Electrification of flight
Next stop: Your gliding club

Jens Trabolt Nov 2021

Contents of this talk

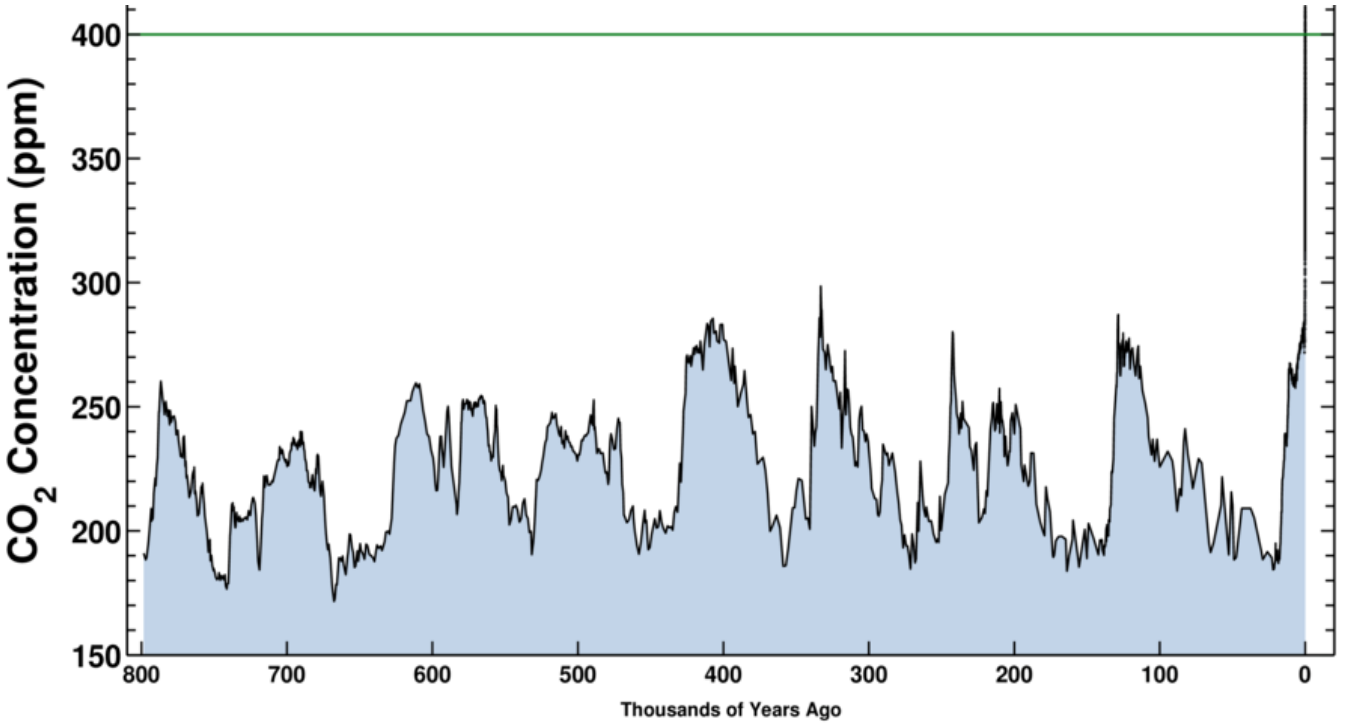
- Pros and cons of going electric?
- Future of electric gliding? Look at the automotive industry
- Recent progress in electric gliders

There will be a pop quiz in the end!

Why go electric?

Our Pawnee is doing a fine job.
There has always been fluctuations in Co2-levels

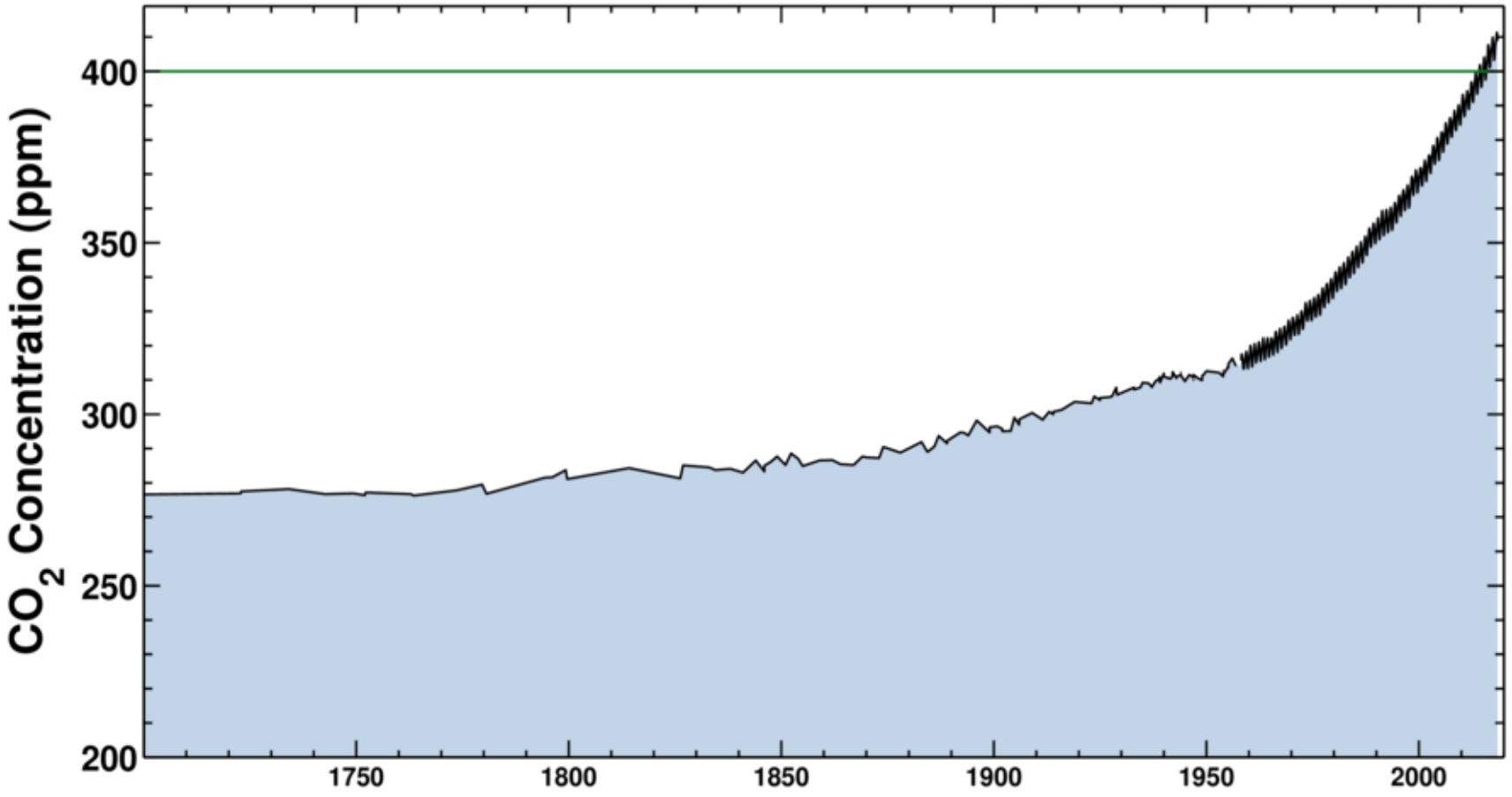
Yes but ….



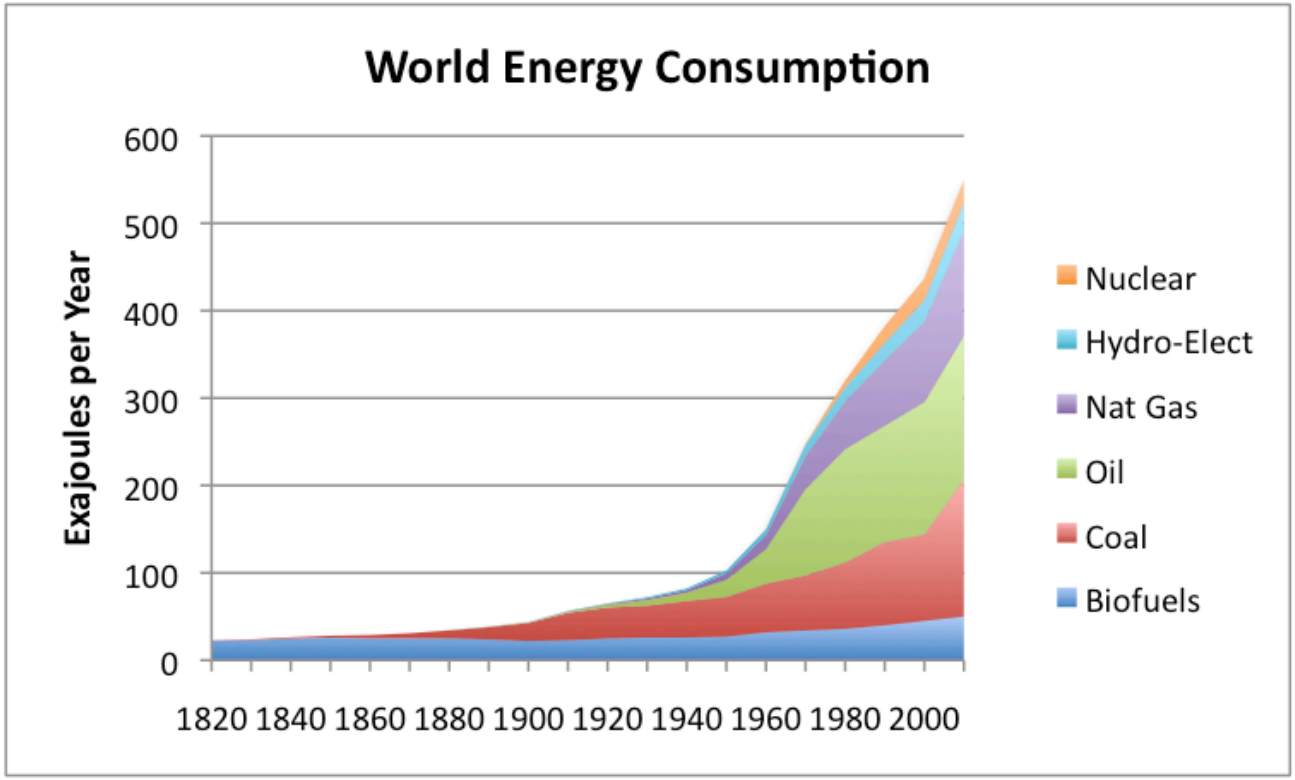
Latest CO_2 reading
August 28, 2018

406.70 ppm

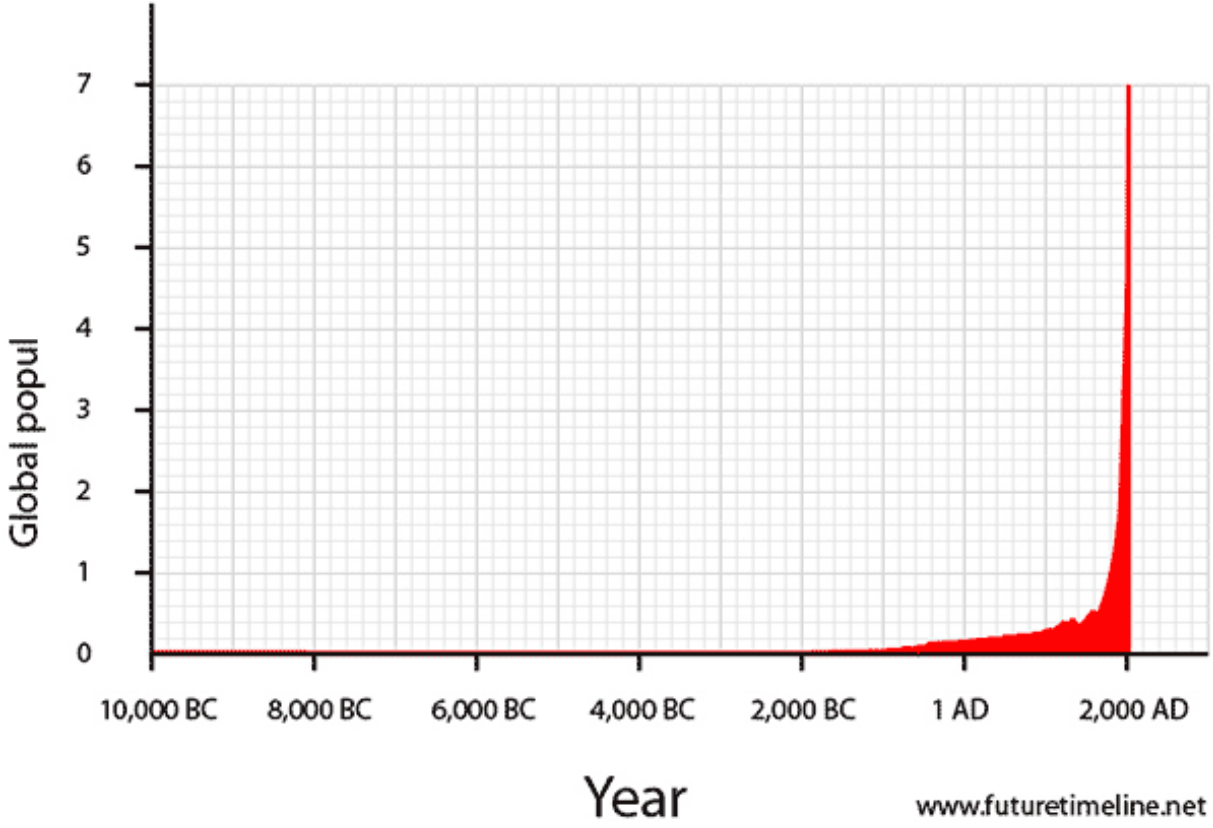
415,72 ppm
12 nov 2021

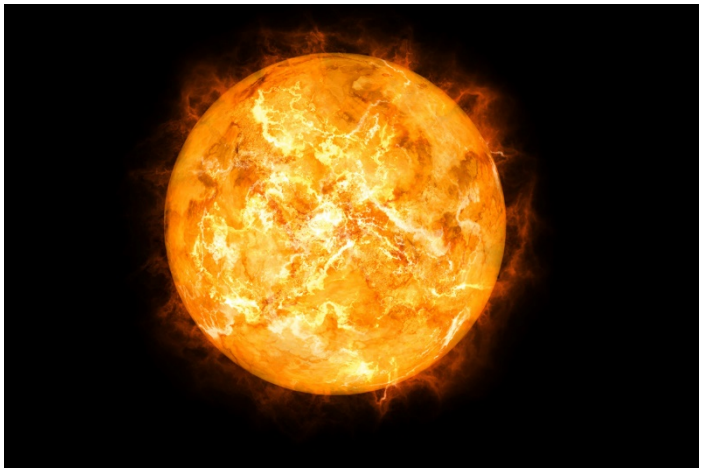


Elevated Carbon levels?
What could possibly cause this?



Why are we burning so much fuel?
Global population explosion





No need to burn coal, gas or oil

The Sun: A giant hydrogen fusion reactor - 600 mill tons hydrogen/sec) 1 kW/M^2 delivered to Earth

1 hour of sunlight can power all energy demands on Earth for an entire year

Fuel for another 5 billion years …
(vs oil/coal that will run out eventually – 100-300 years)

Question: Will we have access to gasoline in 2035?

Solar powered (electric) drivetrains

Pro

- Quiet, vibration free, clean (no oil, smell or smoke),
- Highly energy-efficient motors (90% vs 15%),
- No direct carbon emission during use (with green electricity - DK Wind/Solar share 50 % 2020)
- Low pilot workload, no crazy stuka-dives (turbo)
- Few mechanical parts, less maintenance

- Area of global massive investment
- Certification standards are improving

Solar powered (electric) drivetrains

Cons (all battery related!)

- Limited energy density (8,9 kwh FES vs 125 kWh in 13 liter petrol, but much higher motor efficiency helps to level the disadvantage).
- Somewhat longish charging times (turbo gliders irrelevant, but relevant for future e-towplanes).
- Costly (so far), heavy and delicate batteries.
- Ressource-demanding batteries

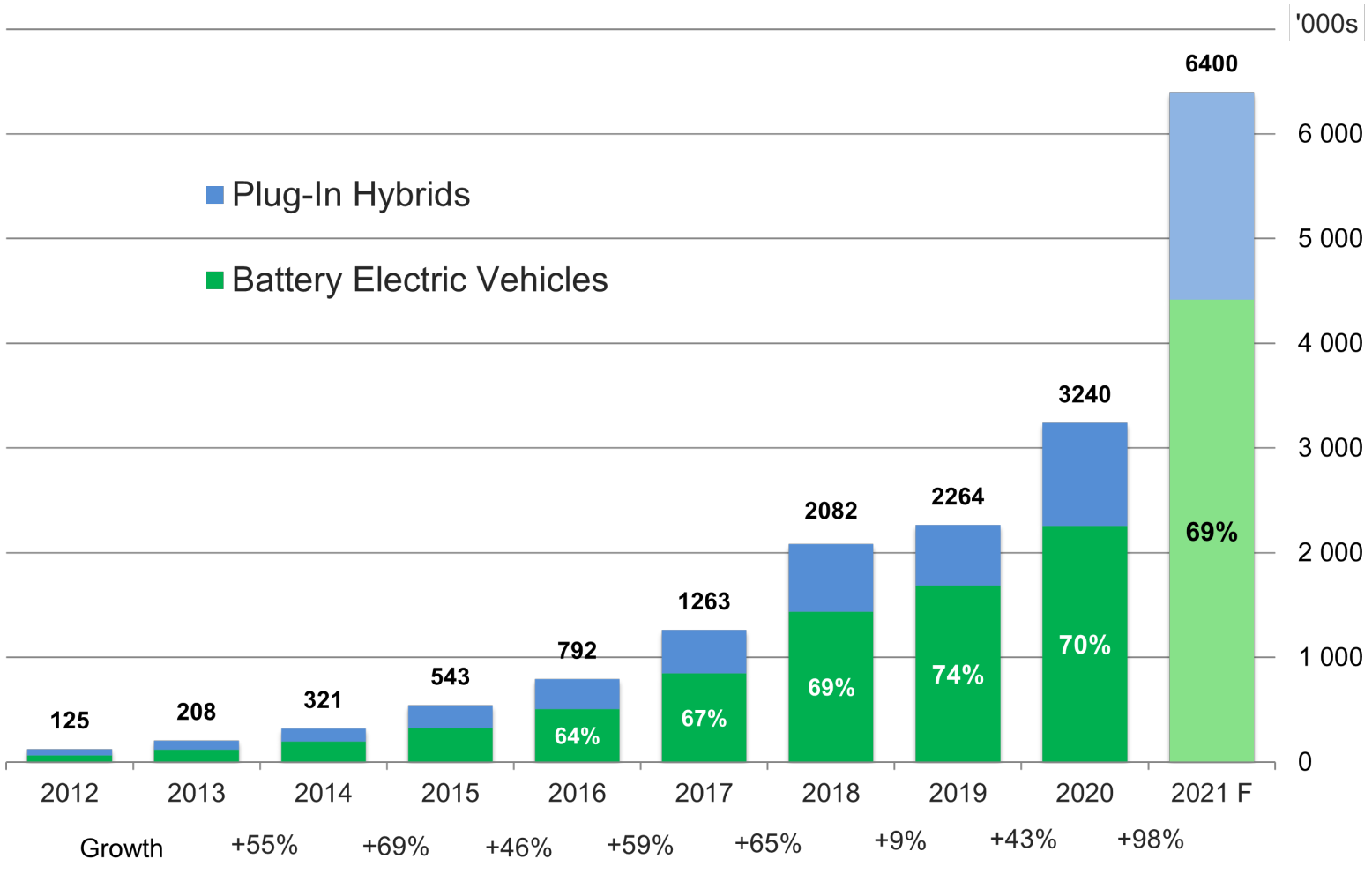
The high volume automotive industry is a driving force (also in electrifying gliding)

-Better tech

-Cheaper tech

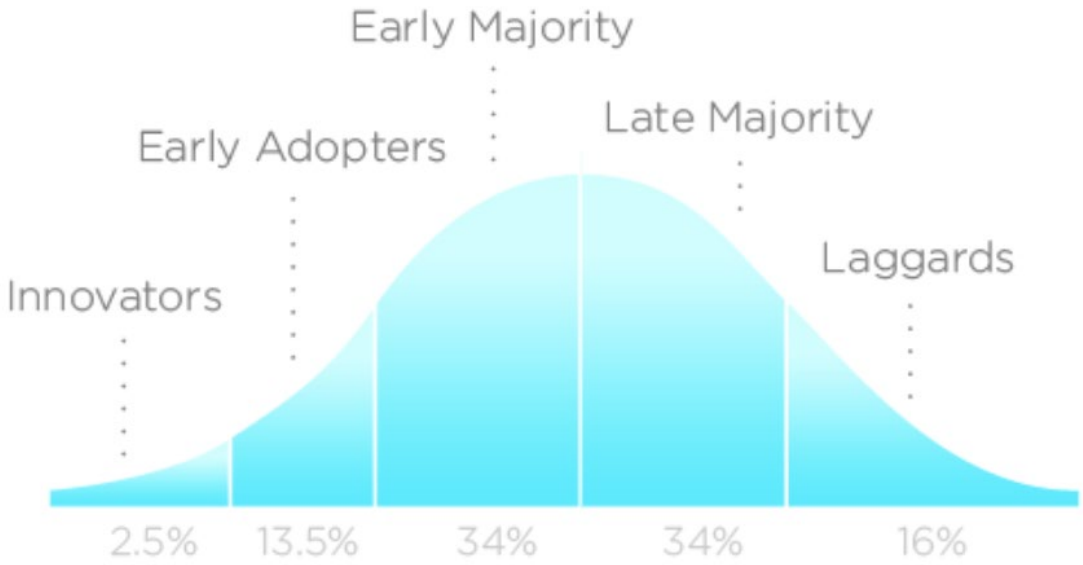
GLOBAL PLUG-IN VEHICLE SALES

EV VOLUMES



Projected x 3 sales of BEV/PHEV cars since my last talk in 2018

Innovation adoption lifecycle
Diffusion of innovation; Everett Rogers, 1963



Q: Who is buying electric cars now?
Q: Who is buying electric gliders now?

(A: It's no longer the professor-types(innovators), that will accept technical difficulties, but the next segment that expect real utility.

*Worldwide Harmonised Light Vehicle Test Procedure (WLTP)

Strict EU emission legislation will boost electrification on a broad scale

CAFE (Corporate Average Fuel Emission)

<u>EU-requirement 2021</u>
95 g CO_2/km

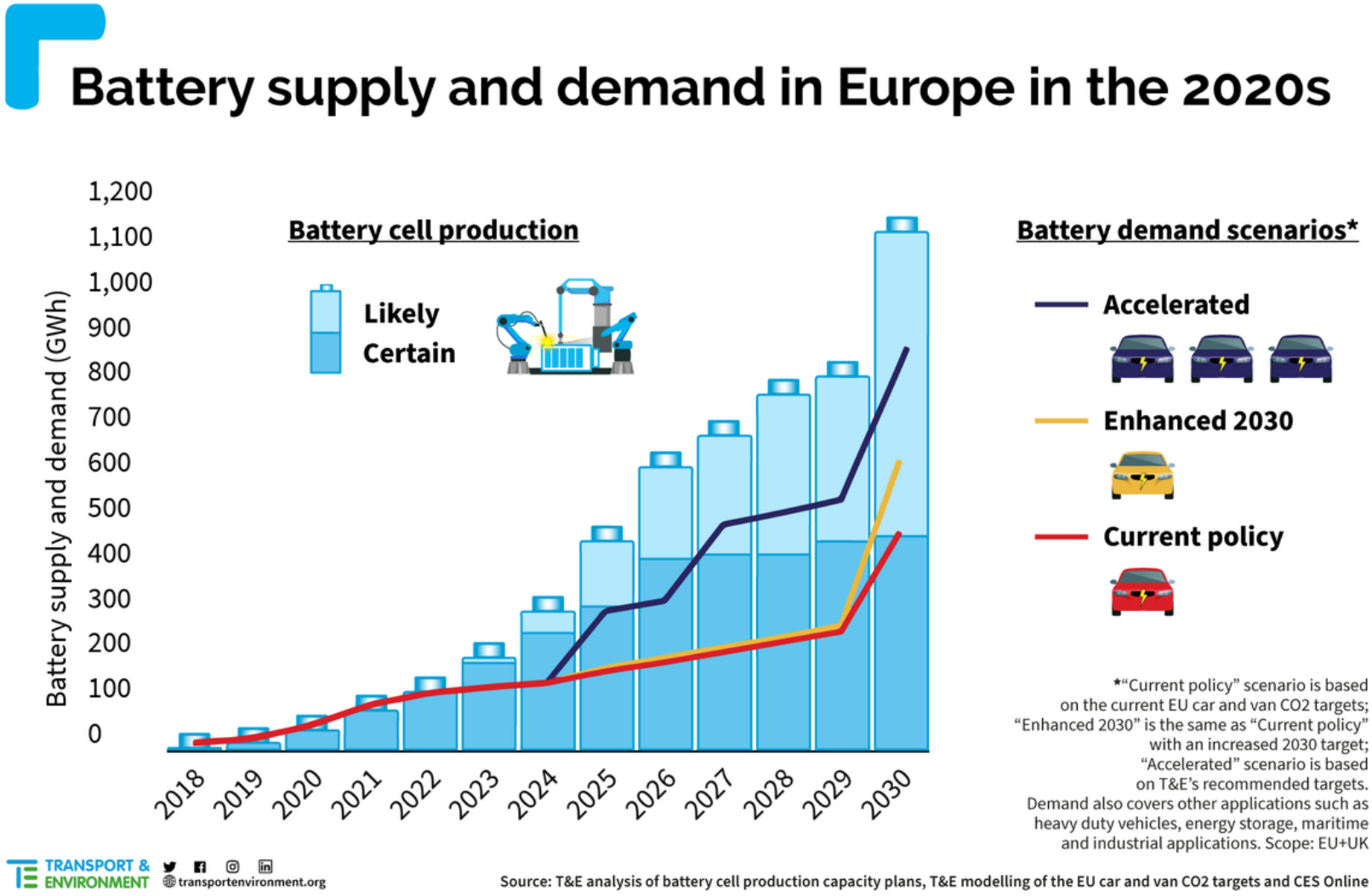
<u>Real average fleet emission 2020 (DK)</u>
125 g CO_2 /km

<u>EU penalty 2021 = 95 euro per gram Co_2/km exceeded over requirement</u>
(E.g. 125 g/ CO_2 /km = 30 grams too much x 95 euro x no of sold cars in Europe.
= 2-figure billion euro fines per automaker (VW, PSA etc.)

The requirement will tighten to 59 grams CO_2 /km by 2030.

<u>Consequence</u>
Legacy automakers will no longer produce fossil cars, even if consumers want them and dealers want to sell them.
Only option is mass introduction of PHEV and BEV cars.

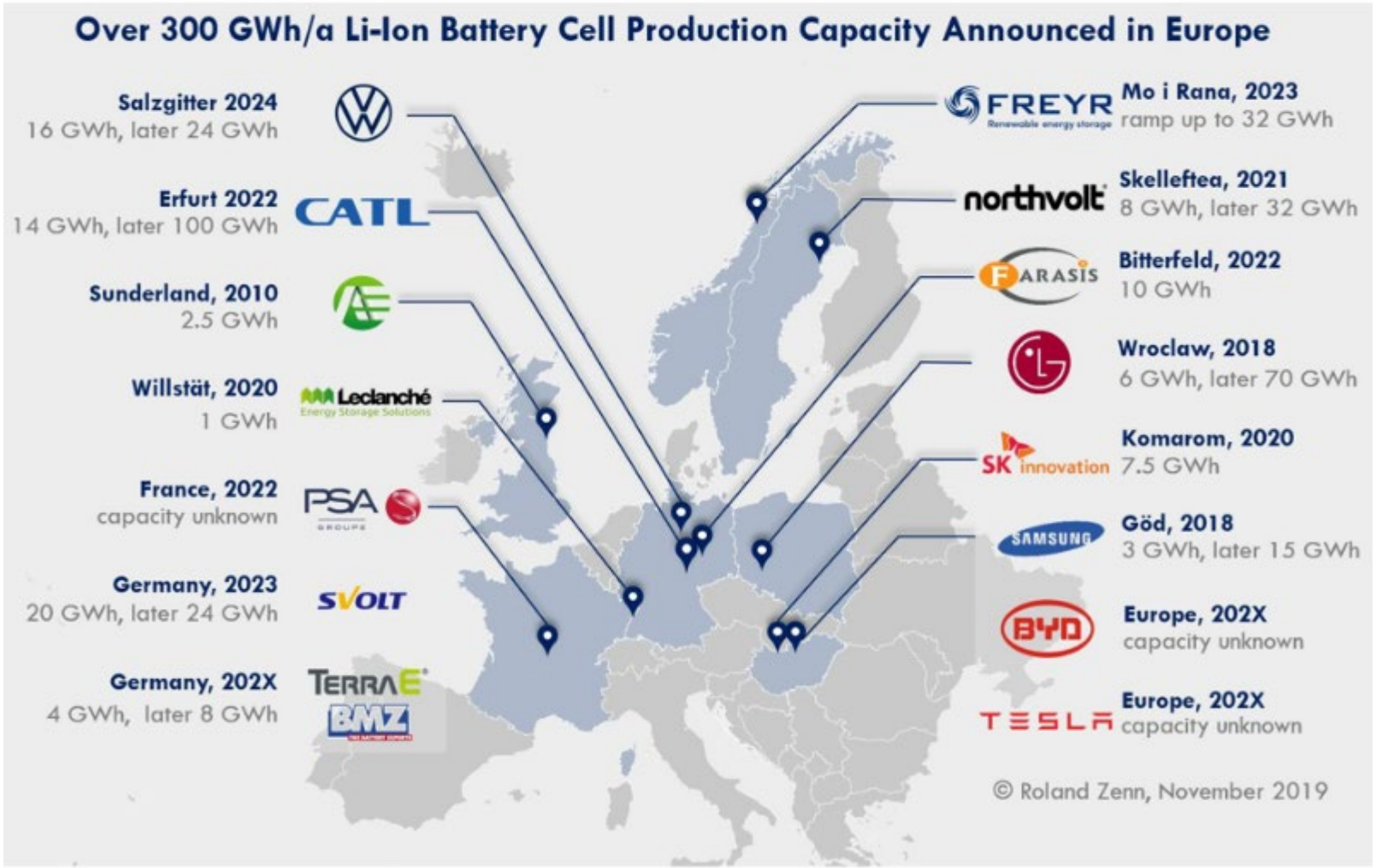
Technology evolution



Technology evolution

Tesla Giga 1 Nevada – Worlds biggest battery factory

Technology evolution



Companies that announced Li-ion battery production lines in Europe and planned capacities. Used with permission of Roland Zenn.

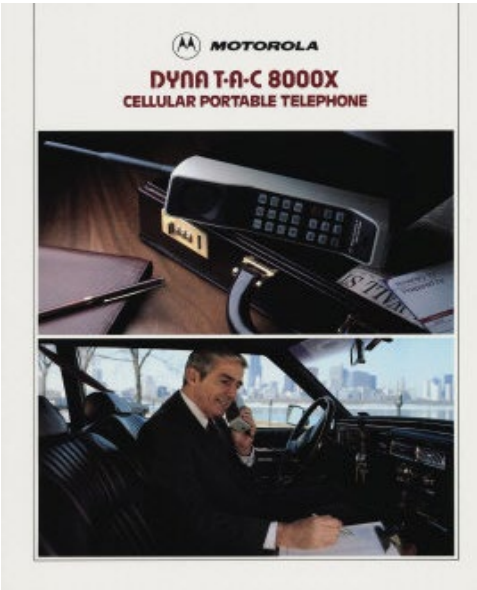
Technology evolution

Tesla
100 GWh demand 2022
3000 GWh (3 TWh) demand 2030 (est)

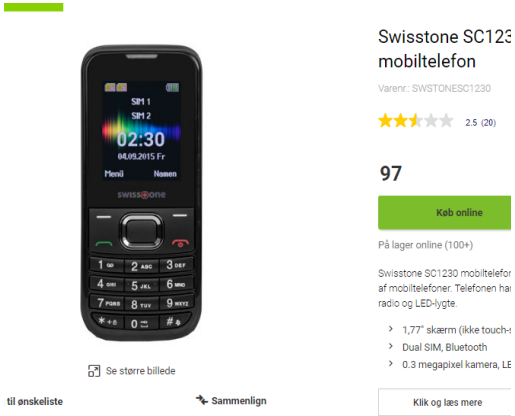
Will electric powertrains follow the standard routine?

Consumer tech always goes “Cheaper, better, faster” with each design iteration

- Production volume/efficiency increase
- Cost decrease
- Performance increase



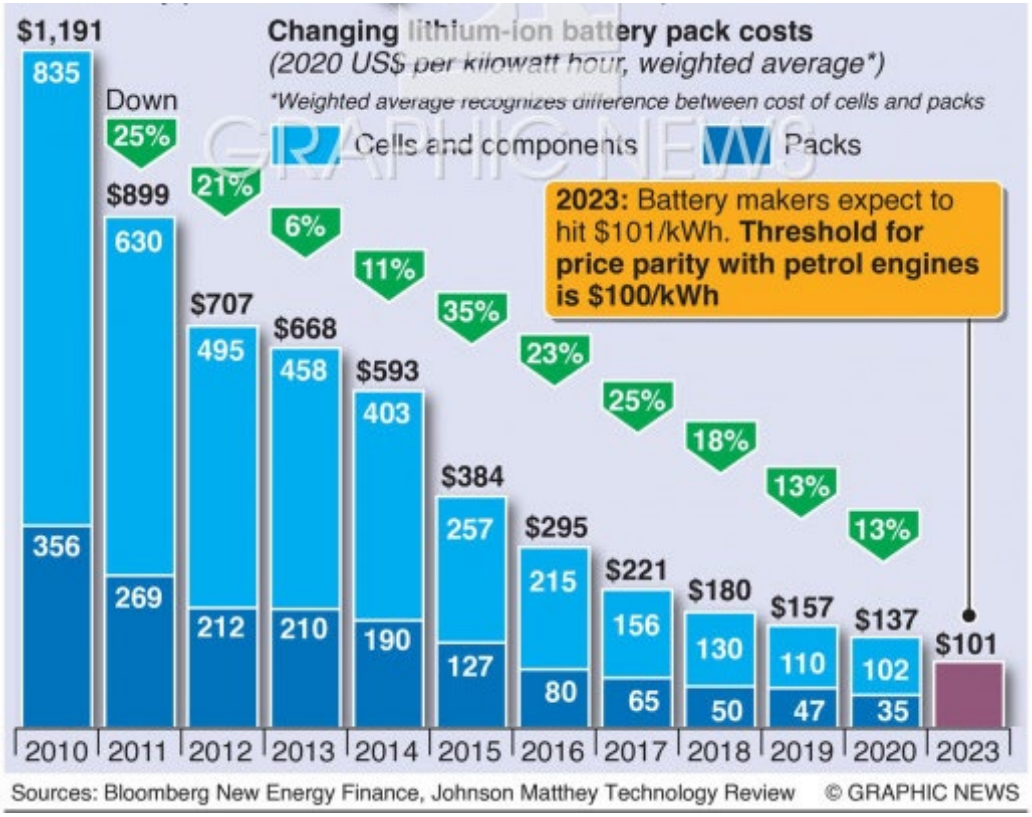
30 design iterations in 35 years)



4.000 USD in 1984
(almost 10.000 in current prices)

Basic phone, 15 USD 2020

Batteries are the main area of improvement – costs are going down



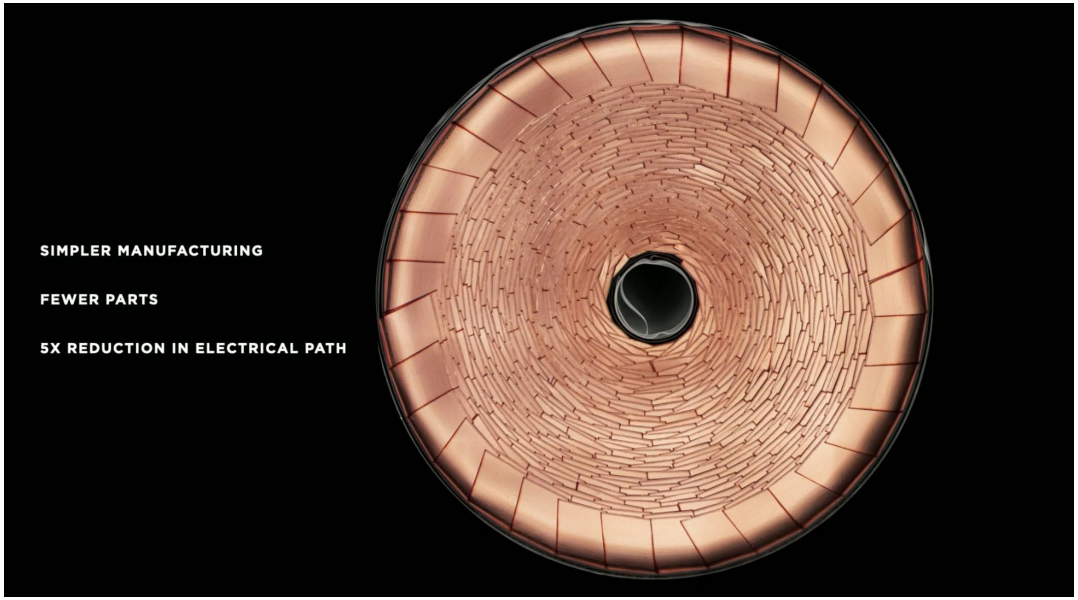
2018 = 180 $/kwh at pack level for Tesla Model 3

2021 = 130 $ (est.)

2023 (est.) 100 $/kwh
Price parity threshold with the cost of a fossil powertrain (engine, fuel tank,cooling, exhaust, gearbox et)

Battery cost is expected to fall further with expansion of global production capacity

Technology evolution

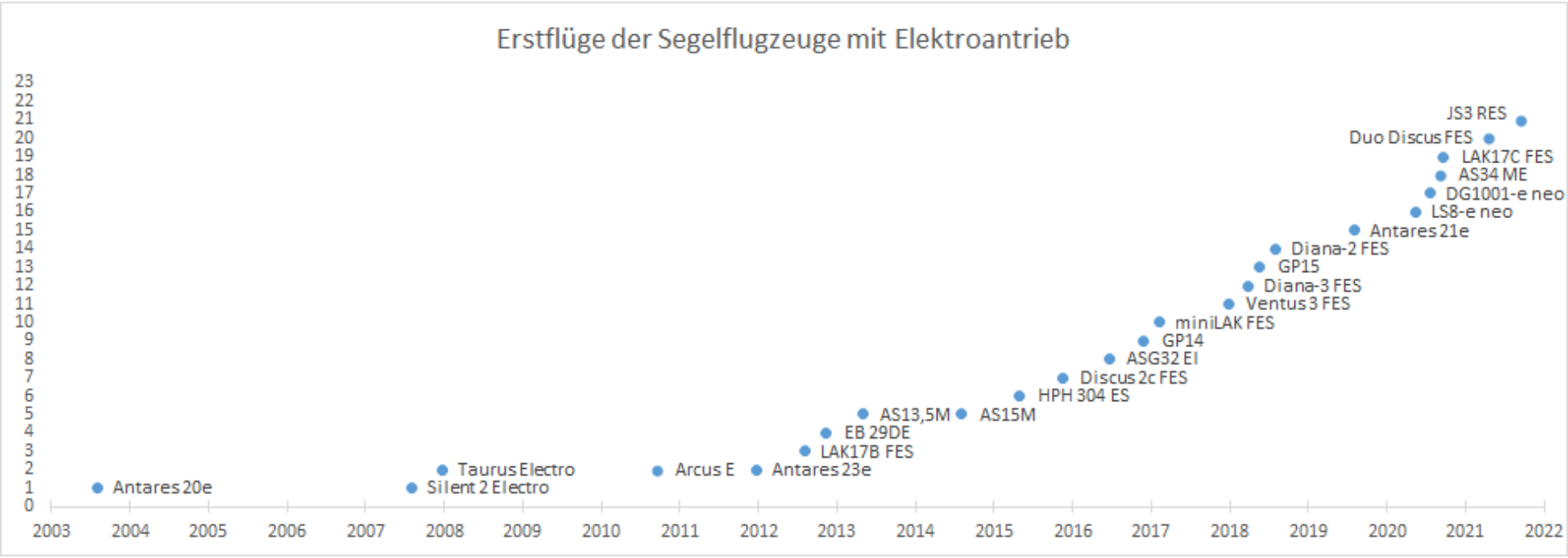


Batteries
Tesla/Panasonic
”tabless” prototype 4680
Est. 2022

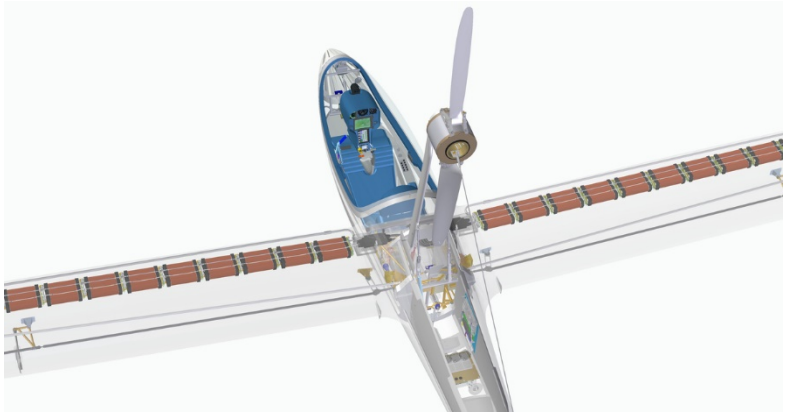
Cobalt-free
Lower cost (56 %!)
Higher energy density
Lower resistance
Better fit in battery-packs

Batteries
More power in less space
Example FES Kokam batteries :
2011 30 kg = 4,2 kWh
2022 40 kg = 8,9 kWh

The electric glider market is booming



Overview of electric aircraft



Lange Antares 20/21/23E (2003)
First real CS22 EASA-certified electric SLG
20/21/23M flapped open class SLG
Aprx 60 produced (including petrol turbo)
42 kW motor (Battery pack 15 kWh/80 kg) from 2022 (new 21700 Tesla-batteries)
Climb performance 4,0 m/s / + 4200 meters alt.gain / + 5600 m in Long Range-version
Lange-powertrain also used in Arcus Electro prototypes

Overview of electric aircraft

Schleicher ASG 32 EL, first flight 2016
Developed in joint venture between AS and technical universities in Hessen.
20 m 2 seater
Electric turbo, 25 kW Emrax motor, 7 kWh battery
Total weight of turbo system: 89 kgs

Climb performance 1,3 m/s (NG test)
100 km range
Status: In production and certified

Overview of electric aircraft

FES-drivetrain 2009 -
HPH Shark
Ventus 2/3 /
LS 8 e neo
Discus
Alisport Silent
LAK 17 /MiniLAK

DG 1001 neo (2020)
Duo Discus (2021)

4,2 kWh (2022: 8,9 kWh!) batteries (2 x 15 kg), 22 kW air cooled motor.

Horizontal flight with 5 kW, 100 km/h / aprx 80-100 km range
Easy drivetrain management: The ultimate non-stress-turbo

<u>Makes cross-country flights easy, also for inexperienced pilots</u>

Overview of electric aircraft

FES System
About 250 gliders flying

Battery Power increase: From 15 (initial type) to 22 kW (present)
Increased fire and mechanical shock protection since 2 fire incidents in 2017

Pro No pylon drag if engine fails, no complex pylon mechanism
Cons A small, but measurable extra drag from the propeller blades (1-2 L/D)

Overview of electric aircraft

Fun fact:
The AS 34 ME scored almost 10 dB(A) lower in noise certification tests than the relatively quiet ASH 31 Mi.
That is subjectively half the volume!

AS 34 Me – 2020
15/18 M standard class SLG (based on ASW 28)
35 kW 228-Emrax-motor (from ASG 32 EL)
8,6 kWh battery in wings (improves cockpit load capacity, but 100 kg wings)
Climb speed 3,7 m/s / 2,5 m/s cont.
Total climb 2200 meters or 1 start to 600 m plus 125 km motor flight
Status: In production and CS 22 EASA-certified

Overview of electric aircraft

AS 34 Me
https://youtu.be/Kq-ecNd_548

Overview of electric aircraft

AS 34 Me
https://youtu.be/ji0afTgzGPU

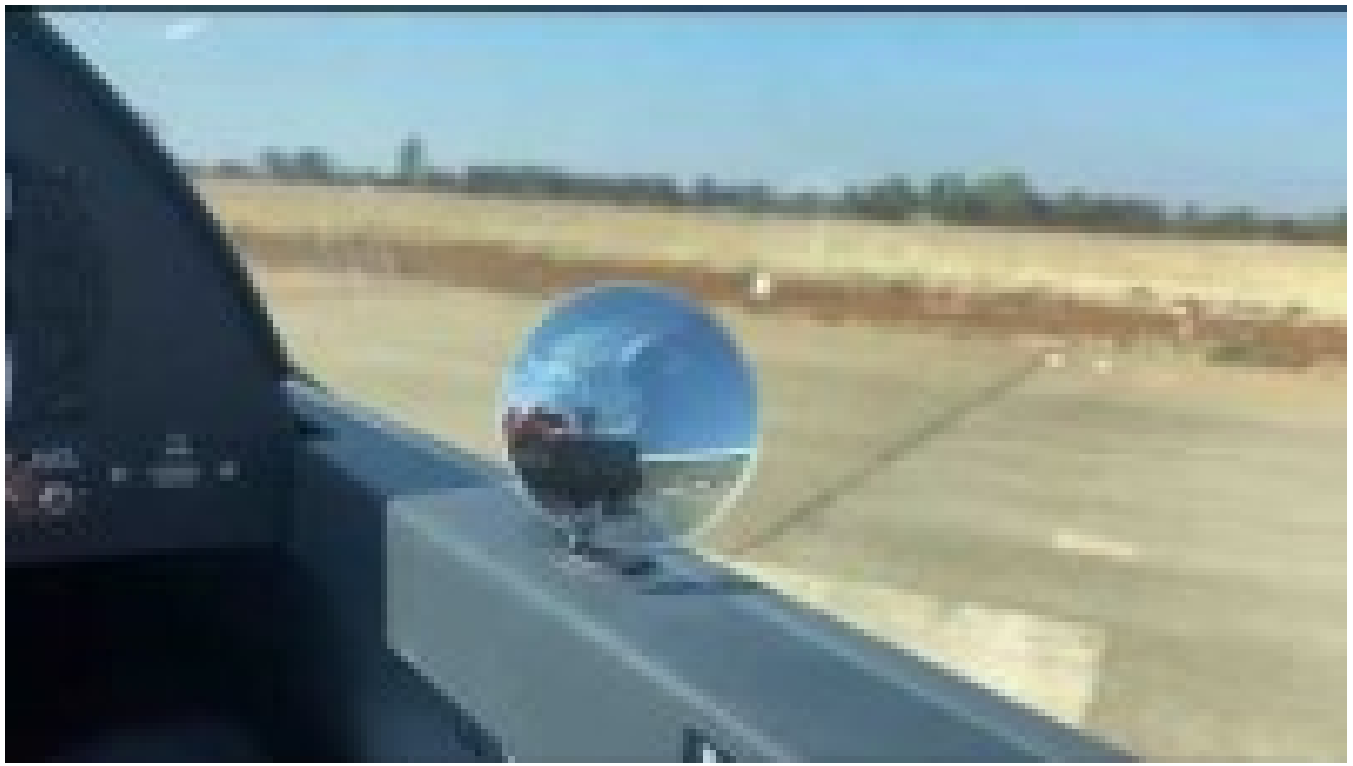
Overview of electric aircraft

Jonker JS3 RES – 2021
15/18 M flapped SLG (up to 575 kg)
9,2 kWh batteries (developed by Emetric (SOLO) 40 kW Emrax 208-motor.
2 x 25 kg battery weight. Fuselage mounted.
Can be flown with single (75 km sustainer) or double batteries.
Approx. 2000 meter climb / 3,5 m/s
In development – small powertrain delays due to global electronic component shortage – Certification probably completed Q1 2022

Overview of electric aircraft

Jonker JS3 RES
https://youtu.be/gMmu98hiLko

Overview of electric aircraft



Jonker JS3 RES system operation
https://youtu.be/vuS_nC3cE7o

Overview of electric aircraft

Onix, first flight November 5th 2018
17 m flapped TMG (e-LSA)
Prototype based on the Rotax-powered Czech TMG “Phoenix”.
60 kW MGM-Compro motor (Battery pack 34 kWh in fuselage), 10-20 kW fast charger
Endurance 150 mins / + 300 km (real life)
Tow hook fitted, tow trials spring 2020
Status: Can be ordered, CZ E-ELA

Global transport electrification will push gliding
Gliding is not an island. Electrification in aviation will develop rapidly as a function of global transport electrification

A good place to experiment
Gliders can fly on very little power – if we want to power a B737, it's a good beginning to start with a Discus.
Gliding is engineering culture. We invented lots of good tech in the past!

They are already here
Most glider manufacturers has some kind of electric gliders now– unthinkable 20 years ago.
How will it be in 15 years from now?

What can we do as gliding community?

- Vote with your wallet: Buy electric gliders
- Interact with manufacturers
- Lobby for development of electric towplanes
- Form work groups

If we succeed, we will hopefully experience:

- Less noise complaints from neighbors
- More fun in flying
- Increased safety (end of the usual turbo accidents?)
- Less social and political pressure (maybe even elevation to role models and rewards!)
- New member-attraction?

We as a sport will emerge strengthened from this.
But only if we adress these issues now.
Thank you