO	200 kN	38%
BPR	6.0	0%
h_{ICA}	41000 ft	4%
s_{TOFL}	1770 m	0%
s_{LFL}	1450 m	0%
Mission requirements		
R_{Mi}	294 NM	-50%
$m_{PL,Mi}$	13057 kg	0%
Results		
$m_{F,trip}$	7800 kg	72%
SS	0.0095	-45%



Environmental Evaluation

Battery Powered A320

A320 Reference Aircraft

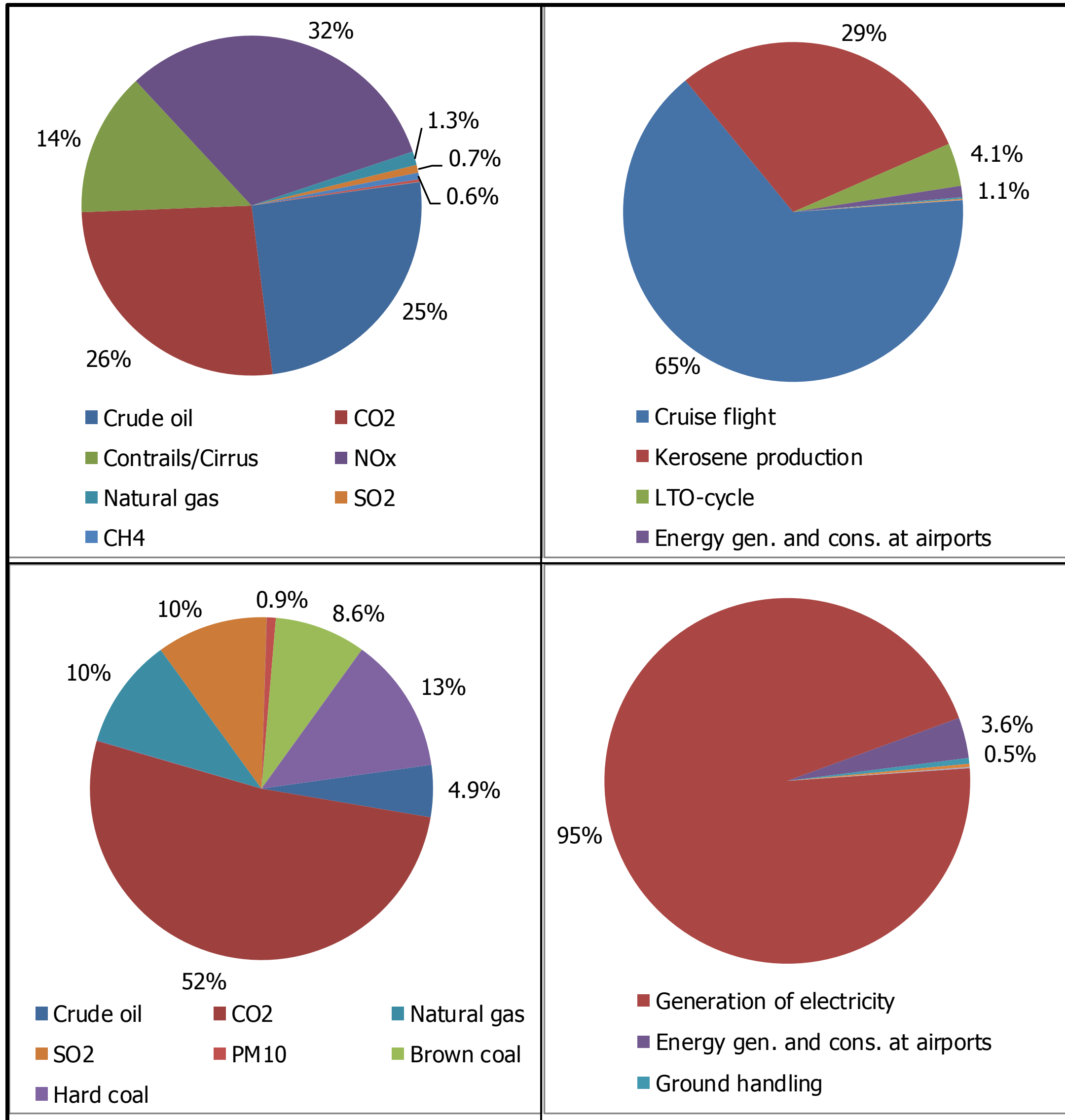
- Contributions of In- and Outputs on Single Score (SS) (left)
- Considered Processes (right)
- SS = 0.0173 points
- CO2 = 0.0045 points in SS

Battery Powered Aircraft

- Contributions of In- and Outputs on Single Score (SS) (left)
- Considered Processes (right)
- SS = 0.0095 points
- CO2 = 0.0049 points in SS

⇒The battery powered aircraft does not save CO2

⇒Generation of electricity dominates SS. With regenerative electricity: SS = 0.0008 points



Validation – Are We Doing the Right Thing?

Validation – Are we Doing the Right Thing?

Connecting Adjacent Megacities – Beijing & Shanghai – Comparing Aircraft with Train

Time	Location	Mode
08:20	Beijing Capital Times Square	Walk
08:30	Xidan	
08:40		
08:50		Metro Line 4
09:00	Xuanwumen	
09:10		
09:30		Metro Line 2
09:40	Dongzhimen	
09:50		Metro Airport Line
10:00	Beijing Capital International Airport	
10:10		
...	...	
11:20		
11:30	Beijing Capital International Airport	
11:40		
11:50		
...	**Aircraft**	Air China 1557
13:20		
13:30		
13:40	Shanghai Hongqiao	
13:50	Pick-up luggage	

(a) Travel mode: metro + aircraft

Time	Location	Mode
08:20	Beijing Capital Times Square	Walk
08:30	Xidan	
08:40	Beijing South Railway Station	Metro Line 4
08:50		
09:00	Beijing South Railway Station	
09:10		
09:20		
09:30		
09:40		
09:50		
10:00		
...	**Train**	
11:20		
11:30		
11:40		
11:50		
13:10		
13:20		
13:30		
13:40		
13:50 **new: 13:28**	Shanghai Hongqiao	

(b) Travel mode: metro + high-speed rail

China High Speed Rail (CHR)
Beijing to Shanghai:
- 1200 passengers per train
- **1200 km distance**
- 350 km/h
- ≈ every 20 min. (an A380 every 10 min.)
- usually fully booked
- 88000 passengers per day (both directions)

Example: Train number G1

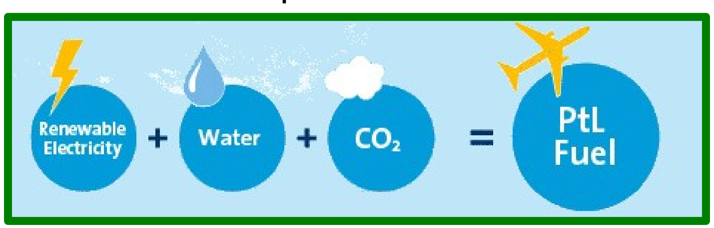
Sun 2017

- Comparison **air transportation versus high-speed rail** for a trip from Beijing Capital Times Square to Shanghai Hongqiao in China.
- Despite the large spatial distance of more than 1200 km, **passengers** using either mode **arrive** approximately **at the same time**. Probability of delays is less on the train.

Many Possible Energy Paths for Aviation

1.	fossile fuel	=> jet engine		no future solution
2.	bio fuel (algae, ...)	=> jet engine		not sustainable
3.	regenerative electricity	=> aerial contact line	=> electric engine	not for aviation
4.	regenerative electricity	=> battery	=> electric engine	**electric**: only for short range
5.	regenerative electricity	=> LH2	=> jet engine	new infrastructure & planes
6.	regenerative electricity	=> LH2 => fuel cell	=> electric engine	see 5.; trade-off !
7.	regenerative electricity	=> **PtL** (drop in fuel)	=> jet engine	same infrastructure & planes
8.	regenerative electricity	=> PtL => GT/Gen.	=> electric engine	**hybrid electric**, heavy
9.	regenerative electricity	=> PtL => GT/Pump	=> hydraulic motor	**hybrid hydraulic** , wait!

PtL: Power to Liquid **GT**: Gasturbine; **Gen.**: Generator



Additional conversions & major aircraft parts: Solutions 6 (one more component) and 8/9 (two more comp.)

Summing up the Considerations for Validation

- Physics favor trains over aircraft (*low drag due to weight*) => less energy, less CO2.
- PtL for jet engines is big competition for any electric flight bringing regenerative energy into aircraft.
- Hybrid propulsion has better applications than in aircraft.
- Unpredictable political environment for short range flights.
- Aircraft are the only means of transportation over oceans **long range.**
  Ships are too slow and hence no regular service, bridges and tunnels are limited in length.
- Trains better on **short range** (*less access time to station, less waiting time in station, ...*).
- Trains better to connect adjancent megacities over land up to **medium range** with high volume.
  A380 is too small and unfit, because designed for long range.
- Aircraft over land, if ...
  - **long range**,
  - **short range** and no train available due to low volume traffic
    - aircraft need less investment into infrastructure than (high speed) trains.
      Construction costs for high speed trains: 5 M€/km to 70 M€/km (2005, Campos 2009)
    - alternative: rail replacement bus service
  - over remote areas, if no train is available (mountains, desserts, polar regions).

So, again:

Where is the market niche for short range, small passenger aircraft with (hybrid-) electric propulsion?

Kontakt

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