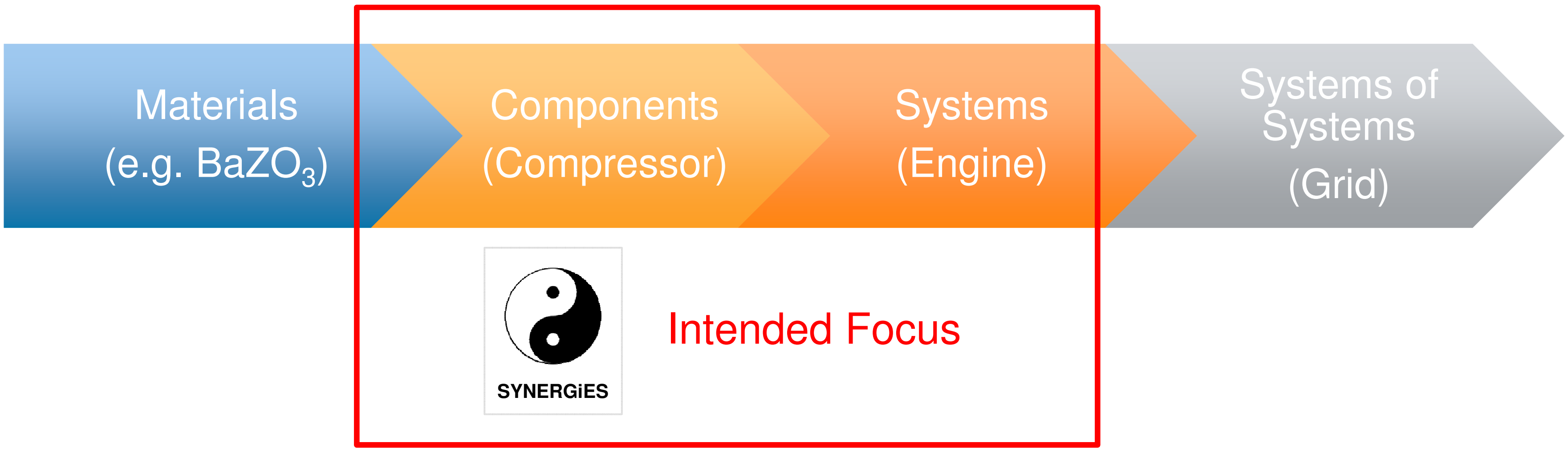
# Breakout Session #1

Opportunities, Challenges & Potential Solutions

# Proposed Program Scope

*<u>Simplified Taxonomy of Engineering Development Efforts</u>*

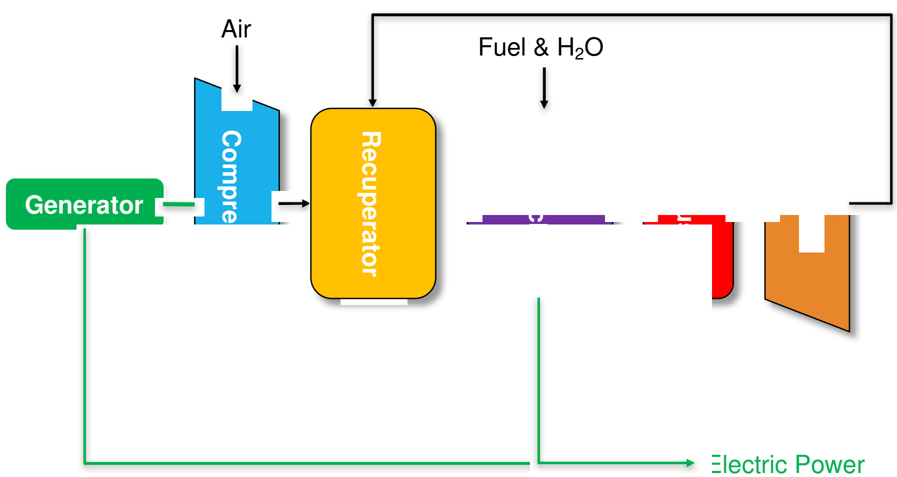


# Opportunity

***Opportunity***

*Economic & environmental value propositions afforded by the potential to locally generate electricity in a highly efficient and fully dispatchable manner.*

*Notional Hybrid System*




*Synergies*

1. FC Waste Exergy → Engine Heat
2. Engine is FC balance of plant
3. ↑ Engine Power → ↓ Fuel Cell Power
4. Potential for Pressurized FC Operation
   - Higher Power Density → Smaller Stack
   - Reduced Cooling Parasitic Penalty

# Opportunity Questions

- Analytical efficiency projections for a “two-stage” hybrid cycle suggest that electric efficiencies could be in excess of 70%.
  - Are these projections too optimistic?
  - What might be the major performance limiters?
  - Are there ”integration issues” that will negatively impact the performance of the fuel cell or engine sub-systems?
- It is also suggested that hybrid systems will be “dispatchable”.
  - Will hybrid systems be capable of load-following or will they be baseload devices?
  - What might be the challenges associated with load following?

# Challenge

***Challenge***

*Realization of the thermodynamic potential* of hybrid systems at a price† afforded by their energy cost savings.*

** $\eta_{elec} \geq 70\%$*

*† Installed Price ≤ $1800/kW, Maintenance ≤ $0.02/kWh*

Installed Price → **Equipment Cost**

Installed Price = **Equipment Cost** + Equipment Margin + Installation Price

$1800/kW = **$900/kW** + $300/kW* + $600/kW†

*Assumptions*
- *Gross Margin = 25%
- †Installation Price = 50% Equipment Price

*Maintenance Cost = $0.02/kWh → ~20% of capital cost/year**

*$0.02/kWh * 8760 hrs/year * 90% ~ $160/kW/year ~ 20% of target equipment cost/year

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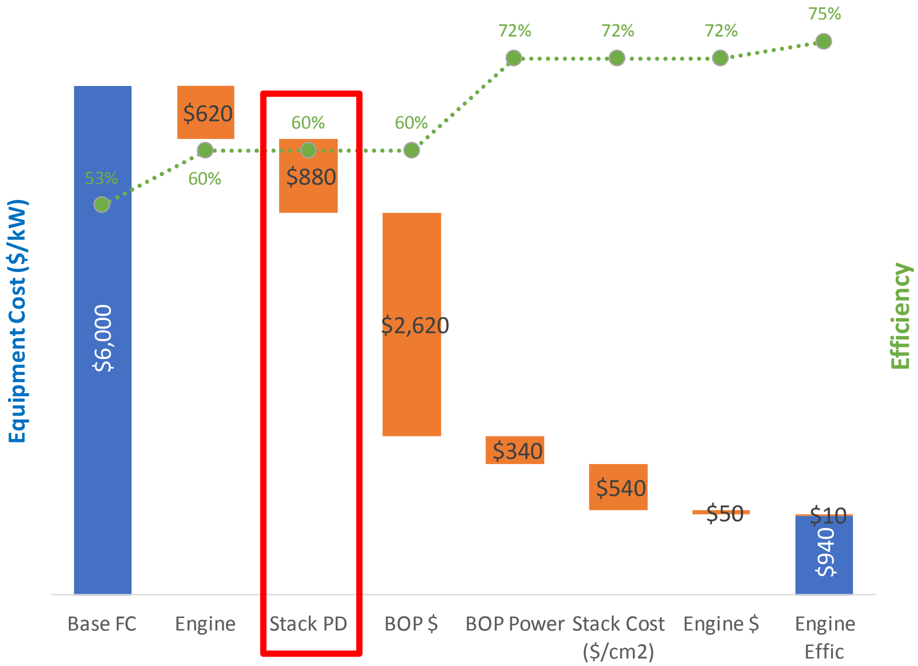
# Quad Charts

# Cost Detail: Stack Cost ($/kW)

*Goal : Increased stack power density with no areal specific cost impact*




Stack Power Density
250 → 500 mW/cm²

*Potential Solution: Pressurization*

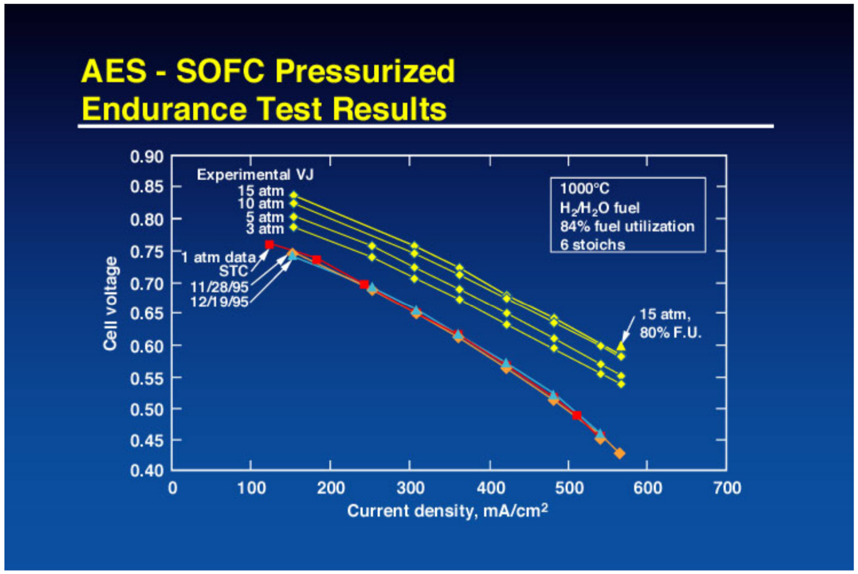



**Figure 4-1 – Measured Cell Voltage vs. Current Density at Various Pressures**

Ref: Siemens Power Generation, High Temperature Solid Oxide Fuel Cell Generator Development, Final Technical Report, 2007.

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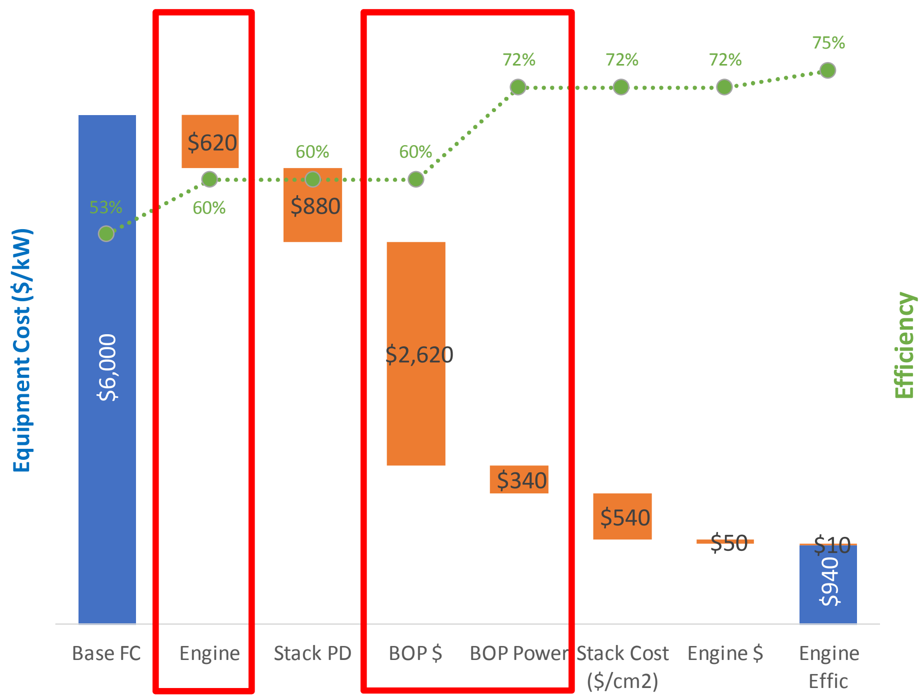
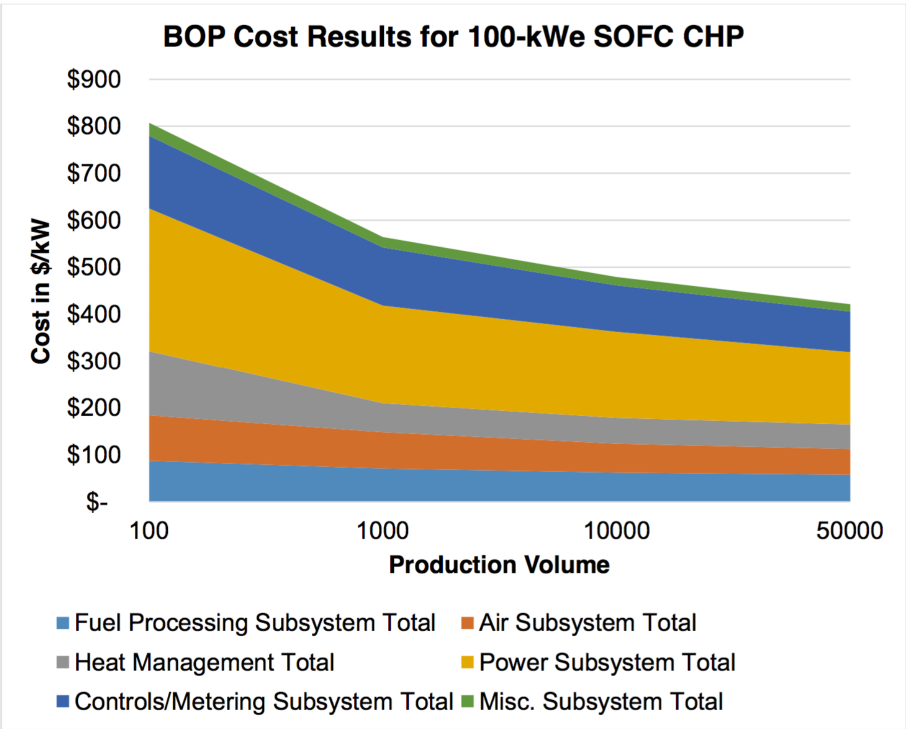
# Cost Detail: Engine/BOP Integration

*Goal: Achievement of thermodynamic & cost synergies*



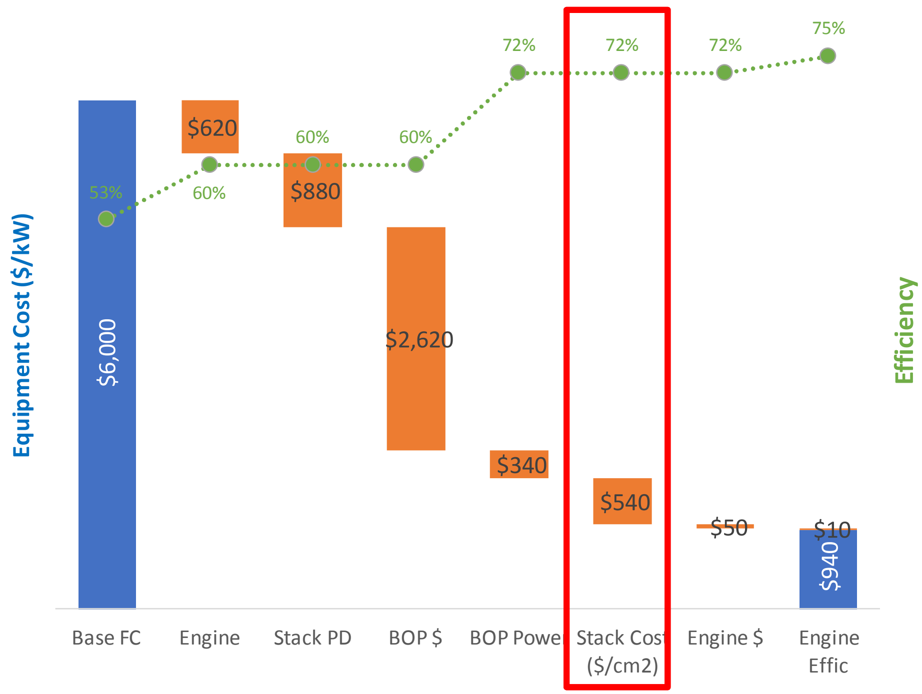




- 40% increase in net efficiency
- 60% decrease in $/kW

Ref: Scataglini et al, A Total Cost of Ownership Model for SOFC in CHP & DG Applications, LBNL

# Cost Detail: Stack Cost ($/cm²)

*Goal: Decreased effective stack manufacturing cost (& acceptable durability)*




~0.4 → ~0.1 $/cm²

*A few starting ideas . . .*

- Manufacturing
  - Automation
  - Reduced material usage
- Materials
  - New MEA and stack materials
  - New supports (e.g. metal)
- BOP Synergies
  - Internal reforming
  - Sulfur tolerance

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