Commercial Airplanes

Fuel Cell APU
Overview

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Overview

• Boeing is looking for ways to cut emissions and fuel use

• Future fuel cells may fit well into our future aircraft

• Apparent benefits look attractive

• There are hurdles, but no show stoppers
Airplanes are already efficient, but further improvement is desired

![Graph showing fuel efficiency vs. load factor for various vehicles](DLD03-15.ppt)

- Large SUV in City (1)
- "Average" 1996 Vehicle (2)
- High-speed Train
- European Inter-city train
- Airplane Envelope (3)

1) US average is 1.6 people per vehicle
2) US commuter car is 1.2 per vehicle
3) 1,500 nmi mission

**Note:**

- DLD03-15.ppt
- DD99-15.xls
- BOEING
We are looking for ways to cut NOx emissions

Large Airplane NOx Emissions at Airport

APU

Engine
Jet fuel is required, so SOFC may be right
Continued weight and size reduction progress is needed
Fuel cells need to become cost competitive
SOFC APUs may replace turbine-powered APUs in commercial aircraft.
“More Electric” architecture is ideally suited for fuel cell APU
A large “more-electric” airplane’s load is large but relatively constant.
A hybrid SOFC APU concept is needed
Hybrid SOFC APU installation concept

Firewall

APU Tail Structure

Future 2015 Solid Oxide Fuel Cell

Fuel cell support hardware
Boeing Commercial Airplanes creates sustainable profitable growth with environmentally preferred products, processes, and services.
In-flight fuel saving opportunity

40-45% Efficient
(Jet-A to electrical during cruise)

≈75% Efficient
(Overall system at cruise)

40% less fuel used

Future 2015 SOFC APU

Jet-A
1 litre

Jet-A
0.6 litre
Fuel saving opportunity on the ground is very attractive

Typical Turbine-powered APU
15% Efficient (over average operating cycle)

Future 2015 SOFC APU
60% Efficient (at std. sea-level conditions)

= 1 litre

75% less fuel used

= 0.25 litre
Overall, FCAPU looks to be beneficial
Fuel cell stack power density needs to be at least 1kW/kg.
Summary

- Fuel cells may dramatically cut emissions and fuel use for aircraft
- Future MEA airplanes will be ideally suited for fuel cells
- Technology still needs to mature
- Good business case can be made
- We need to “work together” to make it happen