



ICAO

STOCKTAKING 2020

Advanced Aircraft Technologies

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Electric Aircraft Opportunities & Challenges

A Boeing Perspective

Hubert Wong

Advanced Concepts | Product Development

Boeing Commercial Airplanes

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Boeing Electric Aircraft Studies

Advanced Concepts – active and realistic approach for over a decade



SUGAR VOLT
Boeing / NASA 2008-2018+



Fuel Cell Demonstrator
BR&T Madrid 2008-2009



ecoDemonstrator Fuel Cell
Boeing / IHI 2012



Hybrid Electric Demonstrator
Cambridge / Boeing 2015



XV-24A Lightning Strike
Aurora 2016- 2018



Cargo Air Vehicle (CAV)
Boeing 2017-



Ongoing Internal &
Competitive Studies
Boeing 2006-



Pegasus
Aurora 2017-



Wisk
Kitty Hawk / Boeing 2019-

Significant Benefits If Challenges Can Be Overcome



Opportunities

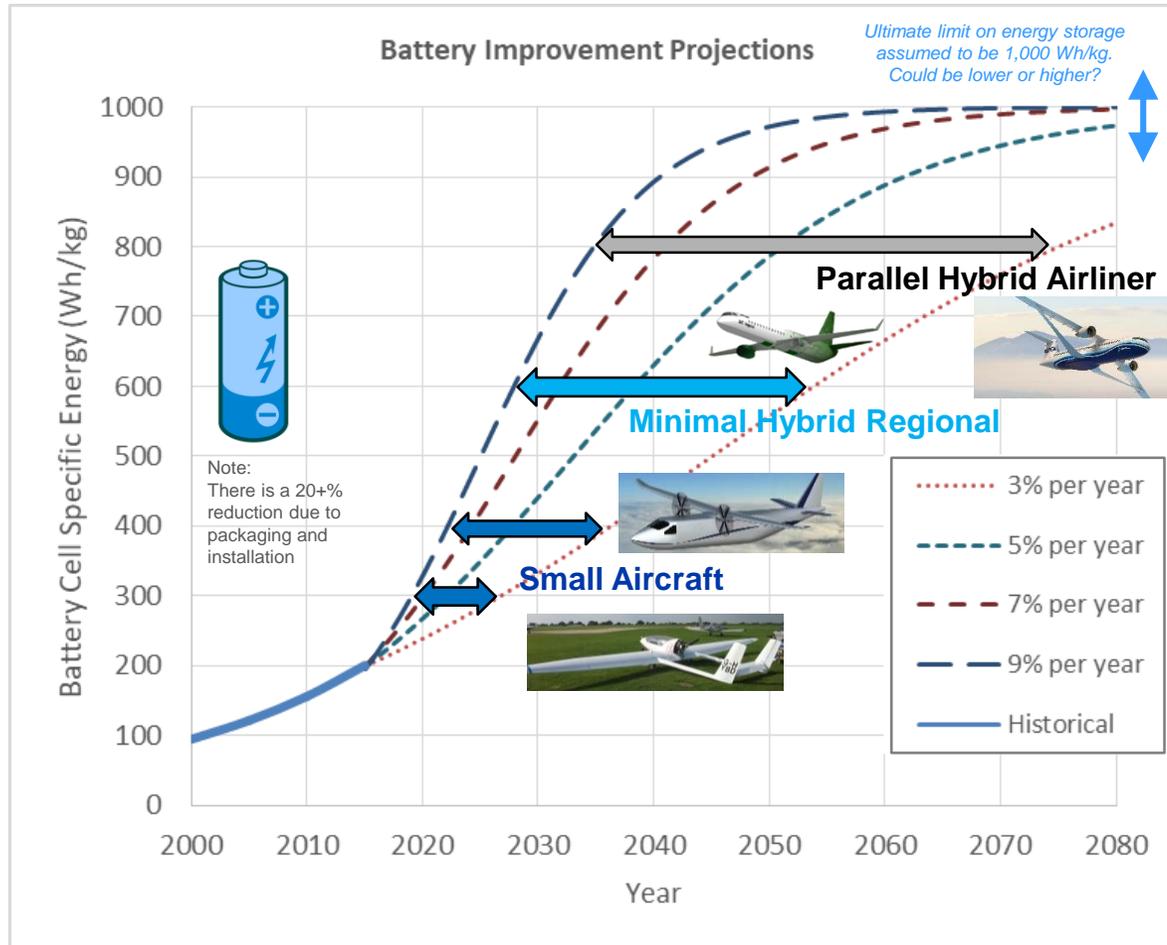
- **Environmental**
 - *Reduced Noise and Emissions*
- **Operational flexibility**
 - *Multiple Power Schedules*
(efficient, quiet, low emission modes)
- **Unique configurations**
 - *Distributed Propulsion*
 - *VTOL/STOL*
 - *BLI*
- **Reduced Cost Potential**
 - *Energy & Maintenance*



Challenges

- **Energy/Power Density**
 - *Limited mission capability*
- **Safety**
 - *High Voltage*
 - *Thermal management*
- **Ground Operations**
 - *Battery swap/charging*
- **Certification Process**
 - *New Technology*
 - *New Standards*

Application Driven by Pace of Technology Development



3%-9% Annual Growth to 1,000 Wh/kg

- Feasibility and EIS/IOC of useful airliner determined by energy storage capability
- Electric and Hybrid Electric (w/energy storage) yield environmental benefits only if sustainable energy used in charging grid
- Electric aircraft to date are an order of magnitude smaller and lower power than a regional size airliner

Current development trends result in near-term application for small aircraft and long-term application for parallel hybrid airliners

Summary



- Boeing understands both the opportunities and challenges of electric and hybrid aircraft
- Boeing has history and an ongoing and active program to study the technologies and possible future applications of electrified propulsion
- More to come for this promising technology area





■ Hubert Wong

- Hubert Wong leads the Sustainable Concepts projects within the Boeing Commercial Airplanes Advanced Concepts group. Hubert is responsible for directing studies investigating novel aircraft technologies and configuration concepts that can contribute to reducing aviation's environmental footprint. He has established electric/hybrid-electric propulsion design methodologies and tools for commercial aircraft at Boeing and has supported the development of low boom supersonic wind tunnel testing methods. Hubert also serves as Part-time faculty in the Aerospace and Mechanical Engineering department at the University of Southern California.



■ Kevin Lutke

- Kevin Lutke is the manager of the configuration synthesis and systems engineering teams in Boeing Commercial Airplanes Advanced Concepts. Kevin and his team focus on protecting Boeing's existing market and expanding into new markets through the application of new technologies to future air transportation systems. His notable projects in BR&T include: Air Launch Assist Space Access and Rapid Eye for DARPA, Revolutionary Configurations for Energy Efficiency and Joint Future Theater Lift for the Air Force Research Labs, and Environmentally Responsible Aviation for NASA. Kevin was also a member of the X-48B and X-48C flight test teams, supporting experimental test flights at Edwards Air Force Base. Kevin's efforts have been formally recognized by the company with the Boeing Silver Eagle Award, the Phantom Works Silver Phantom Award and the Phantom Works Outstanding Achievement Award. Additionally, he has been awarded 23 US patents and has received a meritorious invention award from Boeing.

