

DOE FE Hydrogen Turbine Program

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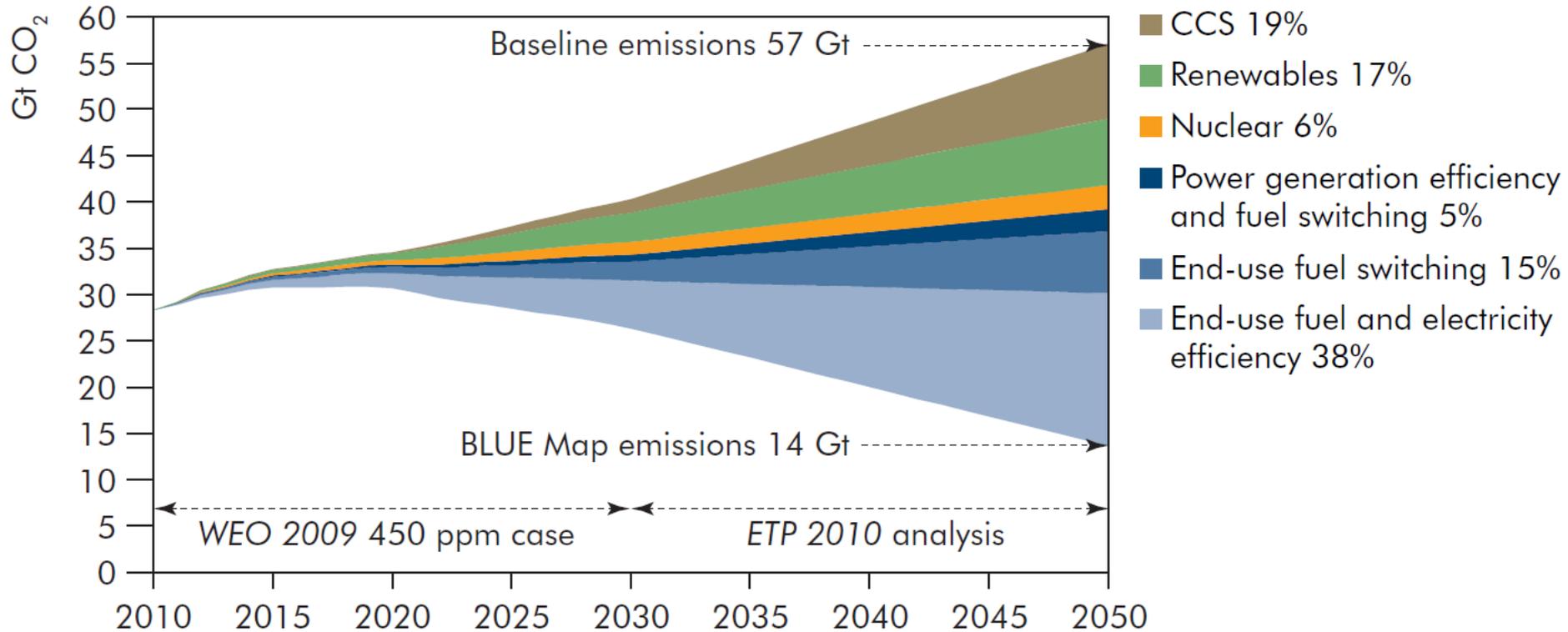
*2012 UTSR Workshop
October 2 - 4, 2012
Irvine, CA*



Presentation Overview

- **Turbine Technology Drivers**
- **H₂ Turbine Program**
 - Budget
 - H₂ turbine projects
 - UTSR
- **Summary and Discussion**

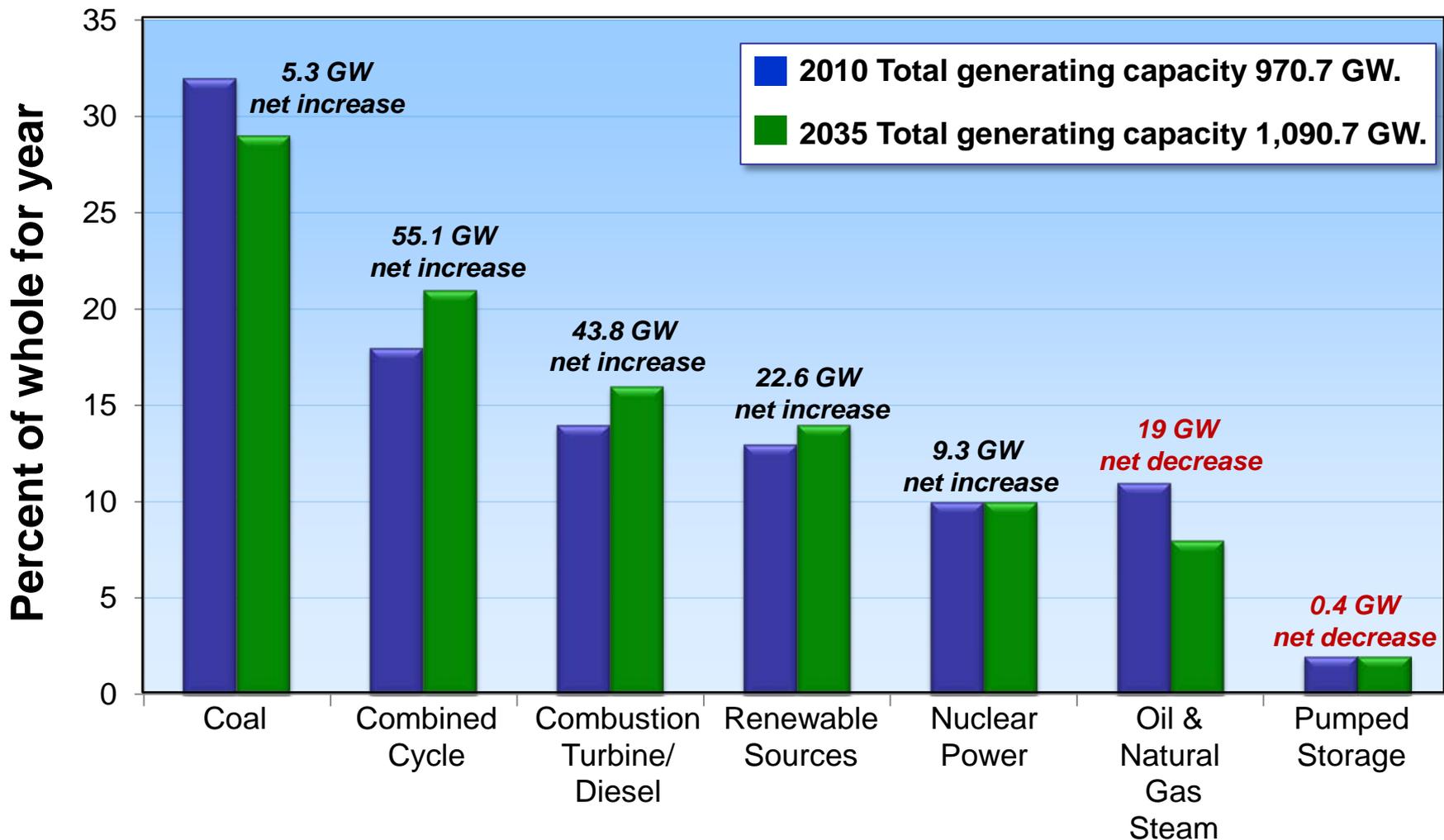
Approaches to Stabilizing CO₂ Emissions



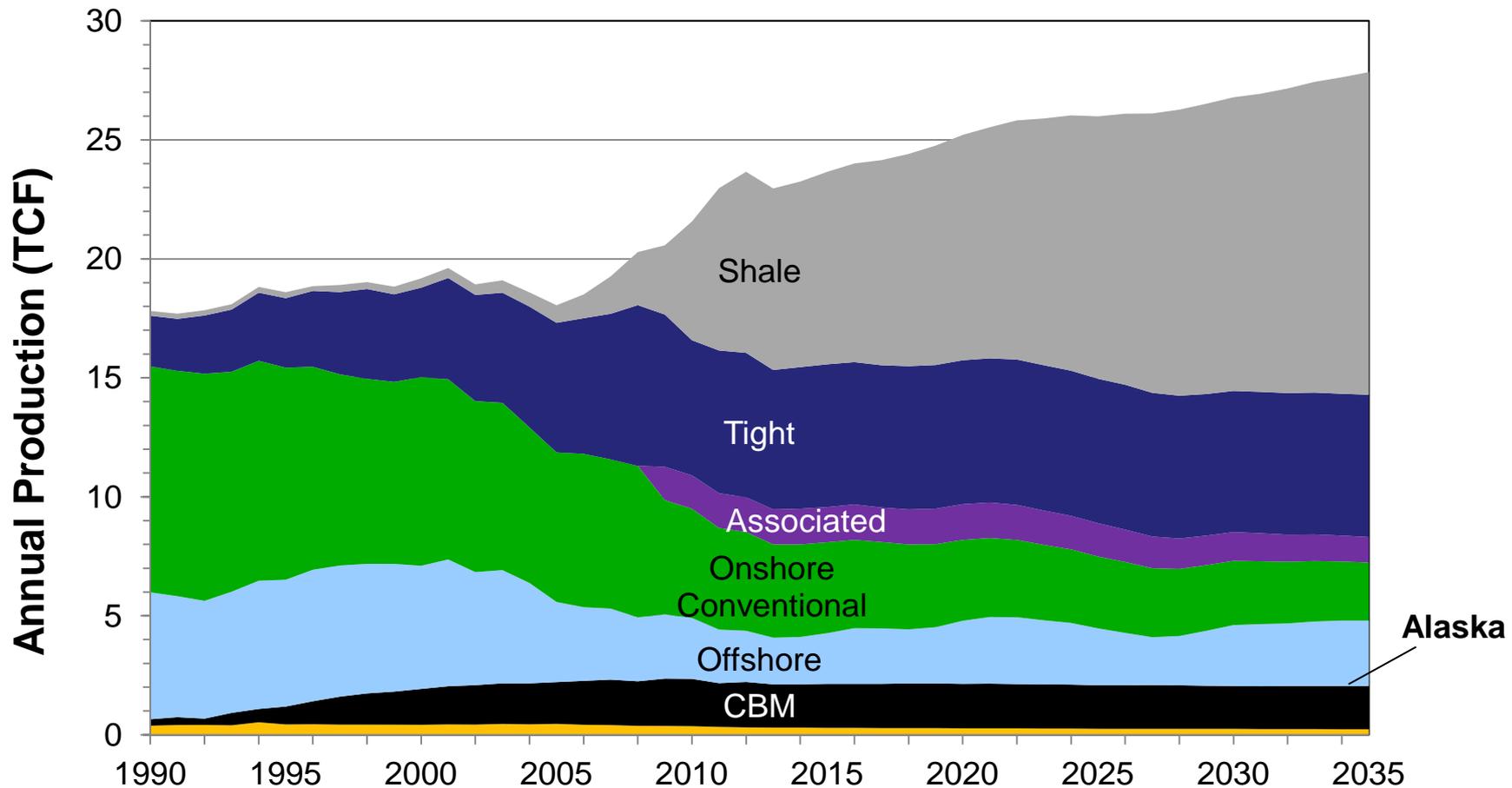
Source: IEA. *Energy Technology Perspectives 2010*.

Electricity Generating Capacity

(net summer capacity expected steady hourly output)

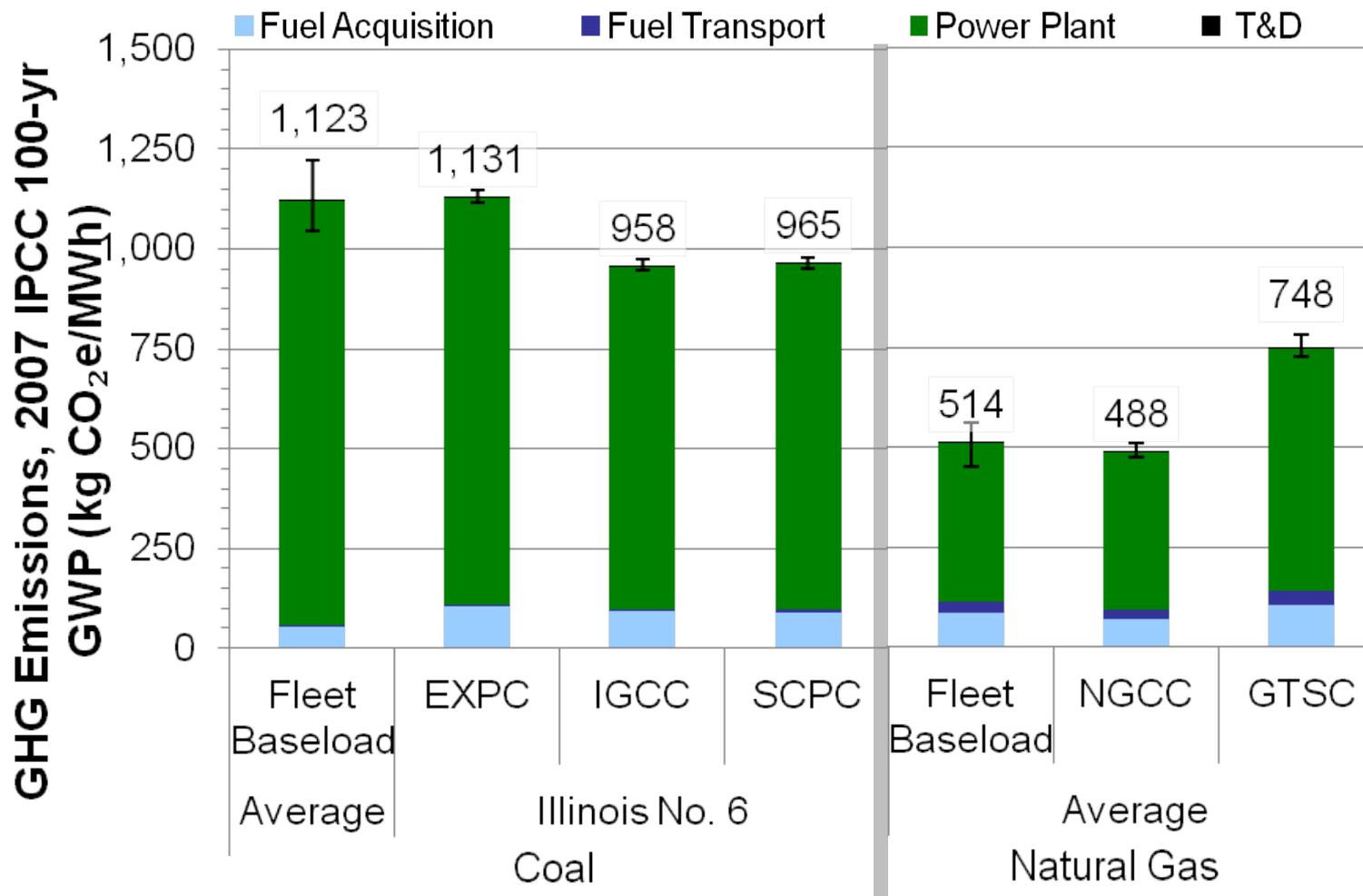


Natural Gas Resource Base and Growth



- NG demand 24.1 Tcf, projected 26.5 Tcf by 2035 (EIA, 2012a)
- Marcellus has ultimate recovery of 489 Tcf (Engelder, '09)

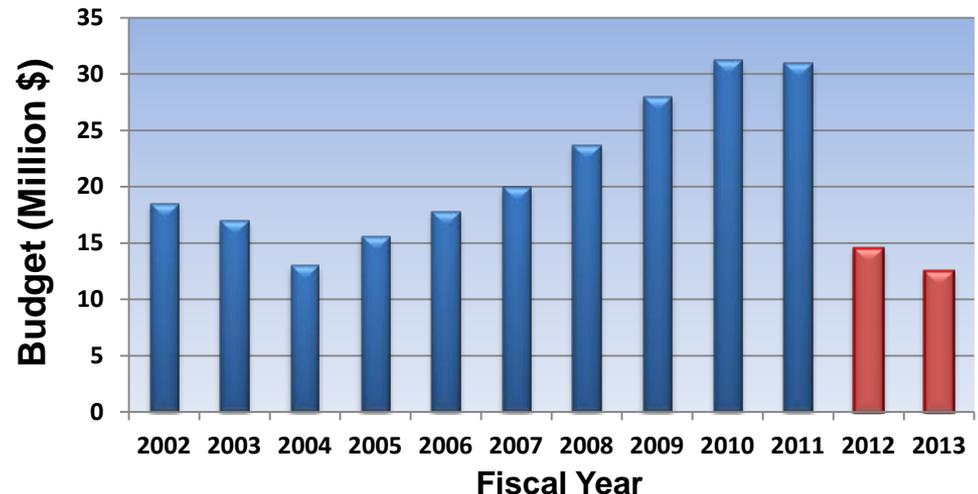
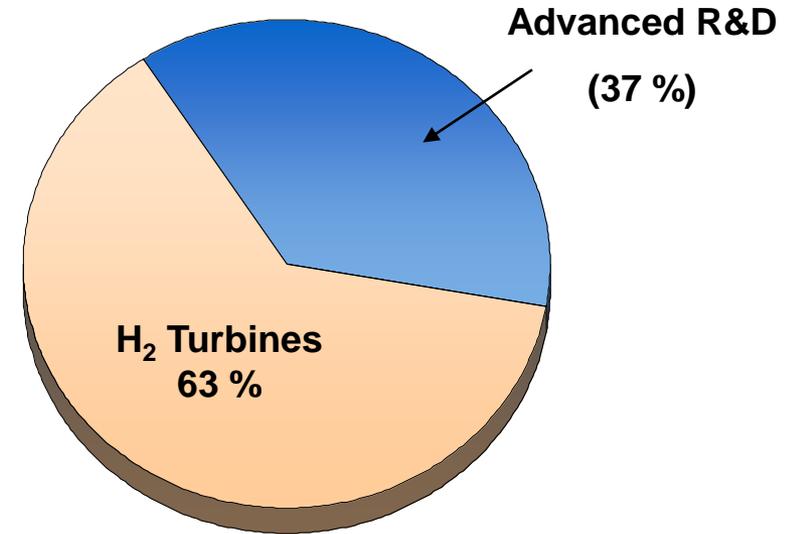
Global Warming Potential of Natural Gas and Coal Power



FE Advanced Turbine Budget / Projects

Fiscal Year 2012 Budget \$15 M

- **Hydrogen Turbines (\$9,411 k)**
 - Adv. H₂ Turbine (GE)
 - Adv. H₂ Turbine (Siemens)
- **Advanced Research (\$5,589 k)**
 - System Studies (NETL)
 - Combustion (LBNL)
 - HX Analysis (Ames and NETL)
 - Materials (ORNL and NETL)
 - Small Business Innovative Research
 - University Turbine Systems Research
 - Program Support

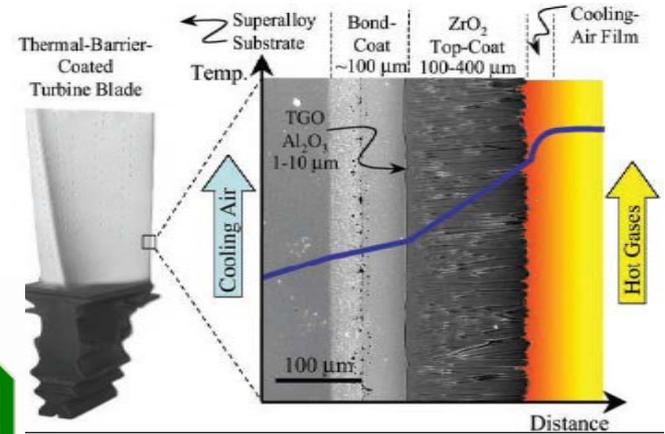


R&D Areas Advance Turbine Performance

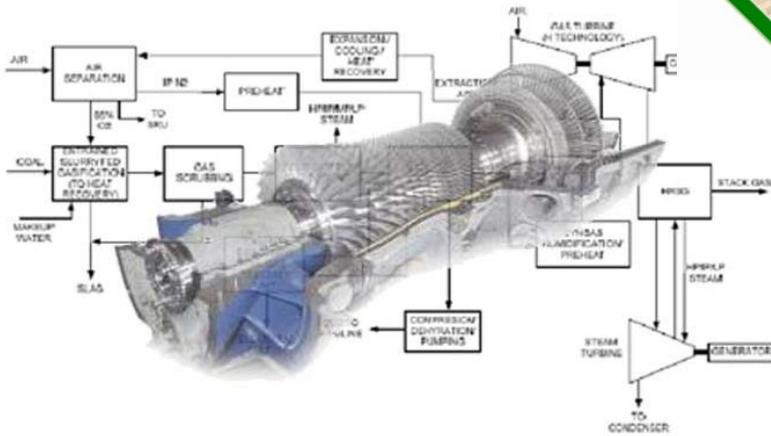
Combustion



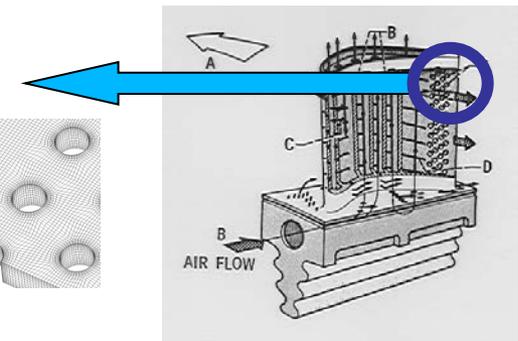
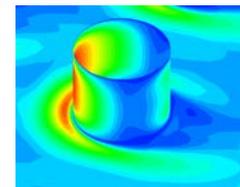
Materials



System Design



Aerodynamics & Heat Transfer



Expected Benefits to IGCC With CCS When Only the Turbine Improves

IGCC with 		2003 7FA-Based Reference	Advanced 2015 Machine	Delta	Delta (%)
Turbine Characteristics	Firing Temperature (F)	2257	2640	383	17%
	Pressure Ratio	16.5	22.8	6.3	38%
	Air Extraction (% of air feed to ASU)	0	15%		
	Turbine Exhaust Temp (F)	1033	1120	87	8%
	Exhaust Gas Flow (lbm/sec.)	1011	1304	293	29%
	Turbine Output (MW)	192	340	148	77%
Performance Measures					
Performance Measures	Net Power (MW)	440	815	375	85%
	Net Plant Efficiency (HHV)	31.1	35.4	4.3	14%
	Total Overnight Cost (\$/kW)	3793	2774	-1019	-27%
	COE (\$/MWh)	118.6	87.5	-31.1	-26%

H₂ Turbine Project Status

GE and Siemens H₂ Turbine Projects for IGCC with CCS

- **Phase II has an end date of 2014 – 15**
- **ARRA portion of these projects ends with Phase II**
- **Accomplishments:**
 - Hydrogen combustion
 - Advanced sealing components
 - Advanced material systems
 - Advanced airfoil core technologies
- **Phase III**
 - Would mean an FOA in

Status of University Turbine Systems Research

- **Currently 21 active UTSR projects**
 - Combustion (9)
 - Heat Transfer and Aero (4)
 - Materials (8)
- **Current plan is to implement a UTSR FOA in FY 2013**
 - OEMs and Universities can influence the topics through this workshop
- **University of Texas at El Paso and Purdue are under consideration for the UTSR workshop in 2013**
- **UTSR Fellowship is working very well**

Summary and Discussion

- **Gas turbine based power systems will be deployed in significant numbers over the next 20 years**
- **DOE's FE hydrogen turbine program is providing technology solutions**
- **Current plan is to issue a UTSR solicitation in FY 2013**