Catalytic Heat Exchanger for SOFC Balance-of-Plant Cost Reduction

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Project Objective

Demonstrate conceptual feasibility of a highly effective catalytic cathode air preheater for a 60kW SOFC power plant to increase plant performance and to reduce the balance of plant cost.

Team Partners

FuelCell Energy, Inc.
Danbury, CT

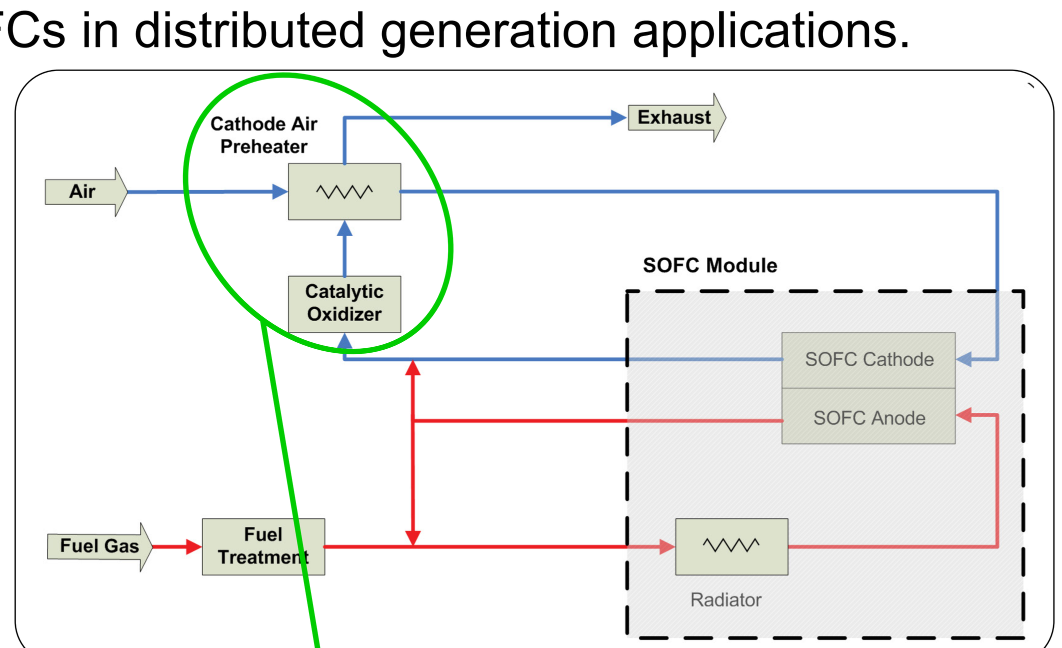
Modine Manufacturing Co.
Racine, WI

BASF Catalysts
Iselin, New Jersey

Project Background

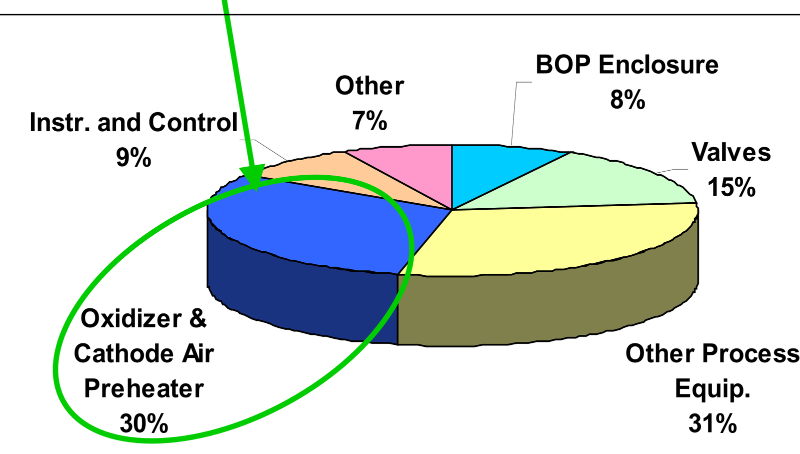
- In addition to SOFC cell/stack performance, cost, and durability improvements – innovative technologies for reducing balance-of-plant (BOP) component costs are required for successful commercial deployment of SOFCs in distributed generation applications.

Typical SOFC-based System

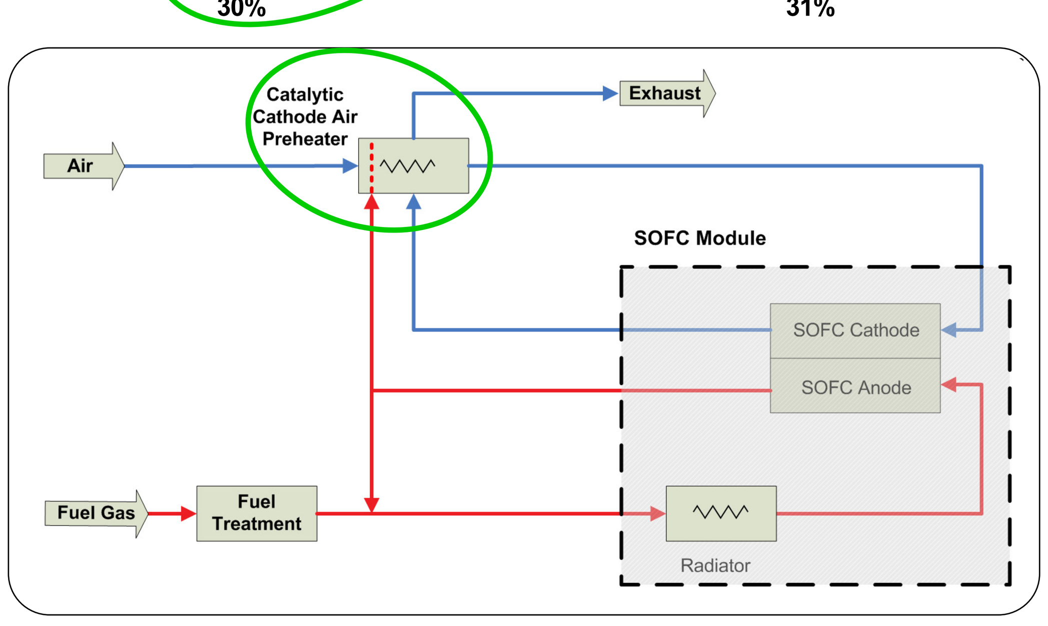


BOP Capital Equipment Cost Breakdown:

Oxidizer and Air Preheater represent the largest opportunity for BOP cost reductions



Simplified System Concept with Multi-Functional Catalytic Heat Exchanger



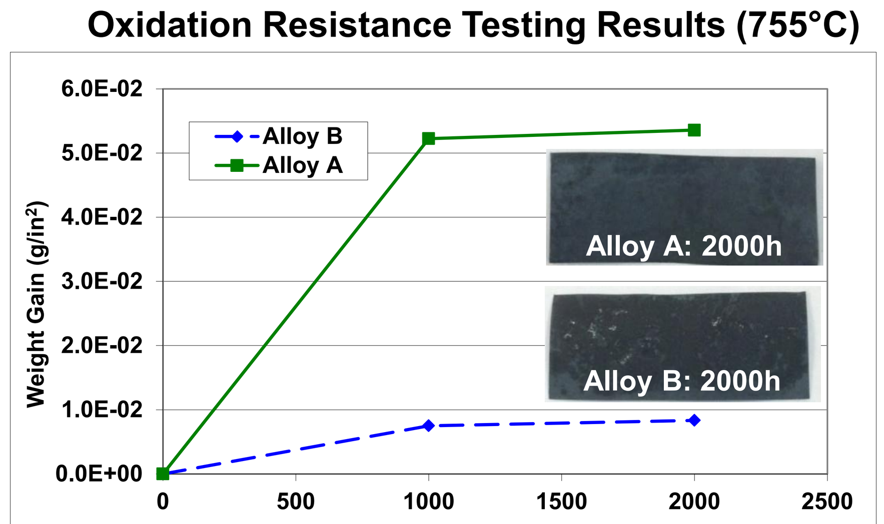
60-80% cost reduction estimated (in high volume production), compared to conventional separate oxidizer / heat exchanger

Material of Construction Selection

Key Material Selection Criteria:

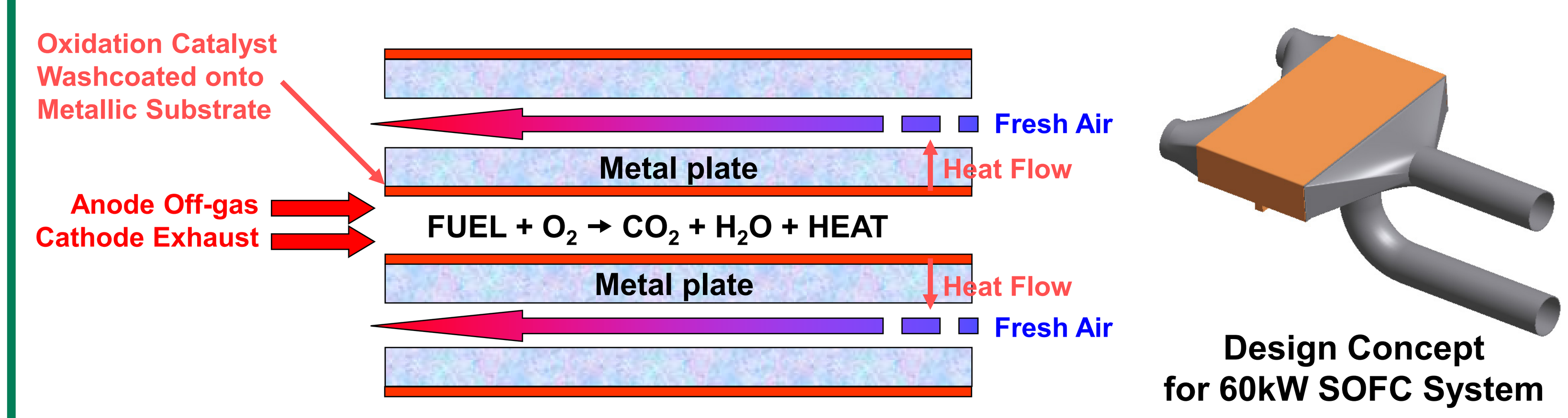
- Oxidation Resistance
- Suitability for catalyst washcoating
- Joining via conventional methods
- Acceptable creep strength
- Availability
- Cost

Oxidation Resistance Testing Results (755°C)

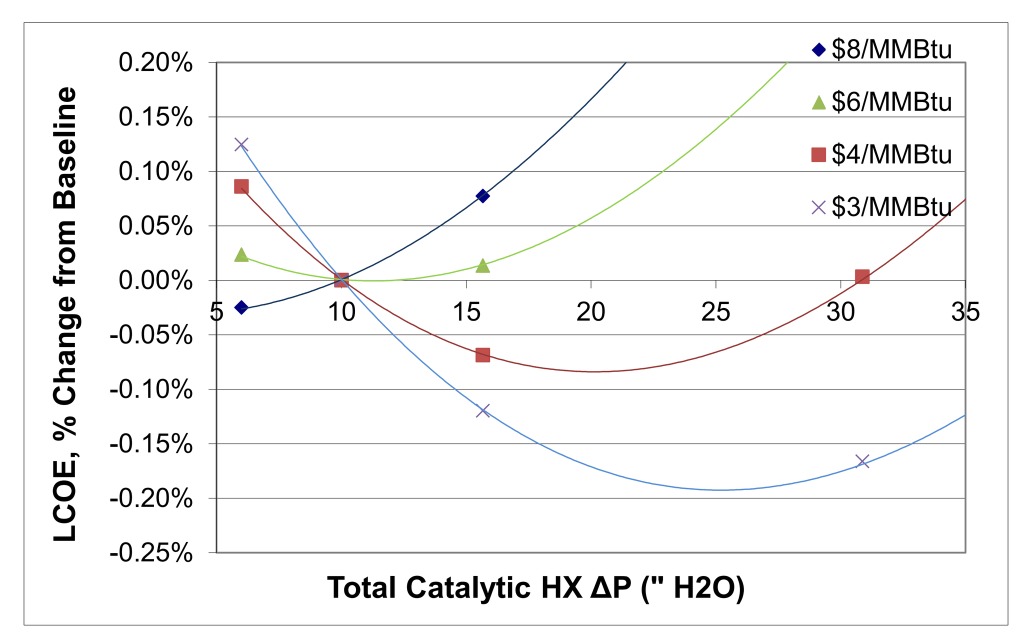


Due to HX design features, maximum temperature is limited to ~770 °C. Therefore, high-Ni Super Alloys are not required.

Conceptual Catalytic Heat Exchanger Design for 60kW SOFC Power Plant



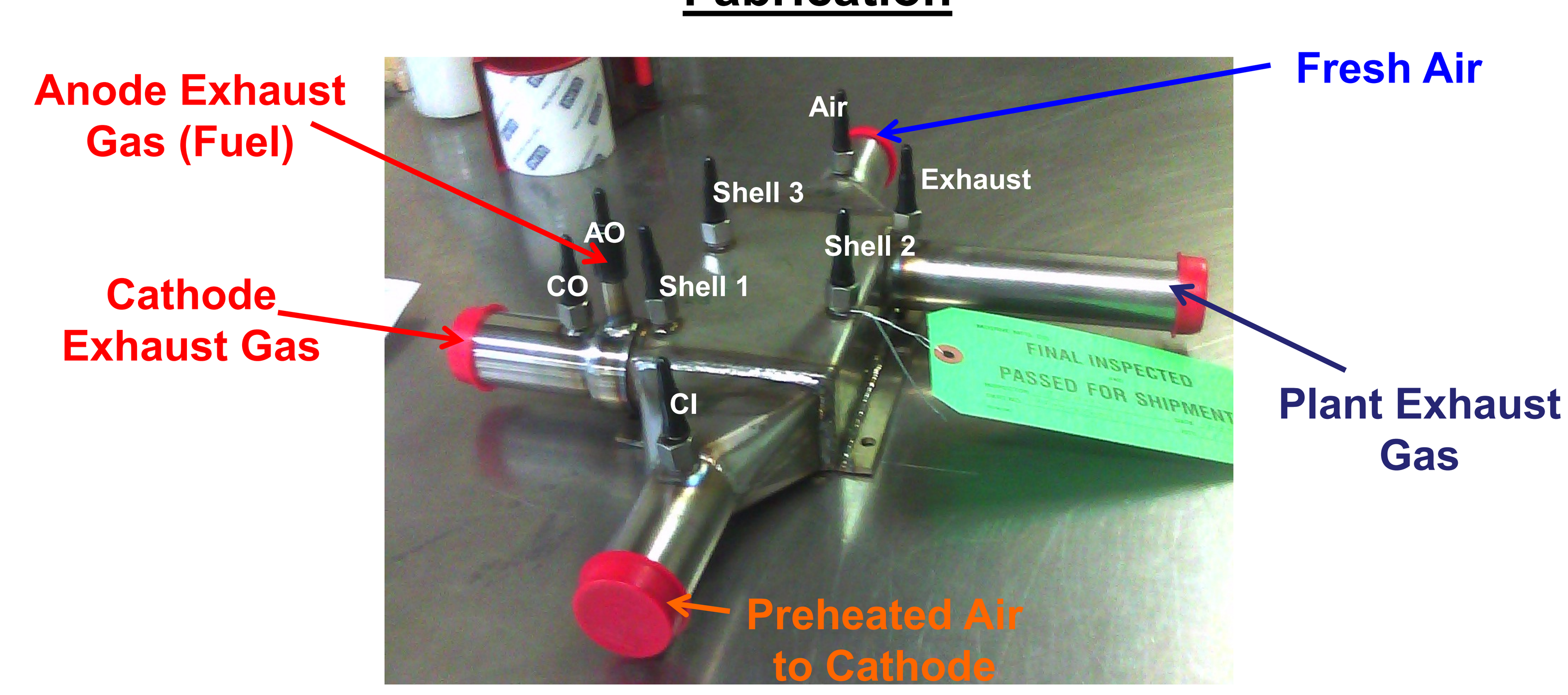
Sensitivity Study: Levelized Cost of Electricity (LCOE) vs. Catalytic HX Pressure Drop Specification



Natural Gas Price ($/MMBtu)	HX dP for minimal LCOE ("H_2O)	Net Plant Efficiency @ Min. LCOE dp Allowance (LHV NG)
$8.00	<6	<59.5%
$6.00	10.5	61.3%
$4.00	20	61.0%
$3.00	25	60.9%

- As fuel prices decrease from $8/MMBtu to $3/MMBtu, optimal dP specification increases from <6 to 25”H_2O

Lab-Scale (3kW$_e$) Catalytic Heat Exchanger Design and Fabrication



- Provisions for pressure measurement at each inlet and outlet
- Provisions for thermocouples at each inlet and outlet, in addition to 3 thermocouples to map shell-side temperatures

Lab-Scale Catalytic Heat Exchanger Testing Results

- Maximum combustion temperature was well-controlled
  - No temperature run-away observed
  - Maximum combustion temperature is effectively moderated even up to 2x the design fuel flow rate
- Hot-in to cold-out approach temperatures:
  - 94 °C without fuel flow (non-catalytic mode)
  - 19.4 °C with fuel flow (catalytic mode)
- Heat duty
  - As tested = 2.85 kW (test facility maximum temperature limited)
- Total pressure drop at Normal Operating Conditions = 7.8 ”H_2O (below 10 ”H_2O target)

FCE’s “10 kW” Subscale Test Facility

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