Gliding electrifed?

Jens Trabolt 2022

22 kW engine
(but will fly on 4kW)

100 000 kW (100 MW) engine…
(no electrification possible …)

Least and most powerful aircraft in my logbook

NORDIC GLIDING
& Aviation magazine

Jens Trabolt
Editor, NORDIC GLIDING

Pilot and Flight Instructor (gliders, motorgliders)

Test flights on several types of electric aircraft (Discus Fes, LS8 e neo, DG 1001 e neo, Duo Discus FES, eGenius, SunSeeker Duo, Pureflight Onix, Pipistrel Alpha Trainer Electro, Taurus Electro etc)

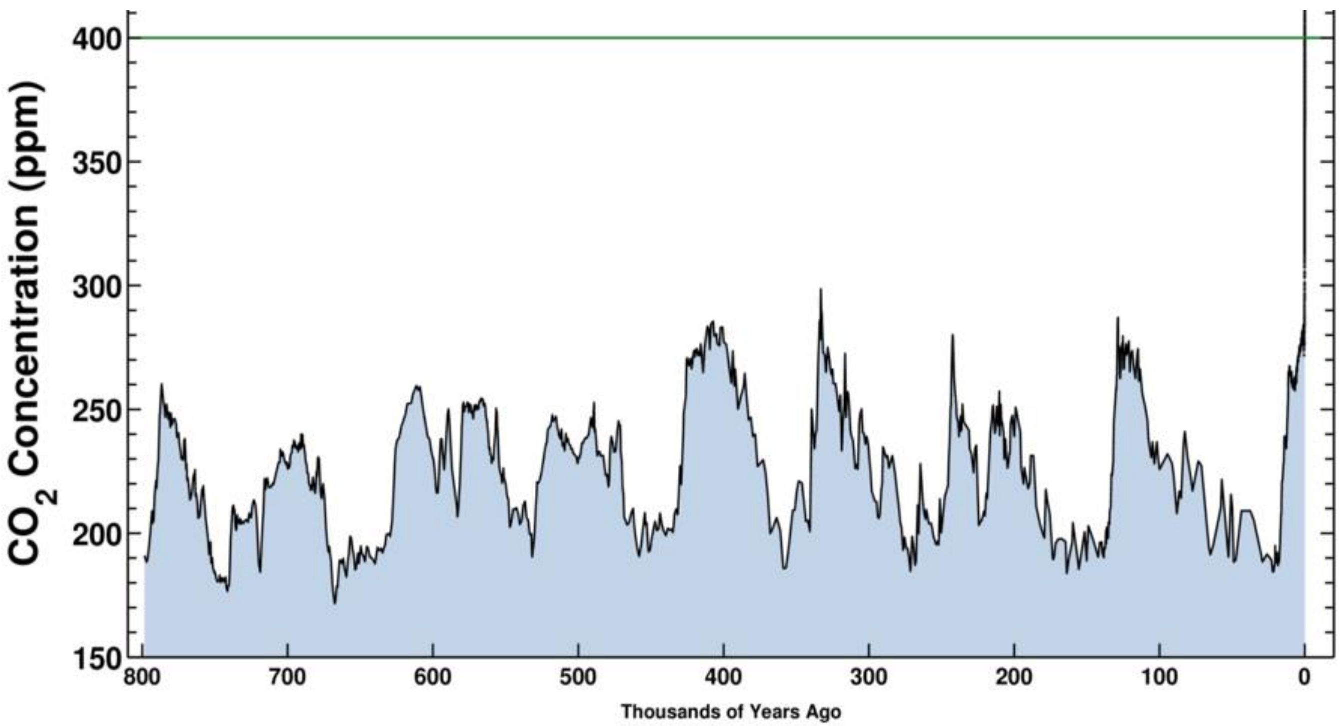
Contents of this talk

- Pros and cons of going electric?
- The automotive industry – a driving force of evolution?
- What is possible **today**: Types of light electric aviation (gliders)

Why go electric?

Our fossil engines are doing a fine job.
There has always been fluctuations in CO_2-levels

Yes but ….

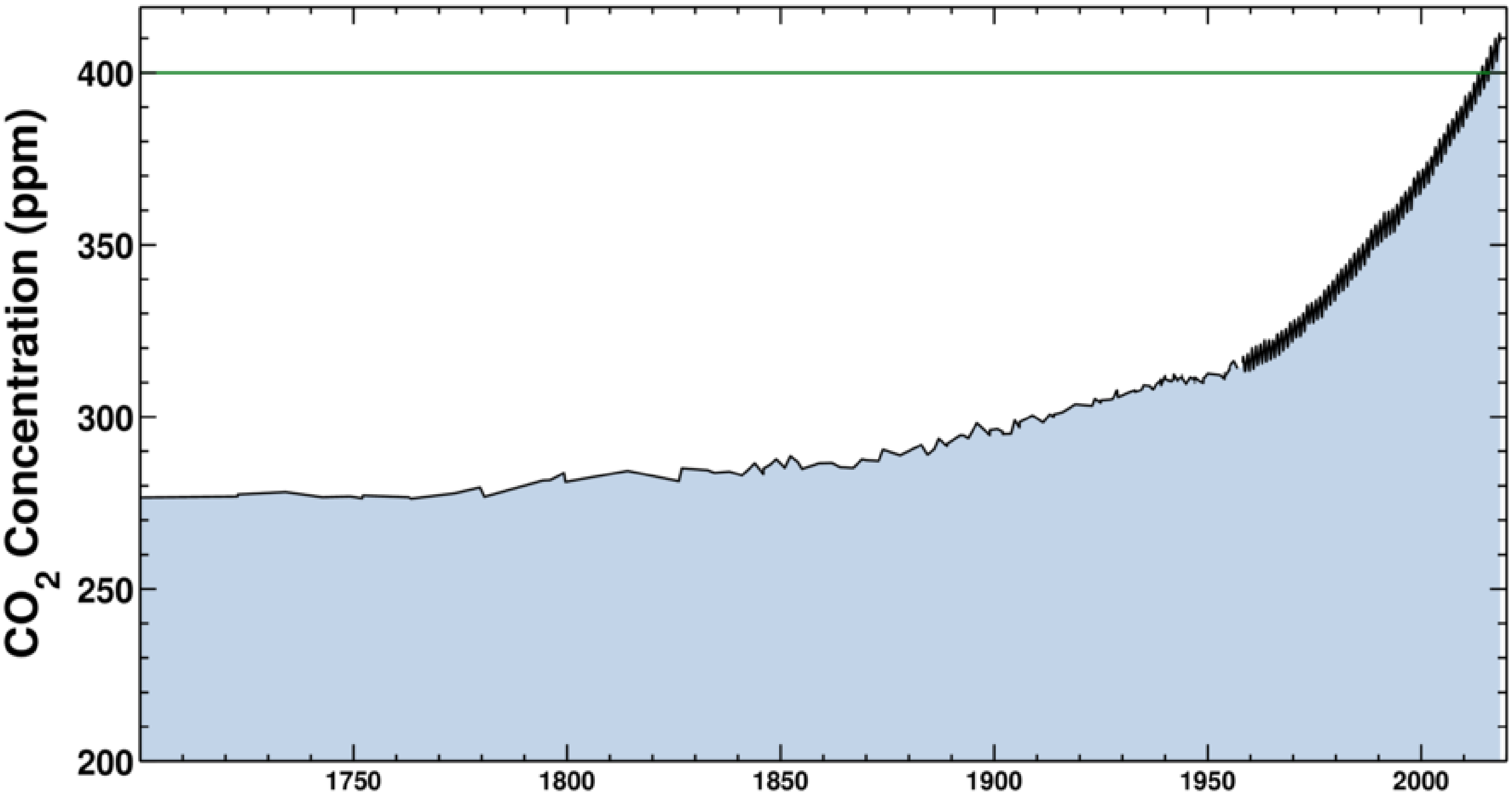


Latest CO_2 reading
August 28, 2018

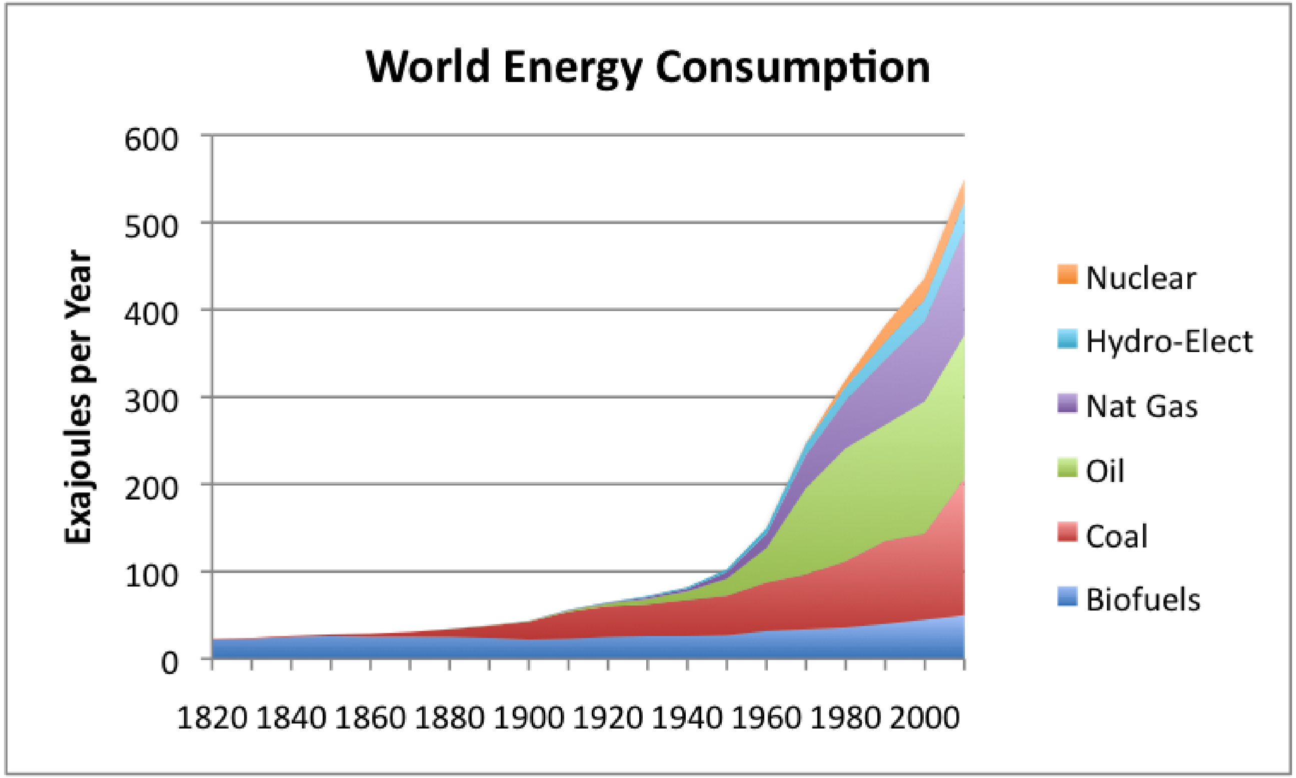
~~406.70 ppm~~

418 ppm
August 12th 2022

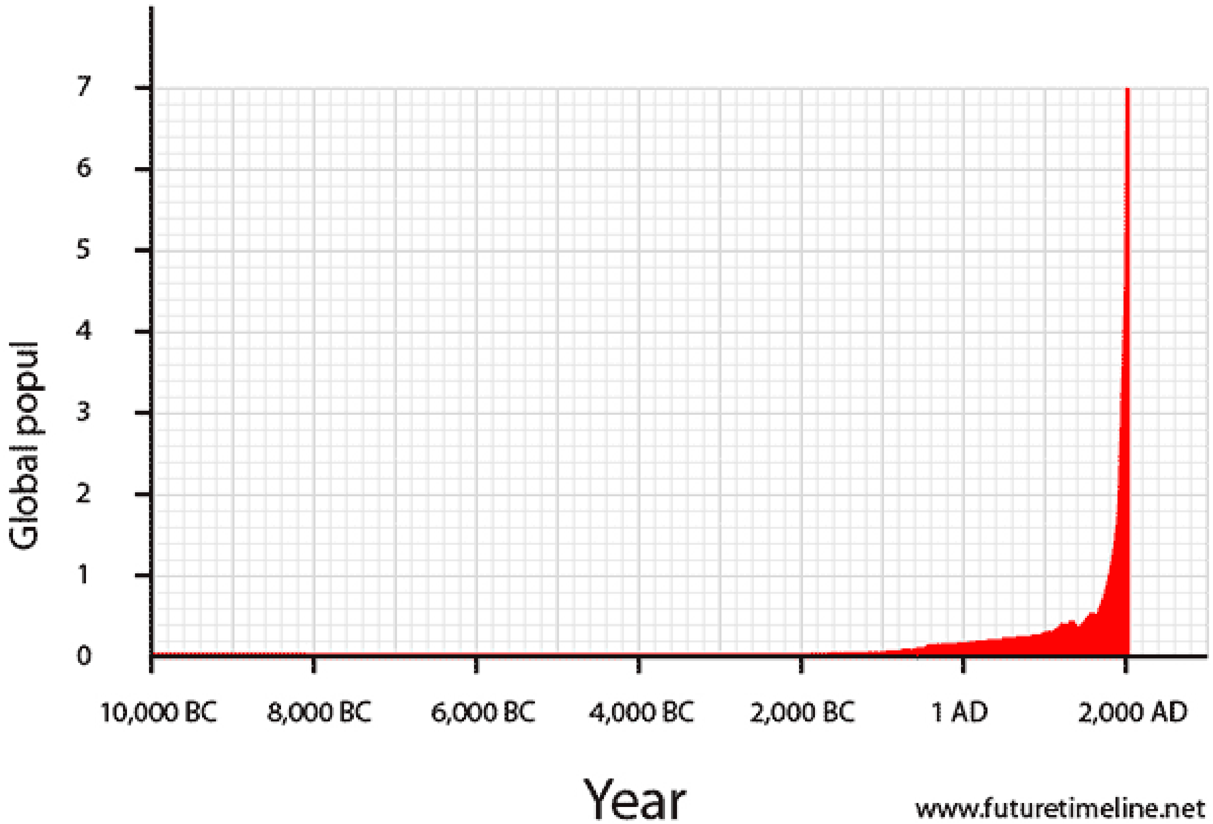
Ice-core data before 1958. Mauna Loa data after 1958.

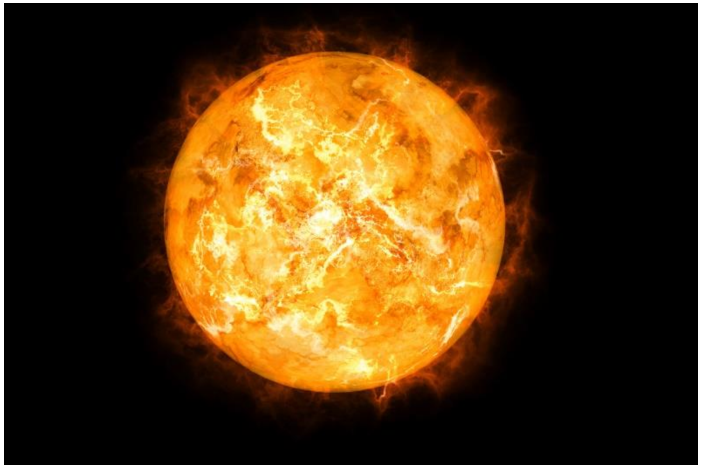


Elevated Carbon levels?
What could possibly cause this?



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 – X-hundred years)

Solar powered (electric) drivetrains

Pro

- Quiet, vibration free, clean (no oil, smell or smoke),
- Highly energy-efficient motors (90% vs 20-25%),
- No direct carbon emission during use (with green electricity - DK renewable energy share 50 % 2020)
- No direct emission of substances of concern during use (Soot, NoX, which are reportedly bad when released in the upper atmosphere)
- Low pilot workload (you tell the software what power setting you would like, it does the rest)
- Few mechanical parts, less maintenance cost
- Low ”fuel” costs
- Area of global massive investment (vs stagnant ICE-tech)
- Certification standards are improving

Solar powered (electric) drivetrains

Cons (all battery related!)

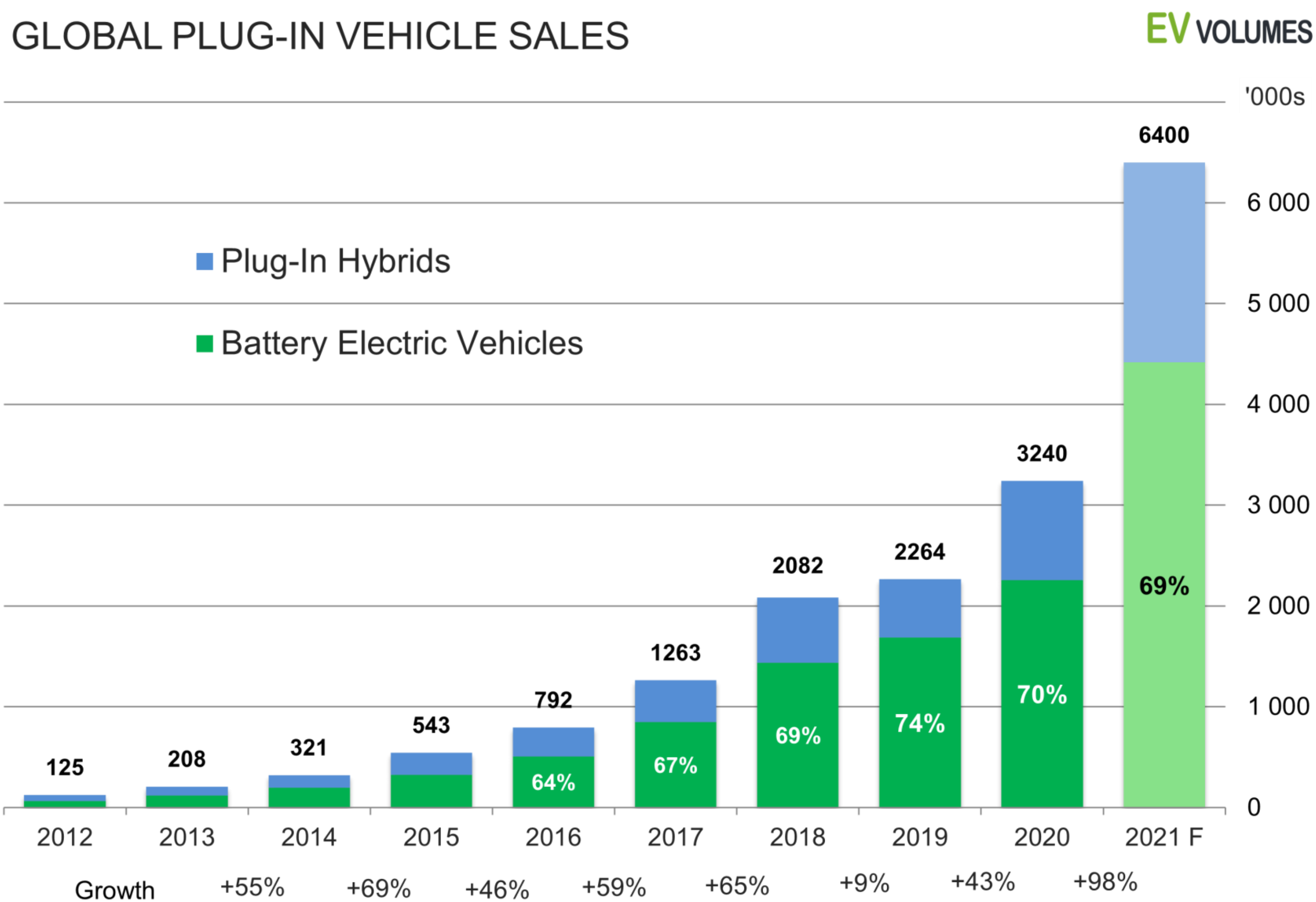
- Limited energy density in even the best batteries, but much higher motor efficiency helps to level the disadvantage.
- Somewhat longish charging times.
- Costly (so far), heavy and delicate batteries.
- Ressource-demanding batteries (but is improving – no cobalt in future gen.batt.)

Electric cars!

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

-Better tech

-Cheaper tech



Massive growth in BEV-sales

*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

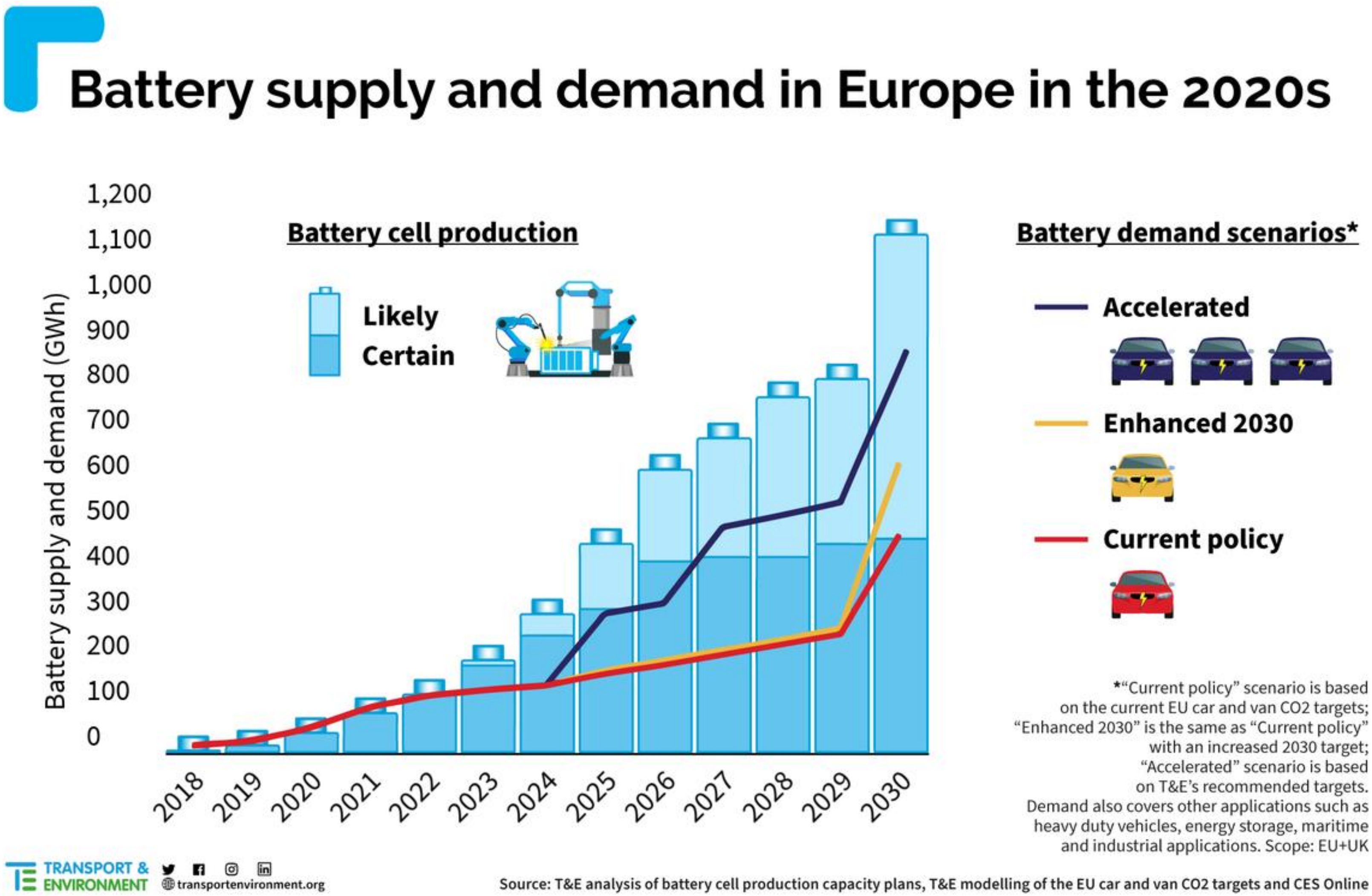
<u>Real average fleet emission for popular automakers 2020 (DK)</u>
125 g CO_2 /km

<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.

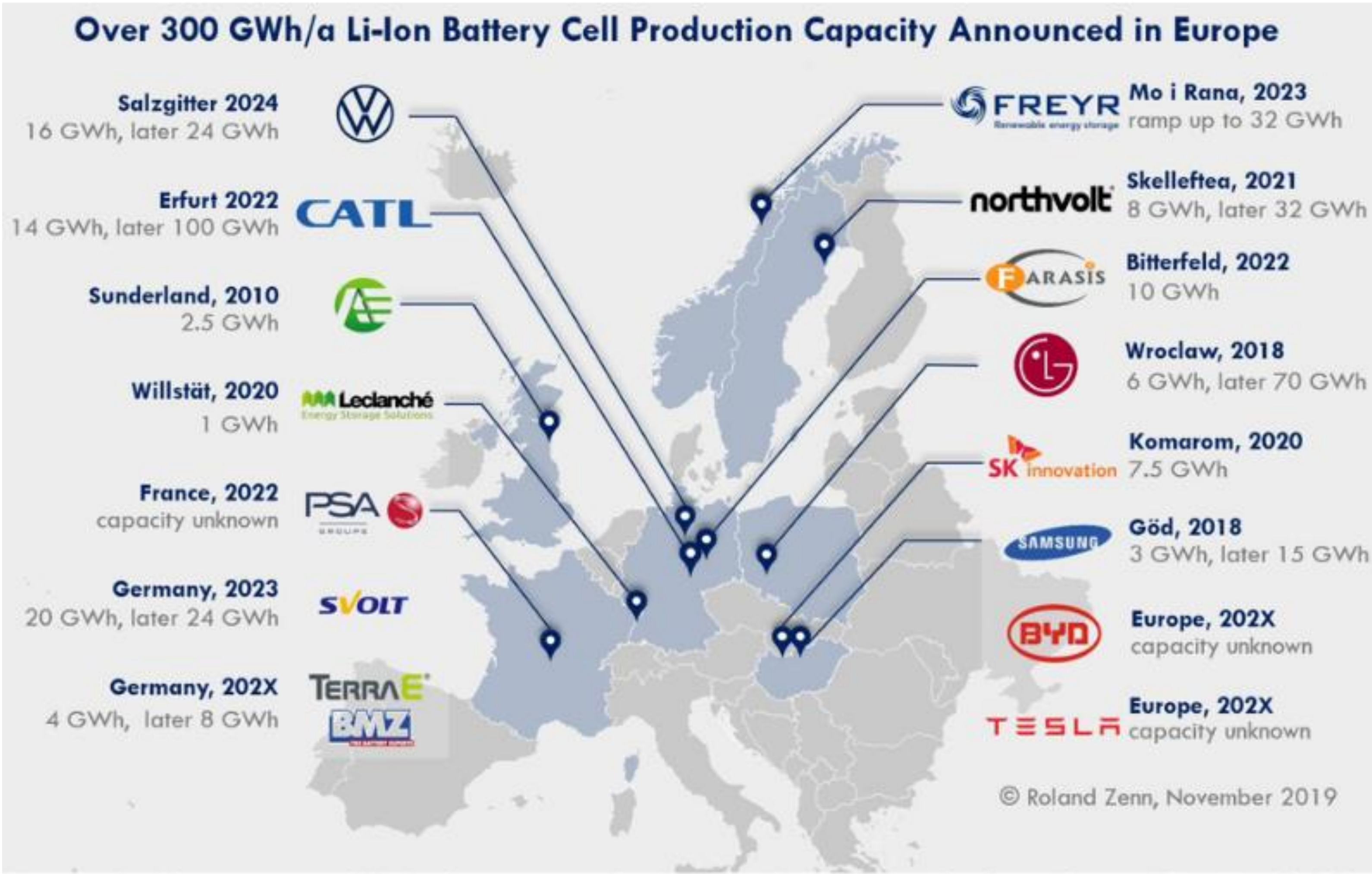
Technology evolution



Technology evolution

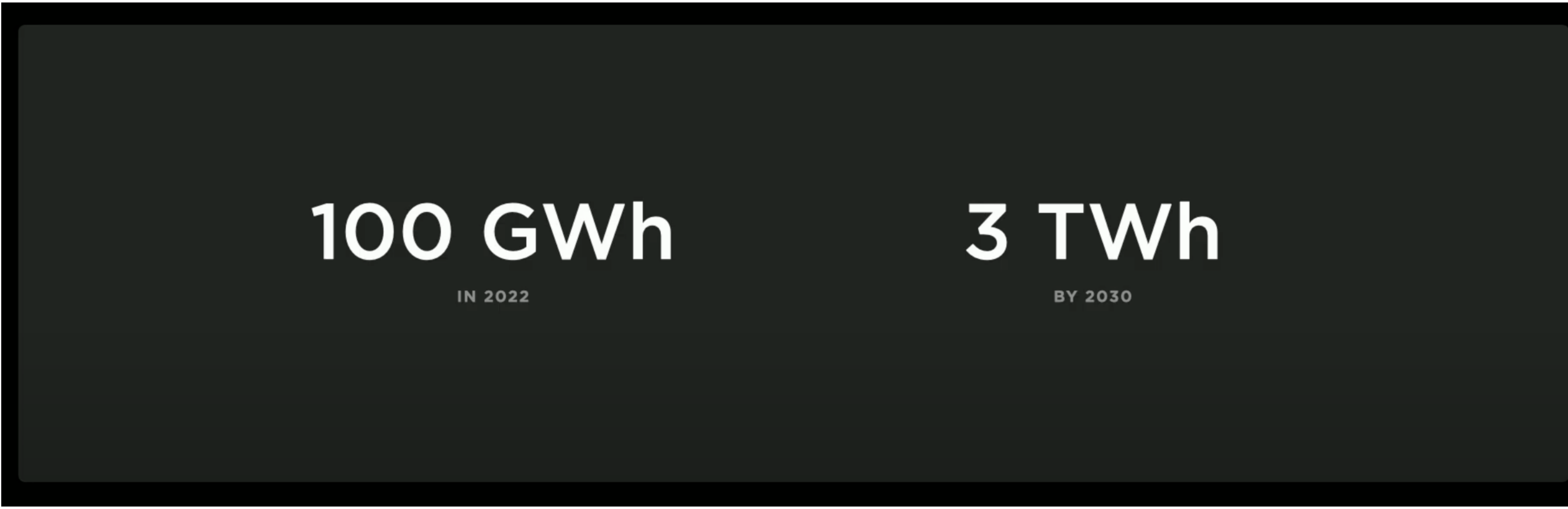
Tesla Giga 1 Nevada – Worlds biggest battery factory

Technology evolution



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

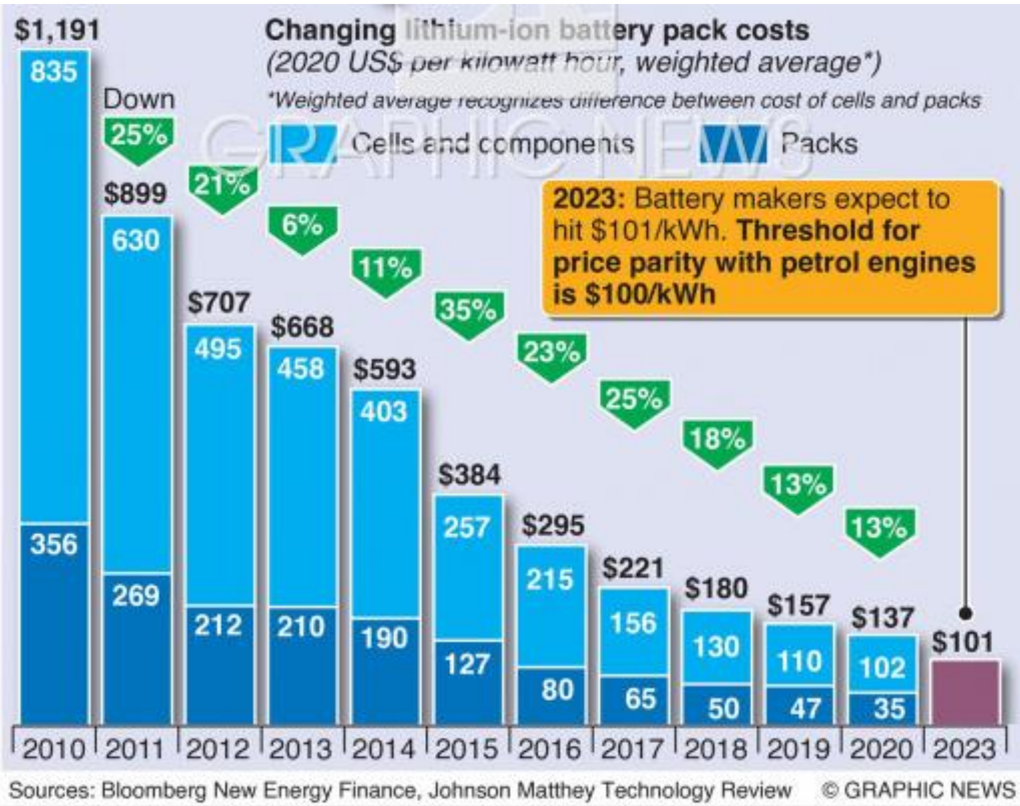
Technology evolution



<u>Tesla</u>

30 x growth in demand by 2030 (forecast)

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



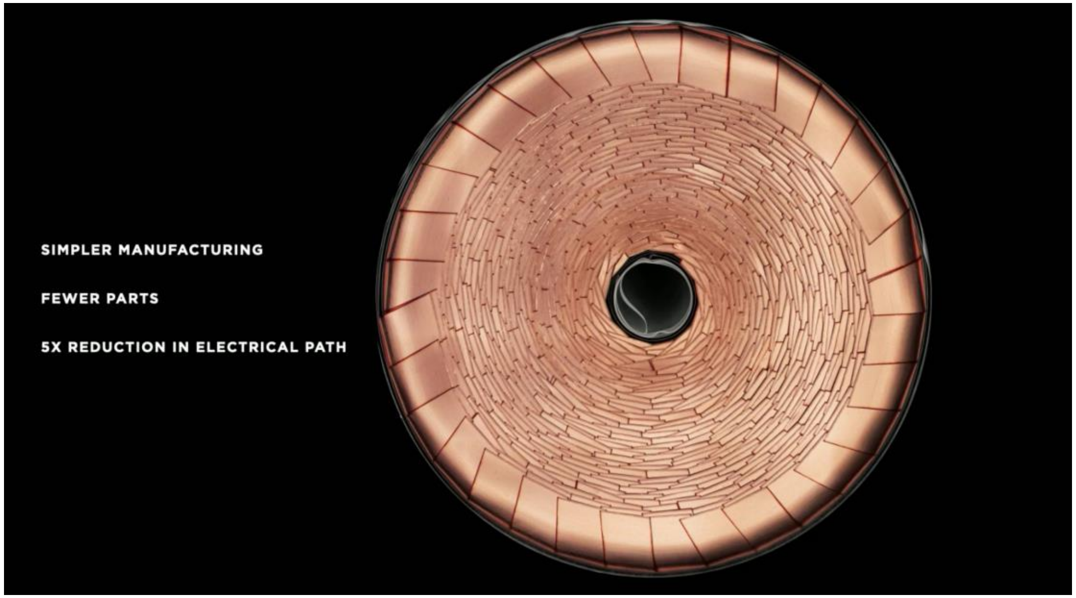
2018 = 180 $/kWh at pack level for Tesla Model 3

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

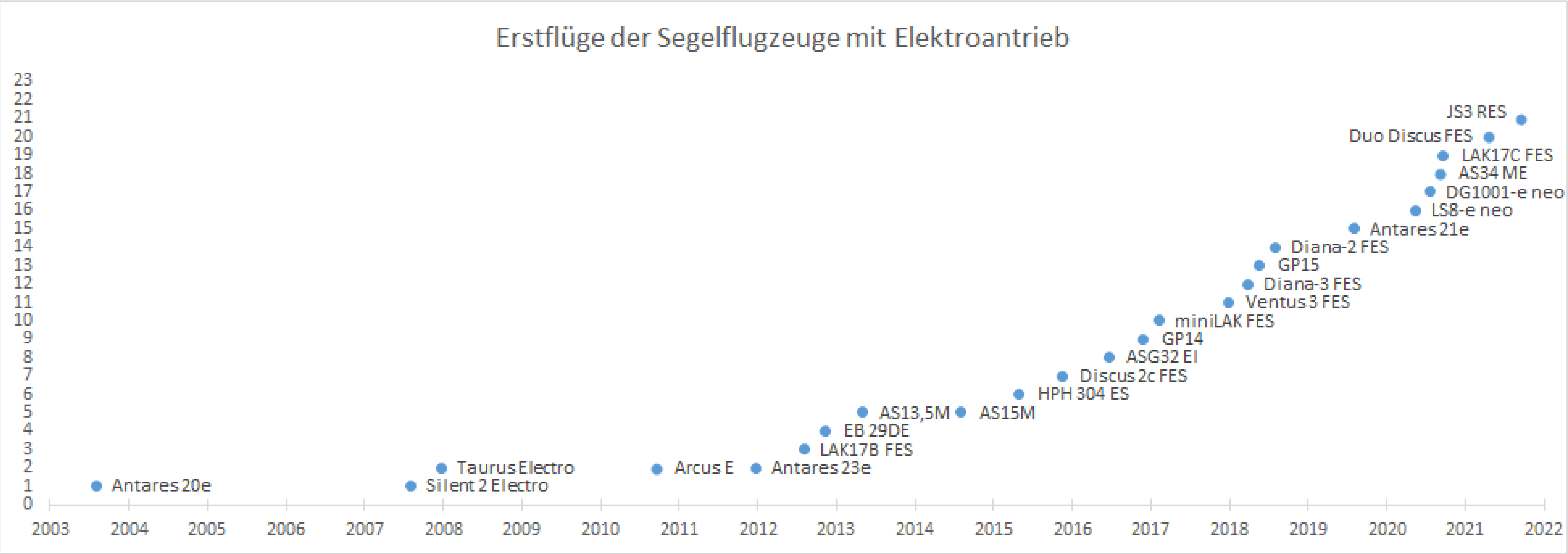
Cobalt-free
Lower cost (56 %!)
Higher energy density
Lower resistance
Better fit in battery-packs

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

Gliding = birthplace of electric innovation in aviation

Gliders are good place to experiment
Gliders can fly on very little power – if we want to power a airliner, it's a good beginning to start with a glider.
Gliding is engineering culture. (e.g. winglets, carbon fibre for aviation use etc)

The electric glider market is booming



Early electric pioners

Gossamer Penguin 1979 – barely…
First solar electric flight, barely
Pioneered by Paul MacCready

Icaré 2 1996
Stuttgart University
12 kW motor, 3,5 kW peak solar panels
Can fly on just 2 kW!

SunSeeker 1 1990
First solar electric flight across
America by Eric Raymond

Overview of current light electric aircraft

Lange Antares 20/21/23E (2003)
Claim to fame: First real CS22 EASA-certified electric aircraft
Aprx 60 produced
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

Overview of current light electric aircraft

Stuttgart University Airbus eGenius, 2011

Experimental aircraft built by students/institute

56 kWh batteries, 80 kWh Sineton motor.

400 km non-stop flight in 2013 and 7 world records by K. Ohlmann

- Airspeed on a 100 km out and return distance: 178,1 km/h
- Airspeed in a straight line of 15 km: 229,7 km/h

Range extender with wankel engine in pod under wing is currently being tested (2000 km world record in august 2022)

Overview of current light electric aircraft

SunSeeker Duo, 2013
2 person experimental aircraft built by Eric Raymond, 22 m span, 280 kg
Most sophisticated individually owned solar aircraft in the world.
7 kWh batteries, 25 kW Sineton motor in tail
5 kWp solar cells mounted on wings and horisontal tail (can remain airborne on solar power alone)
Endurance: As long as the Sun shines!

Overview of current light electric aircraft

Integration of solar panels were designed by pioneer Eric Raymond

Solar Impulse 2, 2013

World record long range experimental aircraft

164 kWh batteries 4 x 13 kW motors

66 kWp (kwpeak) solar cells

Circumnavigated the earth by solar power alone in 2016

Longest flight Japan – Hawaii (longest solo flight In the world by any aircraft)

in 117 hours, 52 minutes (almost 5 days) and distance 7,212 km

Overview of electric aircraft

Pipistrel Alpha Trainer /Velis Electro, first flight 2014 as prototype
10 m flapped ultralight training aircraft
Claim to fame: Worlds first practical electric trainer (+100 produced)
60 kW Emrax motor (Battery pack 25 kWh in fuselage), 10-20 kW fast charger
Endurance 75-90 mins (NG flew 41 minutes on a half charge)
Suited for flight schools (potential low cost: 3 euros in “fuel” per hour)

Powertrain development:
Certification standards are written in blood

Pipistrel Alpha Trainer Electro,
LN-ELA crash landing in lake norway 2018 during VIP-demo flight with politician…
Cause: Local inverter overheat due to air pocket in cooling circuit
Aftermath: Many changes to ”Aircraft Maintenance Manual”, improved cooling capacity, larger battery – ultimatively led to EASA-certication.

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
Claim to fame: Endurance 150 mins / + 300 km (real life)
Tow hook fitted, tow trials spring 2020
Status: Can be ordered, CZ E-ELA

Overview of electric aircraft

FES System
Most popular electric aircraft: About 275 gliders flying
Discus, Ventus, Shark, LS8 e, Mini Lak, Lak 17, Silent, DG 1001 e & Duo

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

Horizontal flight with 4 kW, 100 km/h / aprx 80-100 km range

Pro No pylon drag if engine fails, no complex pylon mechanism, quick and stressfree operation
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

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 – delays due to global electronic component shortage –
Certification hopefully completed 2022

Overview of electric aircraft

Jonker JS3 RES self launch
https://youtu.be/J-8R-x1-l3U

So you want electric gliders?

What can we do as flying community?

- Vote with your wallet: Buy electric gliders/aircraft
- 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.

2022: The ultimate club package?

Local solar power + Electric club glider + Electric winch (order one now)

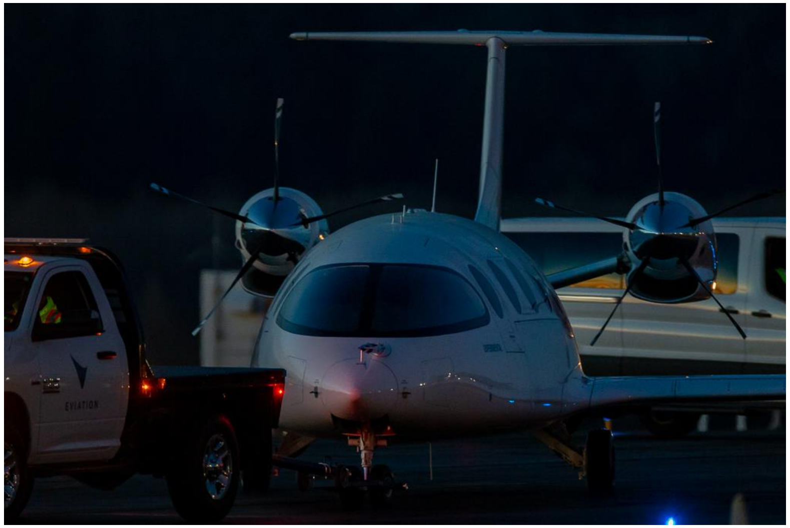
The ultimate in eco/neighbor friendly launches

- Generate own electricity
- Charge your own SSG/SLG-gliders / golf carts / member electric cars.
- Offset club house power consumption (my own club house uses 30 000 kwh p.a.)
- Winch launch electrically and use glider electric engines to connect to thermals

Example 2022

LSV Rheinstetten (Karlsruhe) has installed a 100 kWp solar system on hangar (with local citizen owner-partnership) + electric winch with 1200 m electric cables plowed into to airfield.

Current commercial aviation projects

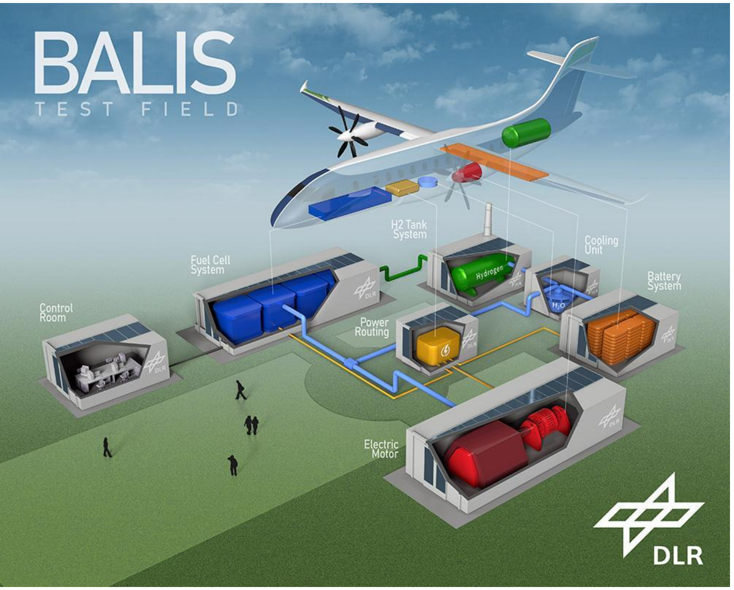


Eviation Alice, taxi-testing January 2022 in Seattle-area
19 m battery electric 9 passenger commuter
Range 800 km (+reserves)
Max cruise speed 390 – 440 km/h
Motors 2 x 640 kW MagniX (comparable power to PT-6 jet turbine)
Battery pack 850 kWh, weight 3700 kg (or 60%) of MTOW.
Planned delivery 2024 (Place your bets now! CS23-Certification of new airframe, legacy tech drivetrain and subsystems usually takes longer…)
Lots of performance has to be measured and documented before launch

Current commercial aviation projects

Heart Aerospace ES 19, engine testing 2021 in Göteborg
Battery electric 19 passenger commuter (offspring to ELISE, (Elektrisk Lufttransport i Sverige) with Chalmers Tekniska Högskola, GTBG)
Range 400 km (Stockholm - Oslo, Helsinki, Östersund, Göteborg)
Max cruise speed 320 km/t (est)
Motors 4 x 400 kW
Runway requirements Min. 750 meters, i.e. small airfields.
Battery pack Aprx 400 kWh, weight 1500-1600 kg
Planned delivery 2026 (Place your bets now!)

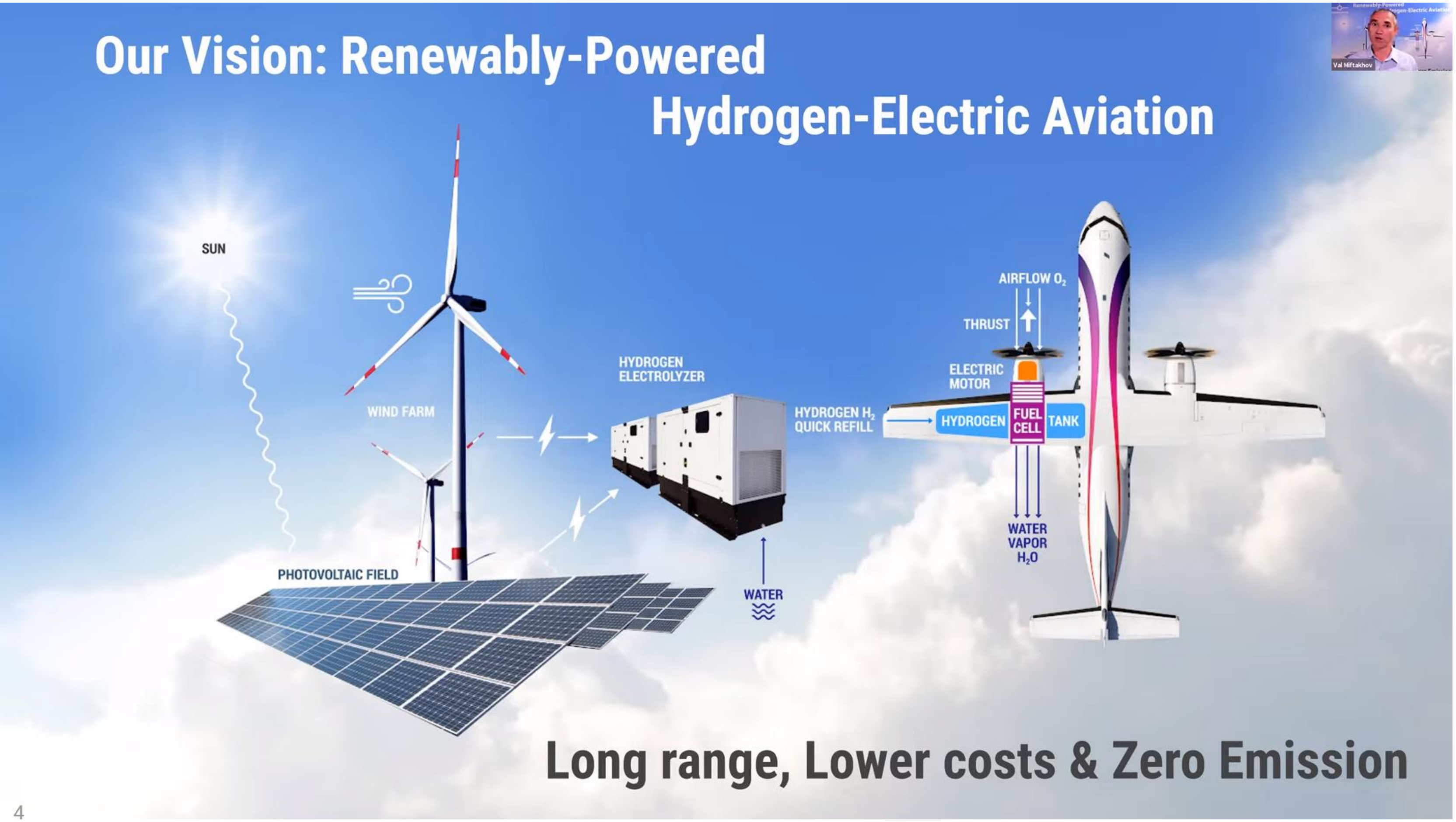
Current commercial aviation projects



BALIS Hydrogen Electric powertrain demonstrator site, German National AeroSpace DLR, Stuttgart
Object: To build a stable and scalable fuel cell powertrain 1,5 MW range

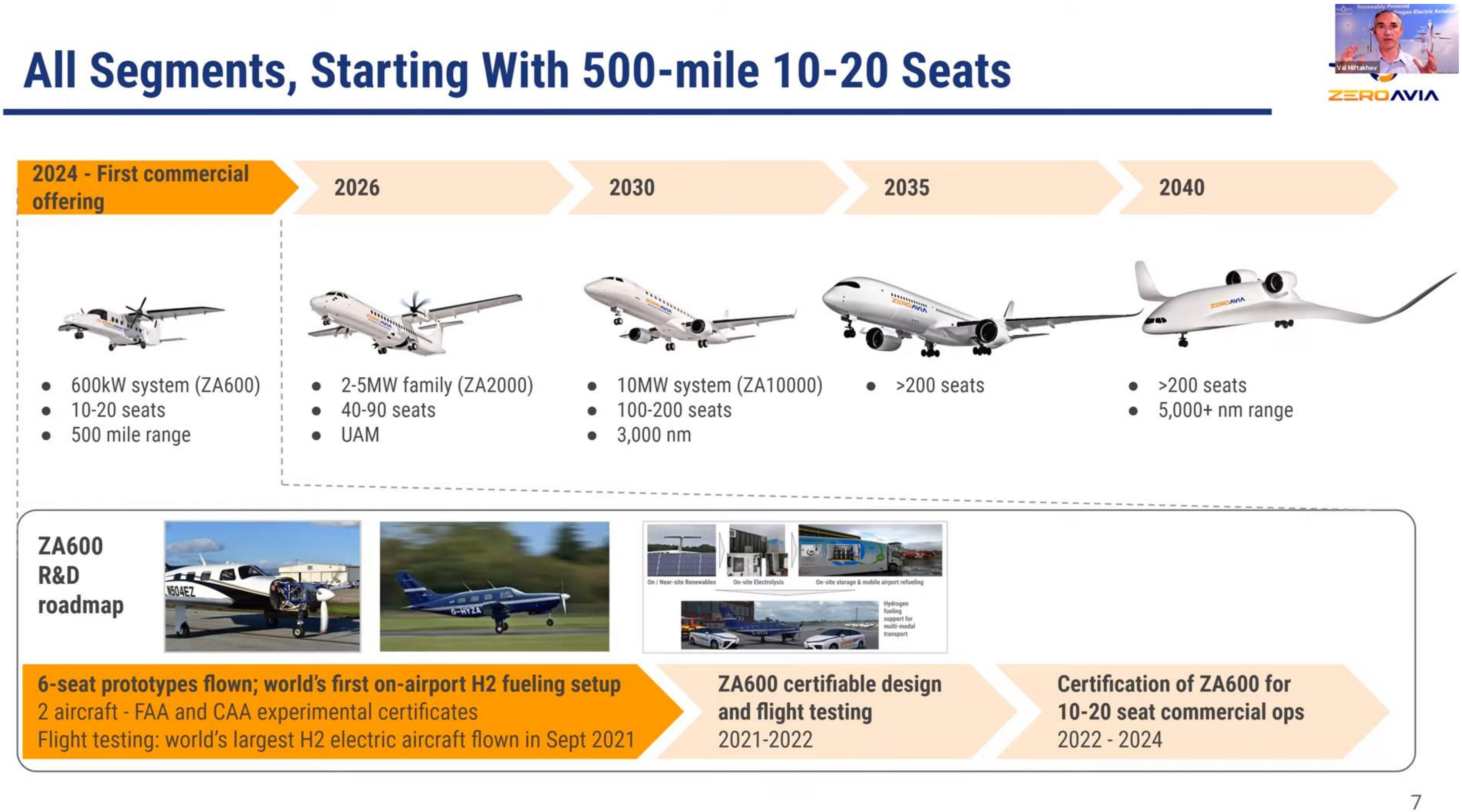
Aimed at proving a powertrain for a 40-60 seat airliner with 1000 km range
Project funding 26 million euros, operation from late 2022
Areas of focus: Fuel cell system, Hydrogen tank tech, Electric motor and the control technology.

Current commercial aviation projects



Zero Avia ,
Hydrogen electric passenger commuter

Current commercial aviation projects



Zero Avia ,

Hydrogen electric passenger commuter

Powertrain development:
Certification standards are written in blood V2

Zero Avia hydrogen electric power train demonstrator
Quote ”Off airport landing” outside Cranfield Airport, April 2021, due to sudden powertrain failure. (despite dual inverters and fuel cells)

The Piper Mirage aircraft takes off on battery electric power.
Continous flight is performed on electricity from a compressed hydrogen gas fuel cell. Zero Avia is aiming at using a future liquid tank technology.

Current commercial aviation projects

Zero Avia hydrogen electric power train demonstrator
Retrofit of electric engines and fuel cell system on a ”classic” Dornier 228 turboprop aircraft.
Commercial operation from 2024 (Optimistic, but using a proven legacy airframe and subsystems makes it possible to apply for a shortcut STC, Supplementary Type Certificate)

What remains to be seen before we can able to book tickets on an BEV or Hydrogen-electric passenger aircraft

- **Certification: Proven safety and performance** in battery and fuel cell powered large commercial aircraft (motors, power electronics, fuel cells, tank technology etc). Aviation regulators are – despite any political pressure - not willing to throw away a century of safety improvements.
- **Cost effectiveness** over time
- **Practical** in day to day commercial operations (refuelling and charging times)
- **Mass scale H2 production and logistics infrastructure**