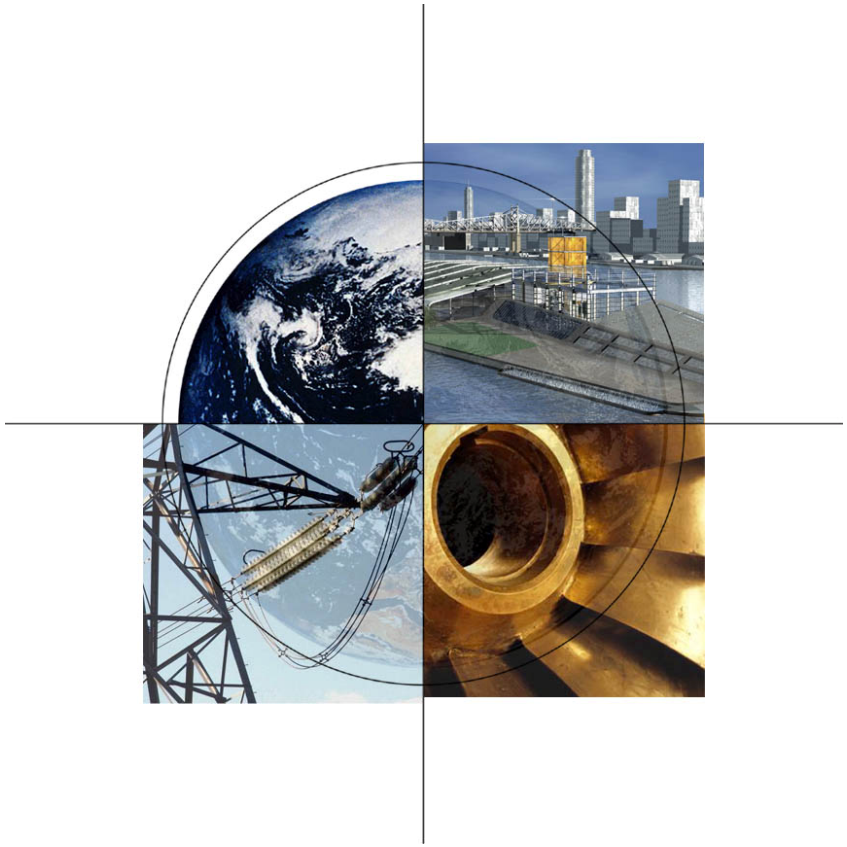
FE Turbine Program



R&D Opportunities for UTSR Program

Presented to:
UTSR Peer Review Workshop
Dinner Talk

October 18, 2005
Clemson, SC

Richard A. Dennis; Technology Manager
National Energy Technology Laboratory

Outline

- Goals (1)
- Approach / Contribution (2)
- Cycles (3)
- New Projects (1)
- Technical issues (2)
- Discussion (1)

DOE Fossil Energy Coal Program Goals

- ***Advanced Power Systems –***

  By 2010 develop advanced coal based power systems capable of 45 – 50 % efficiency at < $1000 / kW.

- ***Near Zero Emissions Energy from Coal –***

  By 2015 demonstrate future coal based energy plants that offer zero emissions (including CO_2) w/ multi product production (electricity and H_2).

Reference: August 2005 GPRA Program Plan

FE Turbine Program Contribution to Goals

2010 Advanced Power Systems Goal

- **Efficiency:** Demonstrate 2 – 3 % pts. improvement in combined cycle (CC) performance (above base line)

- **Cost:** Demonstrate a 20 – 30 % reduction in CC capital cost plus enhanced value for lower COE

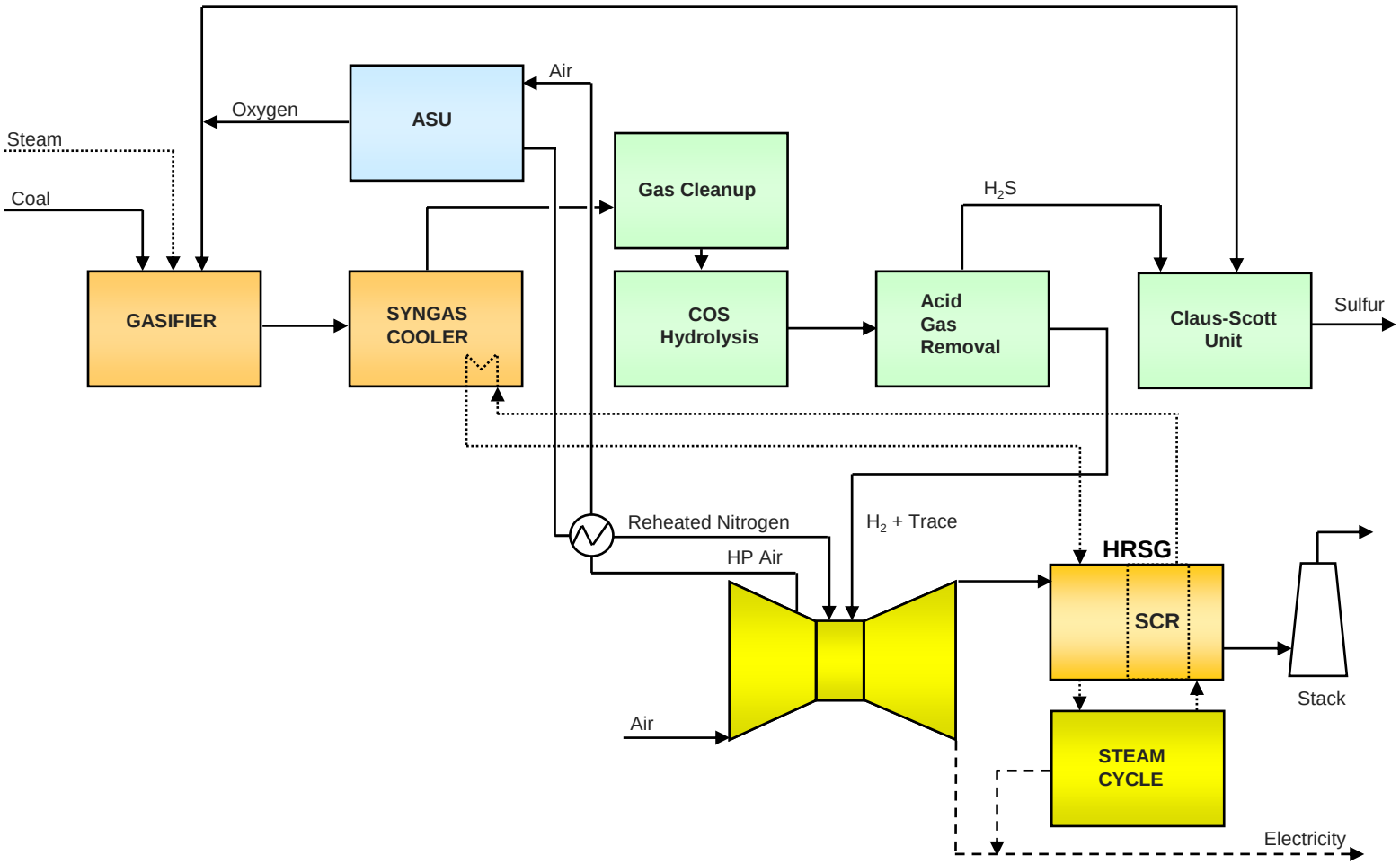
- **Emissions:** Demonstrate combustor emissions with 2 ppm NO_x (@15 % O_2) in simple cycle exhaust

FE Turbine Contribution to Goals
2015 Near Zero Emissions Energy From Coal

- **Efficiency**
  - Hydrogen turbine CC with 3 – 5 % pts. improvement above base line
  - Oxy-fuel turbine based IGCC system > 50 % eff. (HHV)
- **Cost:** Competitive COE for zero emission systems
- **Emissions**
  - H_2 Turbine based IGCC demonstrate w/ 2 ppm NO_x (@15 % O_2)
  - Oxy-fuel turbine based IGCC with zero emissions (100 % turbine exhaust captured and sequestered- zero criteria pollutants and CO_2)
- **Multi Products**
  - H_2 turbine based IGCC w/ higher capacity gasification
  - Oxy-fuel turbine based IGCC w/ multi-product production

Typical IGCC

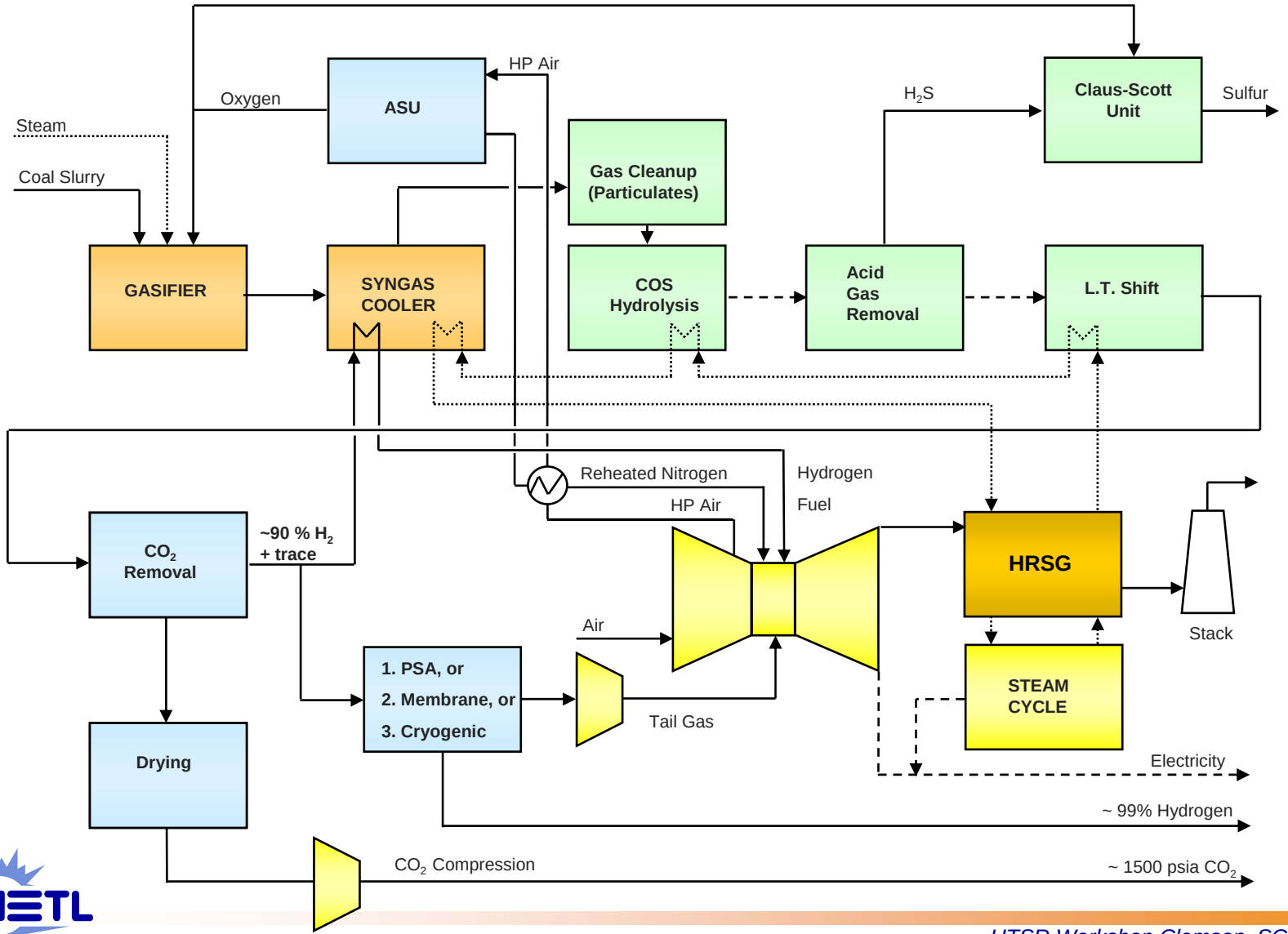
Combined Cycle Power Island for the 2010 APS Goal



Note: SCR shown for completeness, achieving the 2010 goal would do away with the need for an SCR

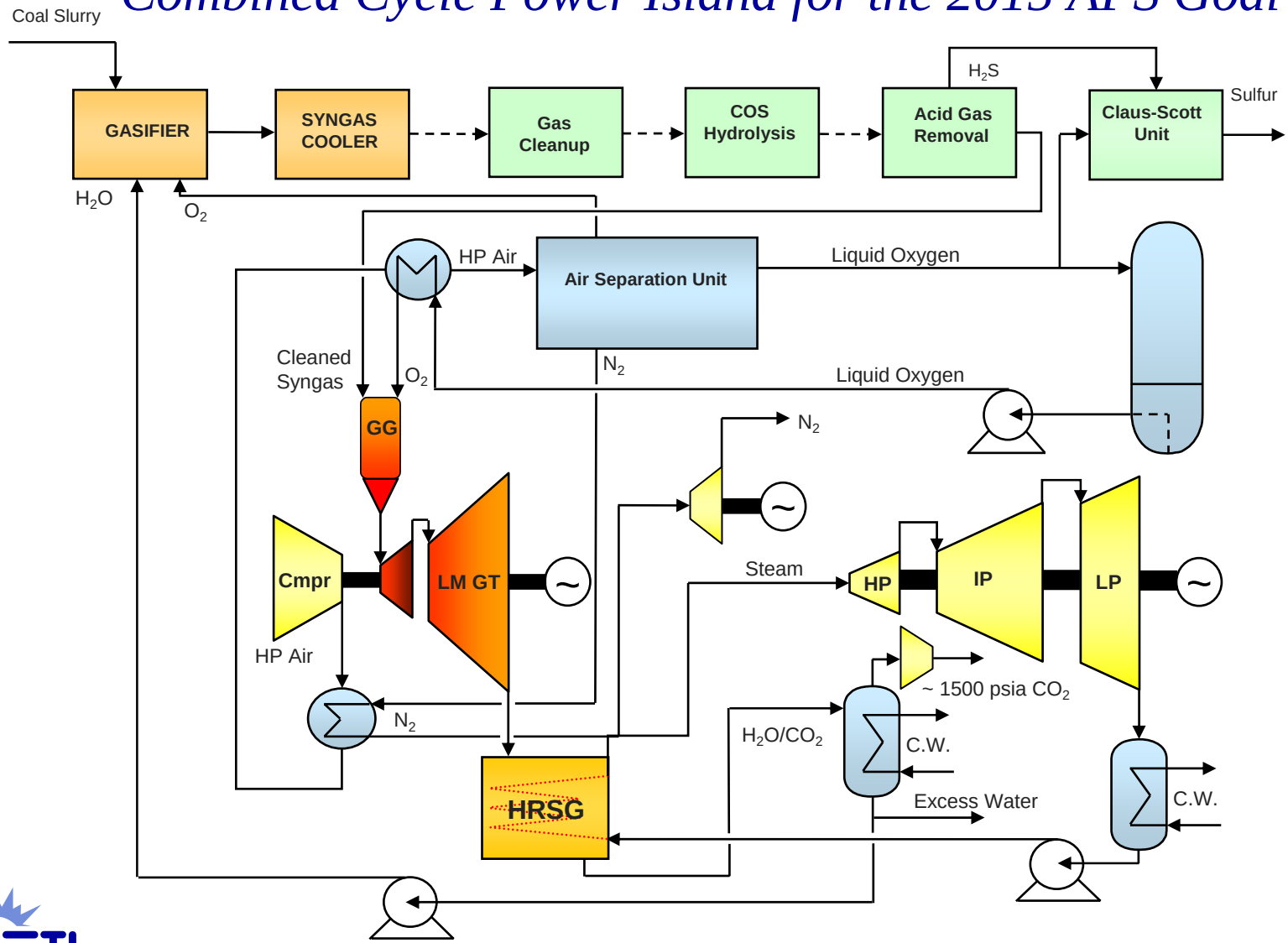
IGCC w/H_2 Production and CO_2 Removal

Combined Cycle Power Island for the 2015 APS Goal



IGCC Oxy-Fuel Turbine Cycle

Combined Cycle Power Island for the 2015 APS Goal



Resolving Technical Issues

Advanced Power Systems 2010 Goal

Approach	Benefit
1. Combustor for 2 ppm NO_X	1. Eliminates SCR and other penalties
2. More durable catalysis	2. Reduced O&M
3. H_2 Premixing	3. Enables low NO_X combustion
4. Higher TIT (~ Δ 210 F)	4. 1 % pt. to simple cycle per ~ 70 F
5. Better TBC materials	5. Higher TIT and less air extraction
6. Enhanced cooling	6. Higher TIT and less air extraction
7. Increase rotor torque limitation	7. Higher specific power reduced capital cost (~ 20 %)
8. Turbine / ASU integration	8. 0.5 - 1.0 % Pts., higher CAPX
9. Enhanced aerodynamics	9. Higher throughput & specific power
10. Ceramic parts	10. Higher TIT

New FE Turbine Program Projects

Turbine Program Key Activities	Contractor
Hydrogen Turbines For FutureGen	
Advanced IGCC/Hydrogen Gas Turbine Development	General Electric
Advanced Hydrogen Turbine for FutureGen	Siemens Power Generation
Catalytic Combustion for Ultra-Low NOx Hydrogen Turbines	Precision Combustion Inc.
Micro-mixing Lean Premix System for Hydrogen /Syngas	Parker Hannifin
Partial Oxidation GT for Power / H2 Co-Production from Coal	GTI
Advanced Oxy-Fuel Turbines for FutureGen	
Zero Emissions Coal Syngas-Oxygen Turbo Machinery	Siemens Power Generation
Coal-Based Oxy-Fuel Combustor / System Development	Clean Energy Systems
Advanced Research for FutureGen	
Analysis of Advanced Brayton Cycles for Zero Emission Plants	UC Irvine
Novel Concepts for the Compression of Large Volumes of CO2	SwRI
Super Sonic Shock Compression of CO2	Ramgen

Discussion Topics ?

- UTSR Research Topics
- FE 2010, 2015 and FutureGen Goals
- New Projects
- FE Turbine Budget
- Other