Fuel Cell Manufacturing
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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

- Ball mill anode support slip with pore former and dispersant
- Anode active layer ink prep with 3 roll mill
- Electrolyte ink prep with 3 roll mill
- Inter-layer ink prep with 3 roll mill
- Cathode ink prep with 3 roll mill

- Tape cast, dry, punch shape, visual QC
- Weigh, screen print, visual and weigh QC, dry
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- Weigh, screen print, visual and weigh QC, dry

- Sinter with continuous tunnel kiln, visual QC
- Sinter with continuous tunnel kiln
- Vacuum leak check

Stack Assembly

Tape Casting
Screen Printing
Sintering
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

![Graph showing DFC Product Cost per kW with reduced costs]

- **DFC Product Cost per kW**
  - Product Costs Reduced >60%

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

**Future Cost Reductions to Less Than $2000/kW**

- **Sourcing & Supply Chain Management** 13%
- **Technology Uprate** 20%
- **Product Value Engineering** 54%
- **Manufacturing Process Improvement** 9%
- **Organization Process Improvement** 4%
- **Global Sourcing** 22%
- **Uprate to 350** 29%
- **Volume Related Sourcing** 14%
- **Volume Related Manufacturing Improvement** 14%
- **MFG Process Improvement** 21%

2.8 MW DFC3000
Examples of Advanced Manufacturing Techniques

Reactive Spray Deposition Technique (RSDT)

MOCVD (Metalorganic Chemical Vapor Deposition)

- MOCVD can deposit films from nm to µm 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