**Objective**

Demonstrate the technical and economic feasibility of building a kW scale pilot plant coal-based fuel cell with participation by industries. This project will address initial development, scaling, and manufacturing of the core technology. Objectives for 2012 include the following:

- Design and fabricate a preliminary fuel cell stack
- Demonstrate the operation of fuel cell stack with hydrocarbon and solid carbon fuels
- Study the effect of different types of carbonaceous fuels on the performance of the fuel cell
- Evaluate the efficiency of the carbon fuel cell

**Evaluation of Carbon Fuel Cell Efficiency-1**

**Definitions of Fuel Cell Efficiency**

<table>
<thead>
<tr>
<th>Efficiency</th>
<th>Definition</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating efficiency</td>
<td>( \eta_{\text{operating}} = \frac{P_{\text{electricity output}}}{Q_{\text{input}}} )</td>
<td>30-35% (not depending on power)</td>
</tr>
<tr>
<td>Thermodynamic efficiency</td>
<td>( \eta_{\text{thermodynamic}} = \frac{P_{\text{electricity output}}}{Q_{\text{input}}} )</td>
<td>Depends on choice of fuel</td>
</tr>
<tr>
<td>Load efficiency</td>
<td>( \eta_{\text{load}} = \frac{P_{\text{electricity output}}}{Q_{\text{input}}} )</td>
<td>70-75%</td>
</tr>
<tr>
<td>Fuel efficiency</td>
<td>( \eta_{\text{fuel}} = \frac{P_{\text{electricity output}}}{Q_{\text{fuel}}} )</td>
<td>&lt;0.90</td>
</tr>
<tr>
<td>Effective efficiency</td>
<td>( \eta_{\text{effective}} = \frac{P_{\text{electricity output}}}{Q_{\text{input}}} )</td>
<td>27-40%</td>
</tr>
</tbody>
</table>

**Fuels**

- Hydrogen: \( H_2 + \frac{1}{2} O_2 \rightarrow H_2O \)
- Methane: \( CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O \)
- Coke: \( CO + \frac{1}{2} O_2 \rightarrow CO_2 \)
- Carbon: \( C + O_2 \rightarrow CO_2 \)

**Fast Pyrolysis of Mansfield Coal in Ar and CO₂**

**The Integration of Individual Fuel Cell-2**

**Three Cells in Series Configuration**

**Testing Conditions**

- \( H_2 \): 100 sscm, 50 vol% \( H_2 \)
- He/CH₄/CO₂: 100 sscm, 25 vol% \( CH_4 \), 25 vol% \( CO_2 \)
- He/CH₄/H₂O: 100 sscm, 50 vol% \( CH_4 \), 5 mol% \( H₂O \)
- Temp: 750 °C

**Future Work**

- Modification of the anode catalyst to increase the activity toward carbonaceous fuels and its gasification products
- Evaluating the efficiency of the fuel cell stack in carbonaceous fuels
- Integration of multiple fuel cell stacks and design a kW scale pilot plant
- Cost analysis of a kW scale fuel cell stack

**Acknowledgements**