



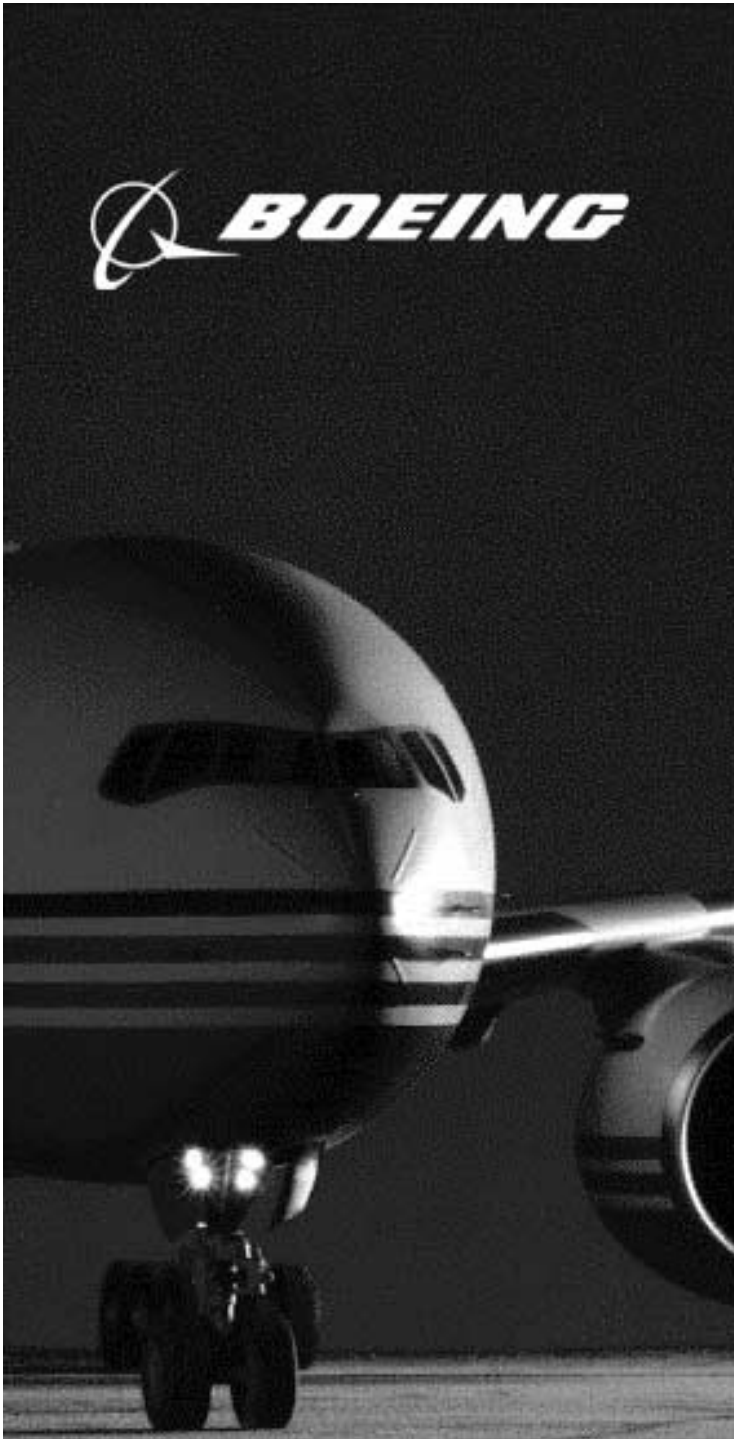
Commercial Airplanes

Fuel Cell APU Overview

Presented at:
**SECA Annual Meeting
(Seattle, WA)**

15 April, 2003

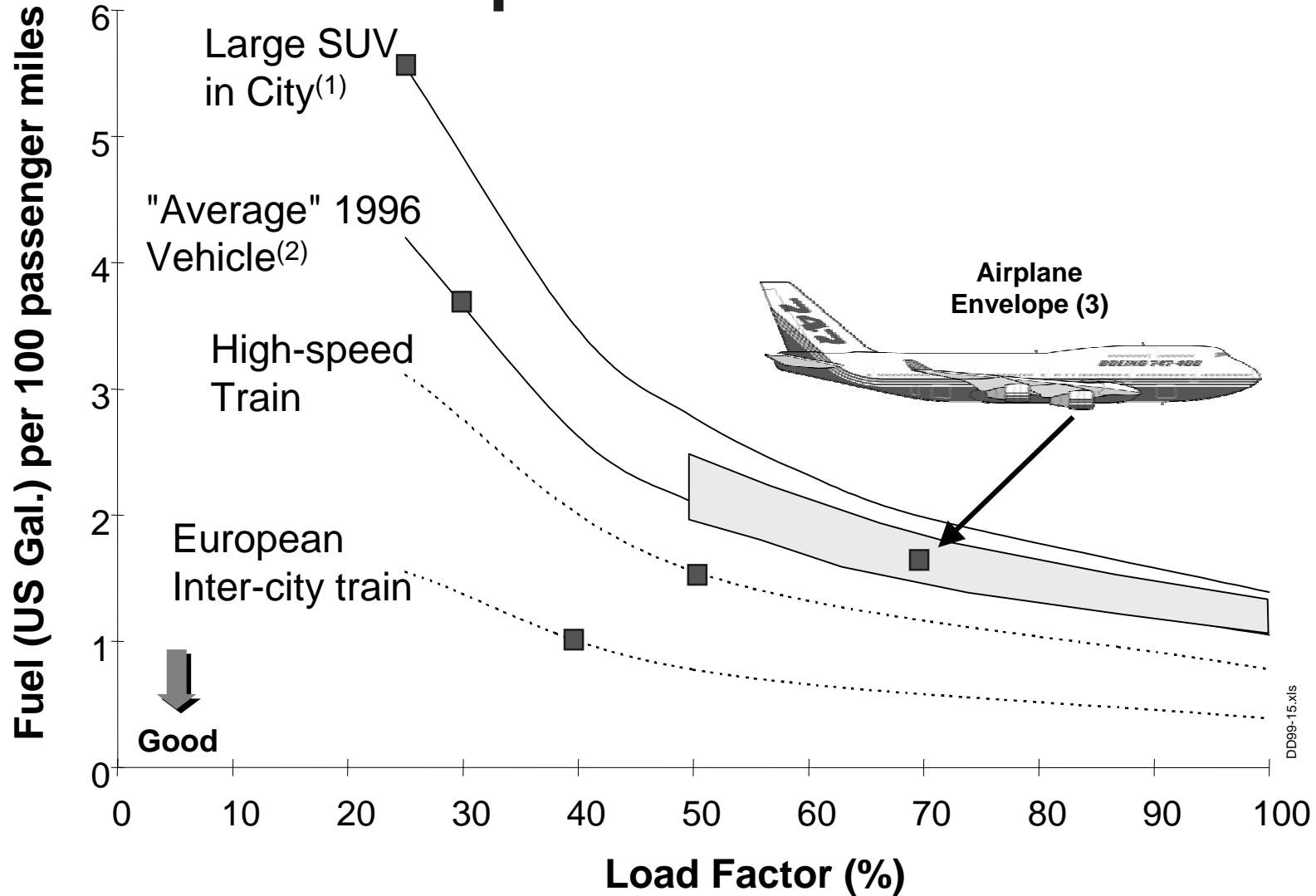
Dave Daggett
Product Development



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

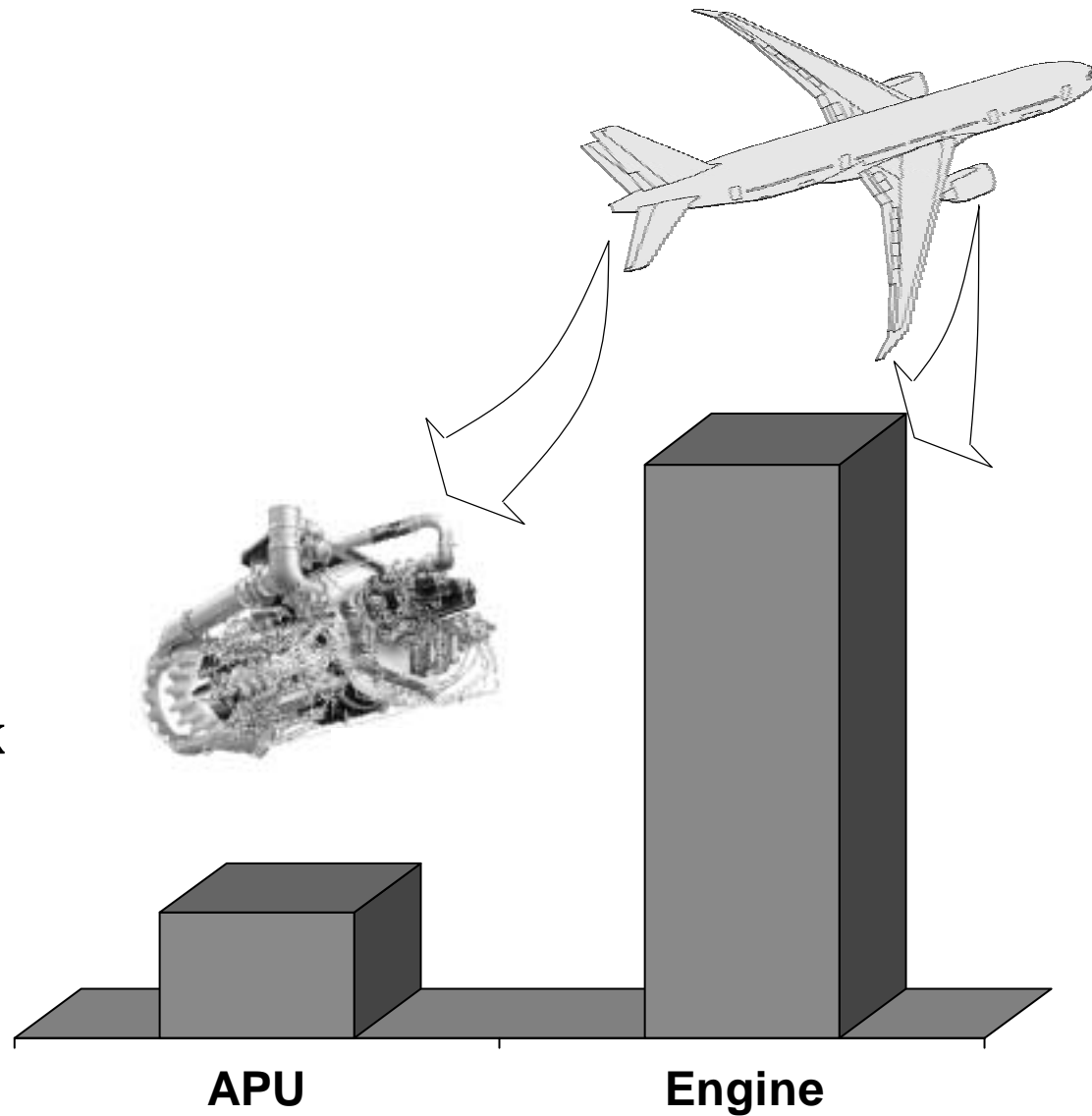


- 1) US average is 1.6 people per vehicle
- 2) US commuter car is 1.2 per vehicle
- 3) 1,500 nmi mission

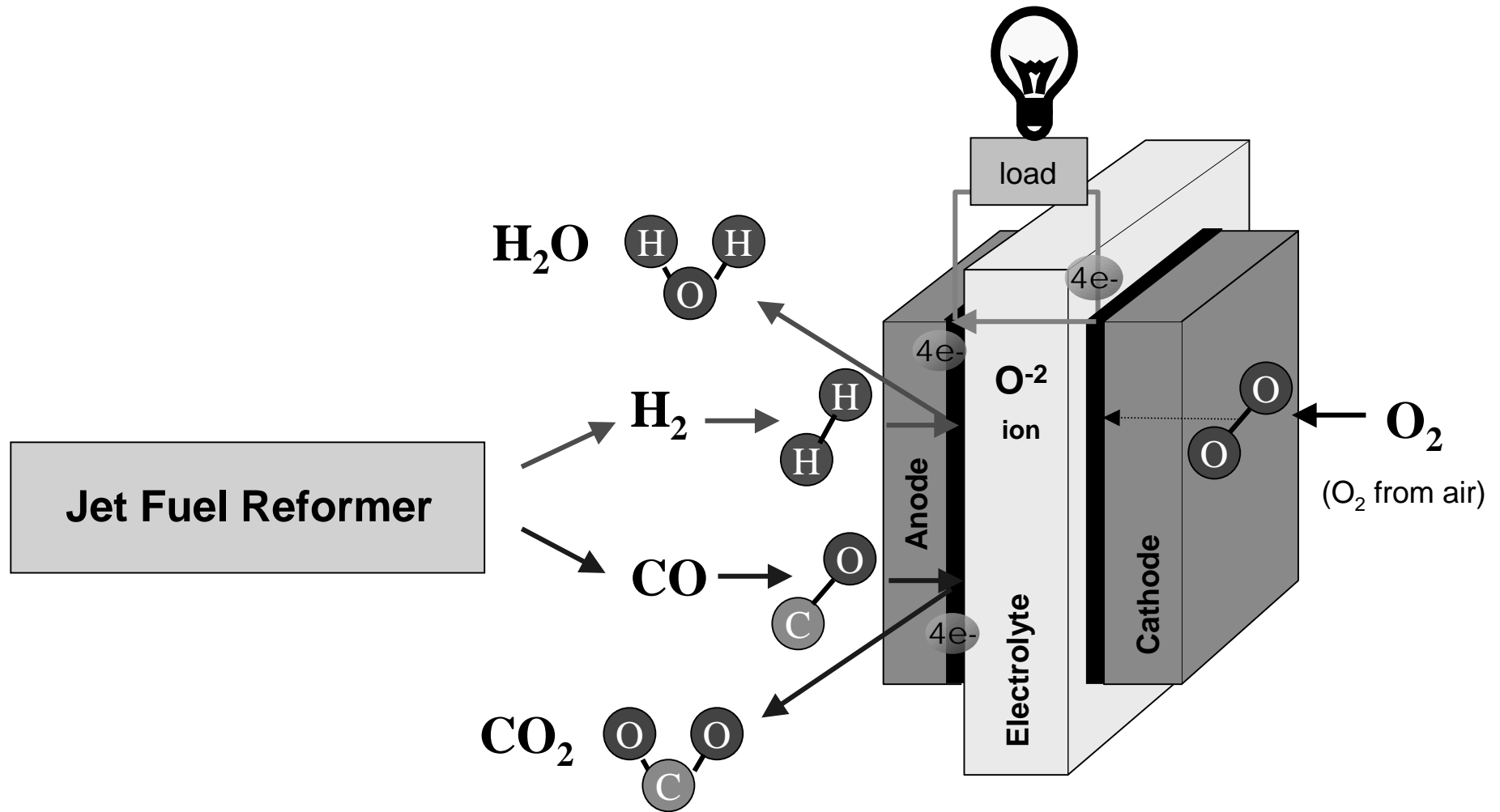
■ = Typical Load Factors

We are looking for ways to cut NOx emissions

**Large
Airplane NOx
Emissions at
Airport**

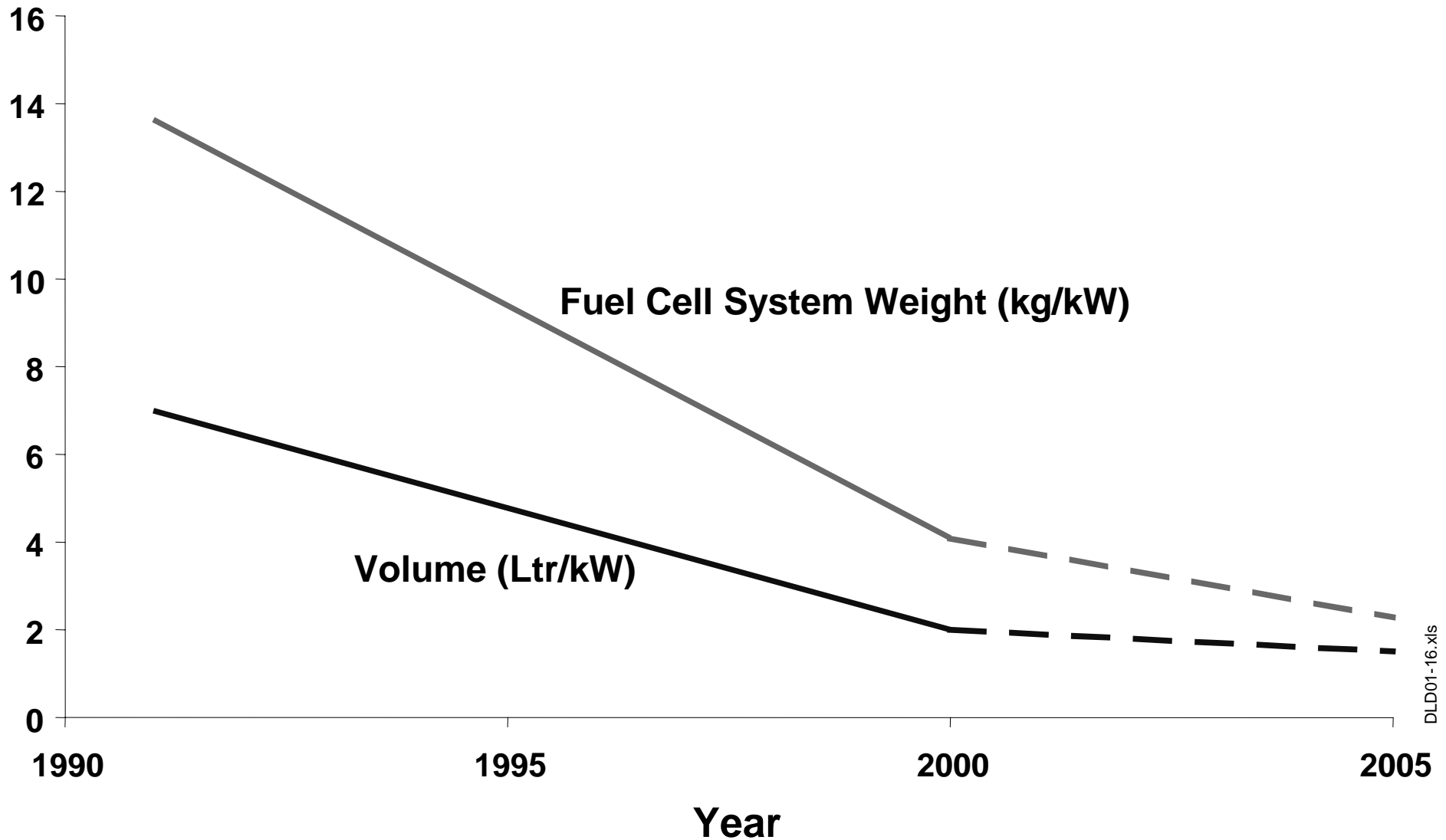


Jet fuel is required, so SOFC may be right



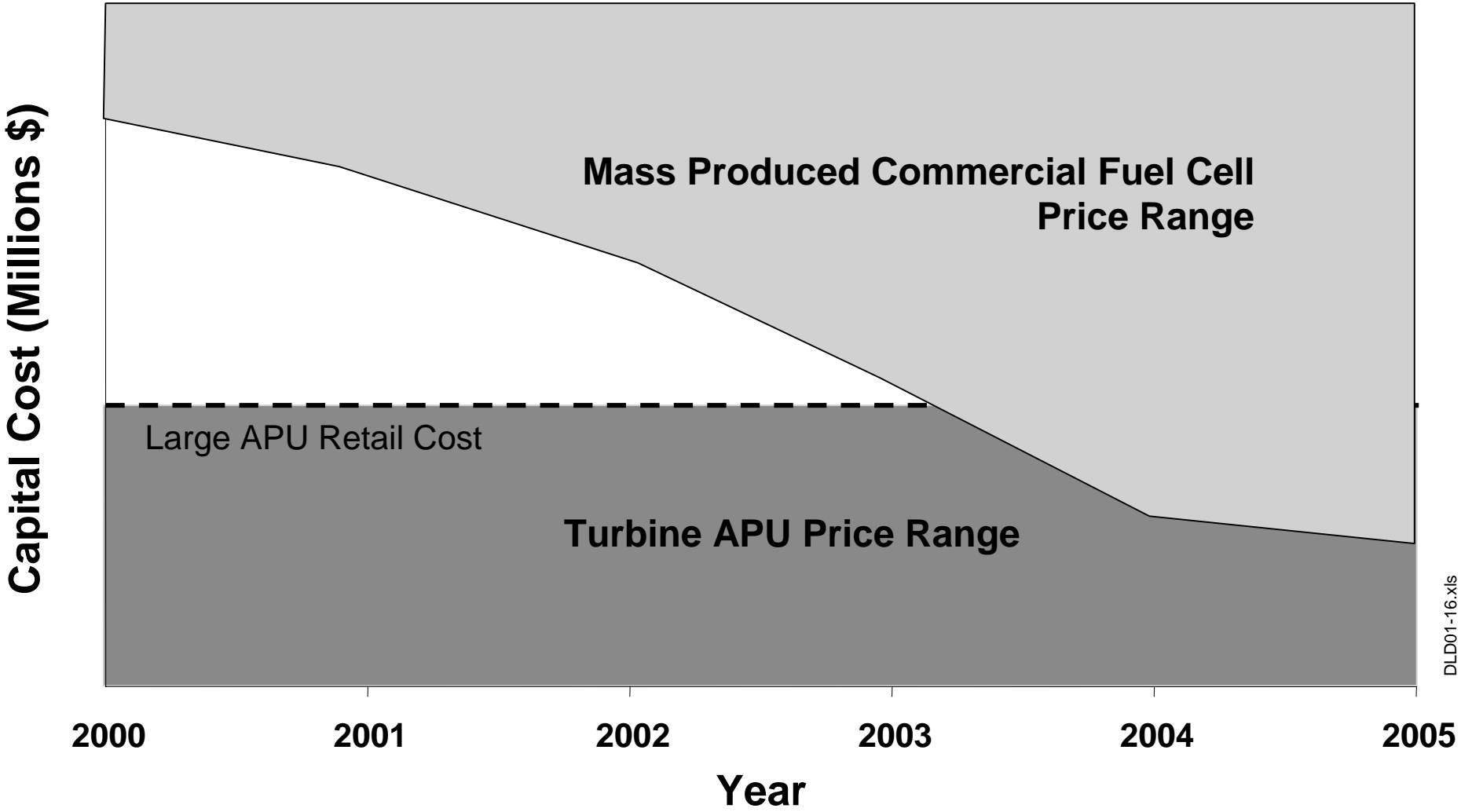
SOFC technology

Continued weight and size reduction progress is needed



DLD01-16.xls

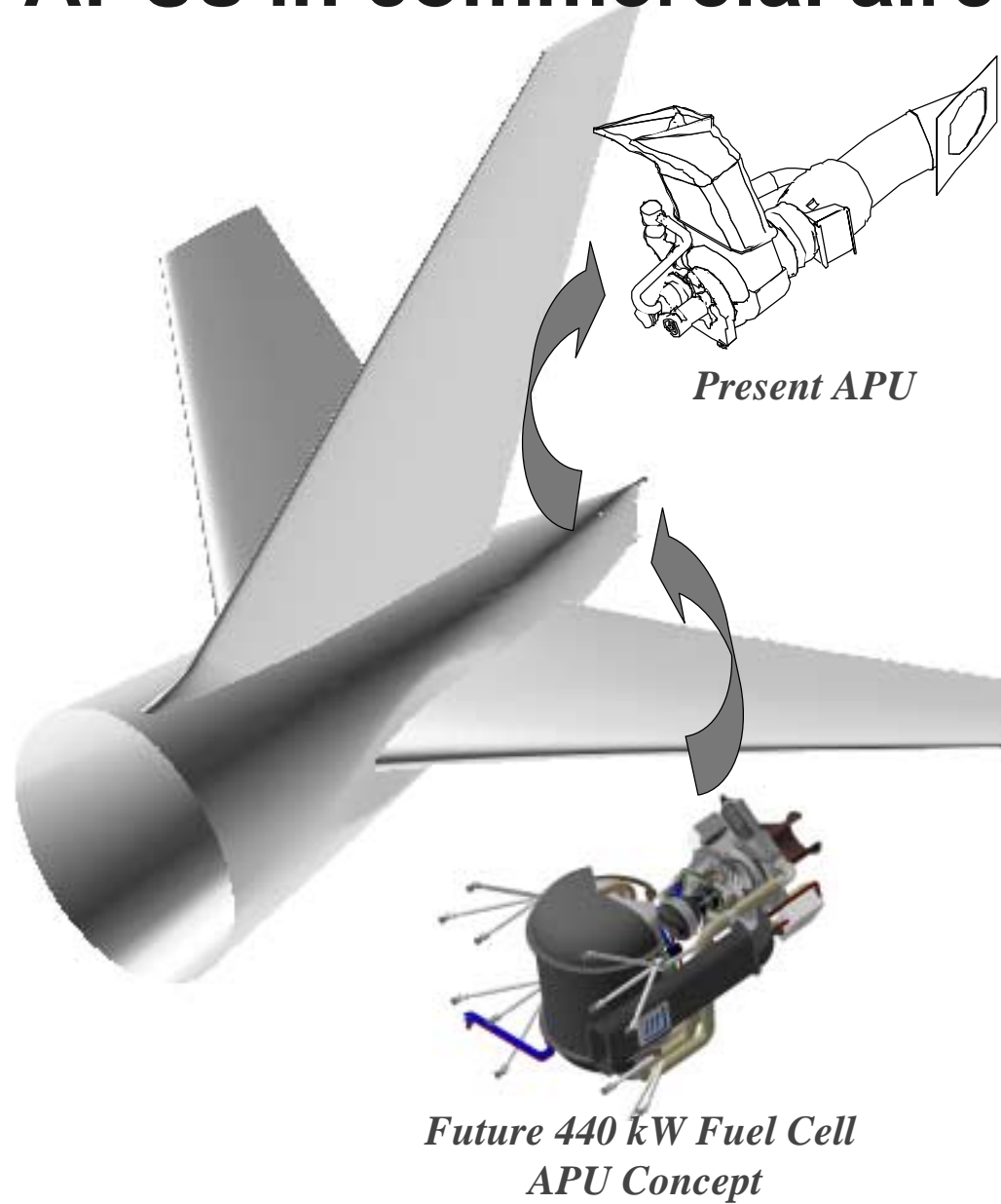
Fuel cells need to become cost competitive



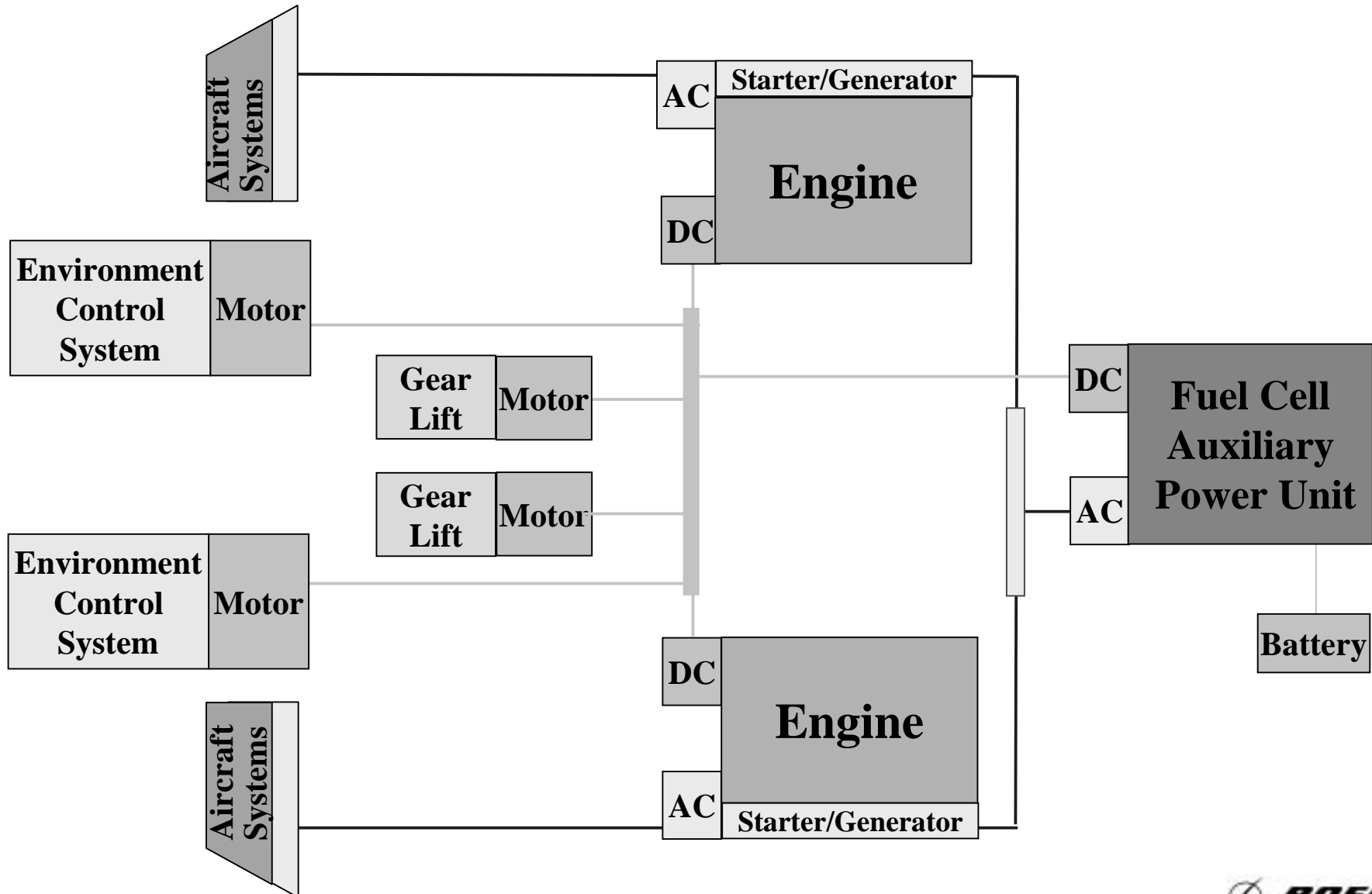
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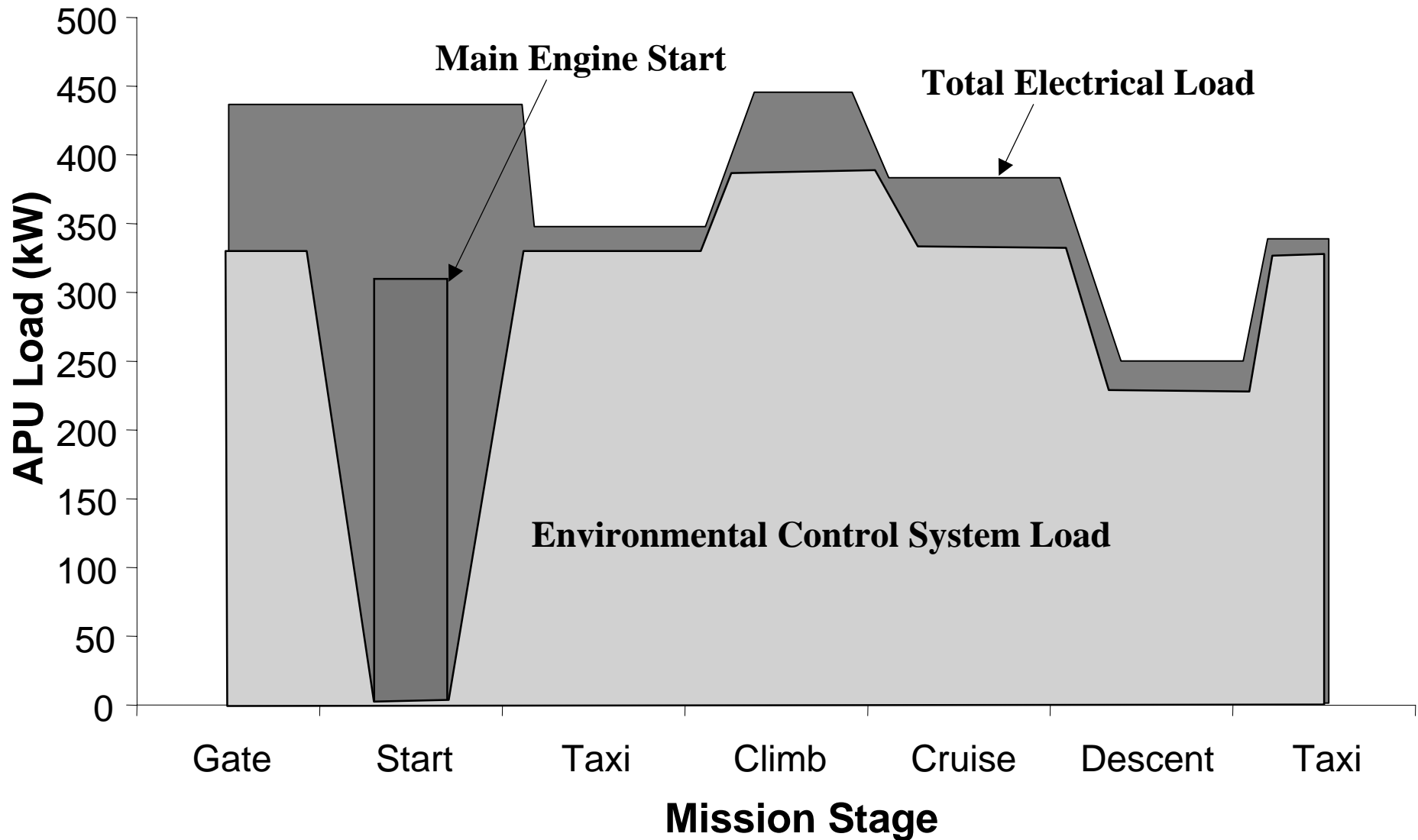
SOFC APUs may replace turbine-powered APUs in commercial aircraft



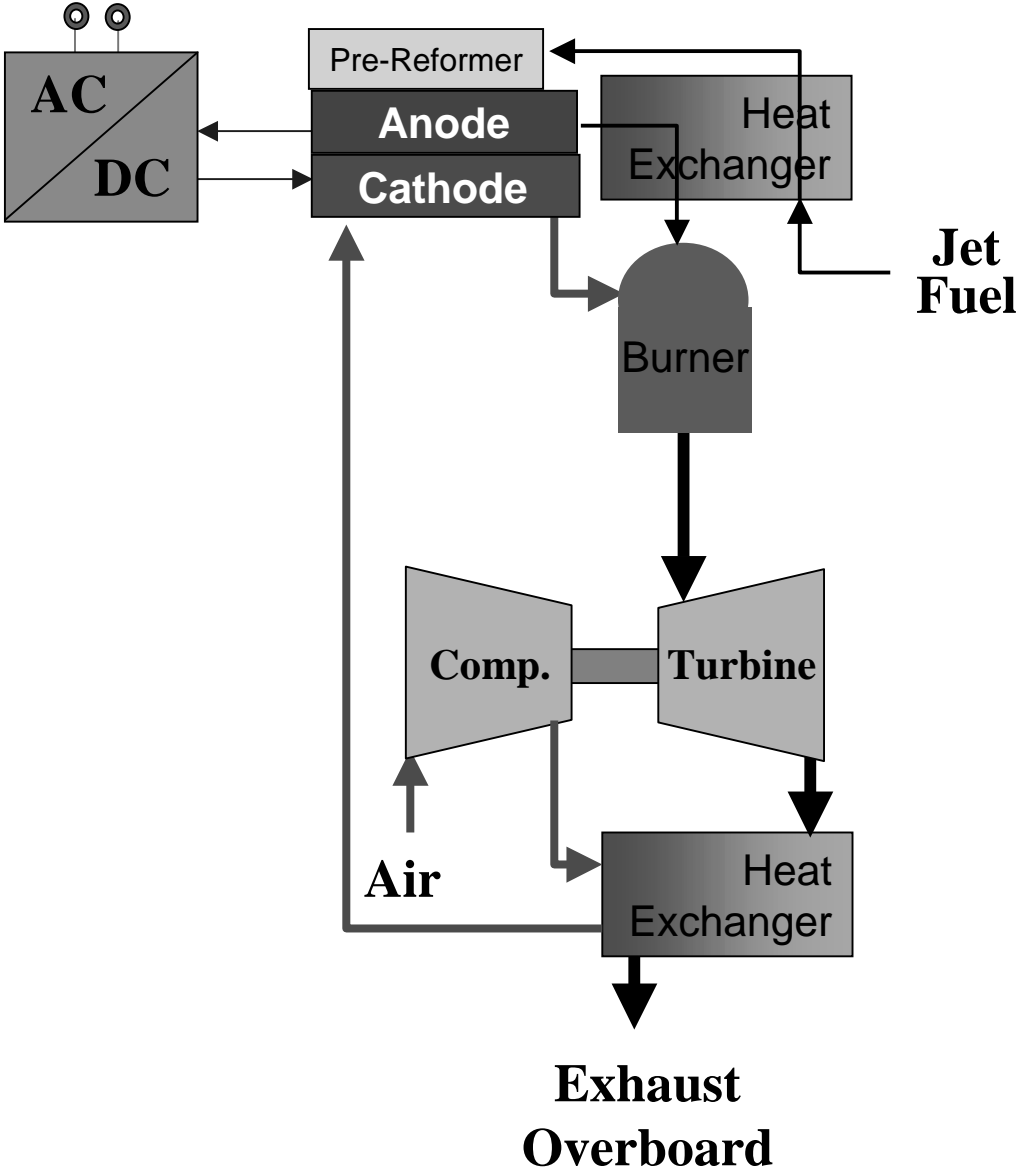
“More Electric” architecture is ideally suited for fuel cell APU



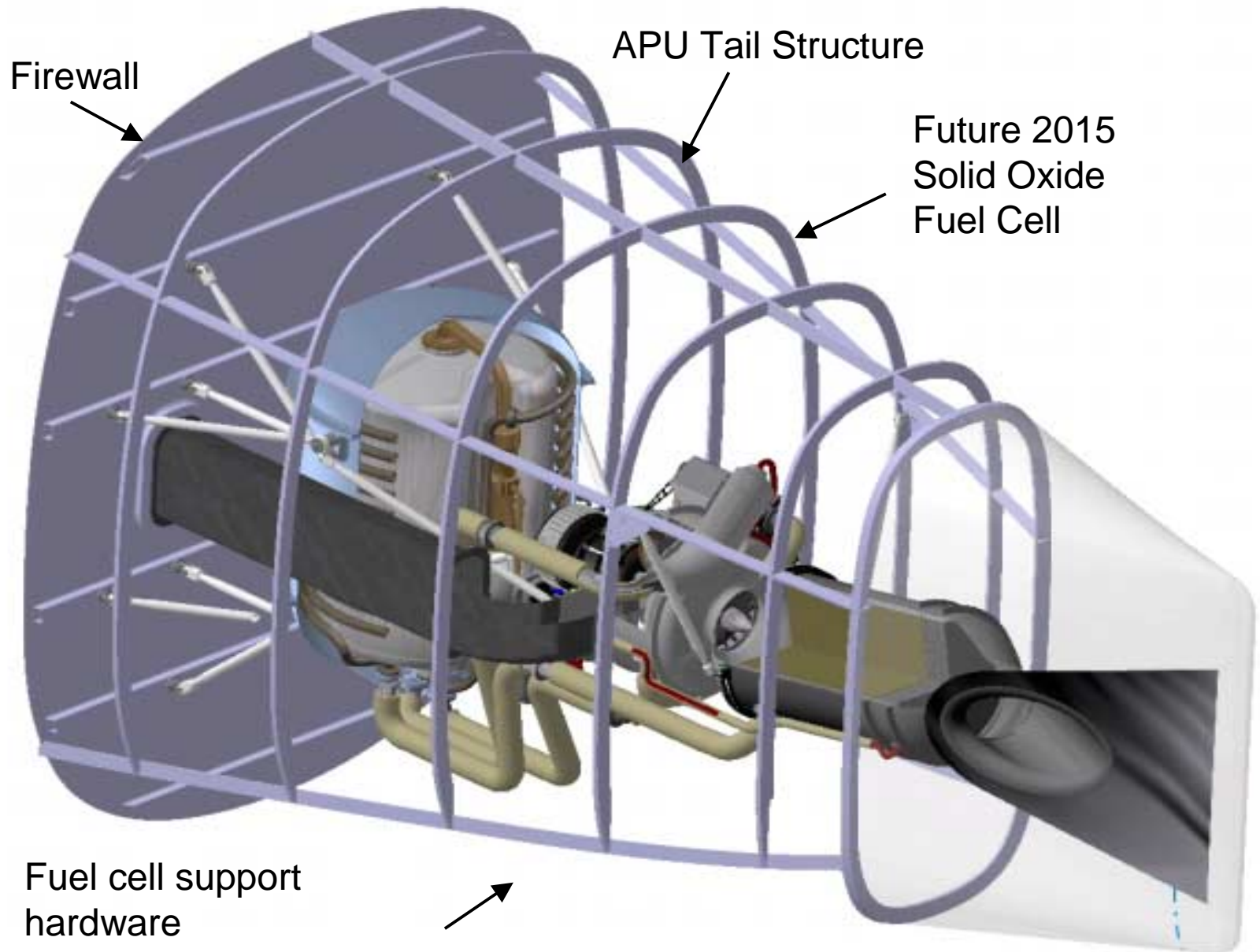
A large “more-electric” airplane’s load is large but relatively constant



A hybrid SOFC APU concept is needed



Hybrid SOFC APU installation concept

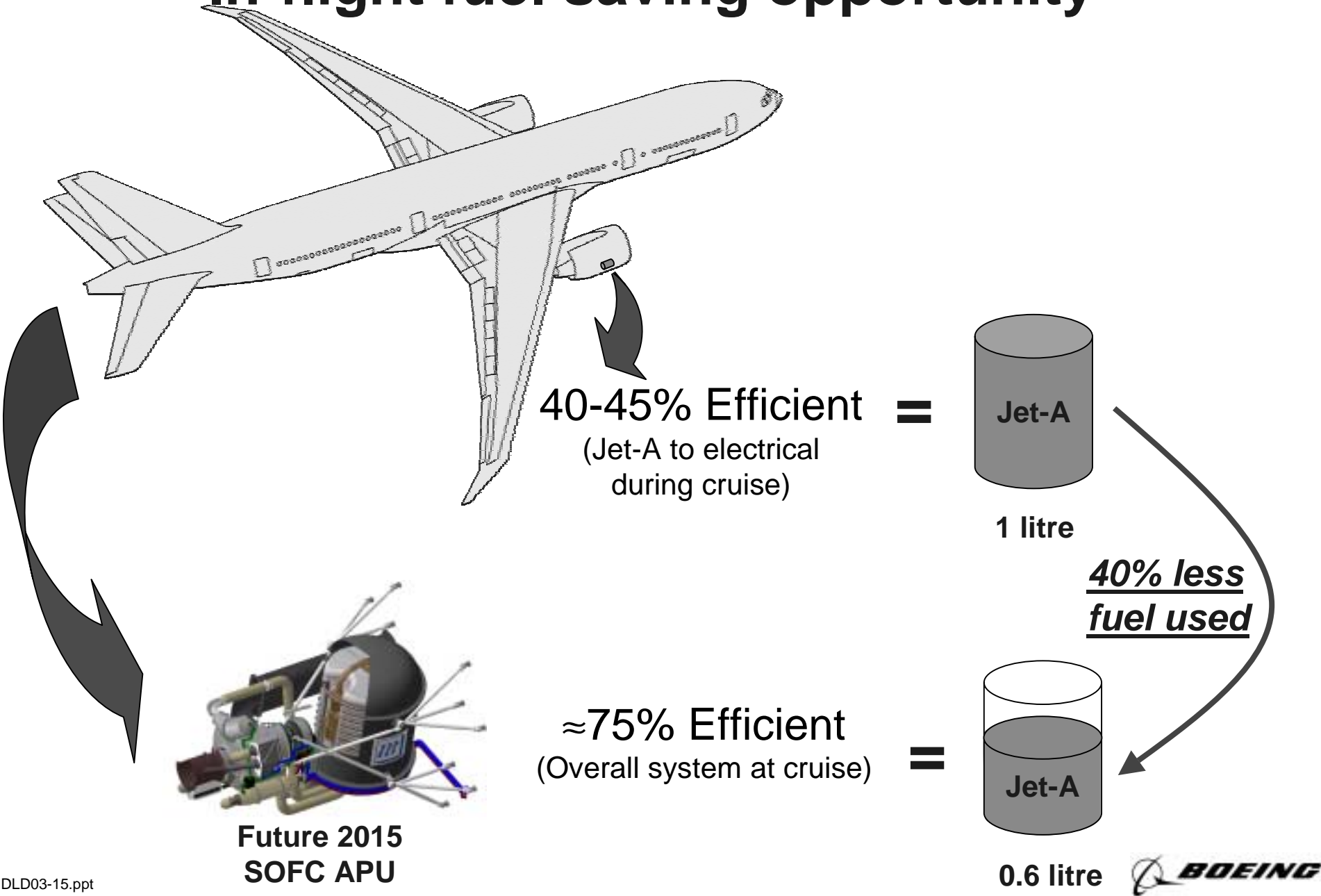


Animation of fuel cell APU

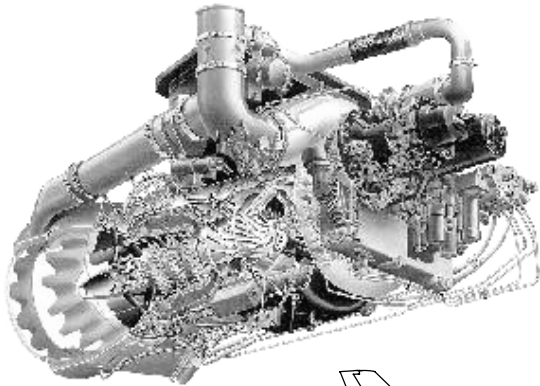


Boeing Commercial Airplanes creates sustainable profitable growth with environmentally preferred products, processes, and services.

In-flight fuel saving opportunity



Fuel saving opportunity on the ground is very attractive



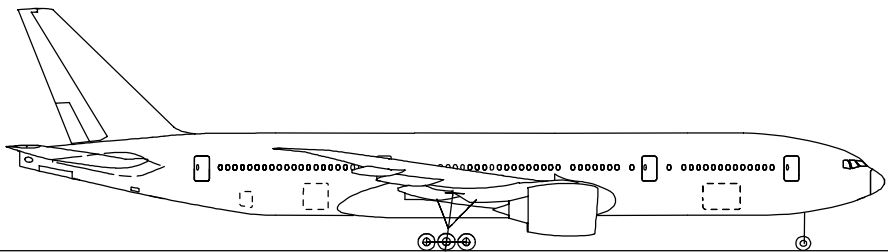
Typical Turbine-powered APU
15% Efficient
(over average operating cycle)

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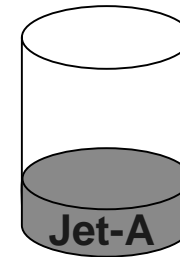


1 litre

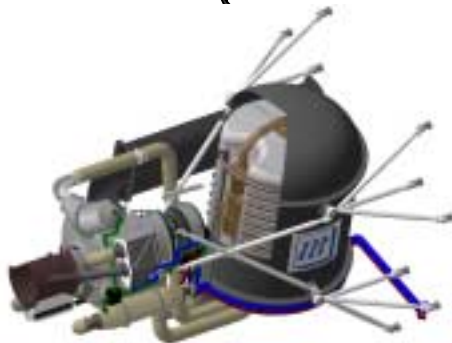
75% less fuel used



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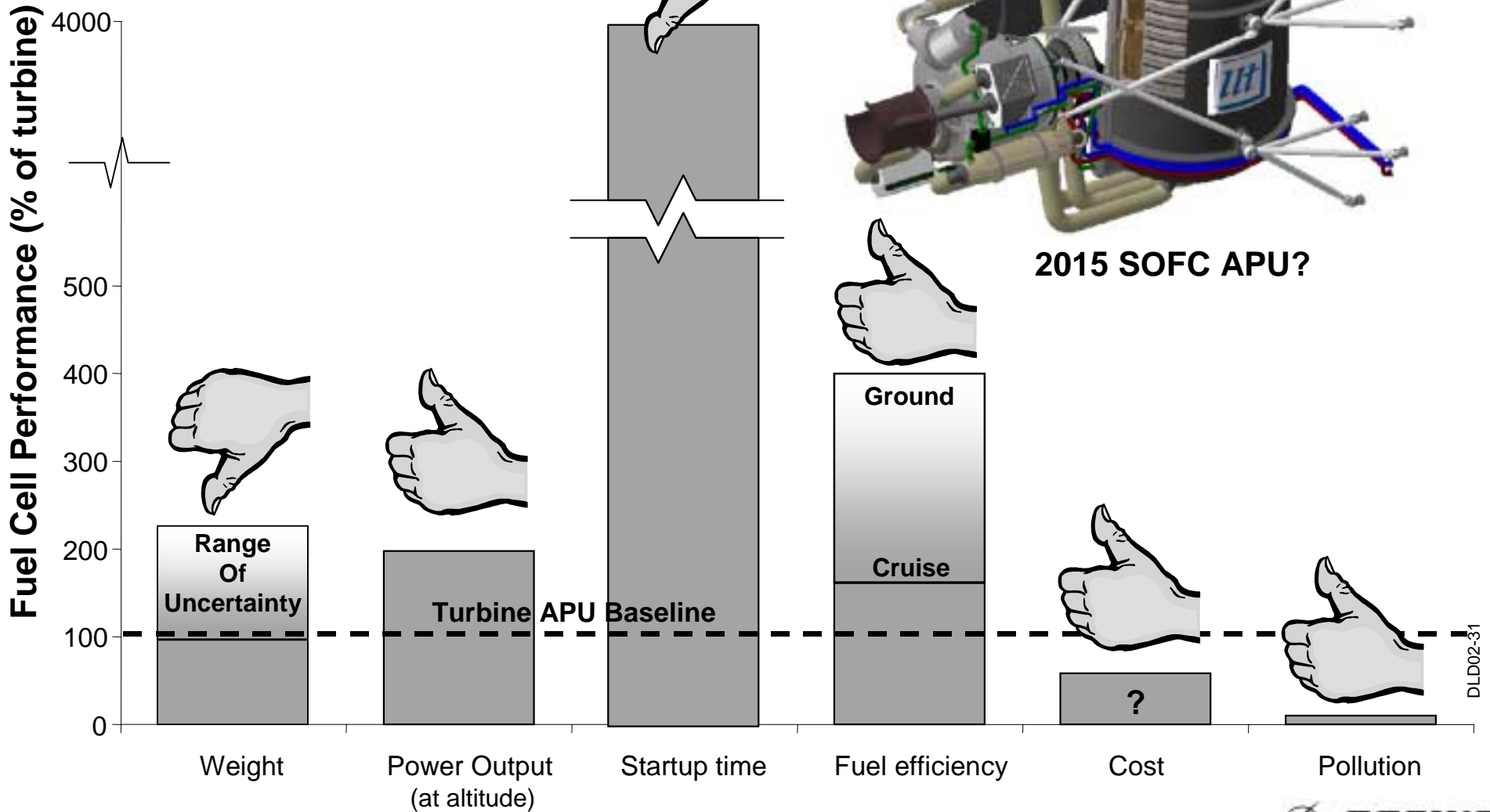


0.25 litre

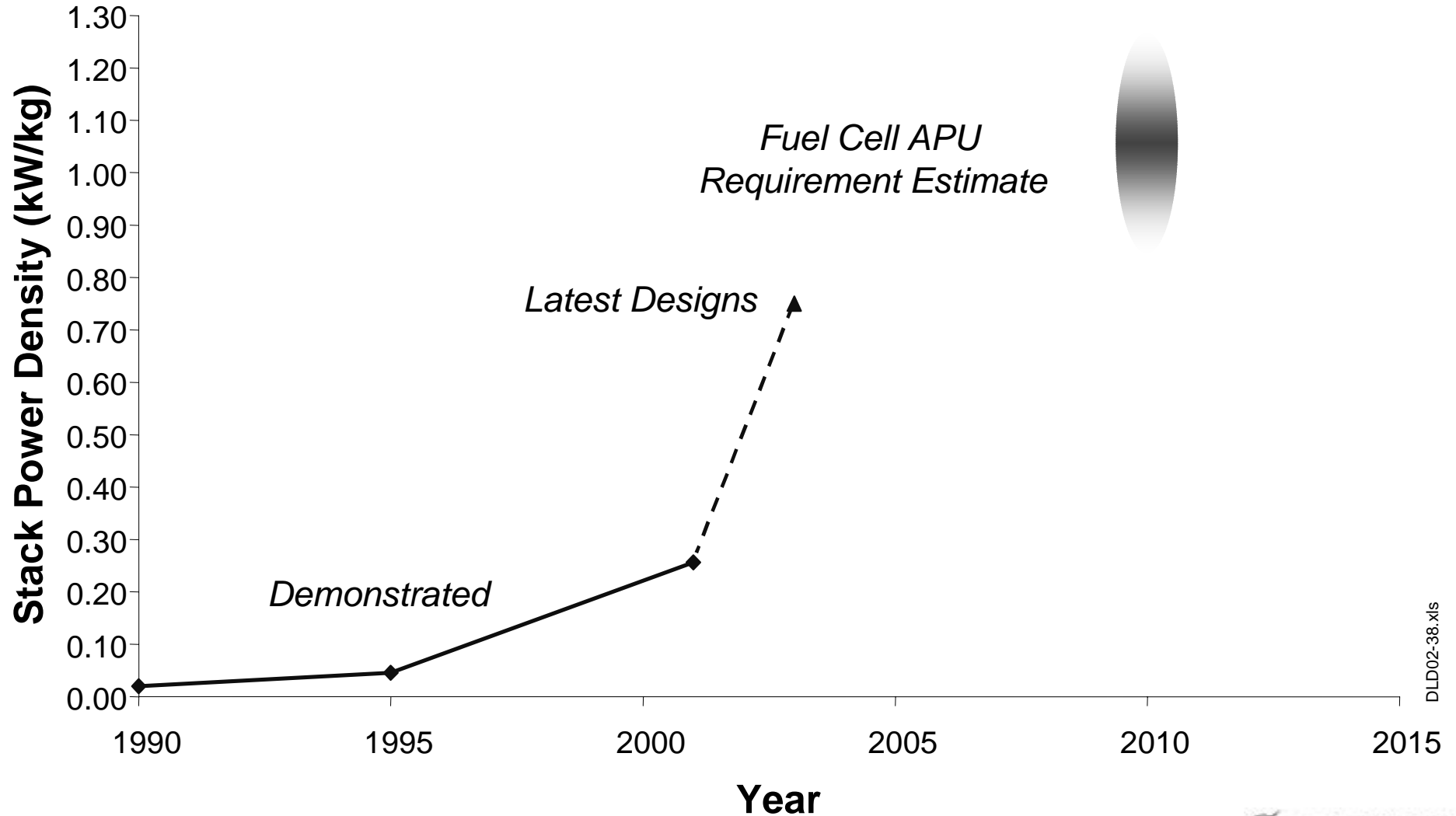


Future 2015 SOFC APU
60% Efficient
(at std. sea-level conditions)

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**