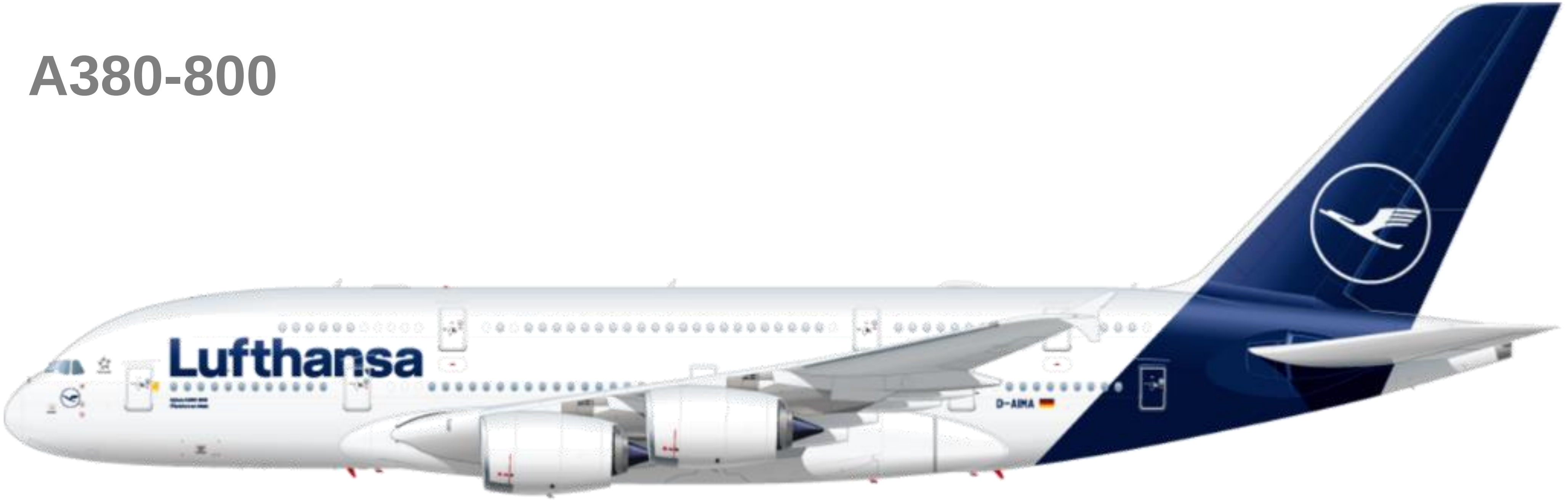
A380-800



Länge	72,73 m
Spannweite	79,80 m
Höhe	24,10 m
Max. Startgewicht	560 t
Max. Reise-geschwindigkeit (Cruise)	910 km/h
Maximal Takeoff Weight	560.000 kg
Maximal Landing Weight	391.000 kg

Max. Flughöhe	13.100 m
Reichweite	12.400 km
Sitze	509
LH	8 First 78 Business 52 Premium 371 Economy

Join at menti.com | use code 9252 2504

Was ist die installierte elektrische Leistung bei einem A380?

ELECTRICAL ON-BOARD SYSTEMS OF FUTURE MORE AND ALL ELECTRIC AIRCRAFT

Dr.-Ing. Andrea Reindl

Wie viel elektrische Leistung steckt im Flugzeug?

More und All Electric Aircraft

Elektrisches On-board System

Wege zu CO_2-neutraleren Luftfahrt

Wie viel elektrische Leistung steckt im Flugzeug?

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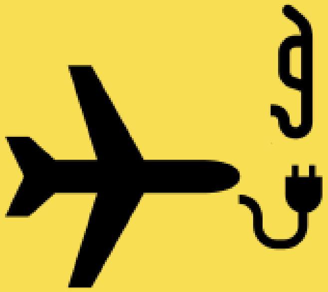
Auflösung

Airbus A380 (More Electric Aircraft) : 1,5 MW installierte elektrische Leistung

Leistungsstarker Fön: 3 kW
~ 500 Föns

Wie viel elektrische Leistung steckt im Flugzeug?

More und All Electric Aircraft



Hybrid

Elektrisches On-board System

Wege zu CO_2-neutraleren Luftfahrt

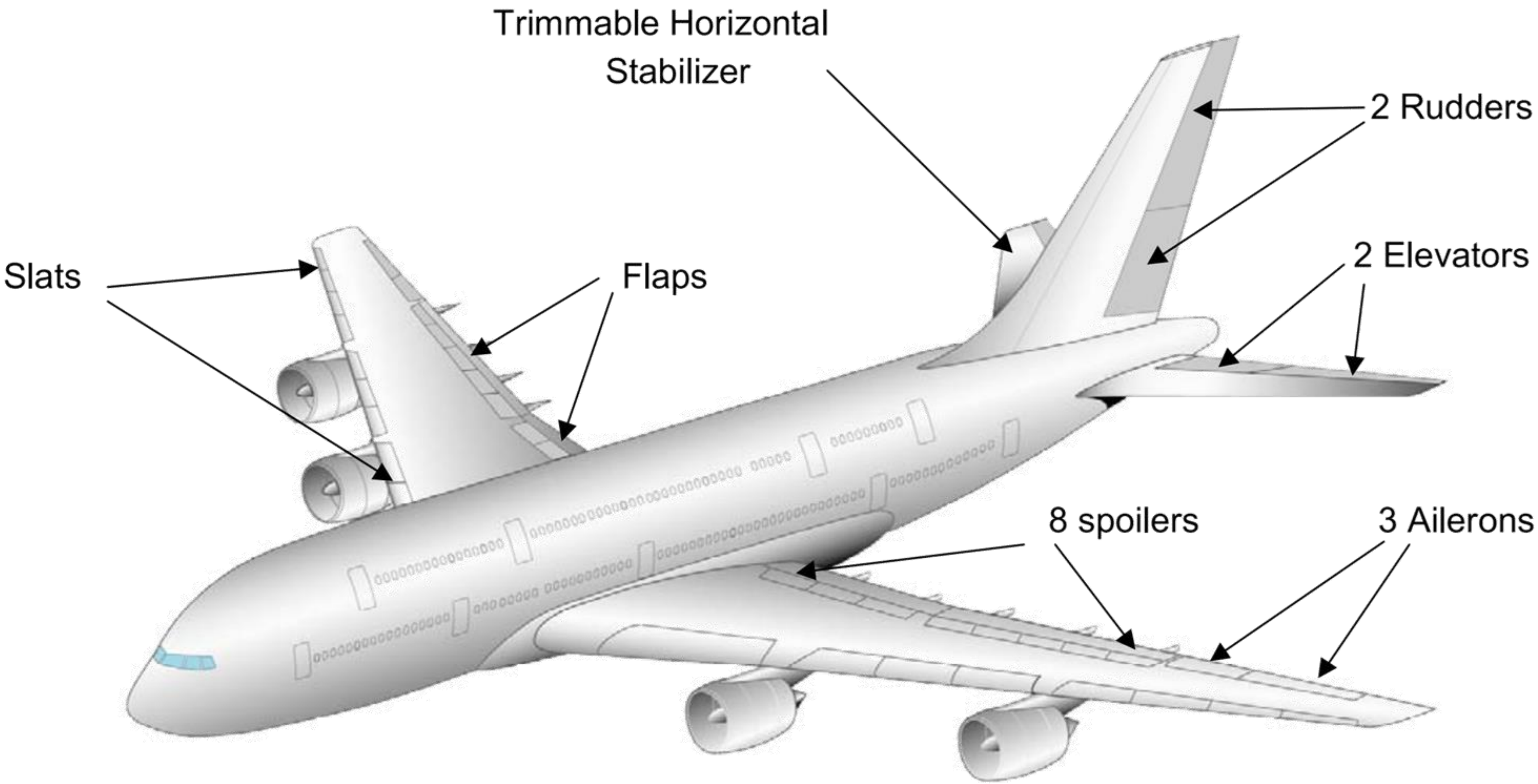
Was ist ein More Electric Aircraft?

Was ist ein More Electric Aircraft?

DLR

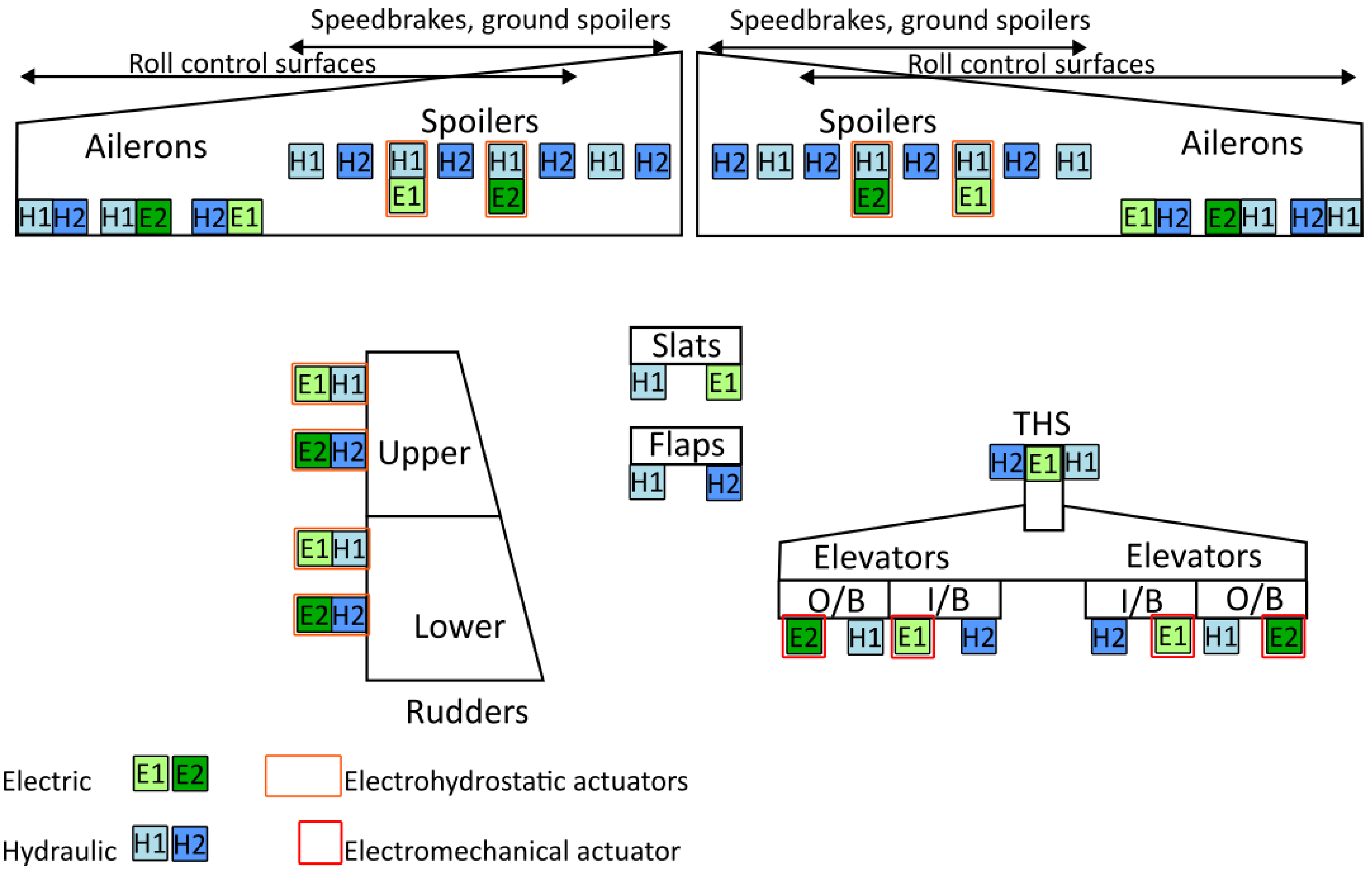
Bei More Electric Aircraft (MEA) werden mechanische, hydraulische und pneumatische System zunehmend durch elektrische Systeme ersetzt.

Primary Flight Control



Van Den Bossche, Dominique. "The A380 flight control electrohydrostatic actuators, achievements and lessons learnt." *25th international congress of the aeronautical sciences*. Vol. 1. Hamburg, Germany: International Council of Aeronautical Sciences (ICAS), 2006.

Energieversorgungssystem Primary Flight Control

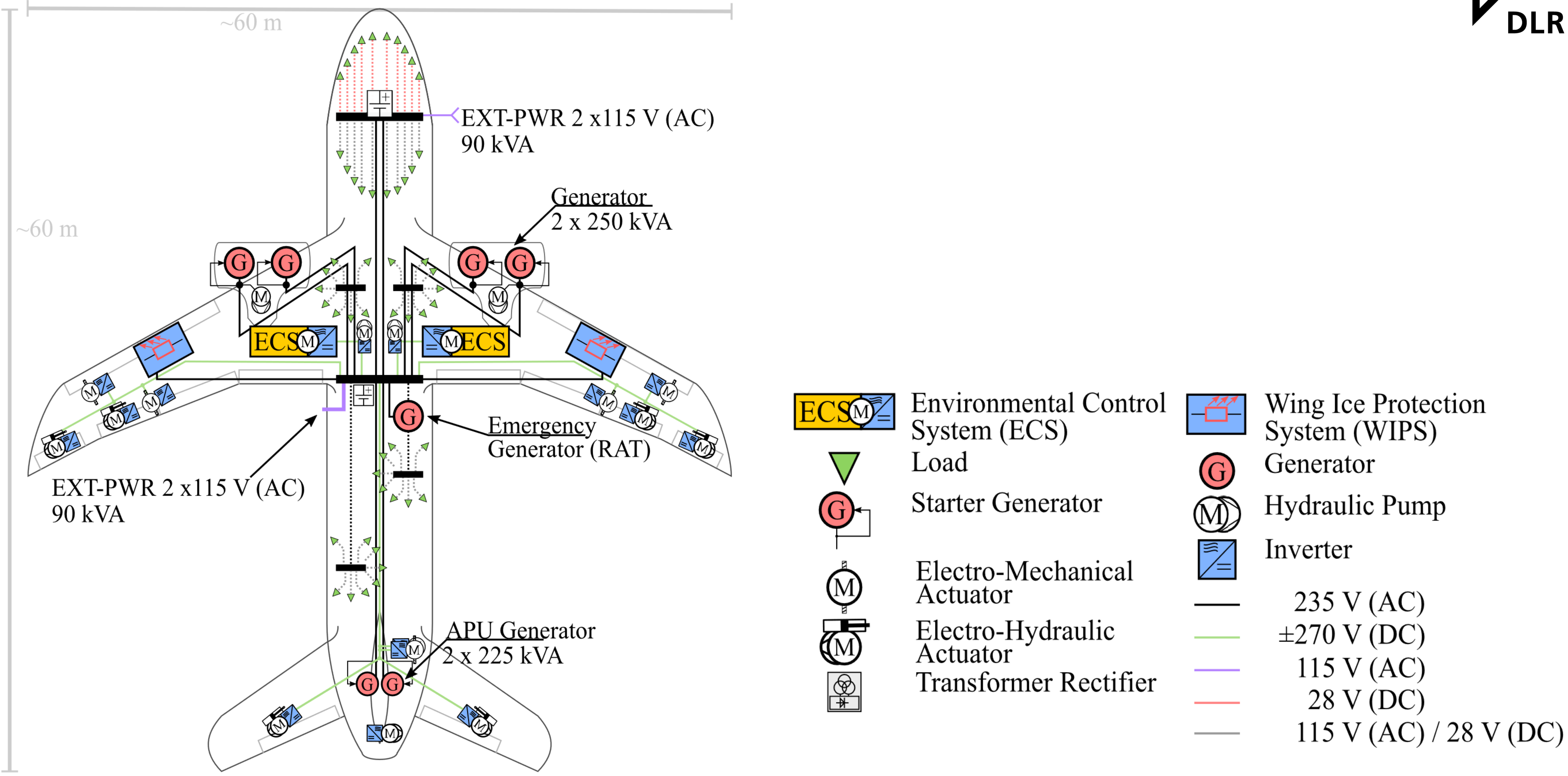


Conventional:
- 3 Hydraulic
- 2 Electric

More Electric Aircraft:
- 2 Hydraulic
- 2 Electric

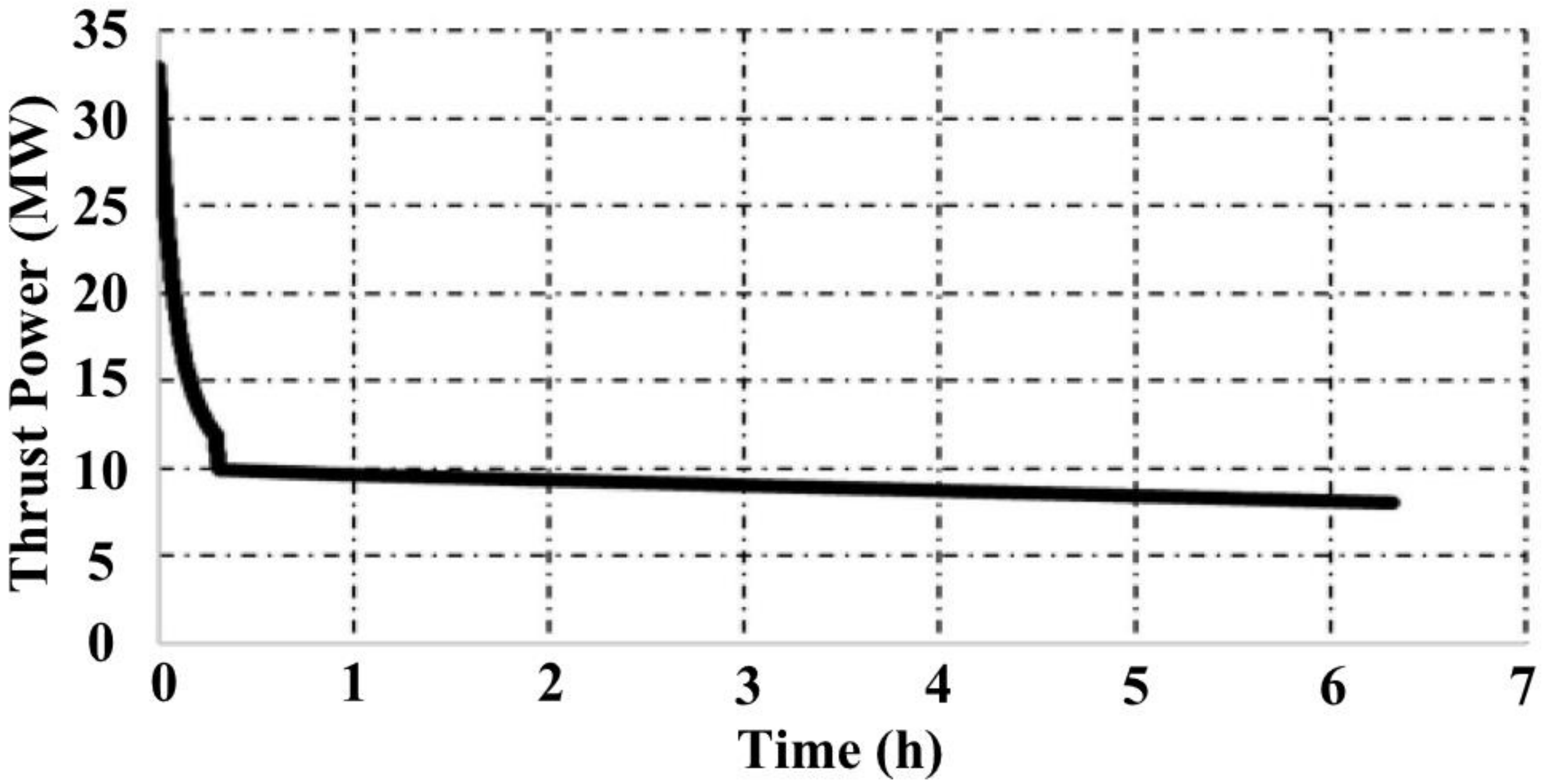
Van Den Bossche, Dominique. "The A380 flight control electrohydrostatic actuators, achievements and lessons learnt." *25th international congress of the aeronautical sciences*. Vol. 1. Hamburg, Germany: International Council of Aeronautical Sciences (ICAS), 2006.

Übergang More zu All Electric Aircraft



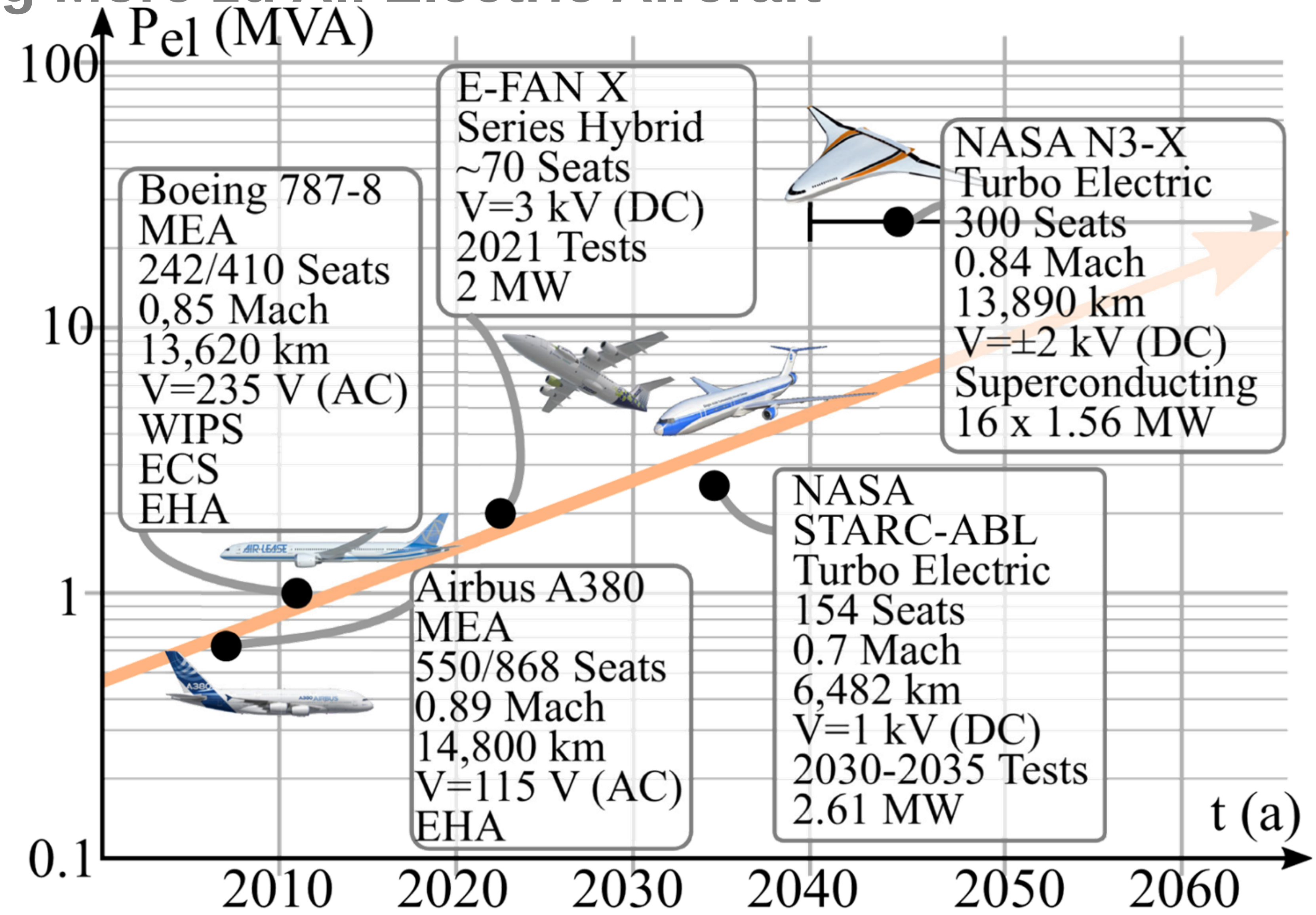
H. Schefer, L. Fauth, T. H. Kopp, R. Mallwitz, J. Friebe and M. Kurrat, "Discussion on Electric Power Supply Systems for All Electric Aircraft," in *IEEE Access*, vol. 8, pp. 84188-84216, 2020, doi: 10.1109/ACCESS.2020.2991804.

Thrust Power Profile of Narrow Body Aircraft (A320)



A. Barzkar and M. Ghassemi, "Electric Power Systems in More and All Electric Aircraft: A Review," in *IEEE Access*, vol. 8, pp. 169314-169332, 2020, doi: 10.1109/ACCESS.2020.3024168.

Übergang More zu All Electric Aircraft



H. Schefer, L. Fauth, T. H. Kopp, R. Mallwitz, J. Friebe and M. Kurrat, "Discussion on Electric Power Supply Systems for All Electric Aircraft," in *IEEE Access*, vol. 8, pp. 84188-84216, 2020, doi: 10.1109/ACCESS.2020.2991804.

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Elektrisches On-board System

Wege zu CO_2-neutraleren Luftfahrt

Eine der Challenges: Elektrisches System

Key Issues

- Leistungsdichte: 10-40 MW begrenztes Volumen und Gewicht
- Paschen Gesetz: Corona Effekt
- Safety Requirements: Failure Rate 10^{-9} pro Flugstunde
- Lange Betriebsdauer und ungewöhnliche, extreme Betriebsbedingungen

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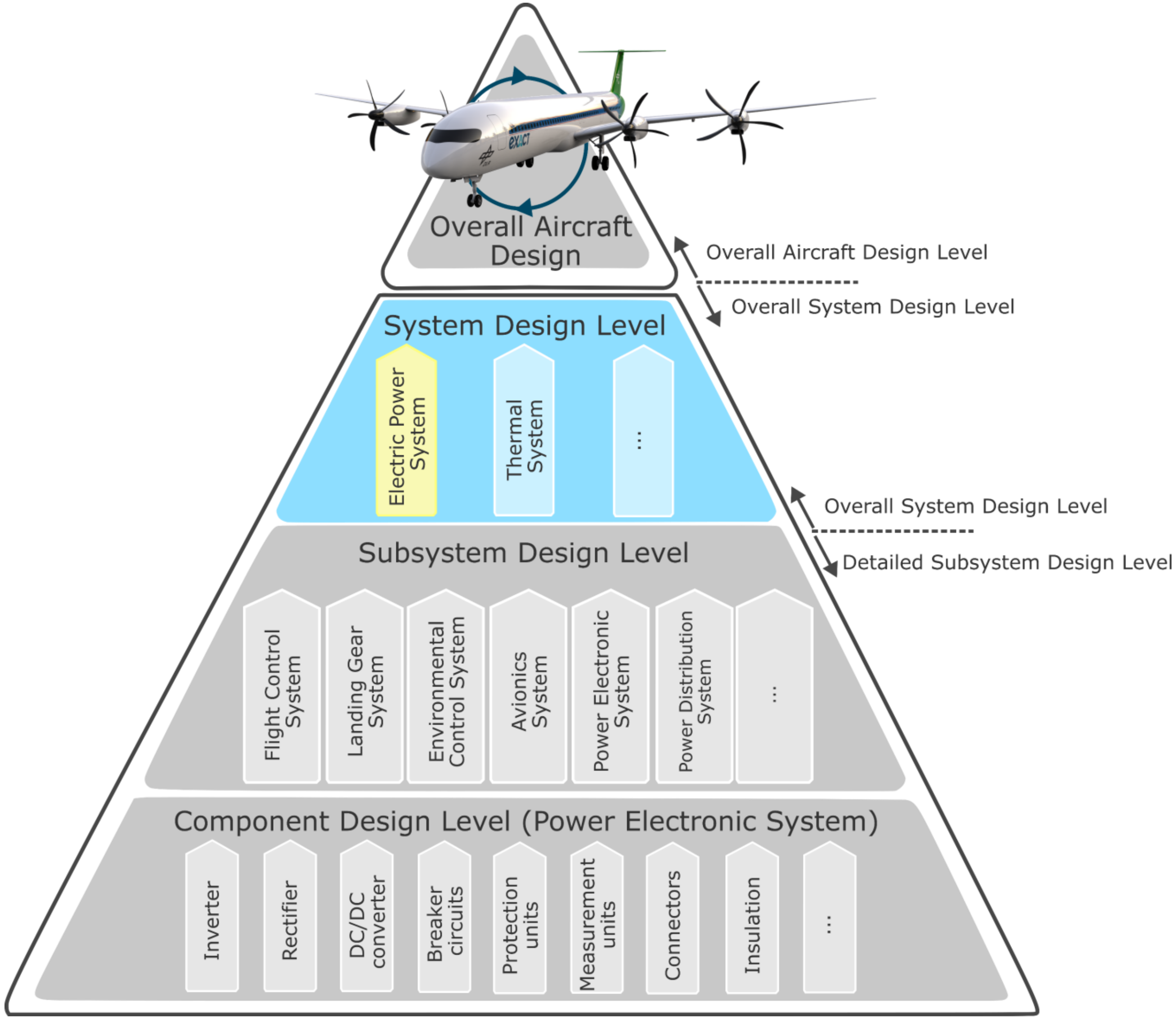
Aircraft Entwurfs Prozess

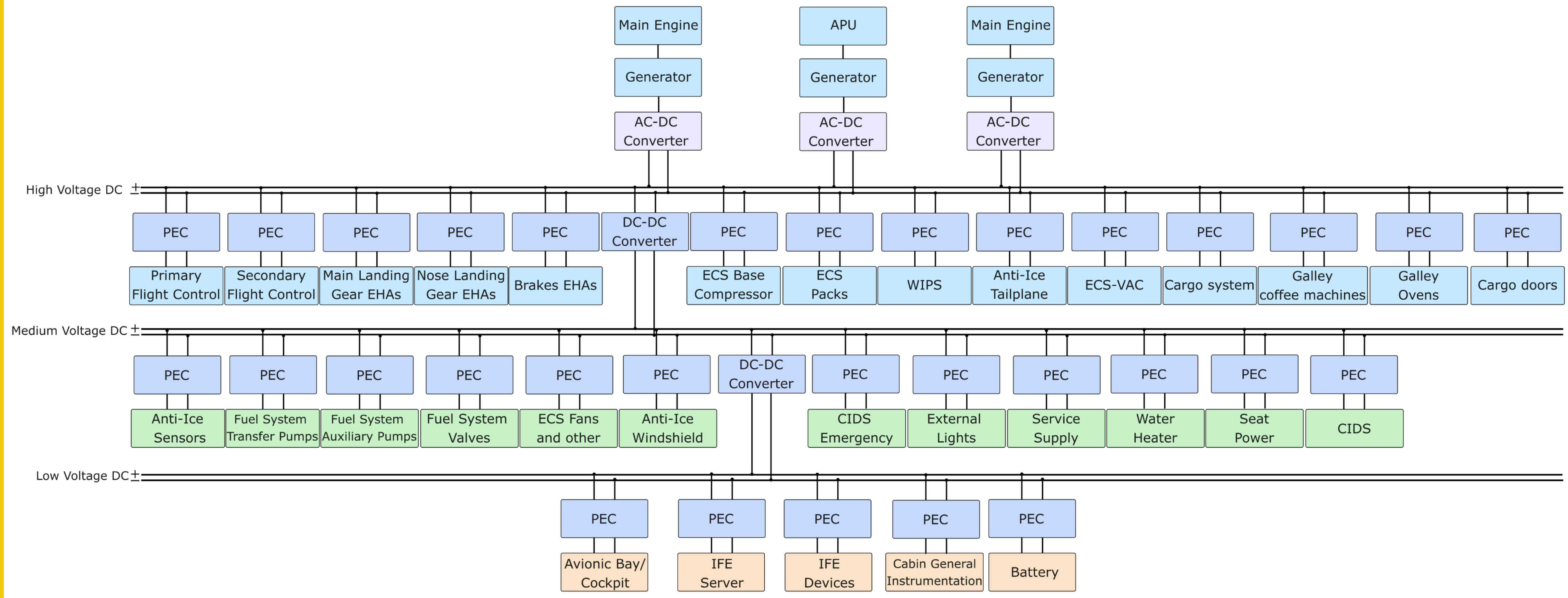


$$\frac{kW}{kg}$$

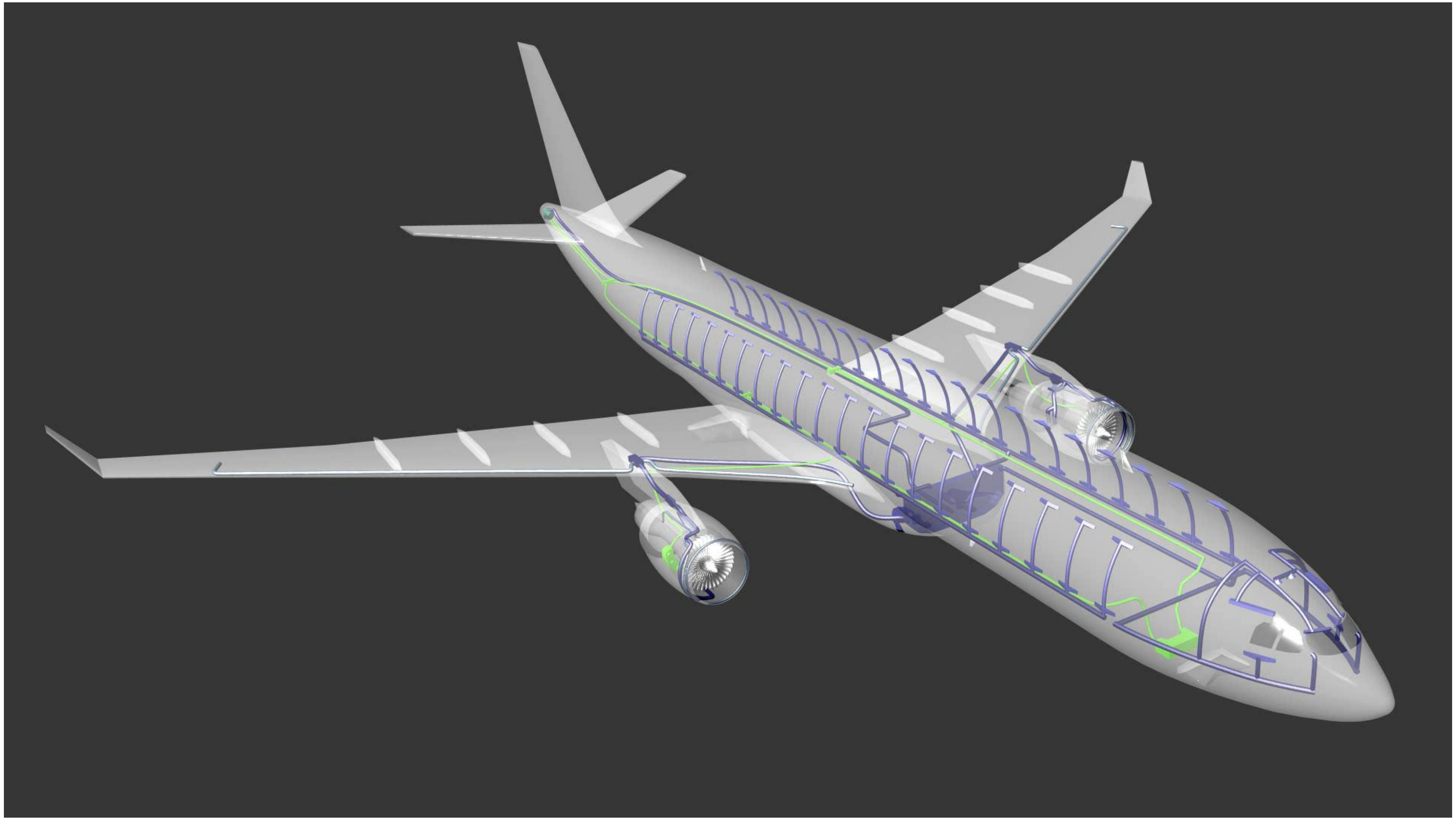
What configuration is required to achieve the function under the constraints from overall aircraft design?

$f_{Switch}\cdots$

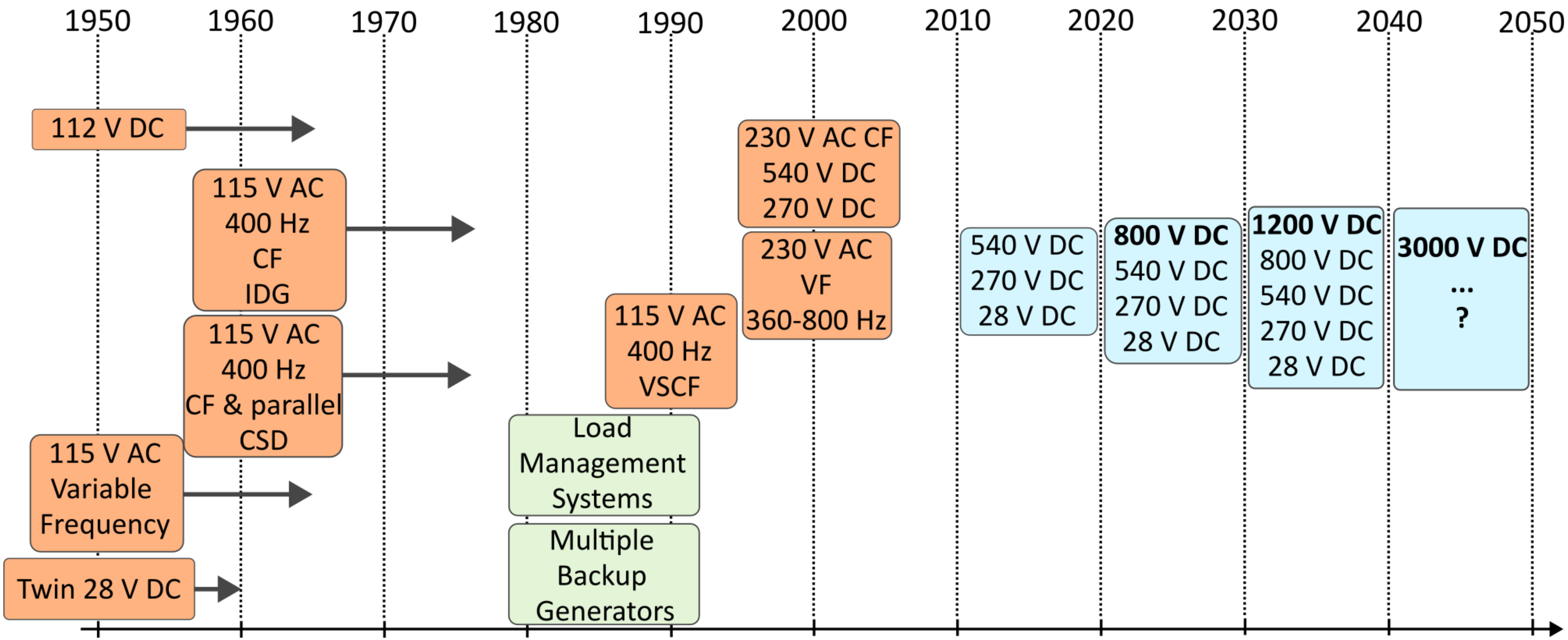
Elektrisches System



Aircraft System Dynamics: Energy Systems (thermal & electrical)

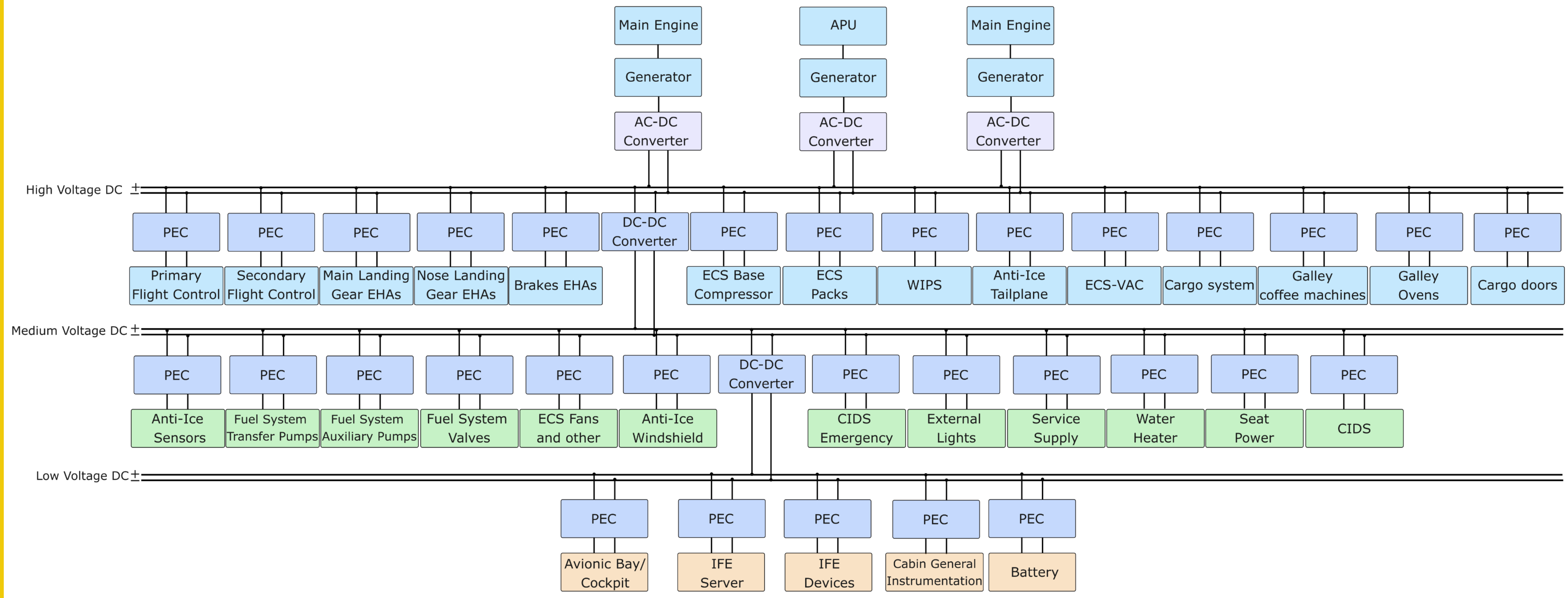


Entwicklung des elektrischen On-board Systems

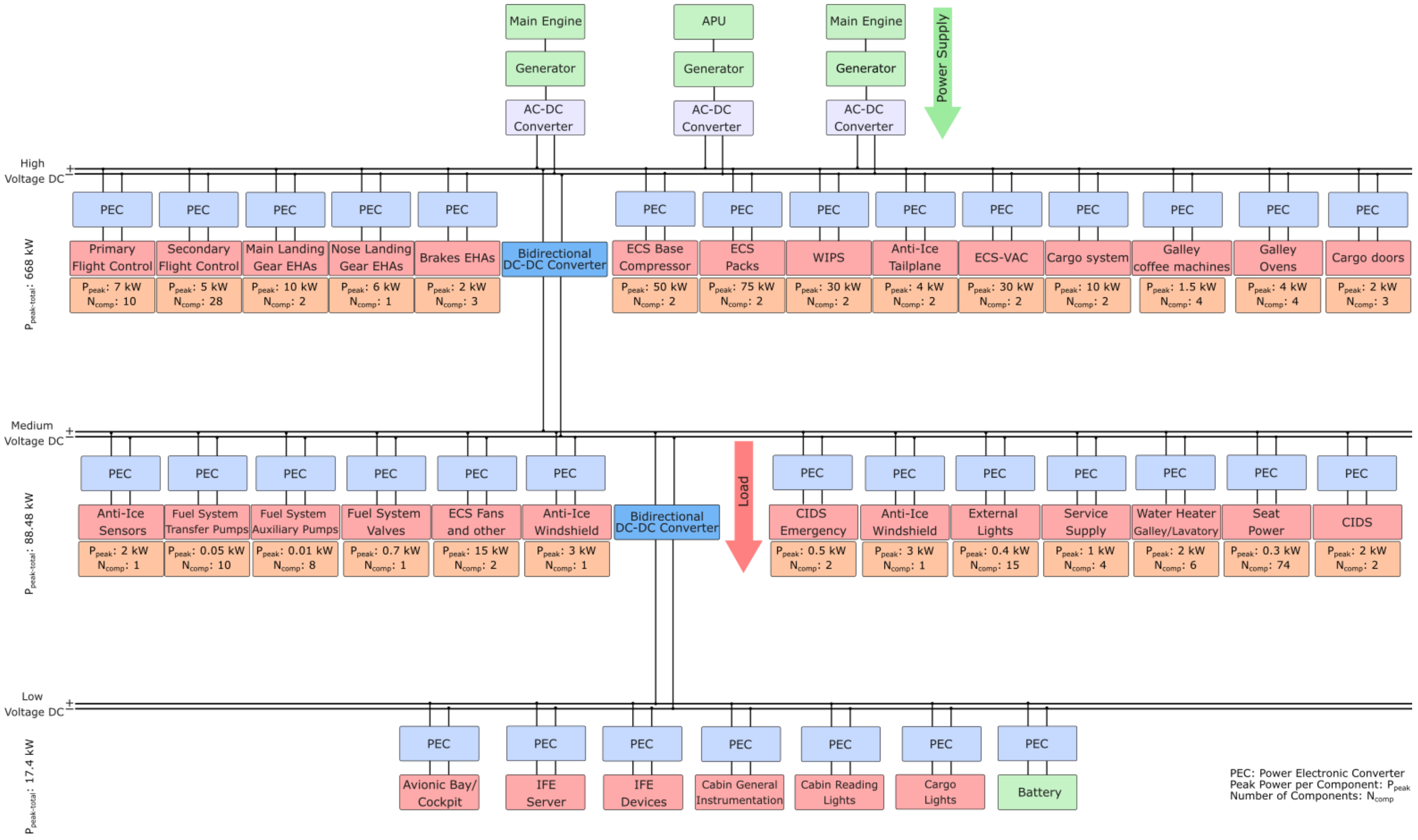


Information Abbildung bis 2000 aus: I. Moir, A. Seabridge, „Aircraft Systems – Third Edition: Mechanical, electrical, and avionics subsystem integration", 2008, ISBN 978-0-470-05996-8, Wiley.

On-board System

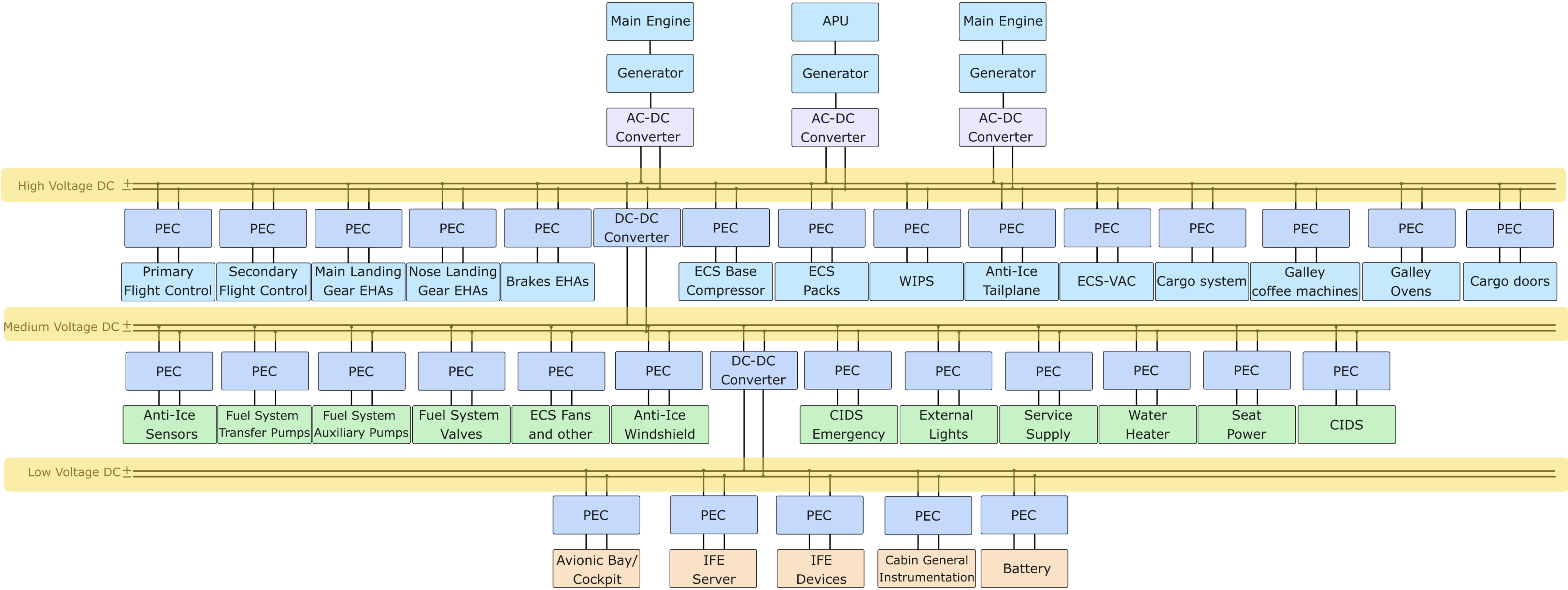


Auxiliary Power Unit (APU)



Main Engine
Generator
AC-DC Converter
APU
Generator
AC-DC Converter
Main Engine
Generator
AC-DC Converter
Power Supply
High Voltage DC
P_peak-total: 668 kW
PEC
Primary Flight Control
P_peak: 7 kW N_comp: 10
Secondary Flight Control
P_peak: 5 kW N_comp: 28
Main Landing Gear EHAs
P_peak: 10 kW N_comp: 2
Nose Landing Gear EHAs
P_peak: 6 kW N_comp: 1
Brakes EHAs
P_peak: 2 kW N_comp: 3
Bidirectional DC-DC Converter
ECS Base Compressor
P_peak: 50 kW N_comp: 2
ECS Packs
P_peak: 75 kW N_comp: 2
WIPS
P_peak: 30 kW N_comp: 2
Anti-Ice Tailplane
P_peak: 4 kW N_comp: 2
ECS-VAC
P_peak: 30 kW N_comp: 2
Cargo system
P_peak: 10 kW N_comp: 2
Galley coffee machines
P_peak: 1.5 kW N_comp: 4
Galley Ovens
P_peak: 4 kW N_comp: 4
Cargo doors
P_peak: 2 kW N_comp: 3
Medium Voltage DC
P_peak-total: 88.48 kW
Anti-Ice Sensors
P_peak: 2 kW N_comp: 1
Fuel System Transfer Pumps
P_peak: 0.05 kW N_comp: 10
Fuel System Auxiliary Pumps
P_peak: 0.01 kW N_comp: 8
Fuel System Valves
P_peak: 0.7 kW N_comp: 1
ECS Fans and other
P_peak: 15 kW N_comp: 2
Anti-Ice Windshield
P_peak: 3 kW N_comp: 1
Bidirectional DC-DC Converter
Load
CIDS Emergency
P_peak: 0.5 kW N_comp: 2
Anti-Ice Windshield
P_peak: 3 kW N_comp: 1
External Lights
P_peak: 0.4 kW N_comp: 15
Service Supply
P_peak: 1 kW N_comp: 4
Water Heater Galley/Lavatory
P_peak: 2 kW N_comp: 6
Seat Power
P_peak: 0.3 kW N_comp: 74
CIDS
P_peak: 2 kW N_comp: 2
Low Voltage DC
P_peak-total: 17.4 kW
Avionic Bay/ Cockpit
IFE Server
IFE Devices
Cabin General Instrumentation
Cabin Reading Lights
Cargo Lights
Battery
PEC: Power Electronic Converter
Peak Power per Component: P_peak
Number of Components: N_comp

On-board System: DC Grid Architectures



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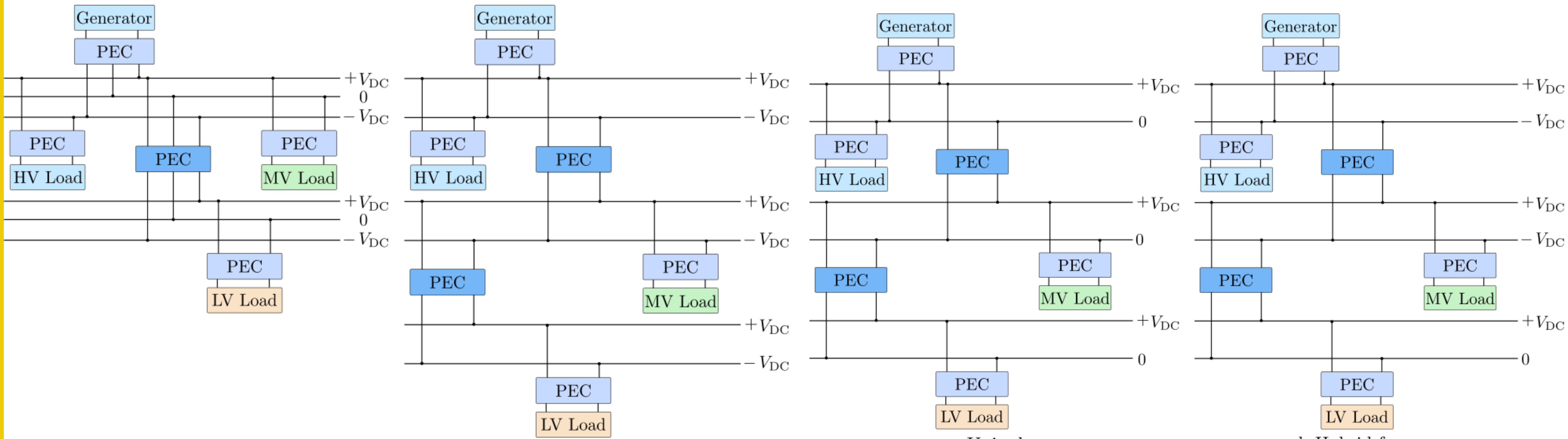


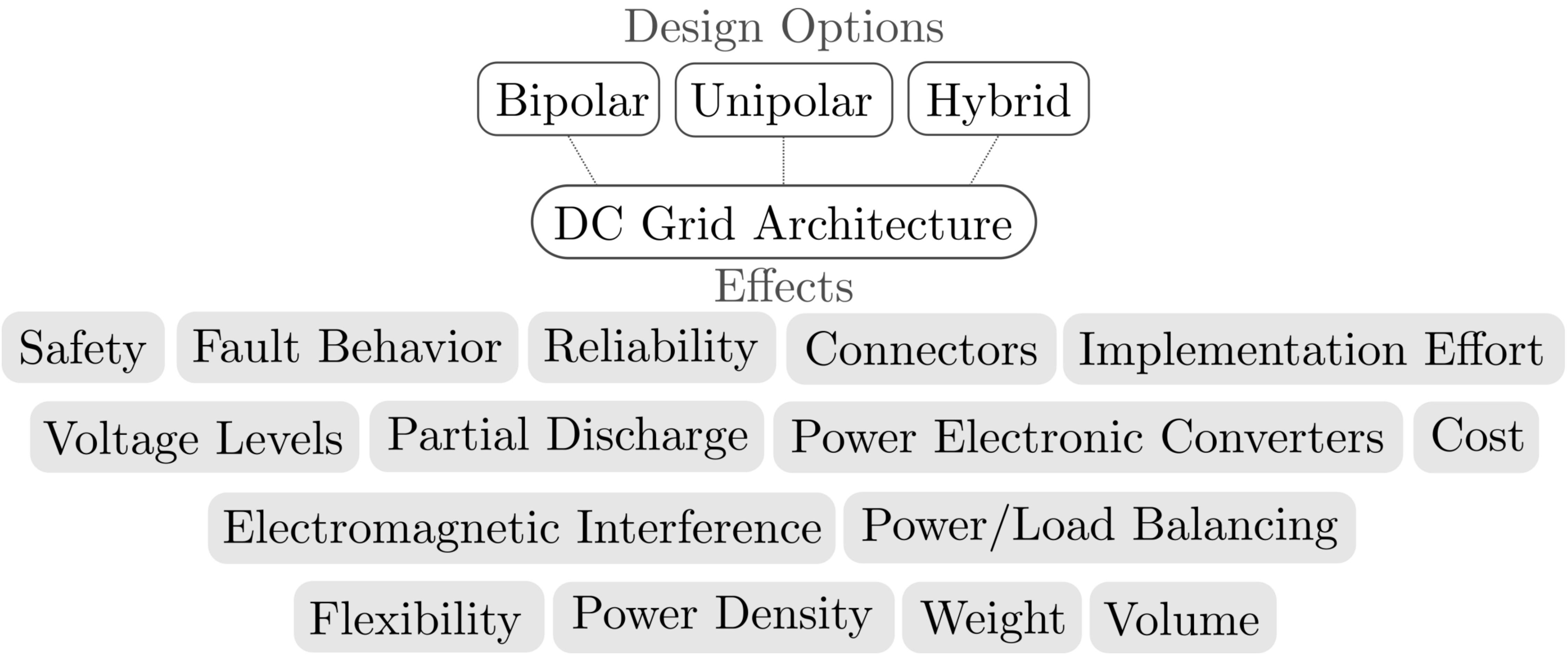
a, Bipolar, three wire

b, Bipolar, two wire

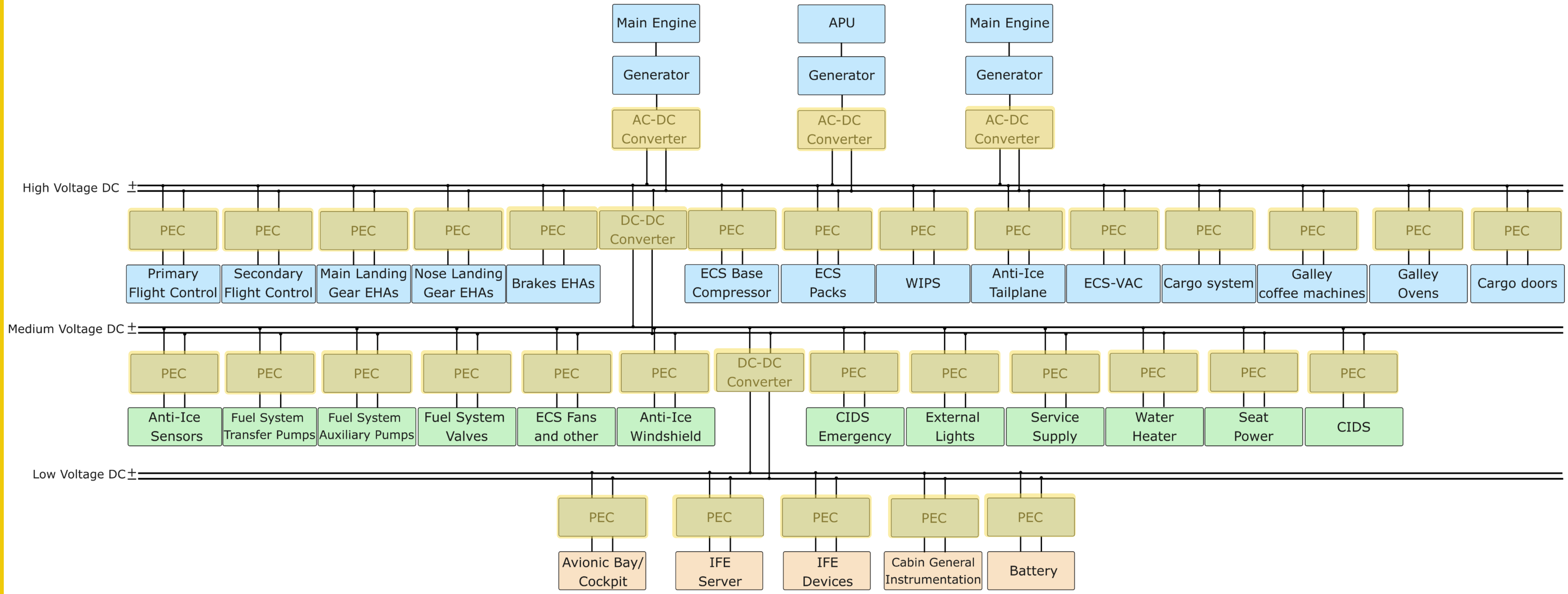
c, Unipolar

d, Hybrid forms, e.g.,
bipolar HV and MV grid, unipolar LV grid

DC Grid Architectures: Options and Effects

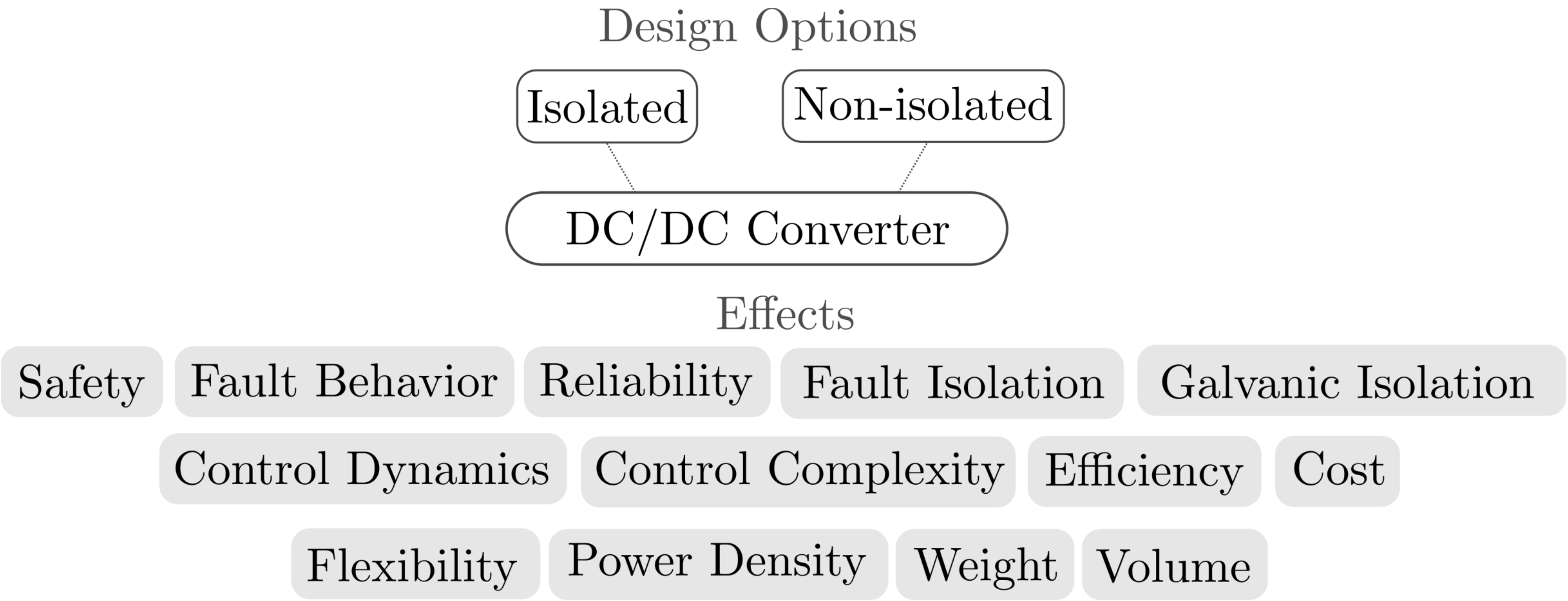


Isolated or Non-isolated?

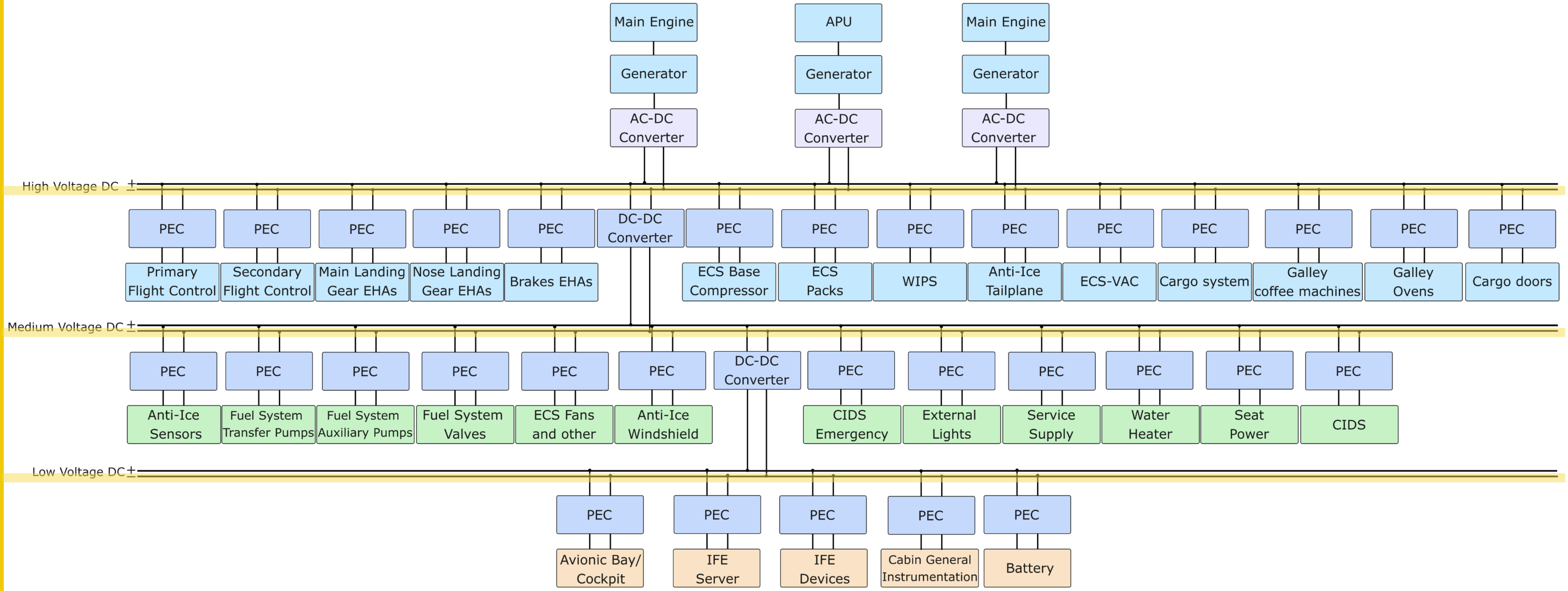


PEC: Power Electronic Converter

Isolated or Non-isolated?



Grounding Scheme



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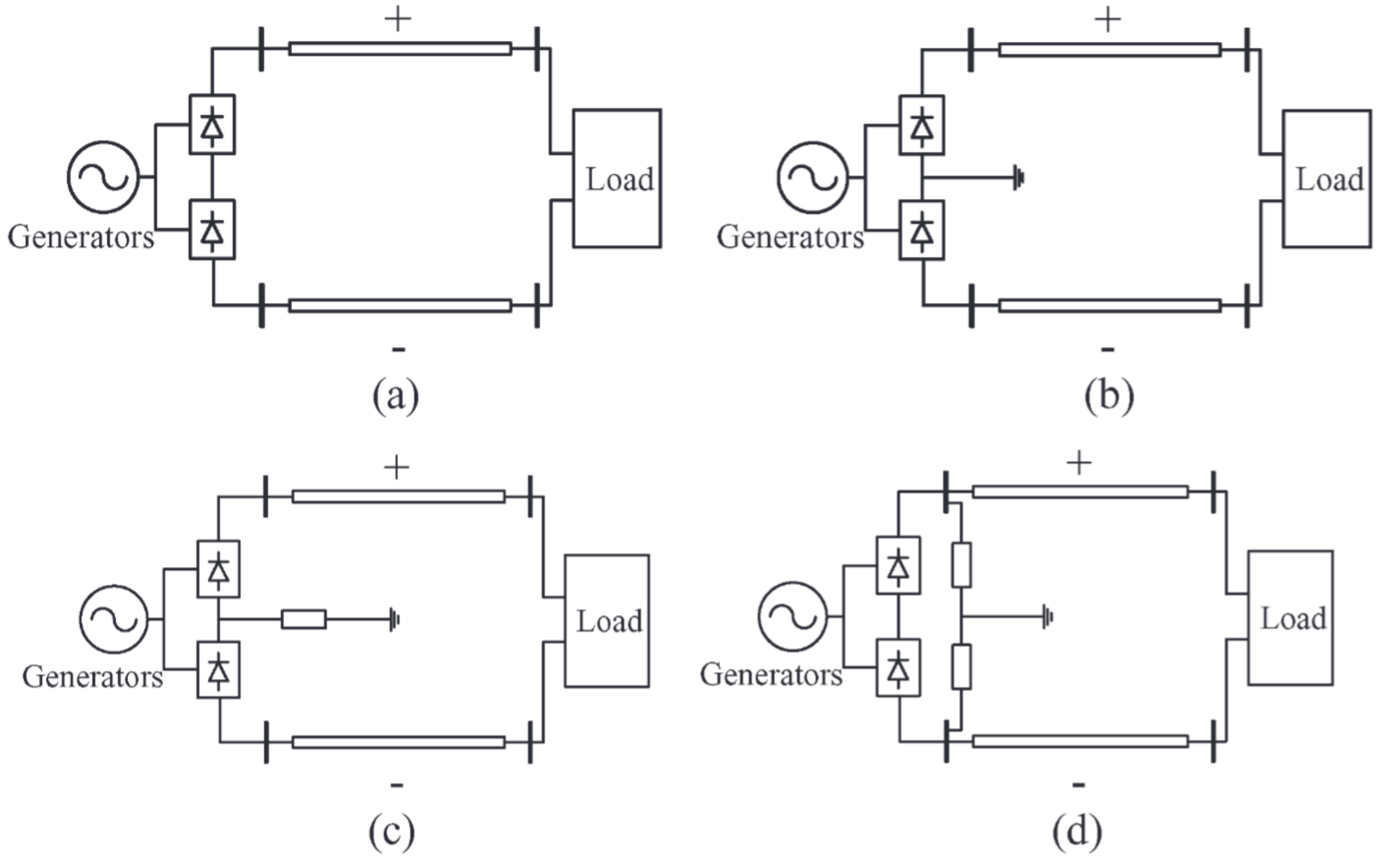

Fig. 5. Grounding system of the shipboard MVDC power system. (a) Ungrounded. (b) Solidly grounded. (c) Grounded with resistor. (d) Grounded with resistors in parallel.

Grounding Scheme: Options and Effect

Design Options

Ungrounded | Solidly Grounded | Grounded via Resistor | Grounded via Two Resistors

Grounding Scheme

Effects

Safety | Fault Behavior | Reliability | Fault Isolation | Fault Detection

Fault Current Magnitude | Fault Current Rate of Rise

Andrea Reindl, Institute of System Dynamics and Control, 10.12.2024

Eine der Challenges: Elektrisches On-board System

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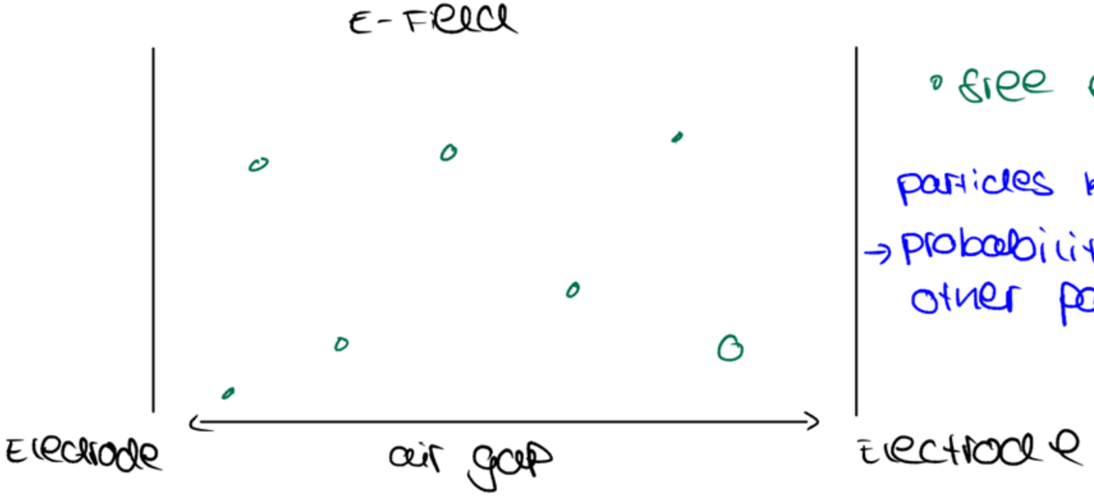
Paschen‘s Law

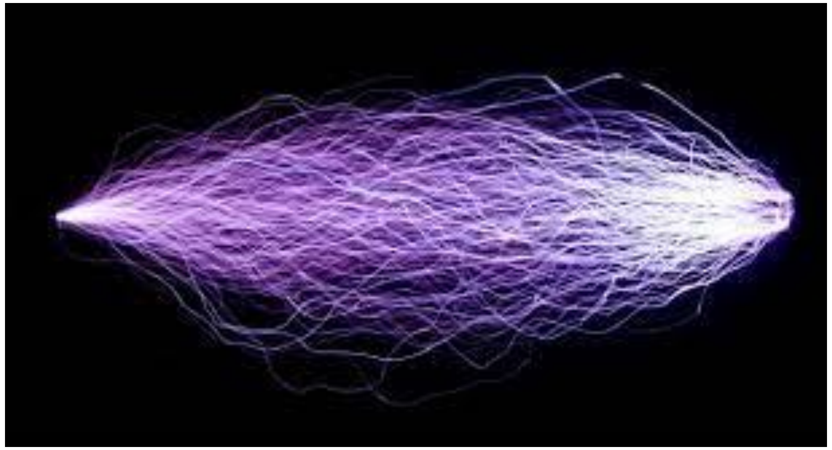
Paschen's Law

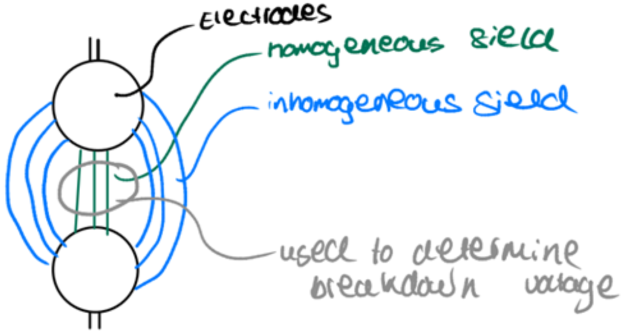


• free electrons

particles kinetic energy ↑

→ probability of collision with other particles ↑





air pressure ↓ (Altitude ↑ e.g.) @ fixed air gap distance

→ mean free path increases ↑

↓

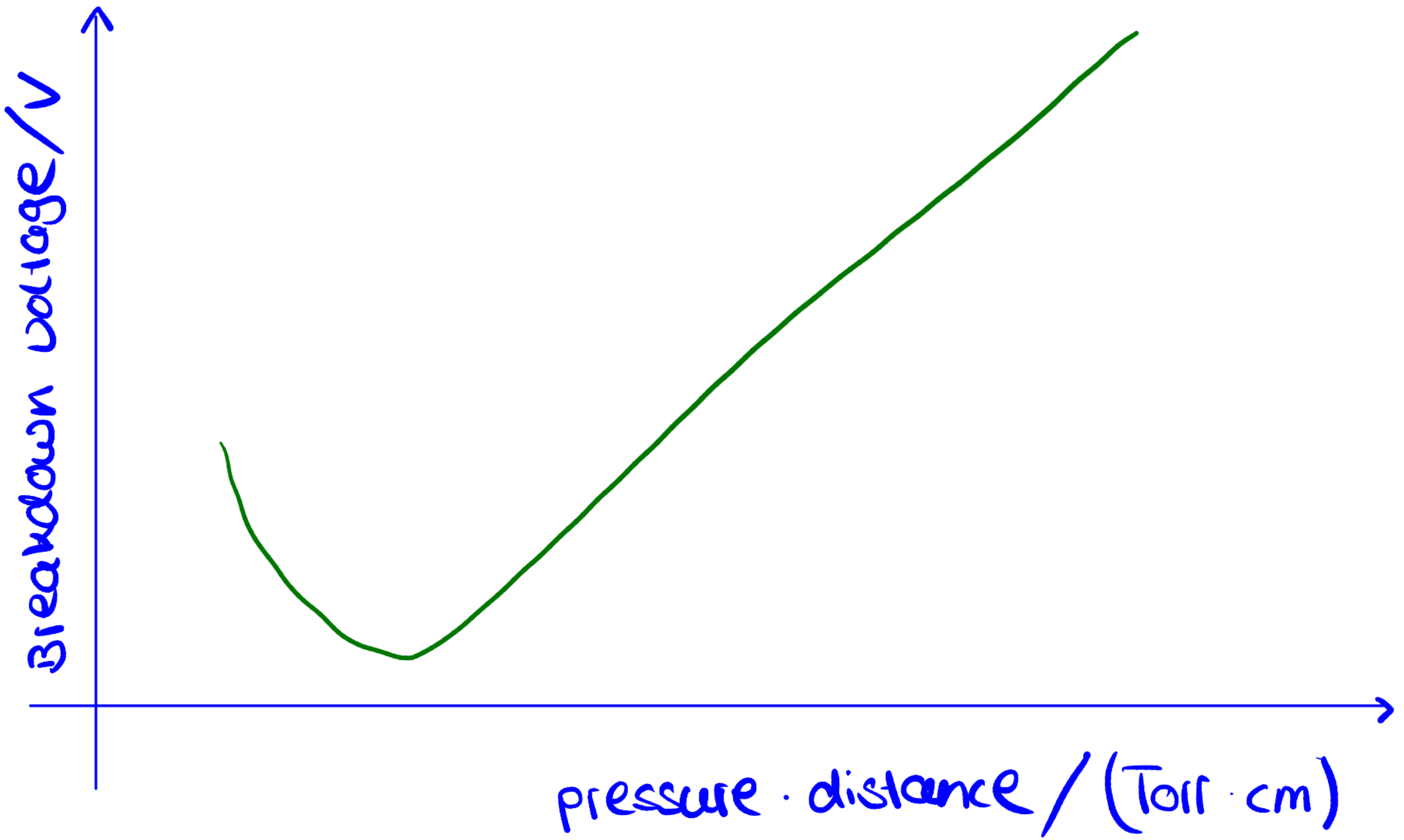
average distance an electrode travels without colliding with air molecule

→ mean free path ↑

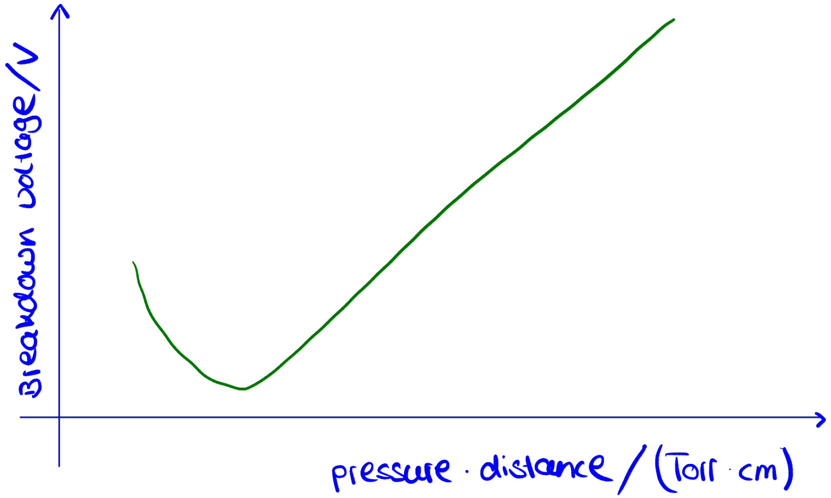
→ electrons gain more kinetic energy before a collision

→ probability of collision being ionising is increased

Paschen Curve



Paschen Curve



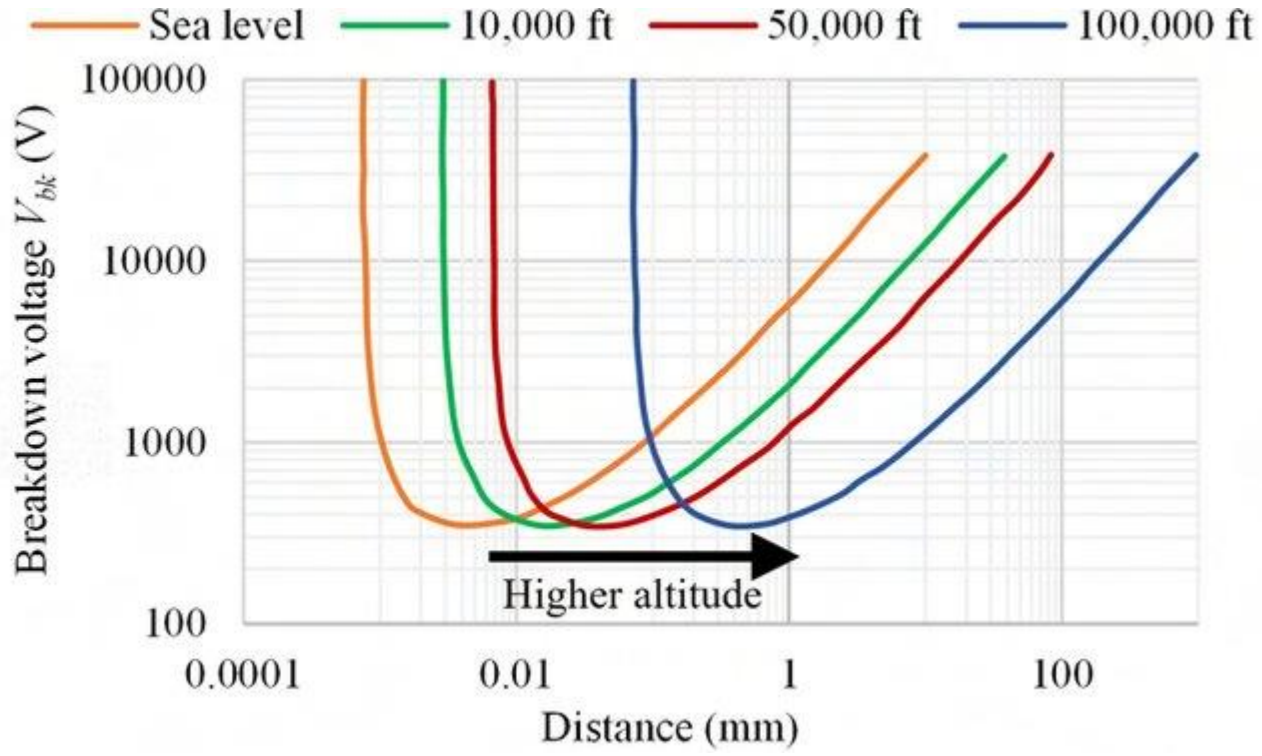
- for every gas there is a Paschen Minimum
- for air, the Paschen Minimum is 327V (7.5 μm distance between electrodes)
- Take Home Message: changing the distance between electrodes or changing the pressure will change the breakdown voltage

→ it will also change the partial discharge inception voltage

- voltage level where first partial discharges occur @ atmospheric pressure ~ 3kV

  @ flight level ~ 860 - 900V

Paschen Kurve



J. Hu, X. Zhao, L. Ravi, R. Burgos and D. Dong, "Enhanced Gate Driver Design for SiC-Based Generator Rectifier Unit for Airborne Applications," *2021 IEEE Applied Power Electronics Conference and Exposition (APEC)*, Phoenix, AZ, USA, 2021, pp. 2526-2531, doi: 10.1109/APEC42165.2021.9487425.

Eine der Challenges: Elektrisches On-board System

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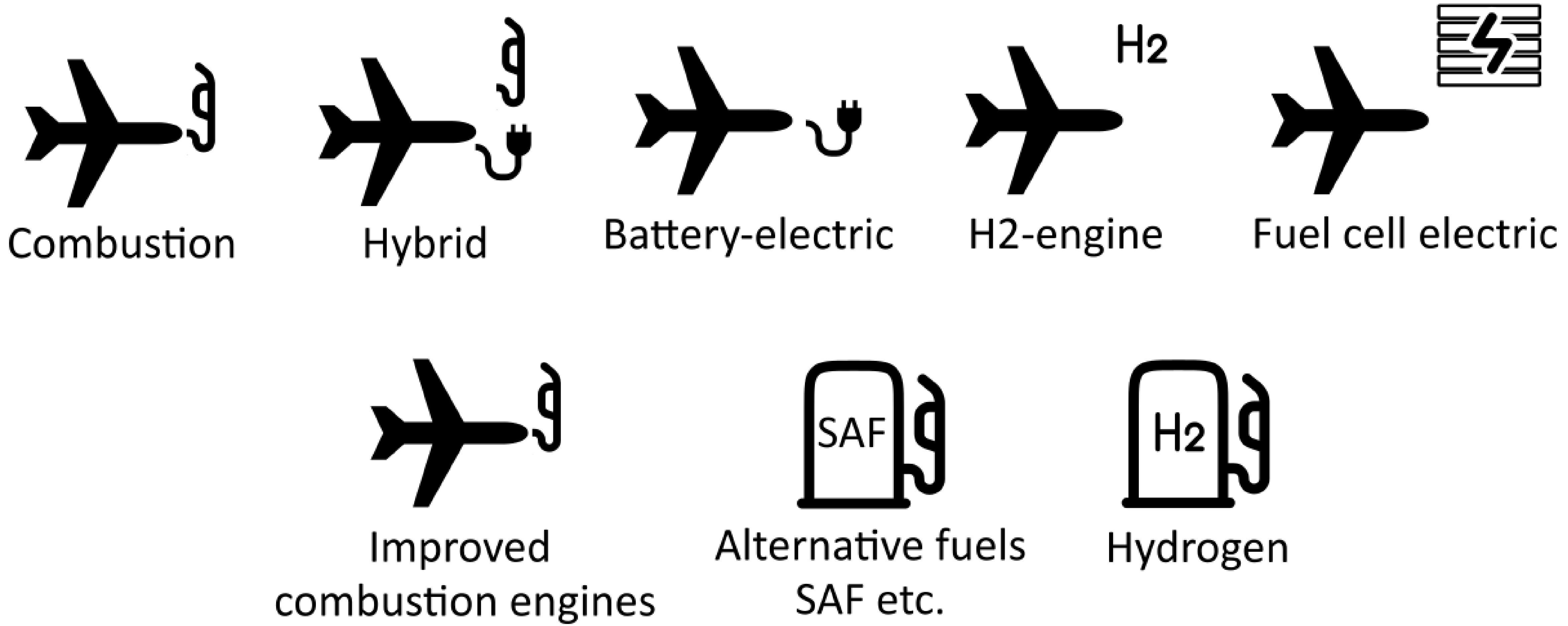
Wege zu CO_2-neutraleren Luftfahrt

Wege zur CO_2-neutraleren Luftfahrt

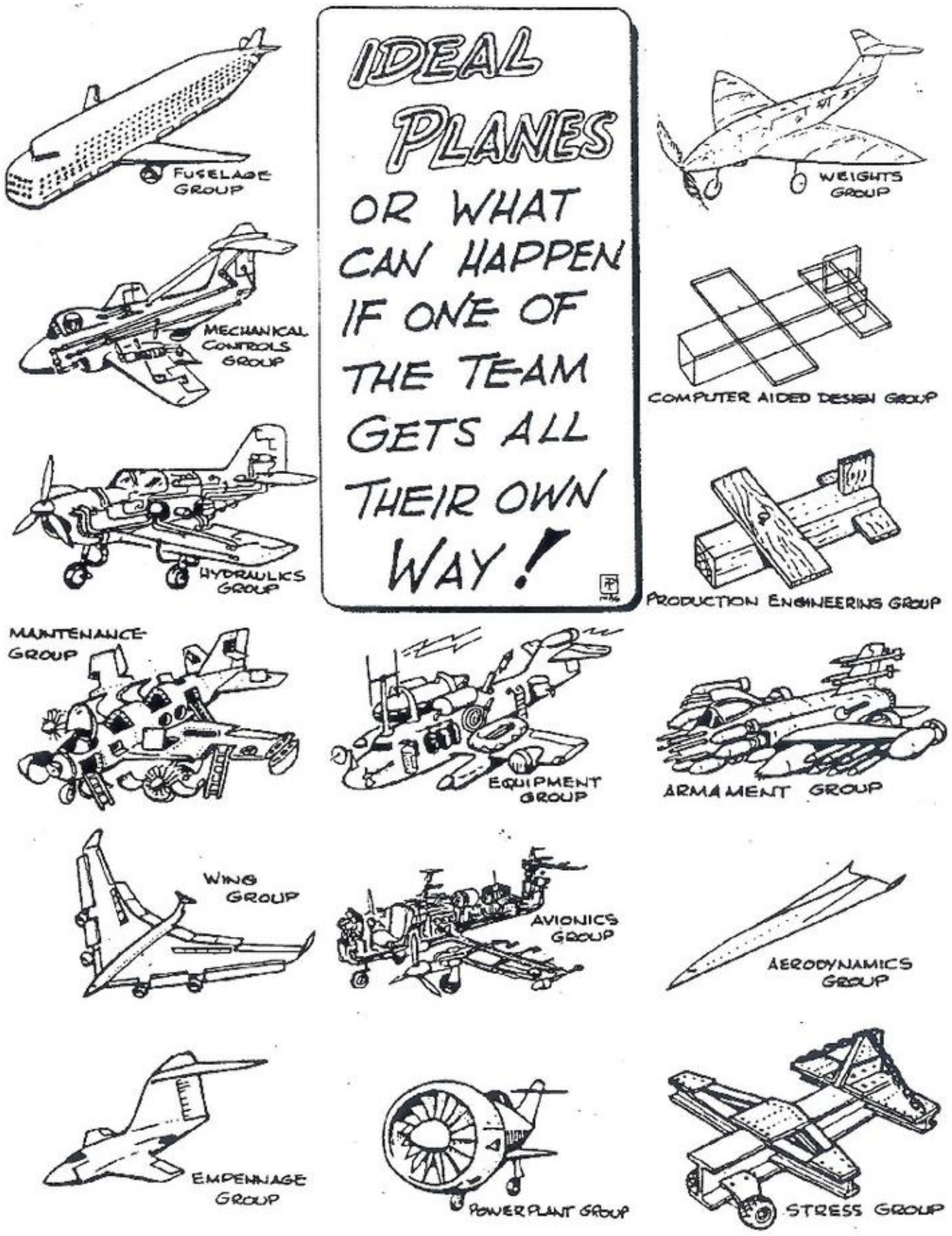


Entwurf neuer Flugzeugarchitekturen um Weg zu CO2-neutralerem Fliegen zu ebnen

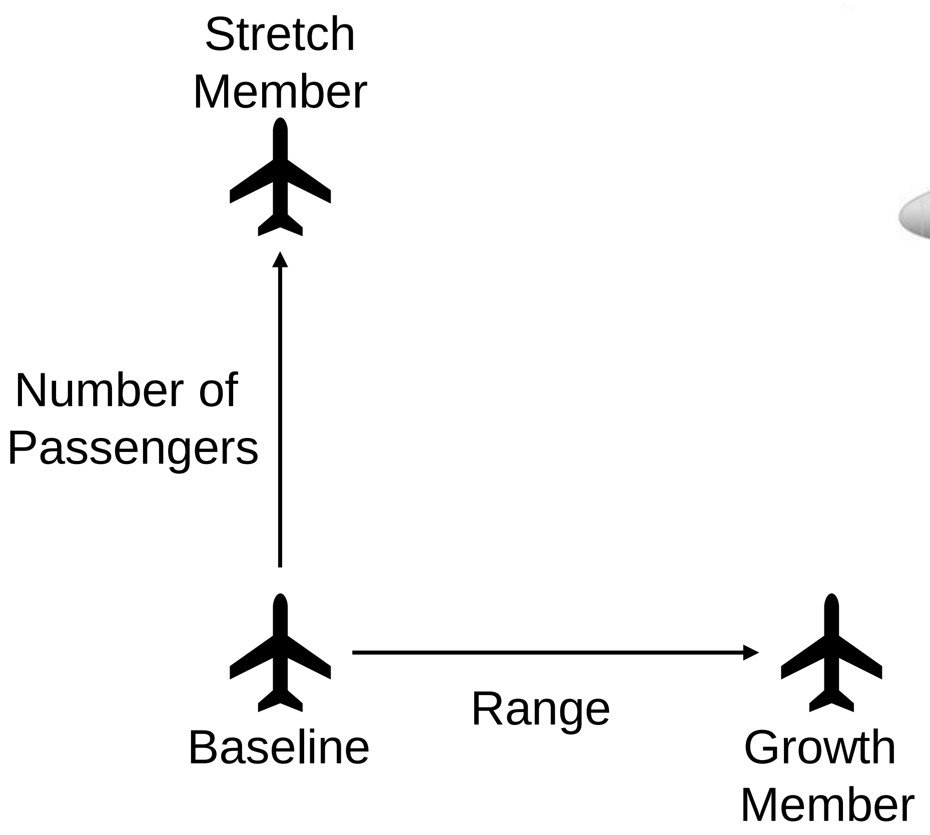
Warum wird Open Fan Technology verwendet?

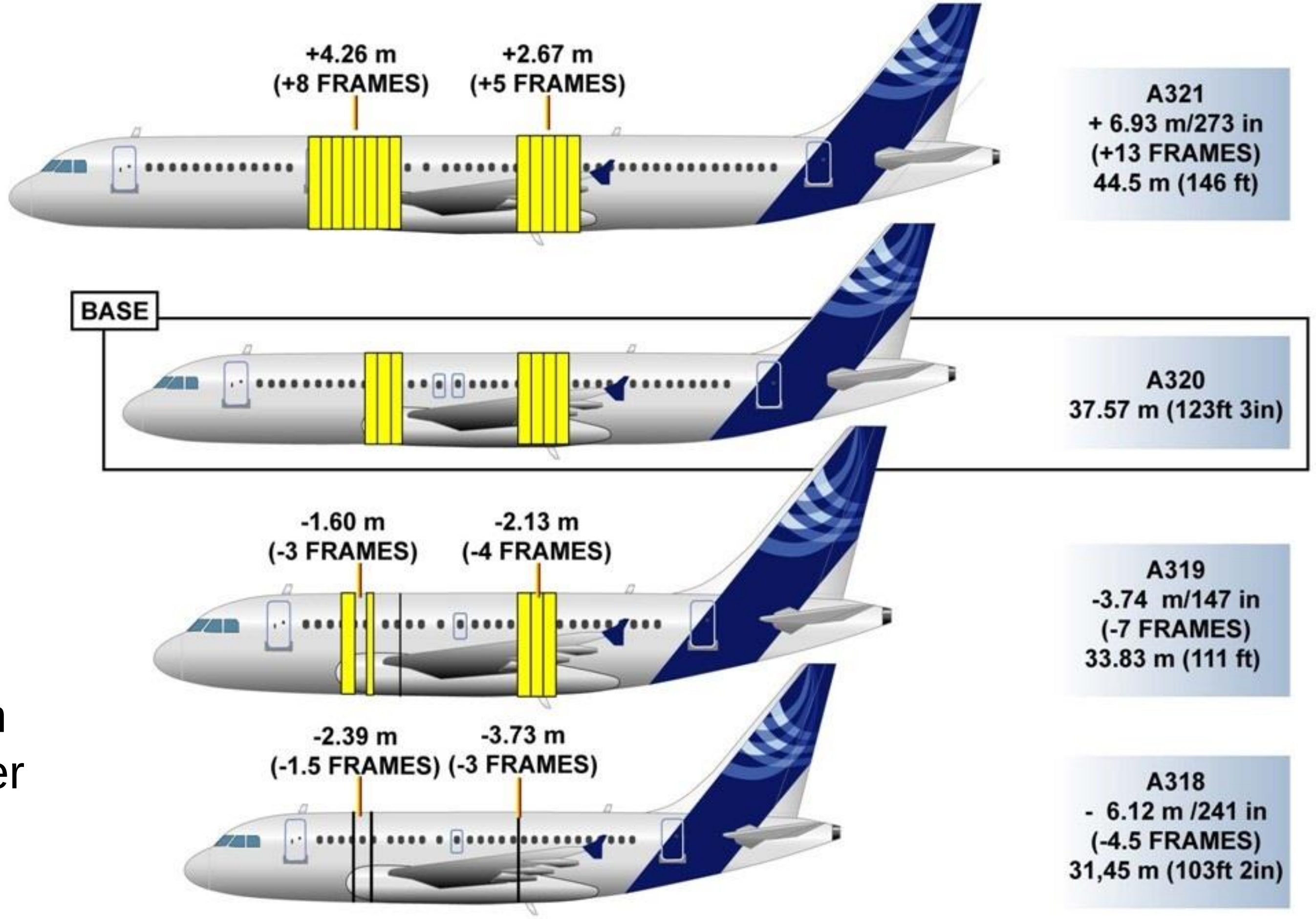
Entwurf neuer Flugzeugarchitekturen um Weg zu CO2-neutralerem Fliegen zu ebnen

Warum wird Distributed Propulsion eingesetzt?


IDEAL PLANES OR WHAT CAN HAPPEN IF ONE OF THE TEAM GETS ALL THEIR OWN WAY!
FUSELAGE GROUP
WEIGHTS GROUP
MECHANICAL CONTROLS GROUP
COMPUTER AIDED DESIGN GROUP
HYDRAULICS GROUP
PRODUCTION ENGINEERING GROUP
MAINTENANCE GROUP
EQUIPMENT GROUP
ARMAMENT GROUP
WING GROUP
AVIONICS GROUP
AERODYNAMICS GROUP
EMPENNAGE GROUP
POWER PLANT GROUP
STRESS GROUP

Family Concept





Aufgabe:

Designen Sie eine Stretch Version mit 15% mehr Passgiere (PAX).

Was muss angepasst werden?

Wie ist die Wechselwirkung zwischen den Systemen?

- Welchen Einfluss haben Konstruktions-änderungen auf die Kräfte?
- Welche Komponenten müssen geändert werden?
- Welche Einschränkungen und Wechselwirkungen müssen bei Änderungen an Komponenten berücksichtigt werden?