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OPTIMAL SOFC SIZE DESIGN FOR MINIMAL COST OF ELECTRICITY ACHIEVEMENT

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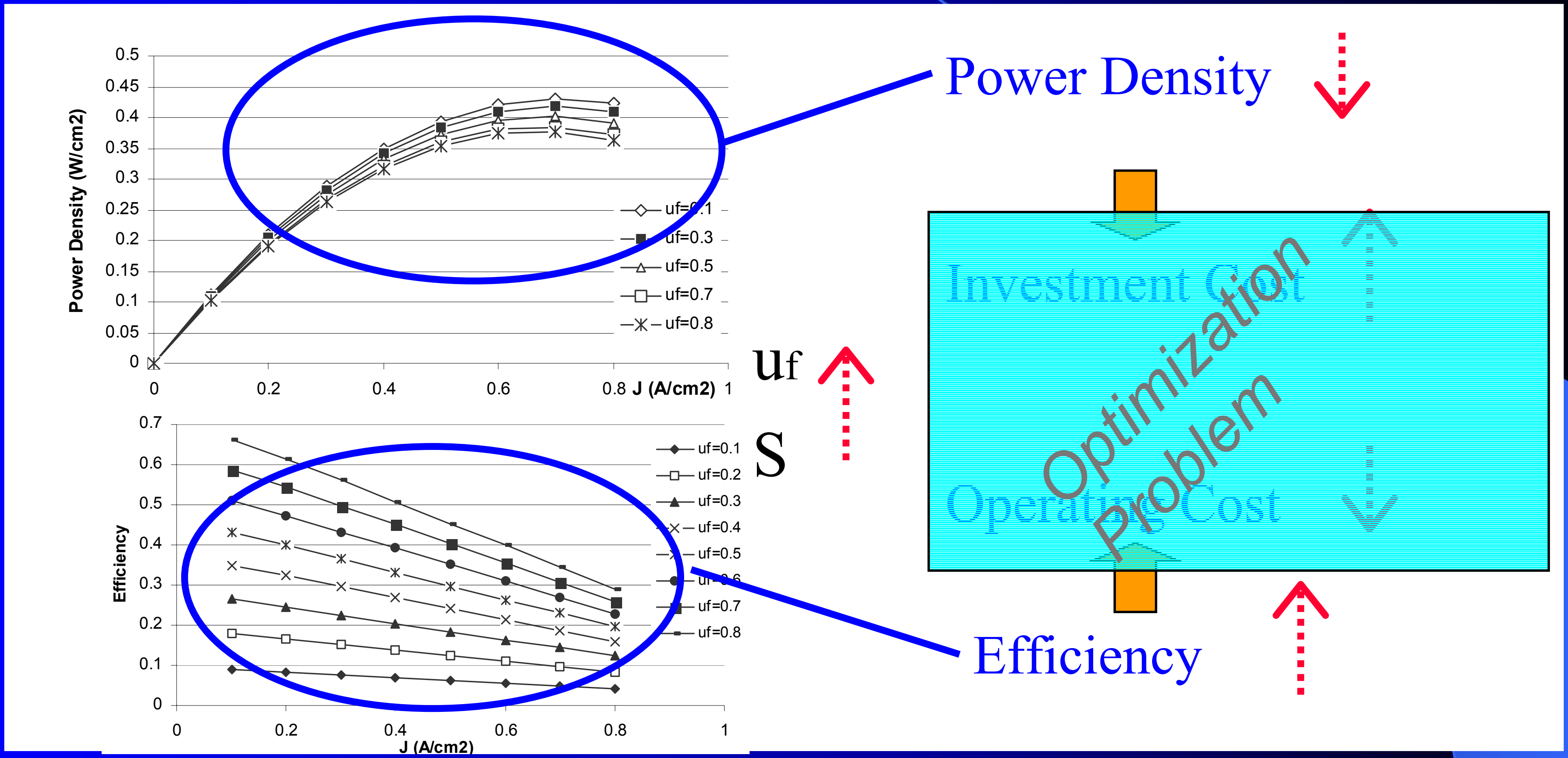
First International Conference on Fuel Cell Development and Deployment
March 7-10, 2004
Storrs, CT

Scope of the Study



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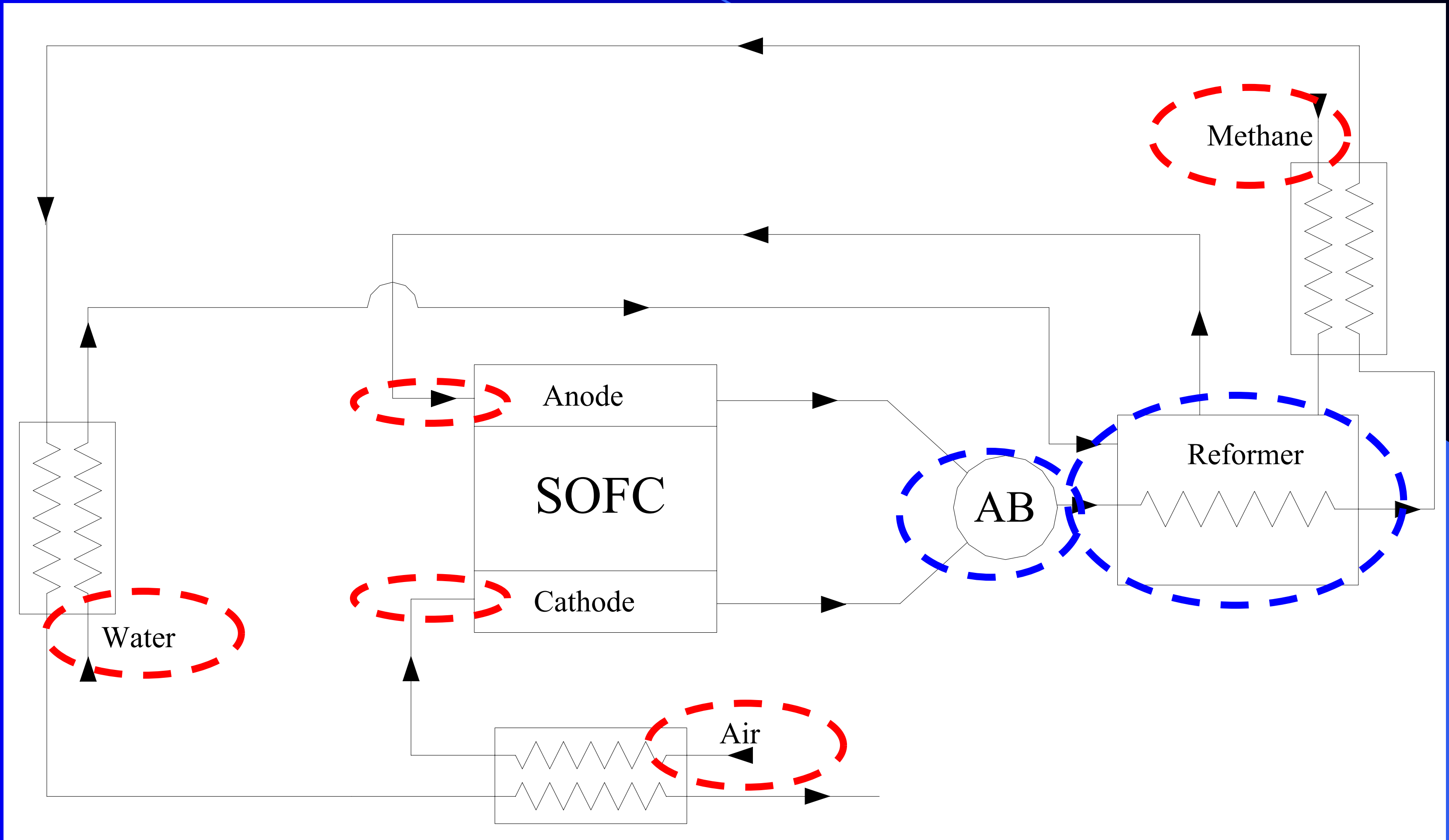
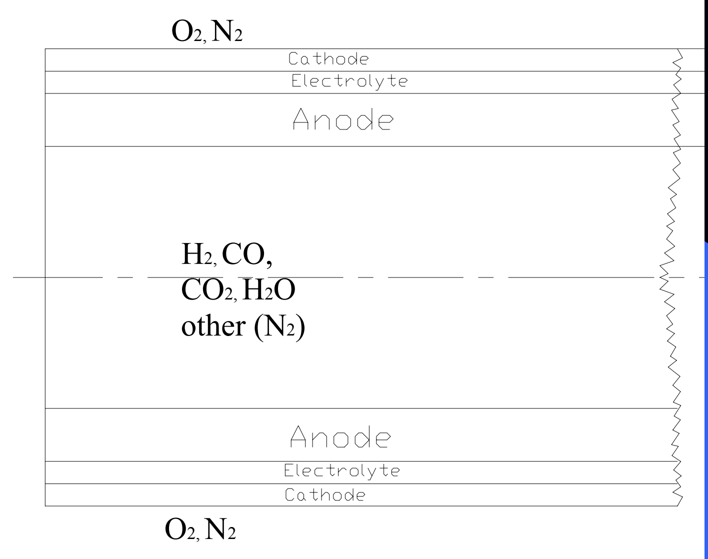
Definition of an SOFC System



Thermodynamic Simulation

- *The thermodynamic performance of the System is simulated using Aspen Plus*
- *The SOFC performance is modeled through an SOFC code, previously developed by the authors*



$$E(x) - V = \left(r + \Omega_{act}(x)\right) \cdot J(x)$$

$$u_f(x) = \frac{\frac{\pi D}{2F}\int_0^x J(\zeta)\,d\zeta}{n_{H_2}(0) + n_{CO}(0)}$$

$$\frac{B}{A} \cdot u_f + \frac{\left(-\frac{B}{a} \cdot C + \frac{A}{a} \cdot G + \frac{B}{a} \cdot V\right) \ln \frac{C - V + \frac{A}{a} \cdot u_f}{C - V}}{\left(\frac{A}{a}\right)^2} - \frac{1}{J_{in}} = 0$$

Economic Model: Assumptions

- *The system economics is compared to a reference case, characterized by a MARR*
- *Net Present Value (NPV) and Pay-Back-Time (PBT) are used as comparison tools*

Outcomes

$$NPV = -I_0 + \sum_{k=1}^{n} F_k \left(1 + MARR\right)^{-k}$$

$$F_k = \left(CoE \cdot W \cdot n_f\right) - \left(CoF \frac{W}{\eta_k \cdot LCV} + O\&M\right)$$

Incomes

$$\eta_k = \eta_0 \left(1 - 0.06k\right)$$

Degradation: 6%/year

Economic Model: Assumptions

$$I_0 = \alpha + \beta S$$ *Investment Cost*

Economic Reference Data

n_f	7680 h/yeat
β	17 cents/cm^2
System/Stack Cost factor	3
Stack Life-time	5 Years
CoF	3.1 cents/kWh
CoE	8 cents/kWh
MARR	7%
n	10 years
O&M	1 cent/kWh

SOFC Reference Data

Electric Power	200 kW
u_{ox}	0.2
u_f	0.6-0.8
Active Surface (S)	75-120 m^2
P	1 atm
T	800 °C
Fuel Type	Methane
LHV (kJ/kg)	47000
Steam to Carbon	2.5

Economic Model: Results

What is the maximum investment cost to achieve a desired PBT (NPV=0)?

PBT (years)	Io ($/cm^2)
1	0.035
2	0.066
3	0.095
4	0.123
6	0.141
7	0.160
8	0.177
9	0.193

A reduction of the BoP cost is needed!!

Conclusion

- *Starting from a thermodynamic model an economic model was developed*
- *The choice of the fuel utilization and stack dimensions are two crucial factors*
- *In order to be competitive, SOFC manufacturing costs must be reduced, as well as BoP costs*