The Next Generation in Portable Power

IEEE

February, 2004

Protonex®

- *What are Fuel Cells?*
- What are they good for?
- What are the challenges?
- What does Protonex do?

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Fuel Cell Technologies

- *Proton Exchange Membrane (PEM)*
- *Direct Methanol Fuel Cell (DMFC)*
- Solid Oxide Fuel Cell (SOFC)
- Alkaline Fuel Cells (AFC)
- Molten Carbonate Fuel Cells (MCFC)
- Phosphoric Acid Fuel Cells (PAFC)

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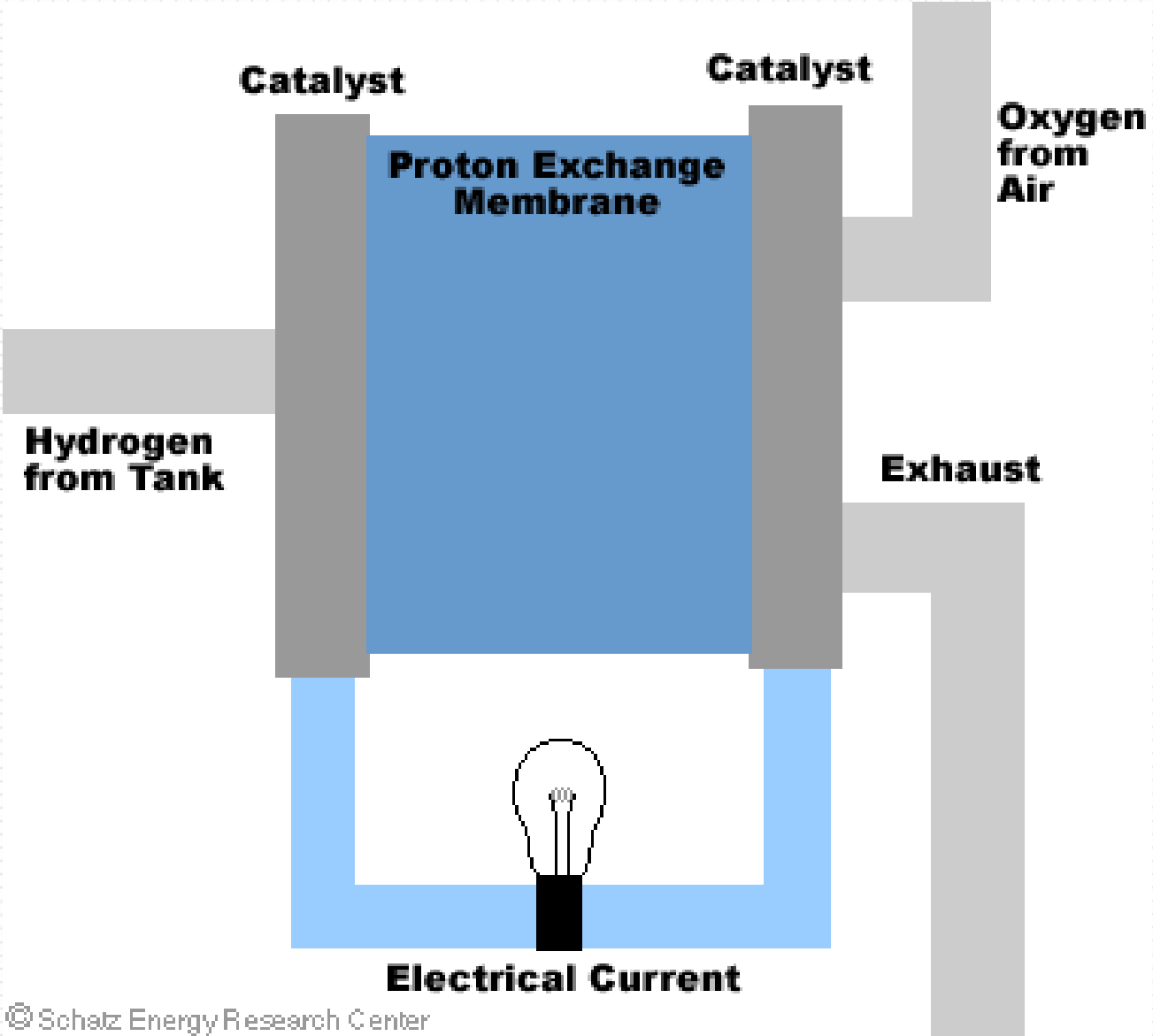
Fuel Cell Animation



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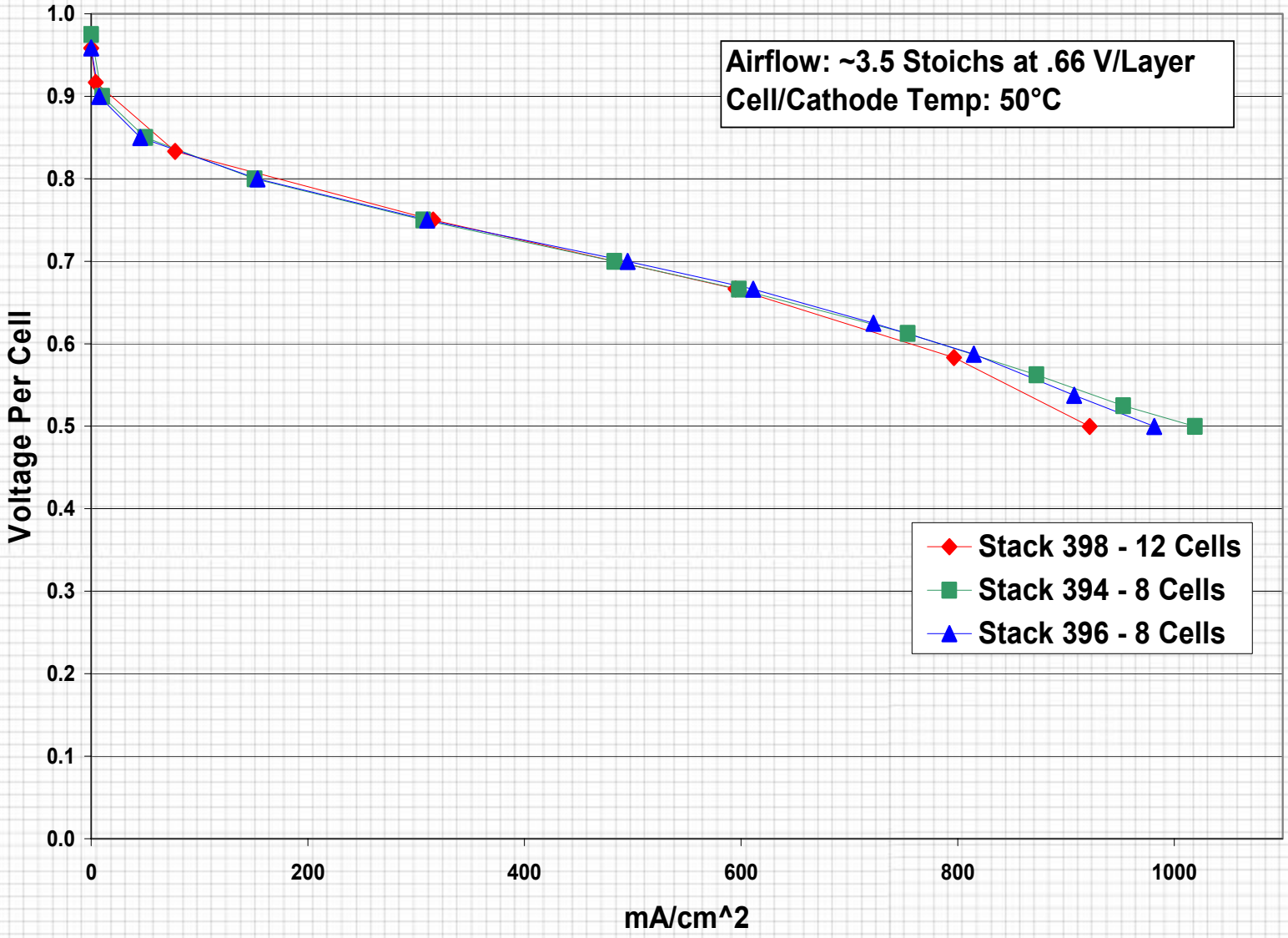
Typical Stack Performance



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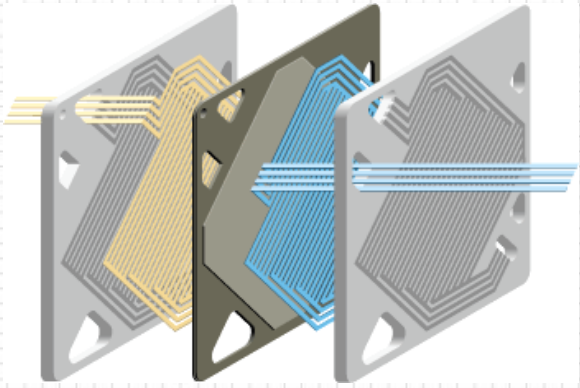
Typical PEM Stack



- More layers increases voltage
- More area increases current

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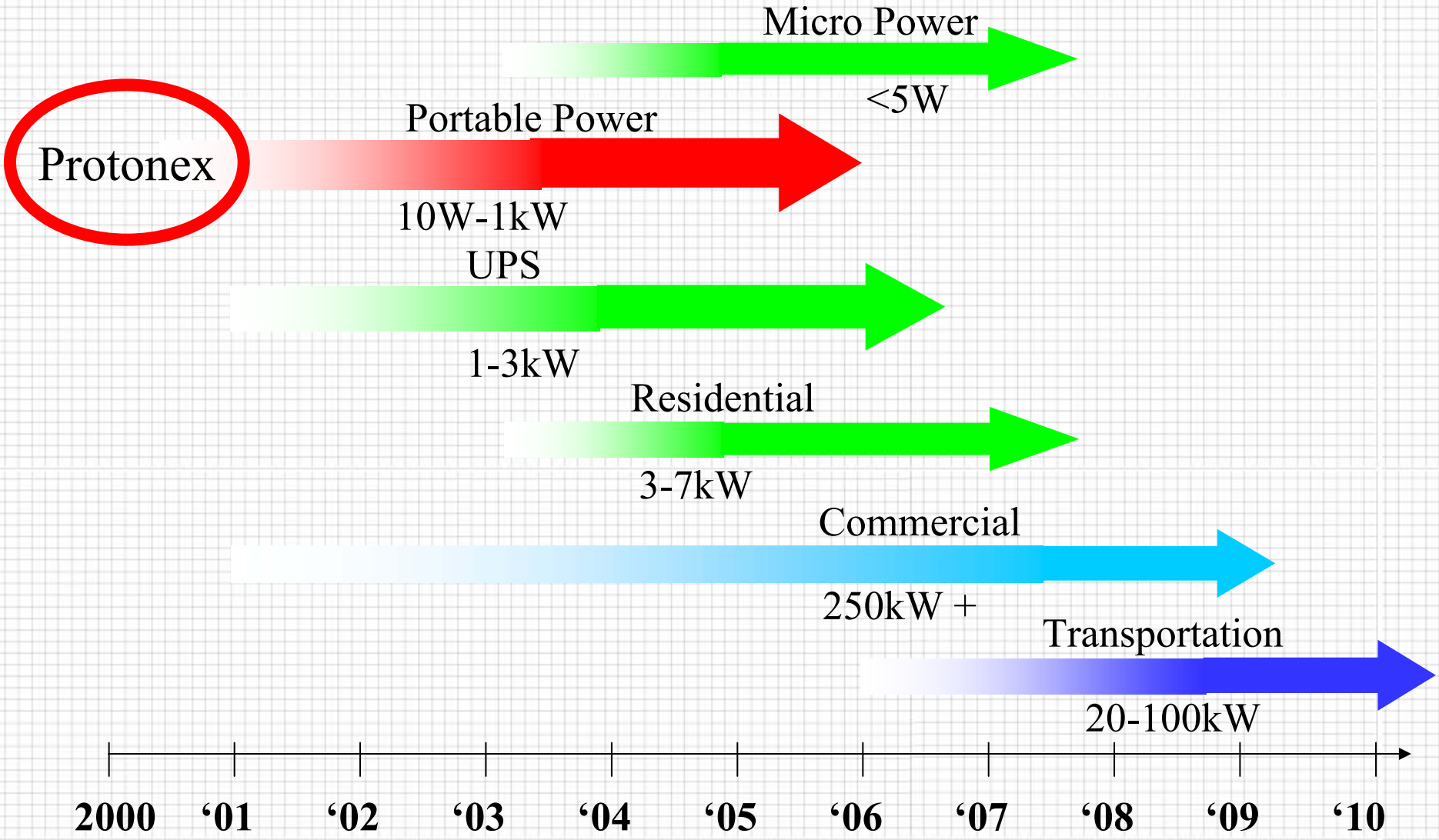
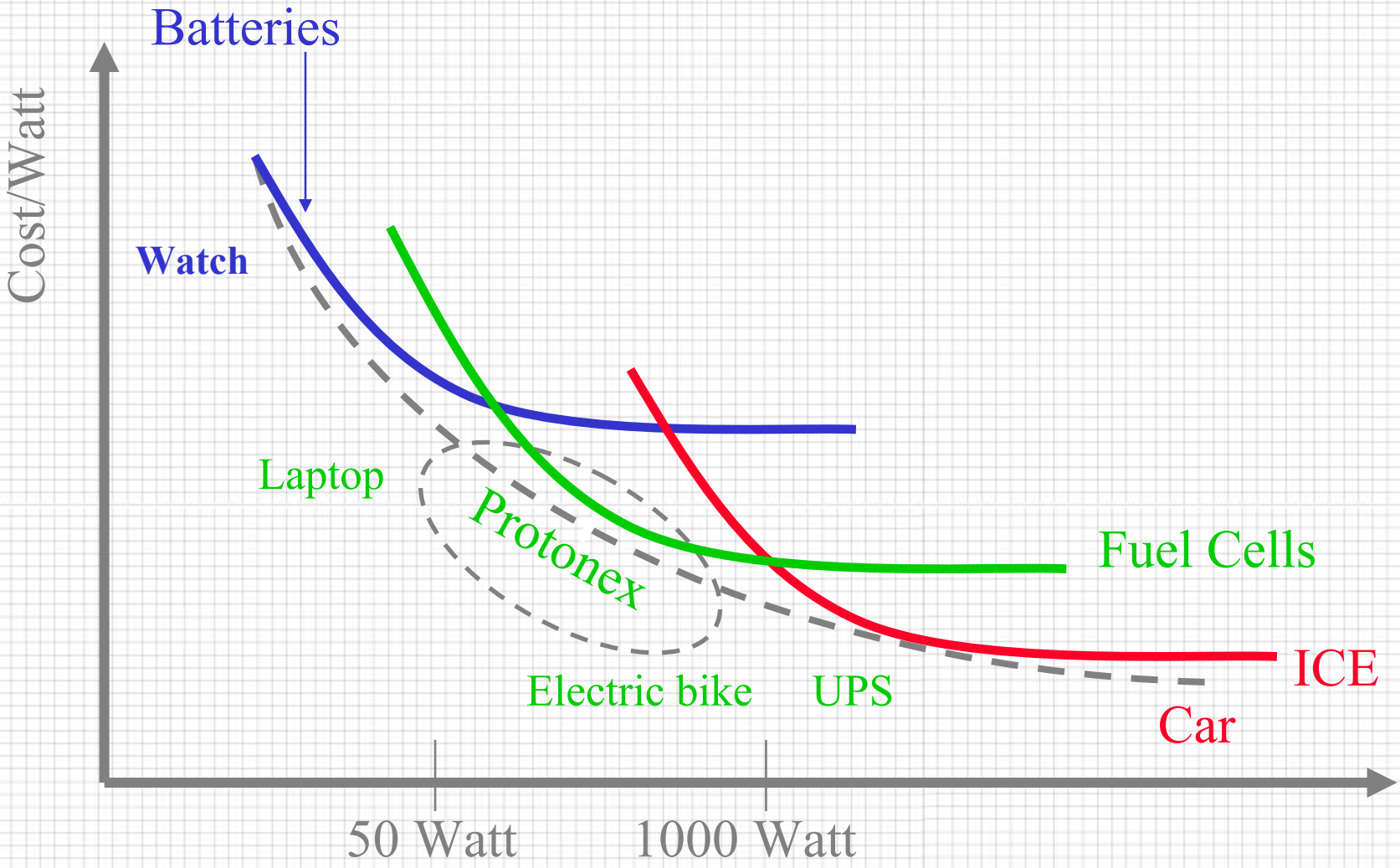
Fuel Cell Markets



Power Range Opportunity



Early Market Focus

- Military (soldier power)
- Mobile Robots
- Portable Industrial / Medical
- Environmental Monitoring
- Remote Telemetry
- Traffic Systems
- Security

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Fuel Cell Industry

NO ONE currently has product!

- Government or other large sponsor patronage
- Prototype sales
- Heavy development spending

Why?

- Wrong initial market focus (residential, automotive)
- Over focused on technology rather than product
- Only address part of the solution
- COST

Fuel Cell Dilemma

- Industry caught in paradox
  - 'Fuel Cells will be affordable when produced in volume
  - Fuel Cells will be produced in volume when they are affordable'

Historical Fuel Cell Challenges

- Fuel source (storage, distribution)
- Cost
  - Materials (historical focus)
  - Manufacturing (Protonex focus)

Multiple Fuel Choices

- Hydrogen PEM
  - Compressed gas
  - Metal hydrides
  - Chemical hydrides
  - Reformers
    - Methanol
    - Diesel
    - Propane
    - Gasoline
- Direct methanol

Fueling Choice is Application-Dependent

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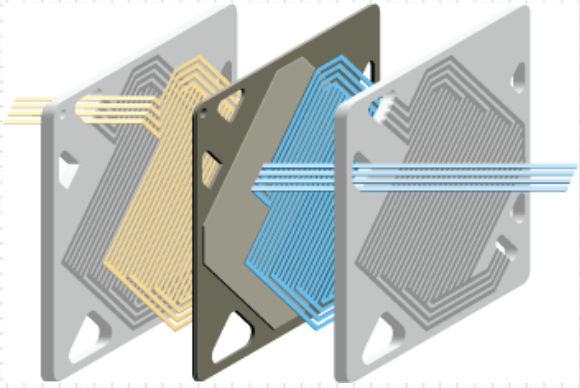
Typical PEM Stack



- Many components
- Critical compression seals
- Sensitive to:
  - Compression
  - Impact
  - Particles
- High skill assembly
- High precision parts
- Low mfg. yield
- High cost

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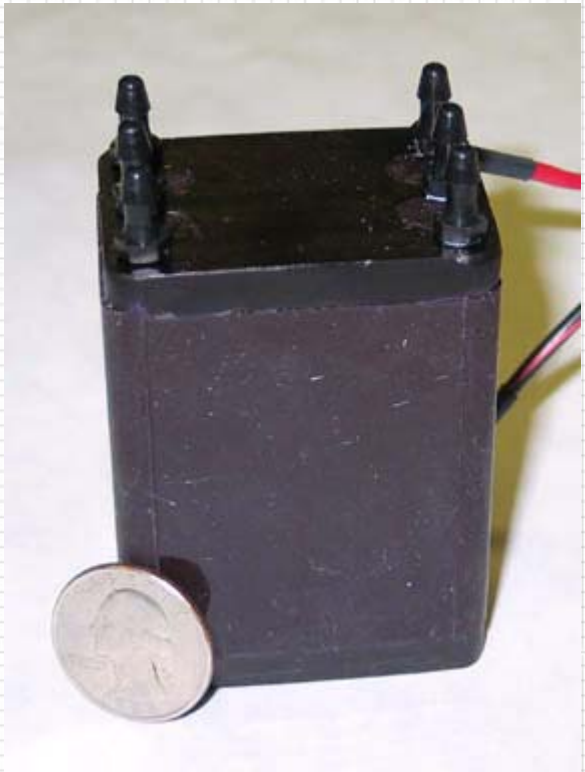
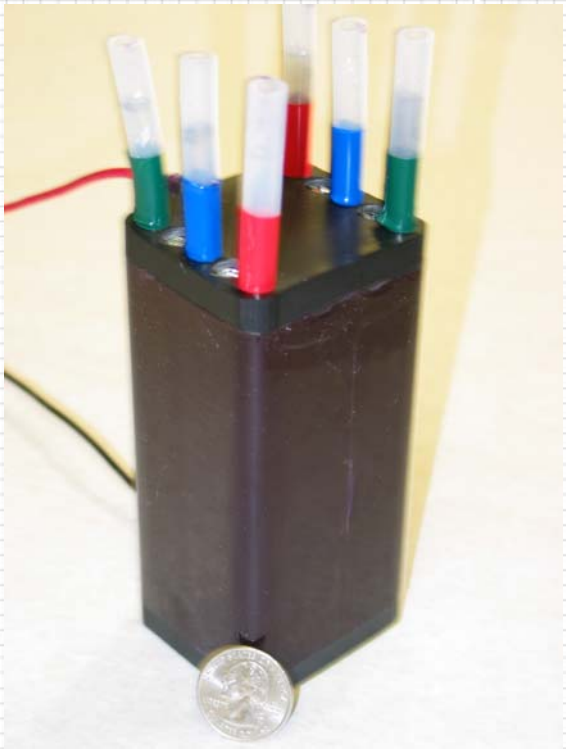
- *What does Protonex do?*

Stack Product



10-50W (12V)
< 200g
3.6 x 5.2 x 6.9 cm
#1806BH

20-120W (12V)
< 300g
4.5 x 6.5 x 6.9 cm
#1812BH



50-250W (24V)
< 520g
5.0 x 5.6 x 12 cm
#3612BH

Design for Manufacturability

Protonex PEM stacks

- No compression seals (no gaskets)
- Requires minimal labor
- Low skill assembly
- Relaxed component tolerances
- Flexible design
- Designed for injection molding

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Reliable Performance

- Minimal system requirements
- Stable, reliable operation
- Ambient pressures
- Little or no humidification

Battery Comparison

Power Source	W-hr/kg
Li Primary	175
Li rechargeable	100-200
Protonex*	425-906

- Protonex fuel cell system in combination with Millennium Cell 'hydrogen on demand'
- Soldier power system 30-50 watts

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More Information

- http://www.h2fc.com/
- http://www.fuelcellstore.com/
- http://www.fuelcells.com/
- http://www.fuelcell-info.com
- http://www.fuelcellsworks.com/
- http://www.protonex.com/