



FuelCell Energy

# **Fuel Cell Manufacturing**

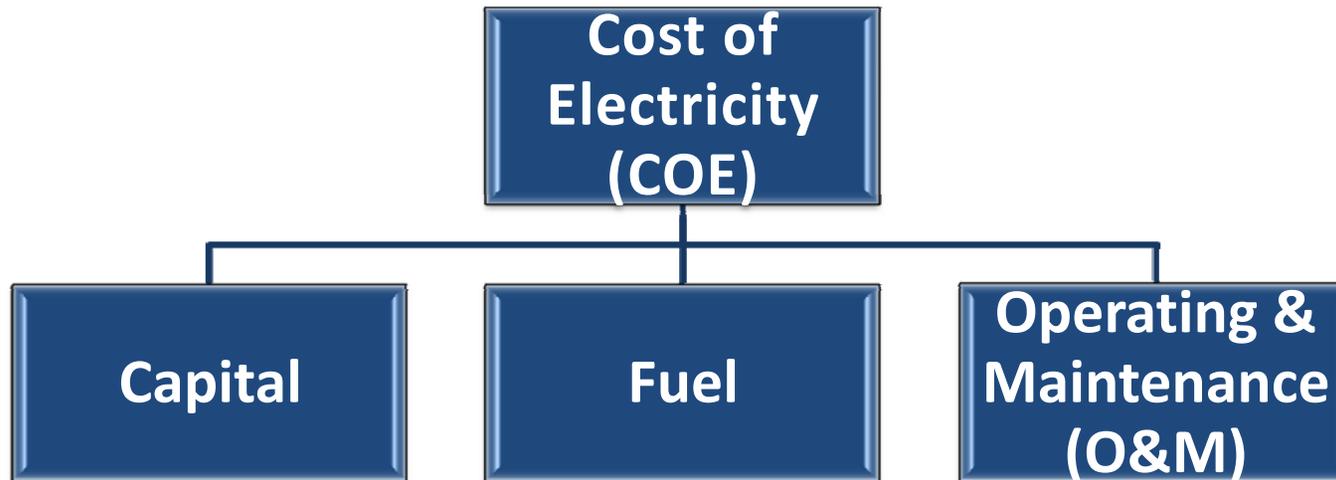
**Hossein Ghezel-Ayagh**

**ARPA-E Electrochemical Approaches to  
Modular Power Generation Workshop**

**June 6-7, 2013**

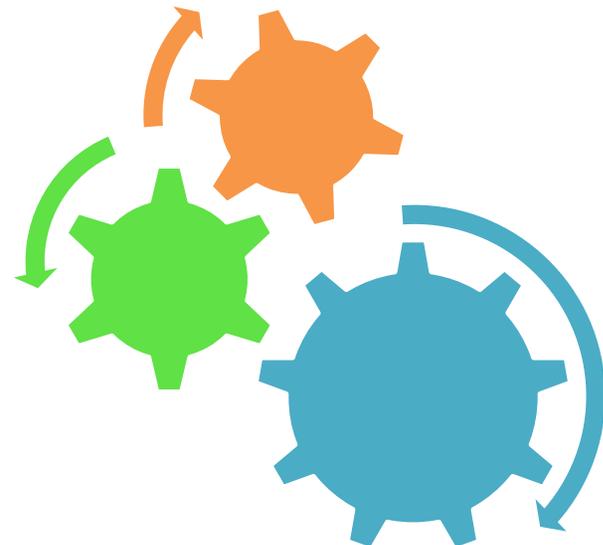
**Chicago, IL**

Ultra-Clean, Efficient, Reliable Power

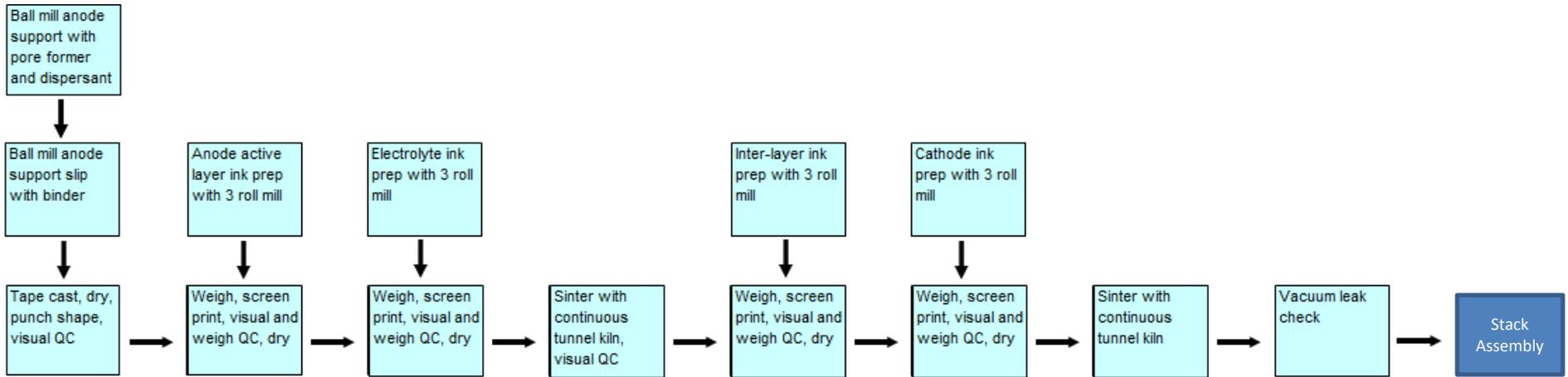


## Factors affecting COE

- Performance
- Materials
- Endurance
- Parts Count (Complexity)
- Manufacturing Processes
- Consumables/Fuel Price
- Labor Rates



# Typical Planar SOFC Manufacturing Steps



## Stack Cost Reduction Focus Areas

### 1. Stack Performance Increase

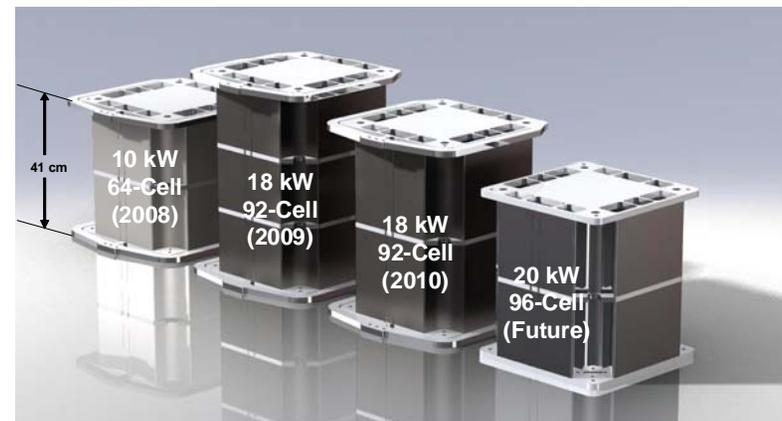
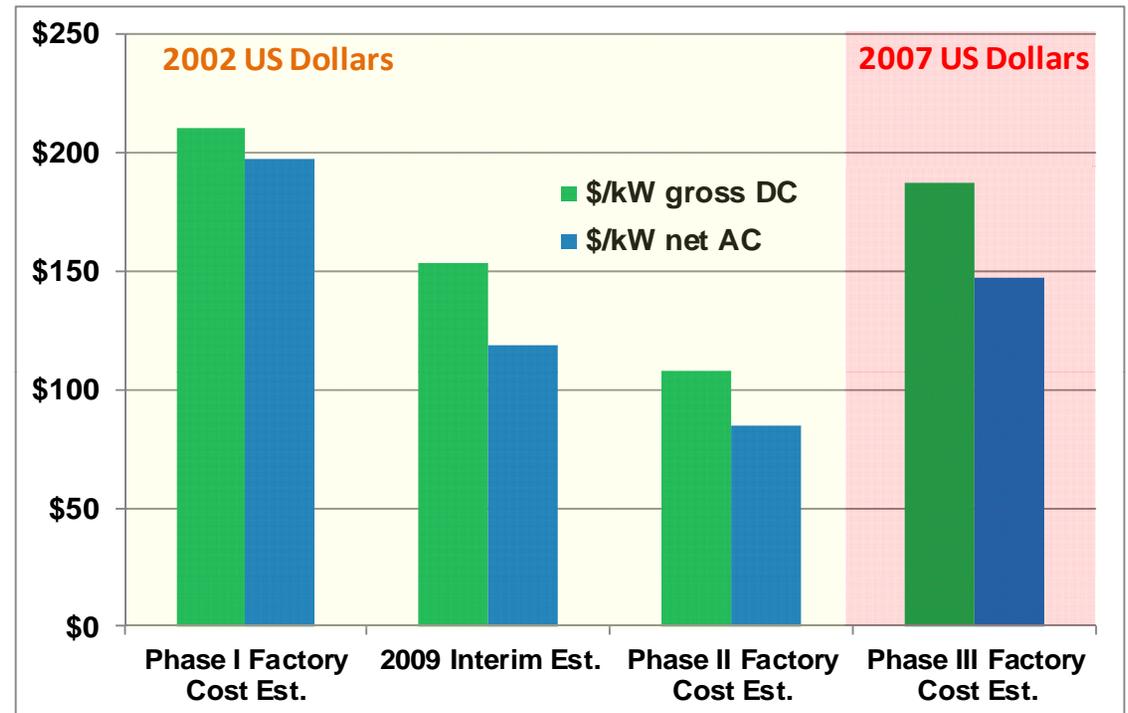
- Increased peak power
- Improved thermal management

### 2. Material Reduction:

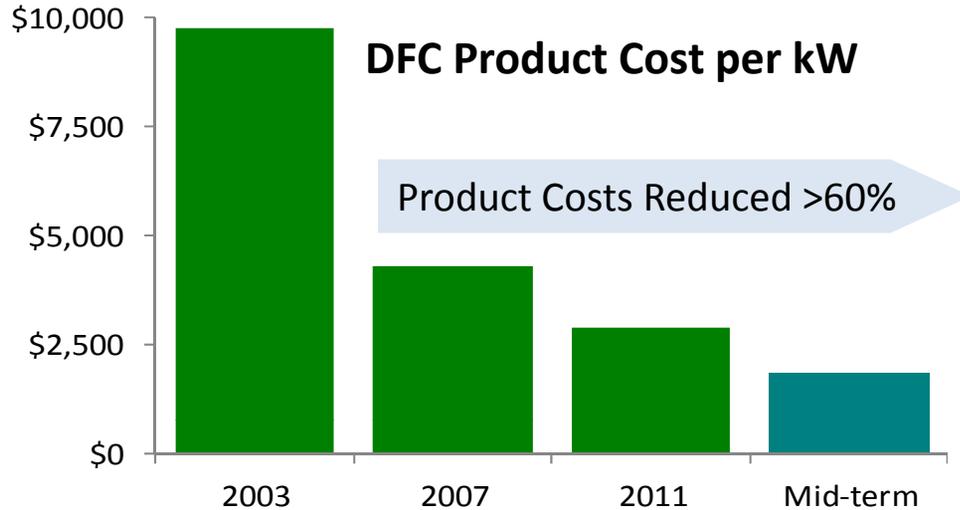
- Thinner cells and stack components
- Interconnect material reduction
- Eliminated intermediate plates

### 3. Manufacturing Process Changes & Optimization

- Interconnect manufacturing development
- Improved material utilization
- Automation
- Elimination of process steps

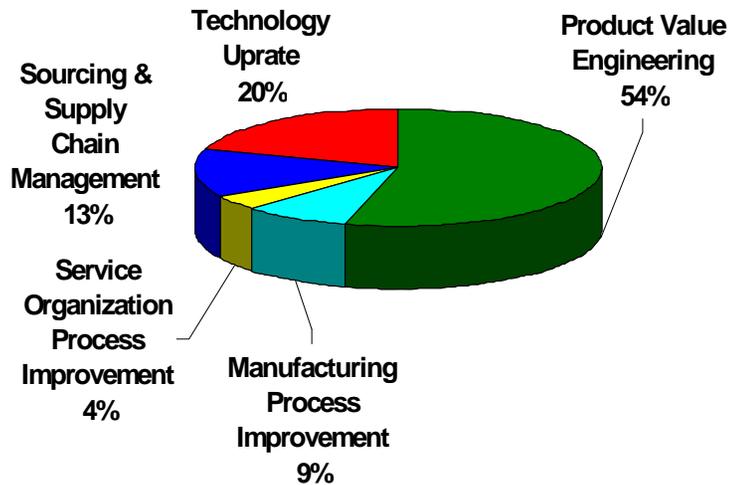


# Historical Direct FuelCell (DFC) Product Cost Reduction Experience

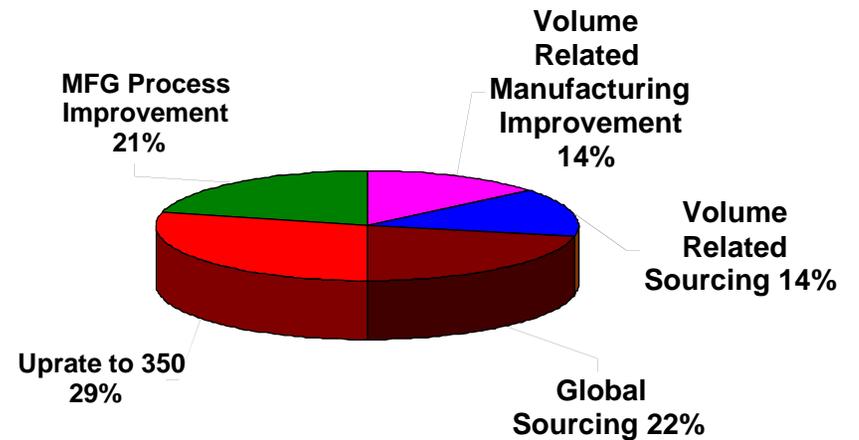


2.8 MW DFC3000

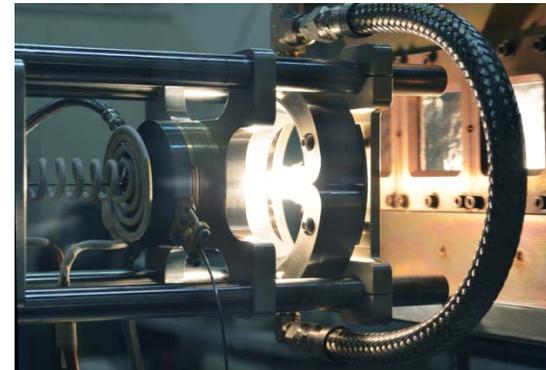
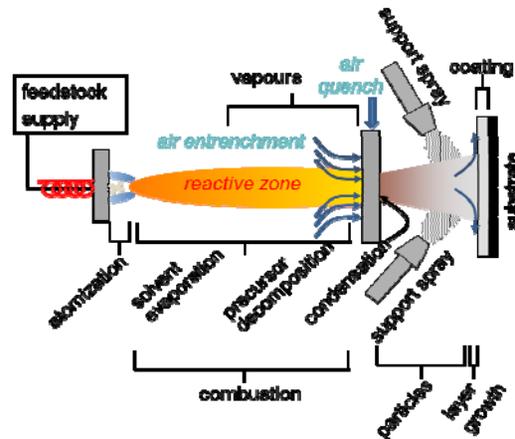
Captured Cost Reduction from 2003 - 2006  
6-9 MW Annual Production  
Status - \$3250/kW



Future Cost Reductions to Less Than \$2000/kW

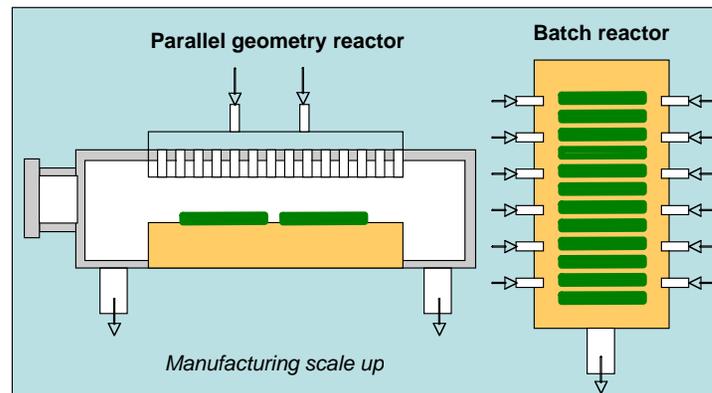


## Reactive Spray Deposition Technique (RSDT)



## MOCVD (Metalorganic Chemical Vapor Deposition)

- MOCVD can deposit films from nm to  $\mu\text{m}$  in thickness over large areas
- Excellent control over composition
- High degree of conformity over uneven surface
- High degree of morphology control



## ***Manual operation***

Production volumes from 1 MW to 10 MW: Pilot Manufacturing

- Use manual equipment with longer cycle times and smaller batch size

## ***Semi-automatic operation***

Production volumes from 10 MW to ~100 MW

- Use medium size equipment and has partial automation in key stations

## ***Automatic operation***

High volume production from >100 MW

- Workstations and material handling system are automated