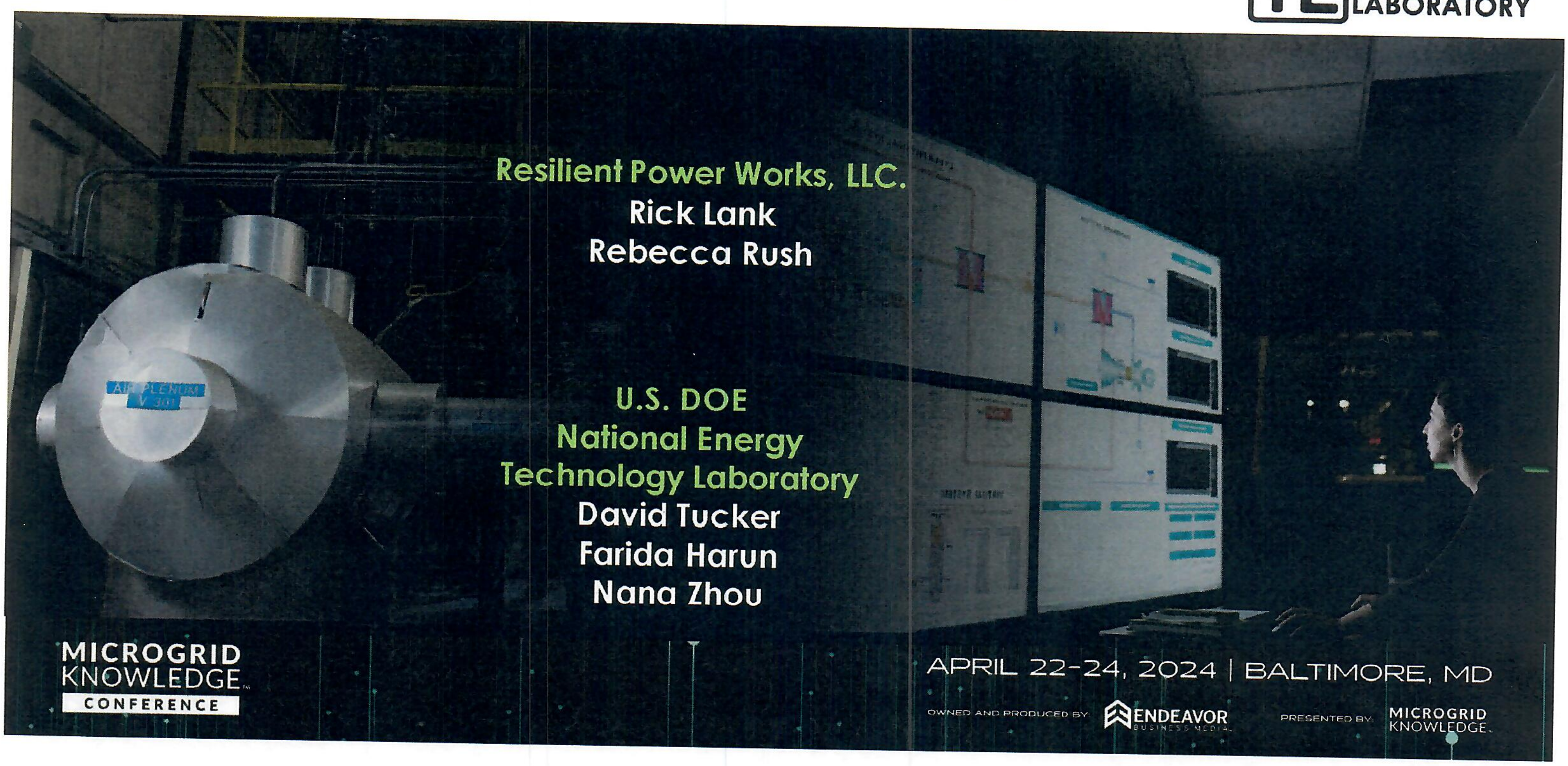
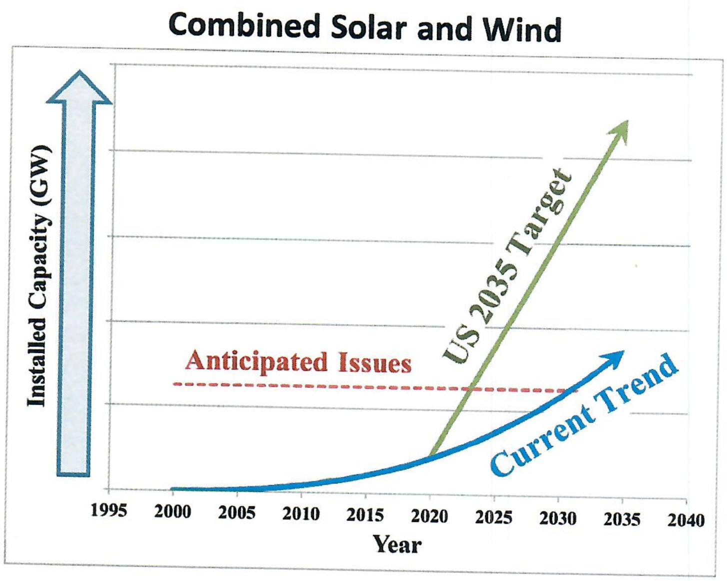
Control Development for Hybrid Systems

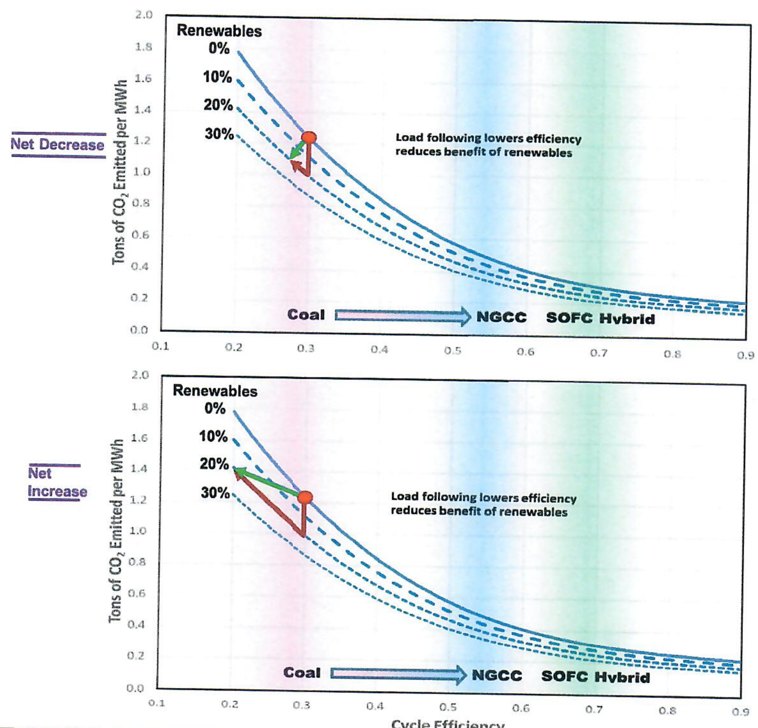
NATIONAL ENERGY TECHNOLOGY LABORATORY



Motivation

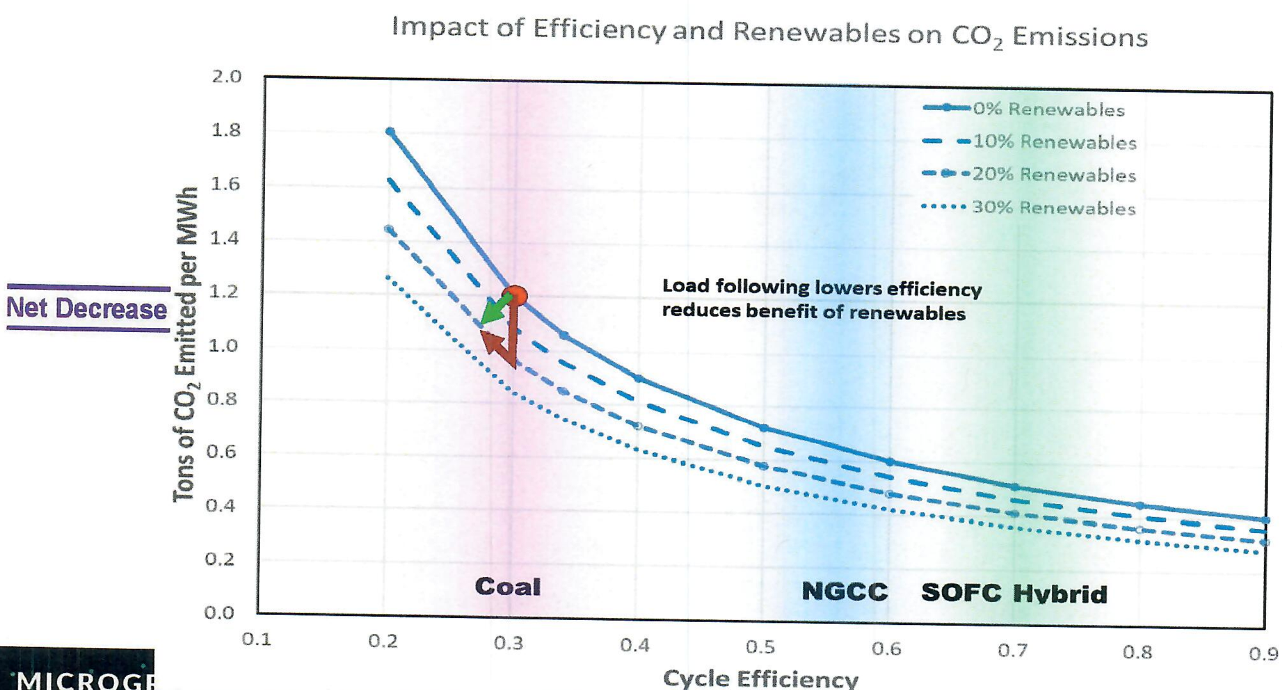


Combined Solar and Wind
Installed Capacity (GW)
US 2035 Target
Anticipated Issues
Current Trend
1995 2000 2005 2010 2015 2020 2025 2030 2035 2040
Year



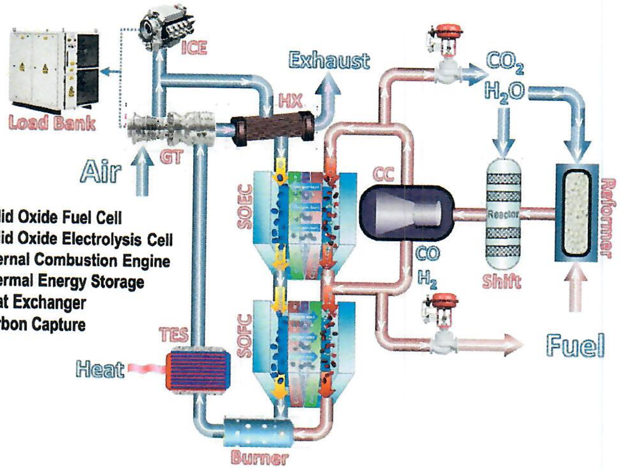
Net Decrease
Renewables
0%
10%
20%
30%
Load following lowers efficiency reduces benefit of renewables
Tons of CO_2 Emitted per MWh
Coal
NGCC
SOFC Hybrid
Net Increase
Renewables
0%
10%
20%
30%
Load following lowers efficiency reduces benefit of renewables
Tons of CO_2 Emitted per MWh
Coal
NGCC
SOFC Hybrid
Cycle Efficiency

Motivation



Impact of Efficiency and Renewables on CO_2 Emissions
Net Decrease
Tons of CO_2 Emitted per MWh
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Cycle Efficiency
0% Renewables
10% Renewables
20% Renewables
30% Renewables
Load following lowers efficiency
reduces benefit of renewables
Coal
NGCC
SOFC Hybrid

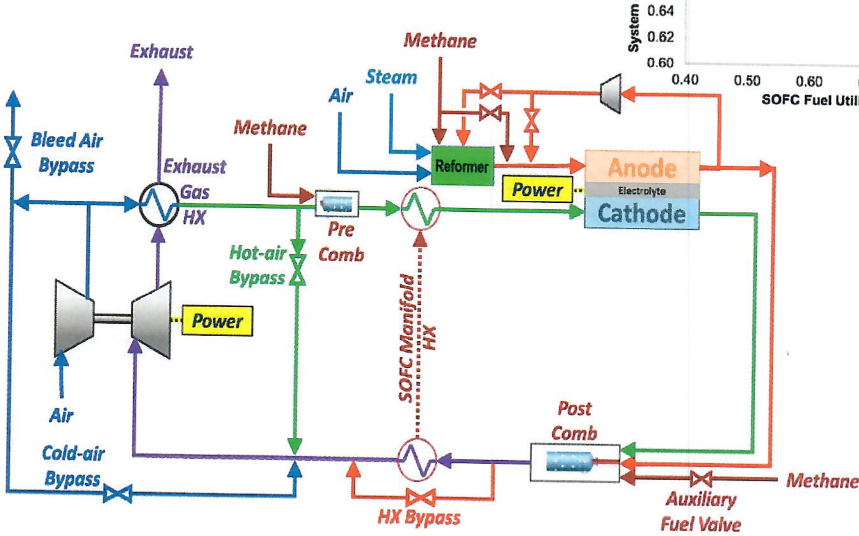
Novel Hybrid Concepts Needed

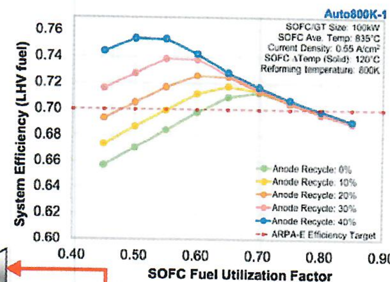


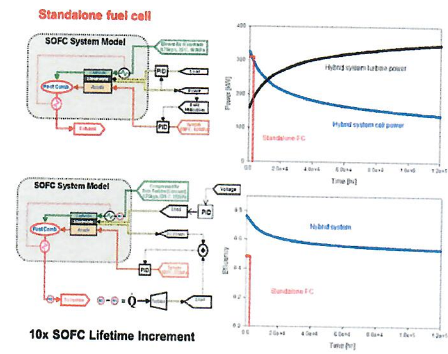
SOFC- Solid Oxide Fuel Cell
SOEC- Solid Oxide Electrolysis Cell
ICE- Internal Combustion Engine
TES- Thermal Energy Storage
HX- Heat Exchanger
CC- Carbon Capture

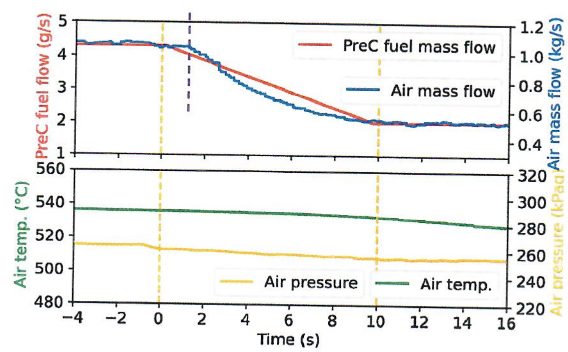
Achieving the highest efficiency and flexibility with the lowest emissions with Integrated Energy Systems

Hybrid Systems









Other Opportunities