

Fuel Cell Ground Power System as Technology Maturation Opportunity for Airborne Applications

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Introductions

Boeing

- System engineering
- Electrical power systems
- Thermal management
- Control systems
- Large scale system integration

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Nu Element, Inc.

- Fuel Reformation
- Desulphurization
- Fuel Cell Integration
- Battery Charging
- Modeling & Simulation

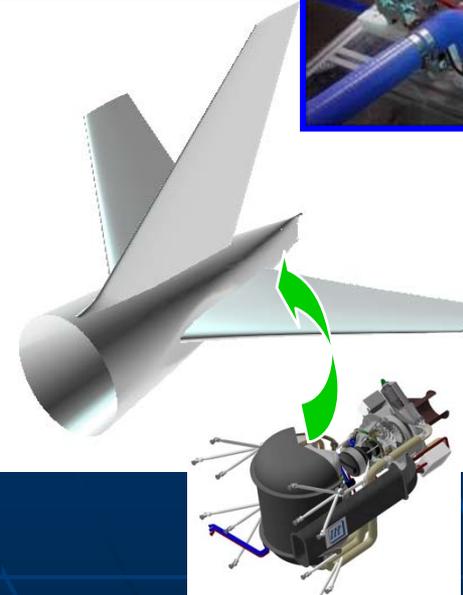
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Potential fuel cell applications for aircraft



- Utility power source
- Regenerable battery
- Peak load alleviator
- Emergency power unit
- Auxiliary power unit
- Special purpose power
- Propulsion power



Current & evolving ground applications for fuel cells



Ground system applications can mitigate aircraft integration challenges

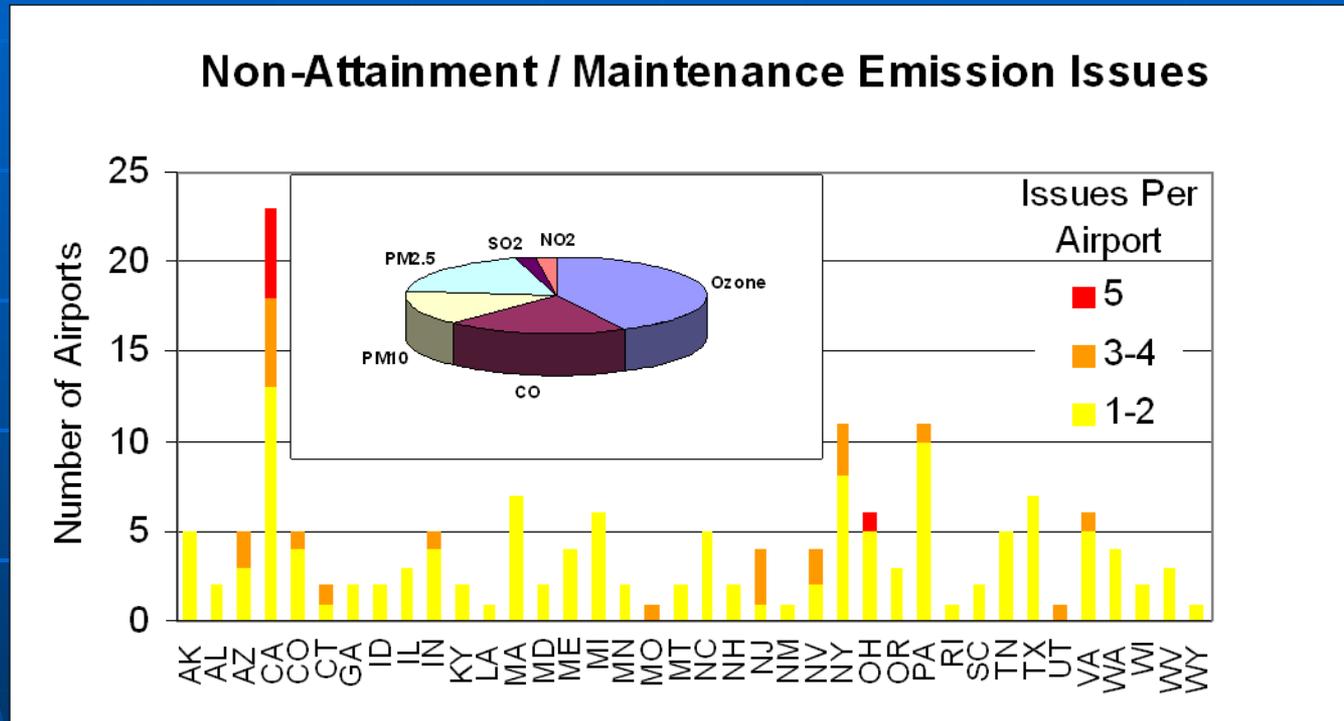
- ⇨ ■ Altitude
- ⇨ ■ Vibration
- ➡ ■ Shock
- ➡ ■ Sand/dust/moisture
- ➡ ■ Thermal interface
- ➡ ■ Operation timing
- ➡ ■ Logistic fuel
- ➡ ■ Performance
- ➡ ■ Safety
- ⇨ ■ Volume
- ⇨ ■ Weight
- ➡ ■ Reliability
- ➡ ■ Maintainability
- ➡ ■ Affordability
- ⇨ ■ Qualification
- Certification

Air / ground synergy:

➡ = High

⇨ = Moderate

Many airports are in emissions non-compliance or maintenance zones

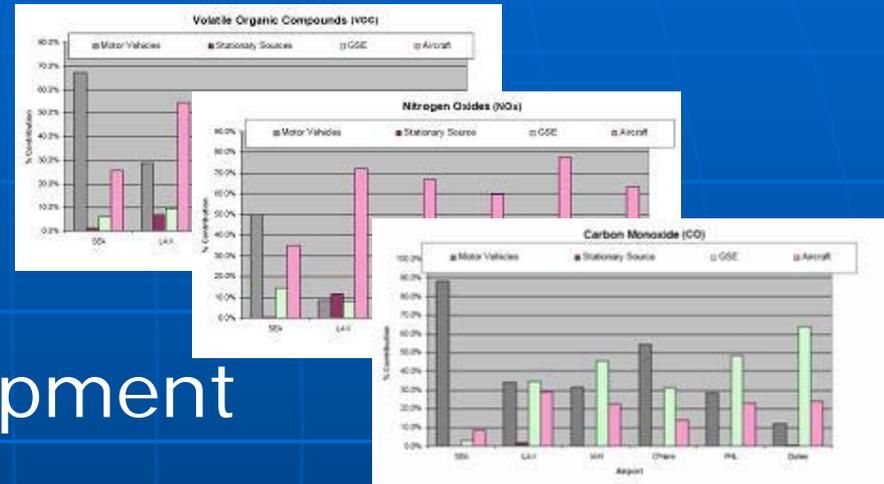


FAA Office of airports Planning & Environmental Division & EPA (Dec '06)

- Local & national regulations are applicable
- Airport revisions require emissions management

Multiple sources contribute to airport emissions inventory

- Local transportation
- Facility
- Fuel tanks
- Airplanes
- Ground support equipment
- ...



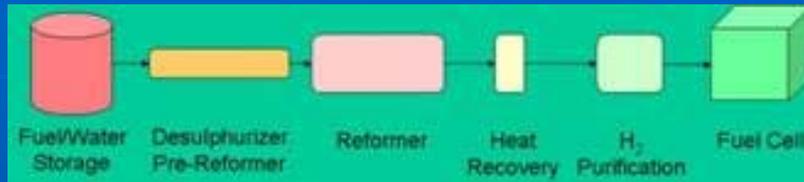
- LAX Master Plan requires zero or reduced emission GSE
- Similar strategies are in place or evolving at other airports

Fuel cell energy solutions significantly reduce emissions

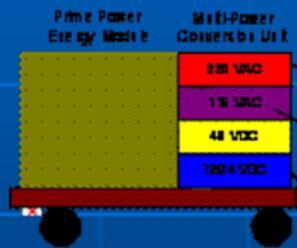
- Greater system efficiency
- Lower CO₂
- No NO_x
- No SO₂
- No particulate matter



Fuel cell energy sources can facilitate "green" Ground Support Equipment



Common fuel cell energy module



Mobile battery charging for electric GSE



Fuel cell ground power unit for aircraft

Mobile Battery Charger

Near Term - Stored Hydrogen



Hydrogen Tank



PEM Fuel Cell



Rapid Charger



- Quiet, low emission operation
- Near-term availability using off-the-shelf equipment & technology spiral for upgrades
- Allows rapid implementation of electric GSE
- Multi-voltage / multi-battery-type compatible
- Provides point-of-use flexibility

Avoids cost of single-use dedicated battery charging infrastructure

Automated methodology is available for characterizing GSE operation



- Characterize duty cycle & power level
- Self-powered sensors / wireless link
- Automated data archive / distribution

Provides objective & cost-effective basis for emissions characterization

Proposed Effort #1

- Mobile rapid battery charging demonstration for expedited use of electric ground support equipment
- 1 - 3 airports / 12 month duration
- Utilize off-the-shelf elements with potential to accommodate multiple vendor technologies
- Hydrogen / PEM fuel cell / rapid battery charger
- Evaluate mobile versus fixed-location charging
- Identify preferred layout for charging systems

Proposed Effort #2

- Automated documentation of ground support equipment operation
- 1 - 3 airports / 12 month duration
- Multiple GSE types - functionality & engine type
- Self-powered sensors & wireless mesh network
- Remotely-accessible database repository
- Compare demonstration technique with current approach for characterizing equipment operation

Questions?