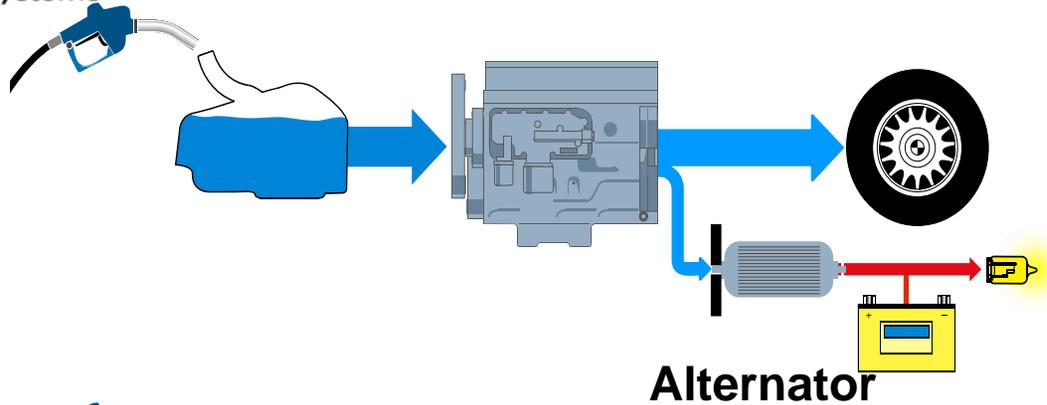


**Solid Oxide Fuel Cell Auxiliary Power Unit :
Status and challenges for automotive applications**

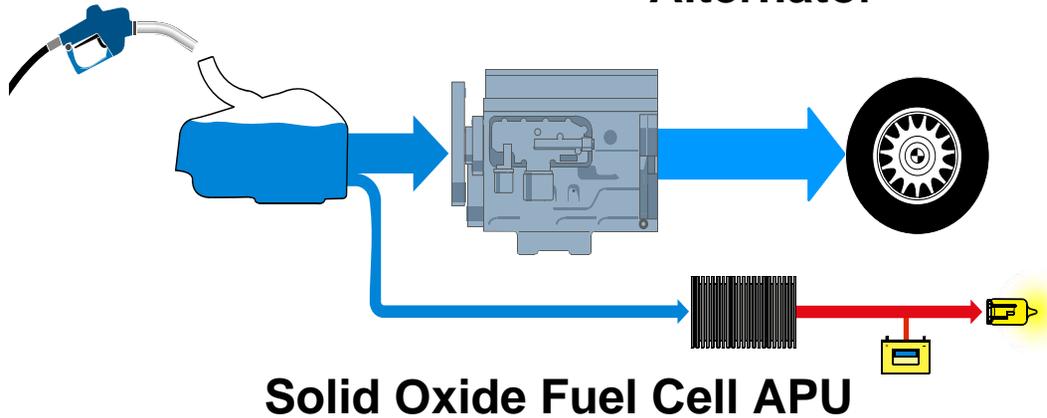
Dr. S. Mukerjee
Delphi Automotive Systems

- ◆ Delphi Automotive Systems is developing Solid Oxide Fuel Cell (SOFC) technology for automotive applications - primarily as an on-board Auxiliary Power Unit (APU).
- ◆ Paradigm shift in the supply of electric power for transportation.
- ◆ Highly efficient and low emissions.
- ◆ Consistent with the increasing power demands in automobiles in the new era of more comfort and safety along with environmental friendliness.

Today:



Tomorrow ?



Why a SOFC APU?

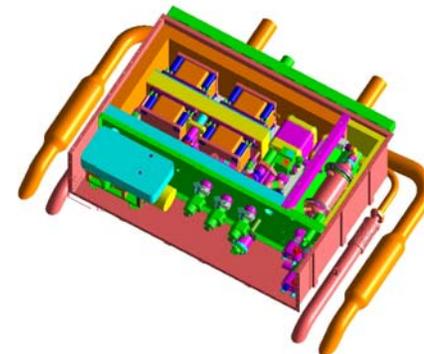
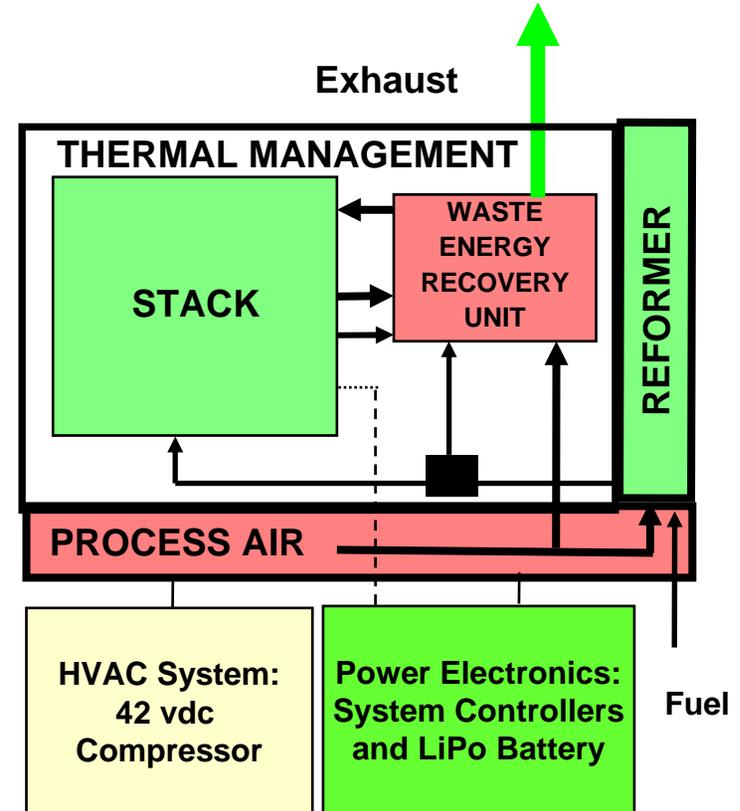
- The APU is not competing with the IC Engine but complements it.
- Highly efficient generator providing power with the engine off
- The SOFC utilizes simple reforming technology
- Less stringent fuel requirements (uses CO as a fuel)

Auxiliary Power Unit (APU) Parts:

- ◆ SOFC Stack subsystem
- ◆ Fuel Reformer subsystem
- ◆ Balance of Plant (BoP)
 - ◆ Process Air Supply
 - ◆ Thermal Management
 - ◆ Waste Energy Recovery
 - ◆ Power Electronics / Controls
 - ◆ HVAC subsystem

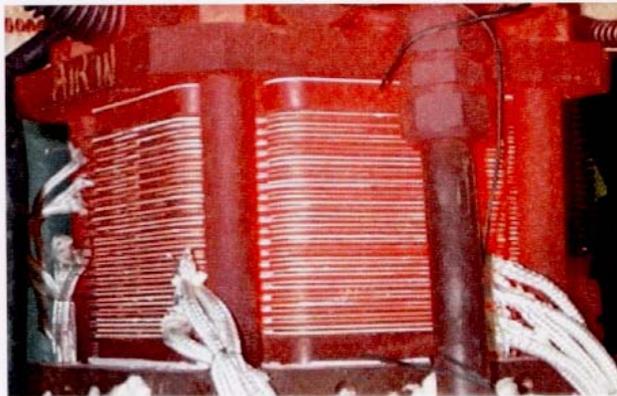
Expected Customer Benefits:

- ◆ can supply electric power with engine on or off, with high efficiency and essentially zero emissions
- ◆ permits operation of any electrical accessory
- ◆ possible enabler for high power-consuming advancements (e.g., PVT)

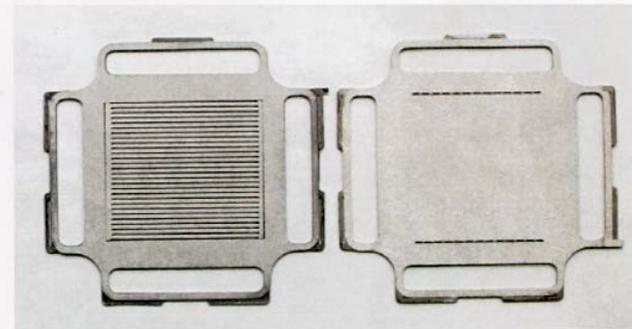


- ◆ Stack developed by Global Thermoelectric
- ◆ Planar anode supported technology for high power density.
- ◆ Metallic interconnects for low cost.
- ◆ Compression seals for thermal cycling.

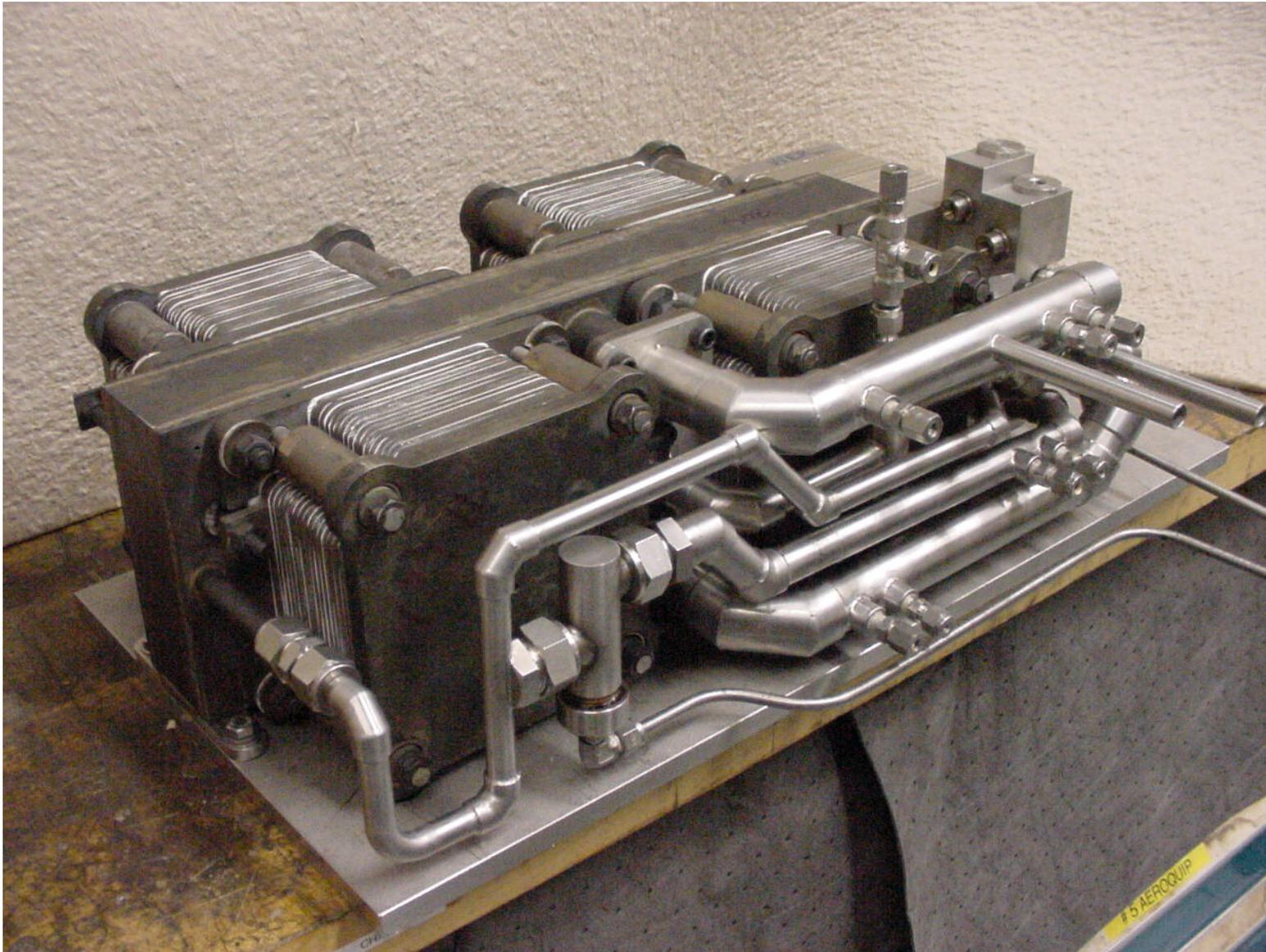
20 Cell - 800 deg. C.



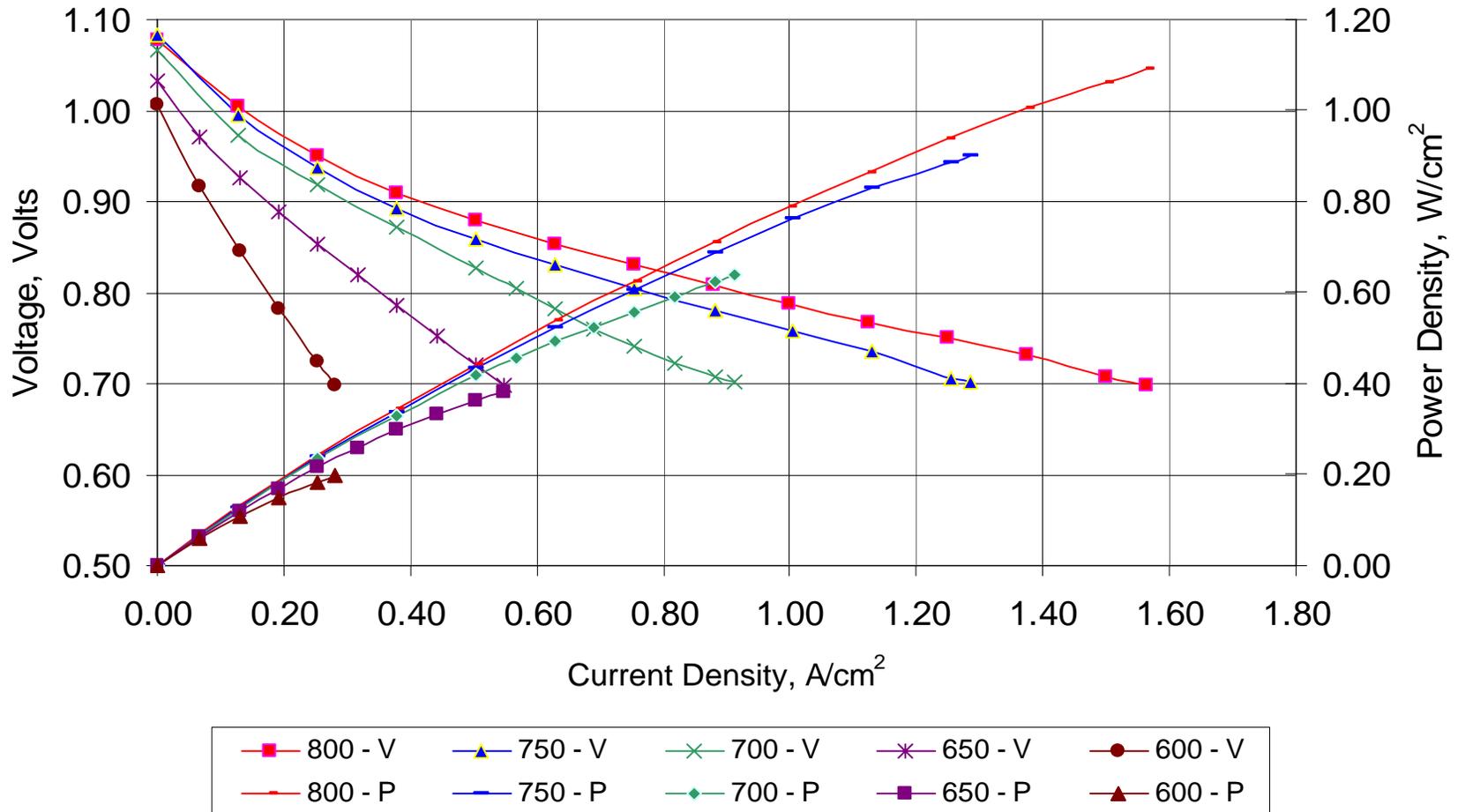
Metal Interconnect Plates



Source: Global Thermoelectric



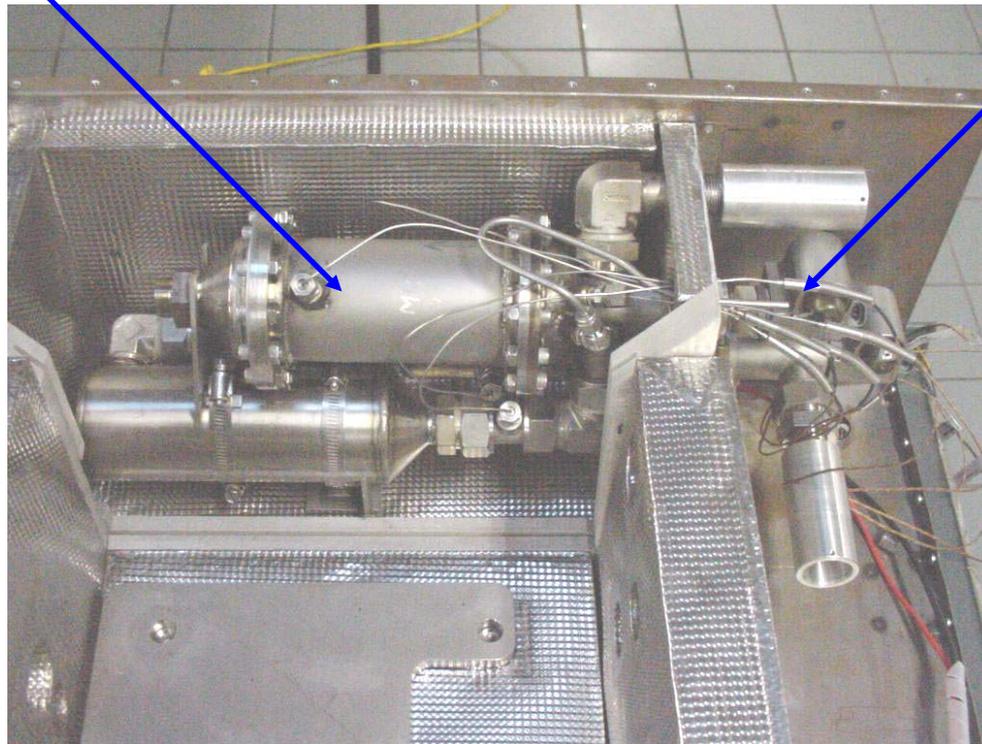
Fuel = hydrogen



Source: Global Thermoelectric

Gasoline Reformer Subsystem

Air / fuel Delivery Subsystem

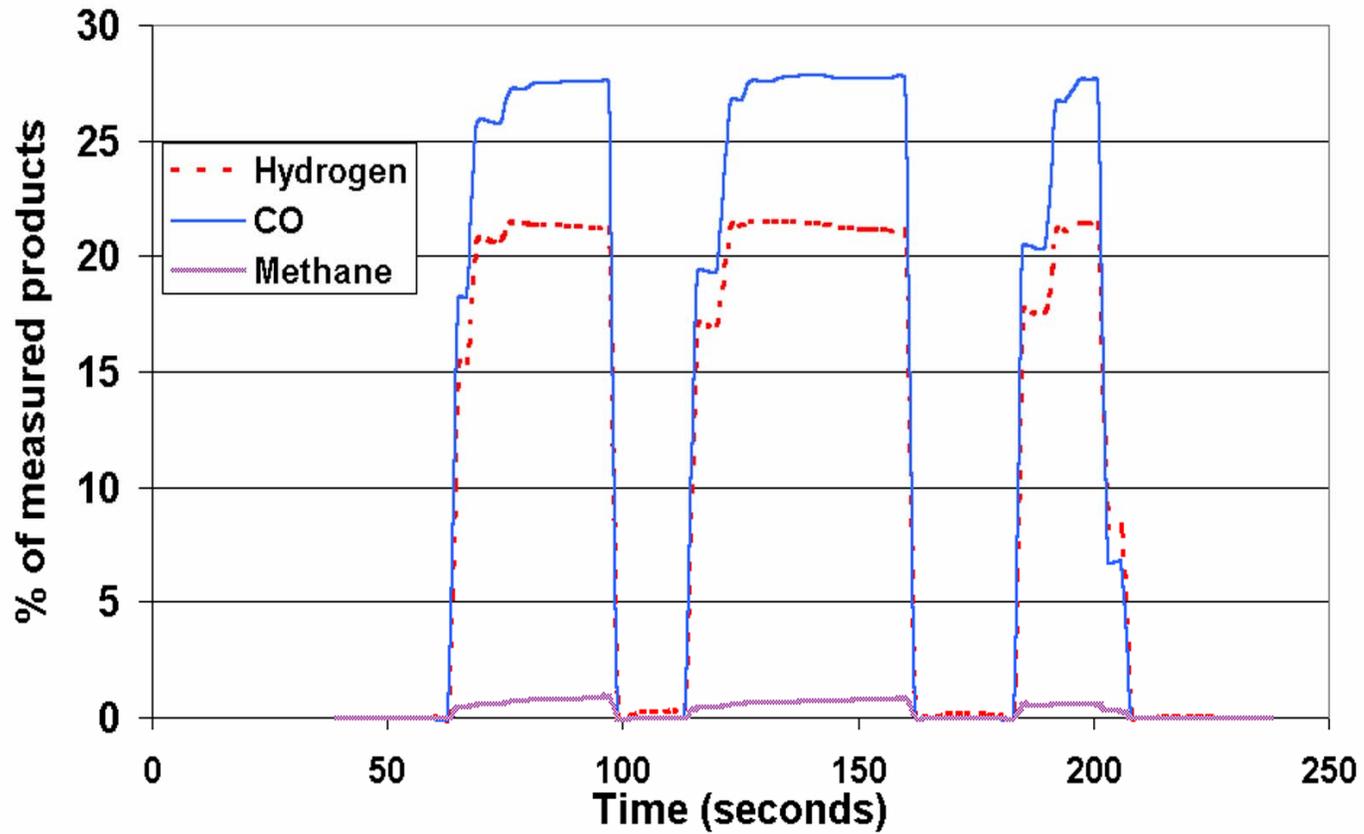


Capacity: 10 kWt Reformate

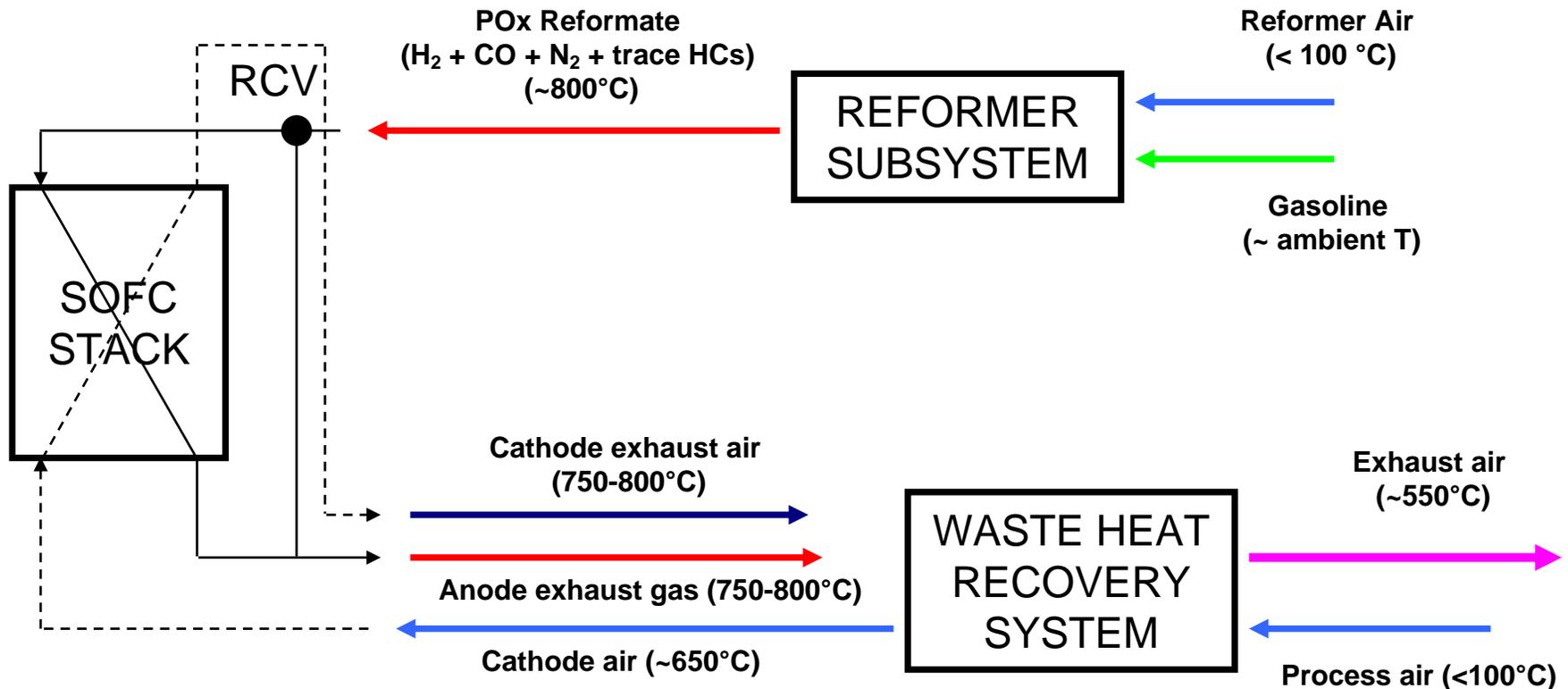
Catalysts: Automotive Derivative

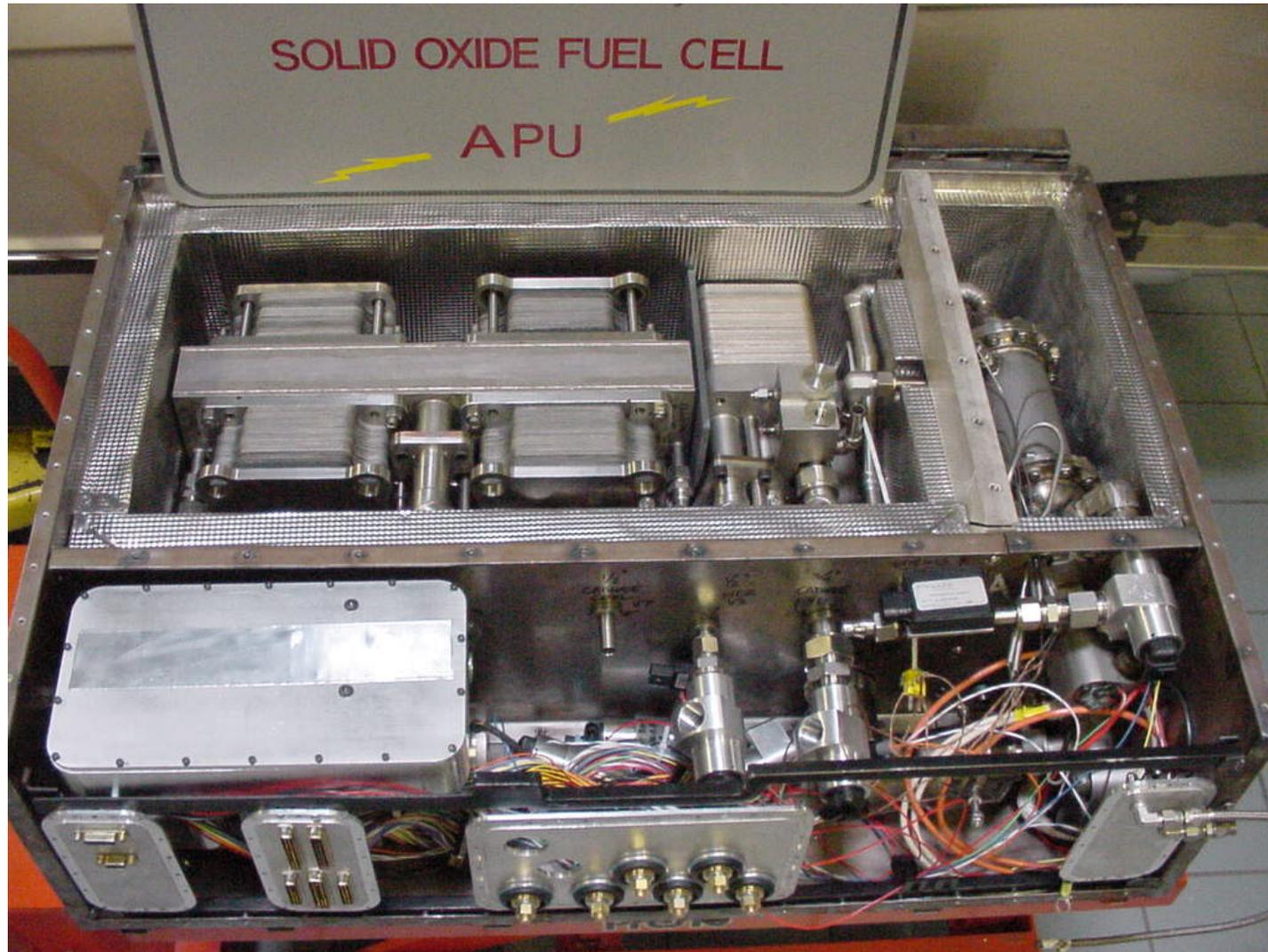
Air / Fuel Actuators: Standard Automotive

Start-up time: < 10 minutes (to SOFC purity reformate)



Reformer / Waste Heat Recovery Integration

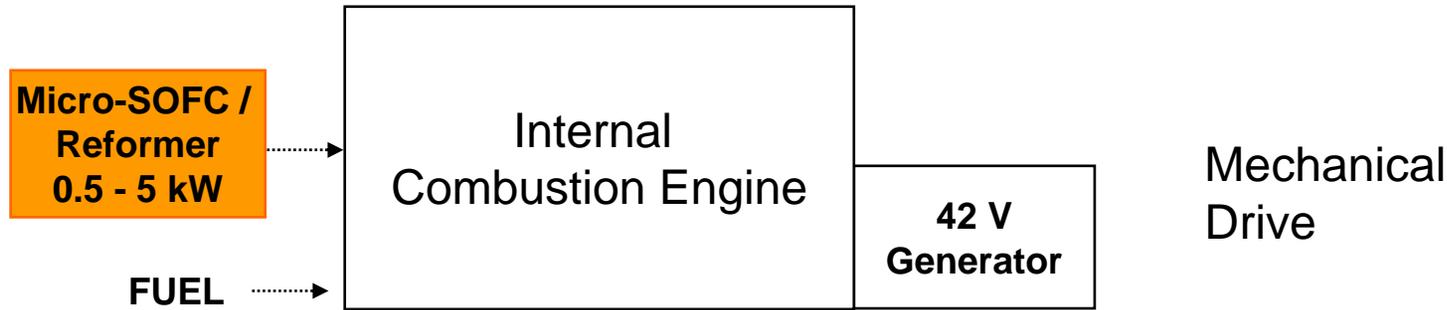




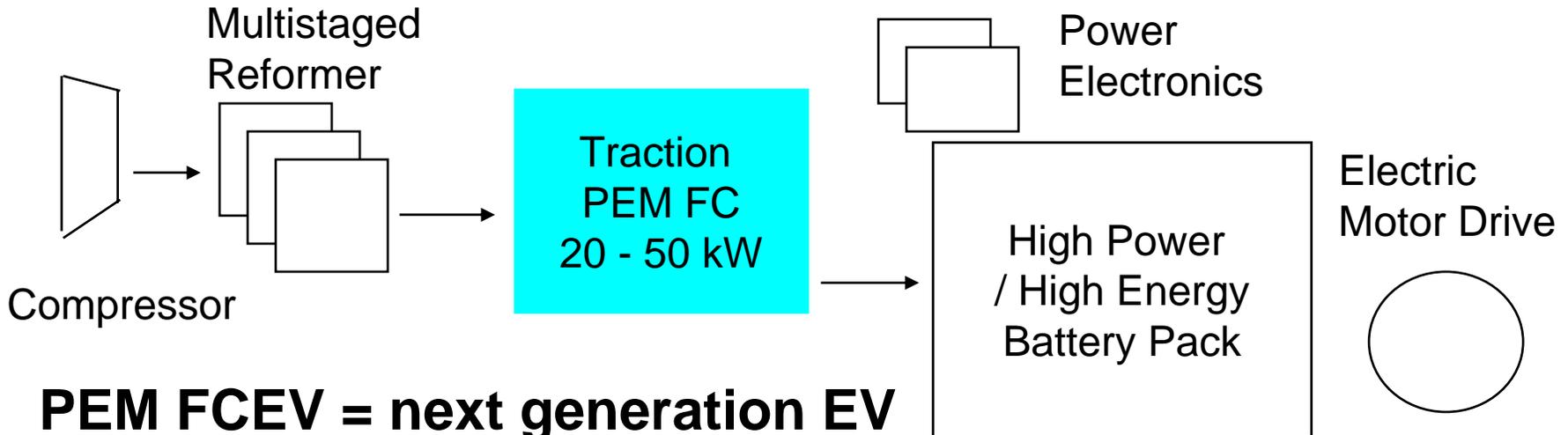
SOFC Has Many Challenges To Be Viable As An Automotive Technology:

- ◆ Cost, Cost, Cost.
- ◆ Power density
- ◆ Higher efficiency.
- ◆ High performance, low cost insulation.
- ◆ Robust balance-of-plant components.
- ◆ Fast startup and thermal cycling.
- ◆ Automotive levels of robustness.

Competing Visions: Improve ICE or Replace it?



**SOFC APU = high efficiency electricity +
future vision for integration with ICE**



**PEM FCEV = next generation EV
(with smaller battery pack)**

- ◆ SOFC is an attractive automotive fuel cell technology.
- ◆ It will enter the market as an APU - a paradigm shift in supply of electric power for transportation.
- ◆ It is not likely to replace the ICE but will complement it.
- ◆ It has other future mechanizations which support the trend to essentially zero toxic emissions and much reduced CO₂ emissions

Delphi Automotive Systems with its partners are working toward bringing this key technology to market.