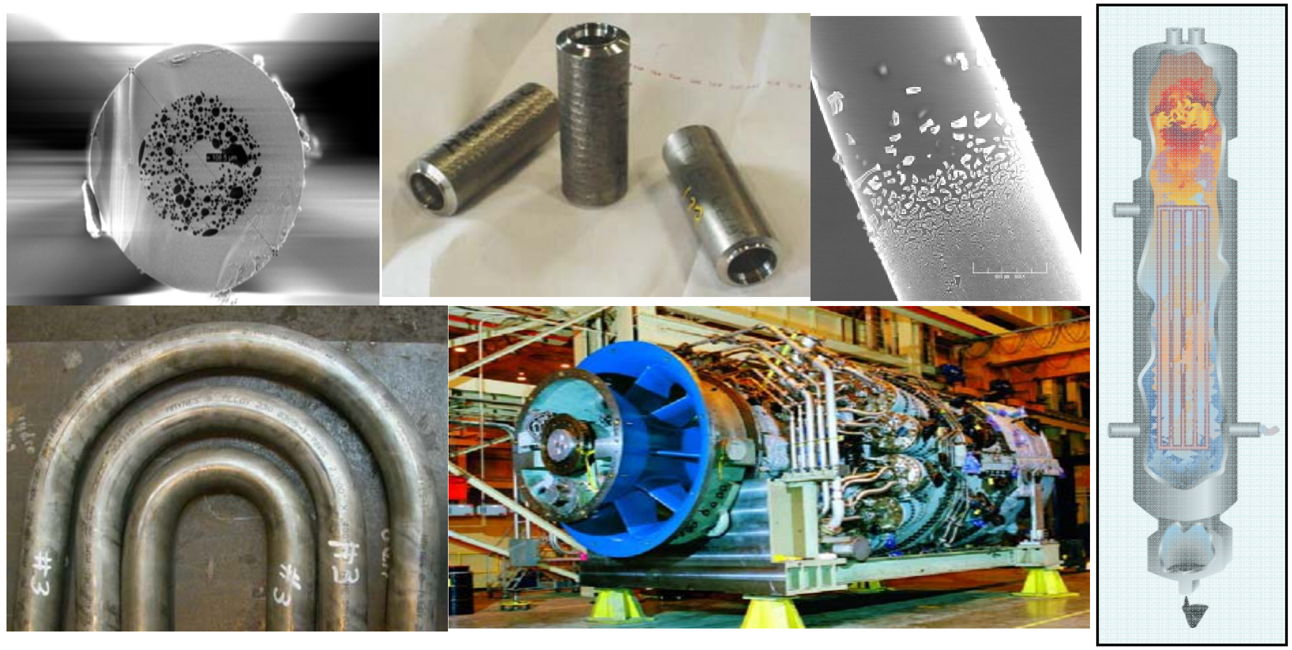
NATIONAL ENERGY TECHNOLOGY LABORATORY



23^{rd} Annual Fossil Energy Materials Conference

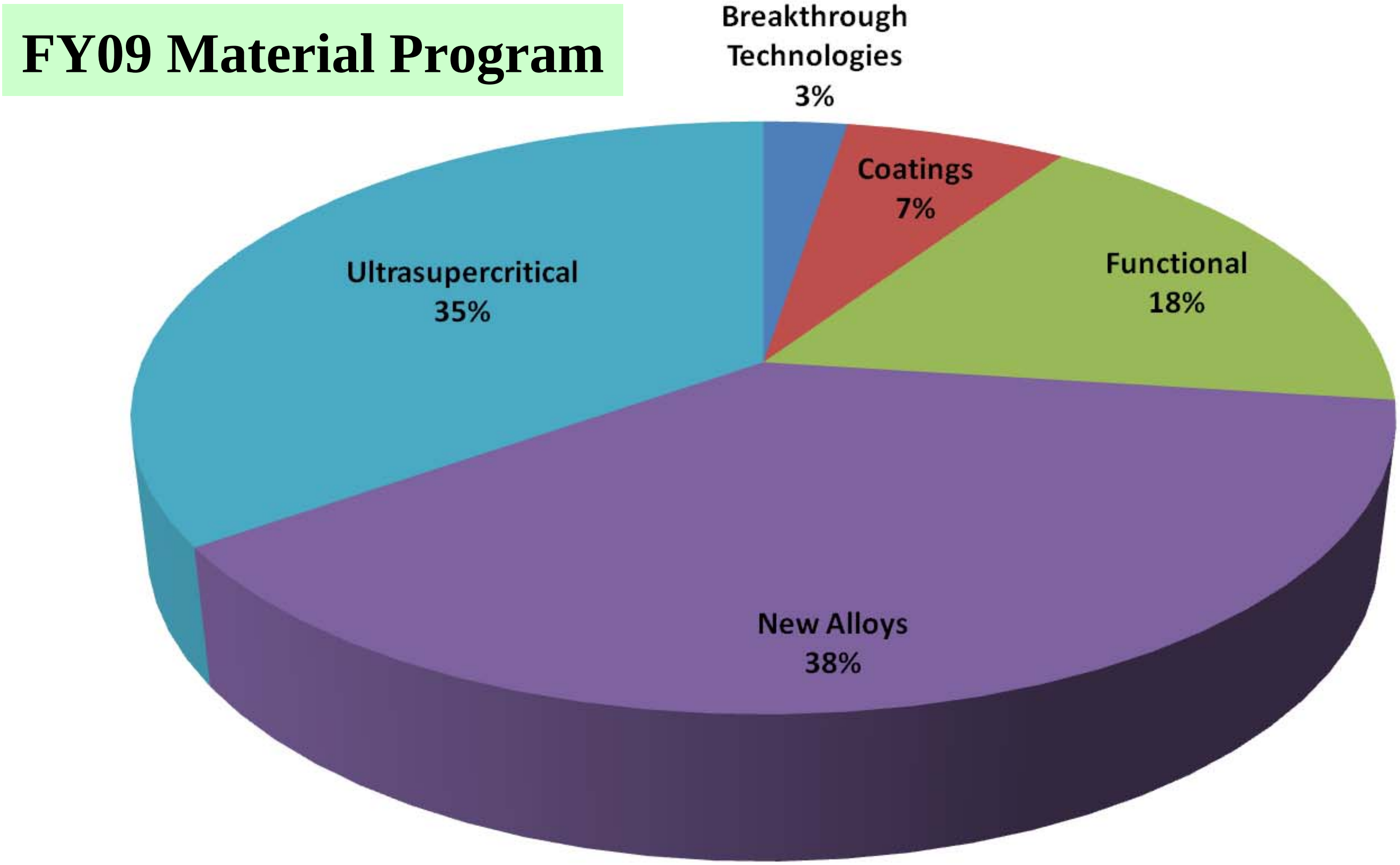
Robert R. Romanosky, Advanced Research Technology Manager

Pittsburgh, PA
May 12, 2009

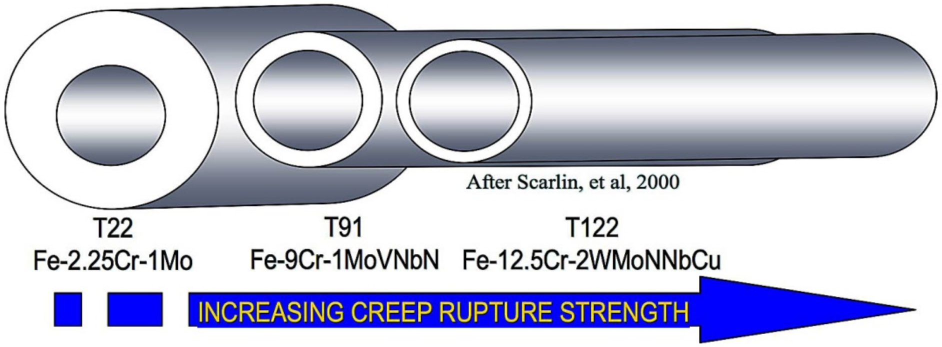
FE Materials Program Goals

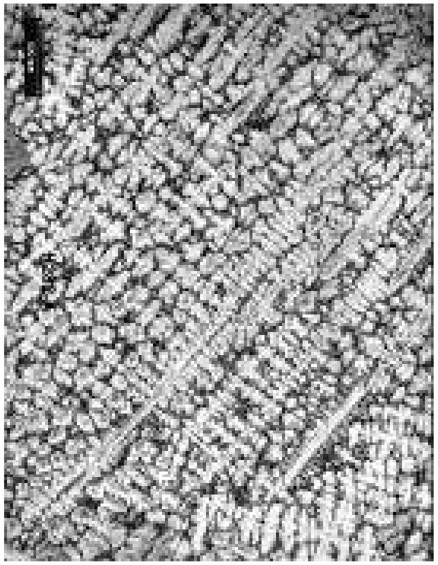
- **Development of new materials that have the potential to improve the efficiency, performance, and/or reduce the cost of existing technologies.**
- **Development of a technology base in the synthesis, processing, life-cycle analysis, and performance characterization of advanced materials.**
- **Development of materials for new systems and capabilities**.

Advanced Research Materials Program



New Alloys


After Scarlin, et al, 2000
T22
Fe-2.25Cr-1Mo
T91
Fe-9Cr-1MoVNbN
T122
Fe-12.5Cr-2WMoNNbCu
INCREASING CREEP RUPTURE STRENGTH

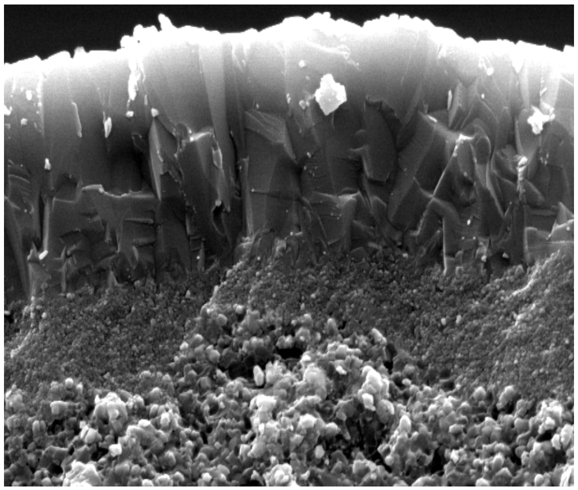


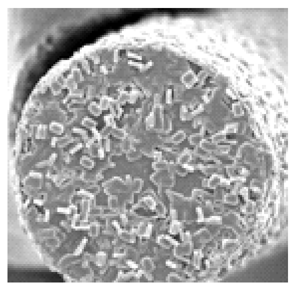
New Alloys Direction

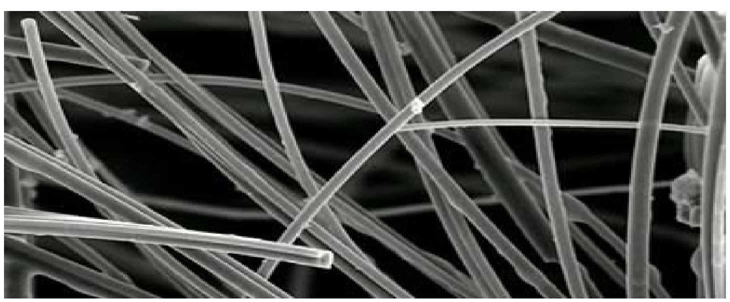
- **Development of Alumina-Forming Austenitic Stainless Steels**
  - Approach: Al_2O_3-forming austenitic stainless steels

- **Room-Temperature Ductility Enhancement of Mo Alloys with Nano-Sized Metal Oxide Dispersions**
  - Investigate the ability to enhance the room-temperature ductility of molybdenum (Mo) based alloys by the inclusion of candidate nano-sized metal oxide dispersions

Functional Materials



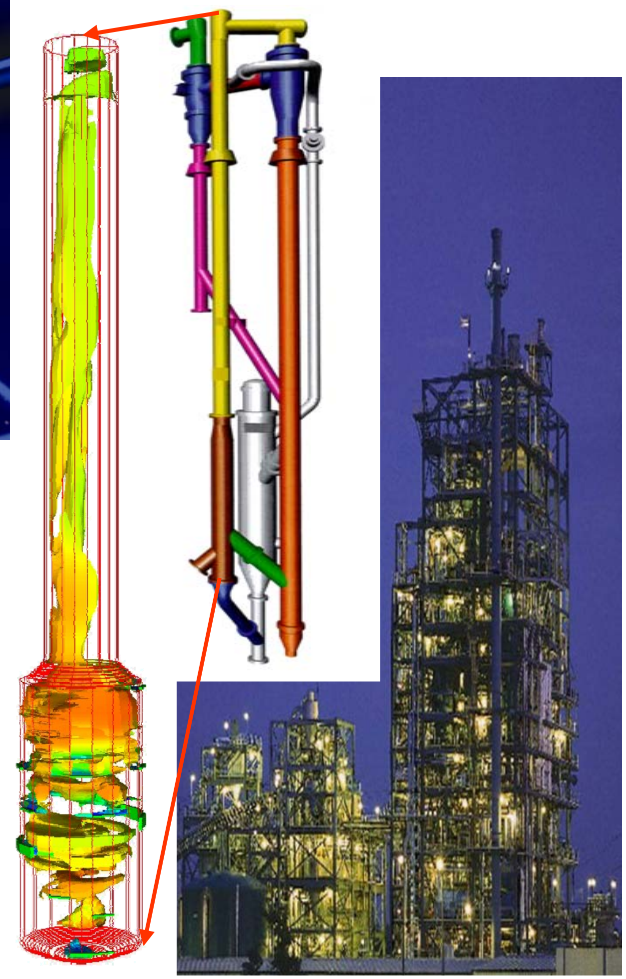




Refractory Development Direction

- **Develop refractory materials that have the performance to enable fuel flexibilitity**
  - **NETL has developed and scaled up with refractory producers non-Cr_2O_3 compositions determined to have high potential for gasifier use *(contain mixtures of MgO, Al_2O_3, ZrO_2)***
  - **Discussions are underway for limited field trials at a commercial gasifier (targeting in 2-3 months)**
  - **Depending on field trials – compositions will be refined or scaled up for additional testing (6-12 months)**

Breakthrough Concepts

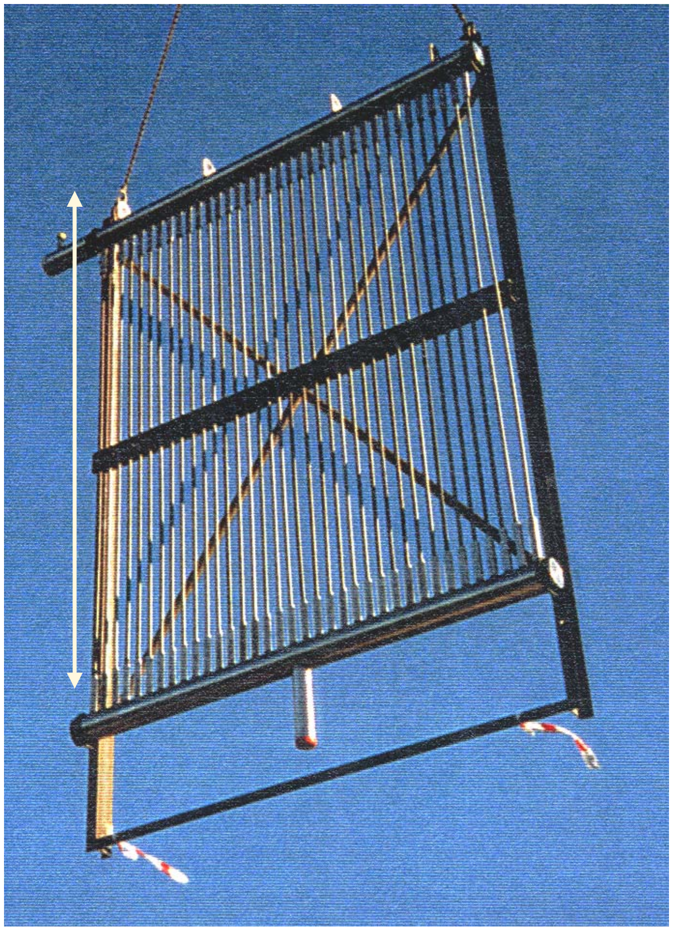


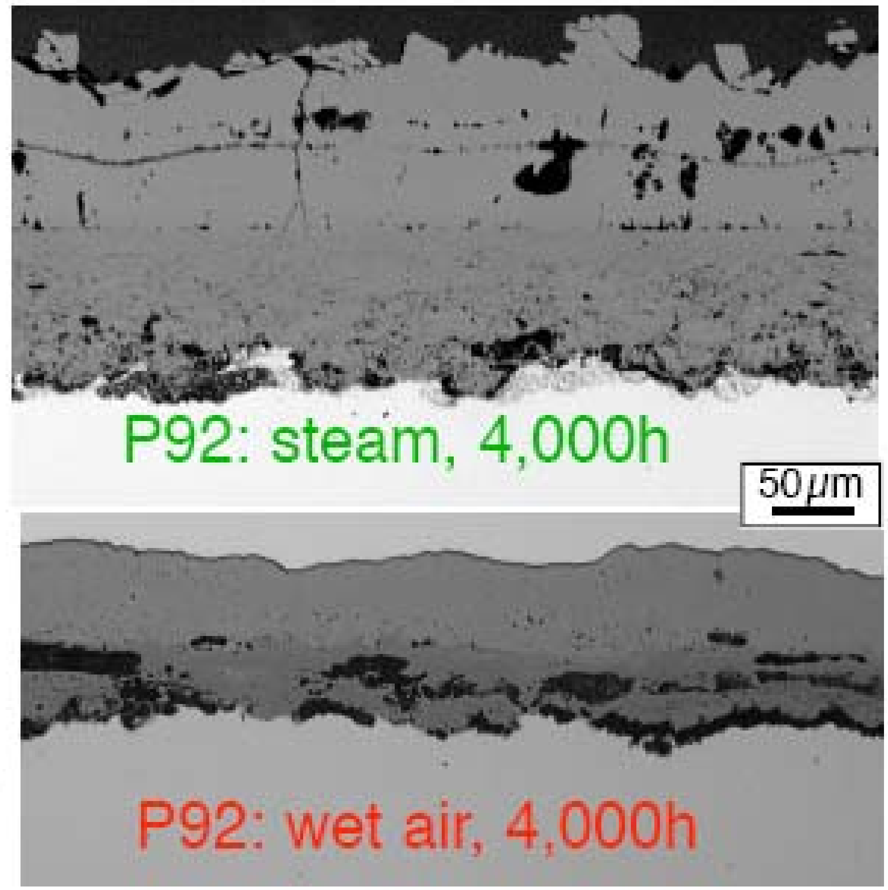
MFIX simulation of pilot scale KBR/Southern transport gasifier

Breakthrough Concepts Direction

- **Integrated Design of Refractory Metal Based Alloys for Fossil Energy Applications**
  - Develop refractory metal based alloys utilizing an integrated design approach
- **Computational Materials Design with Experimental Verification**
  - Combine computational materials development with experimental verification to engineer new high-performance materials

Coatings





- COST 501/British Gas
- Alloy ODM751
- Run at >1100°C for several thousand hours

Coatings Direction

- **Investigate critical issues associated with aluminide coatings on Fe-base alloys & Ni-based superalloys**

- **NDE Methods for Thermal Barrier Coatings**
  - Monitor TBC degradation and predict lifetime
  - Assess TBC reliability and product quality

UltraSuperCritical Materials

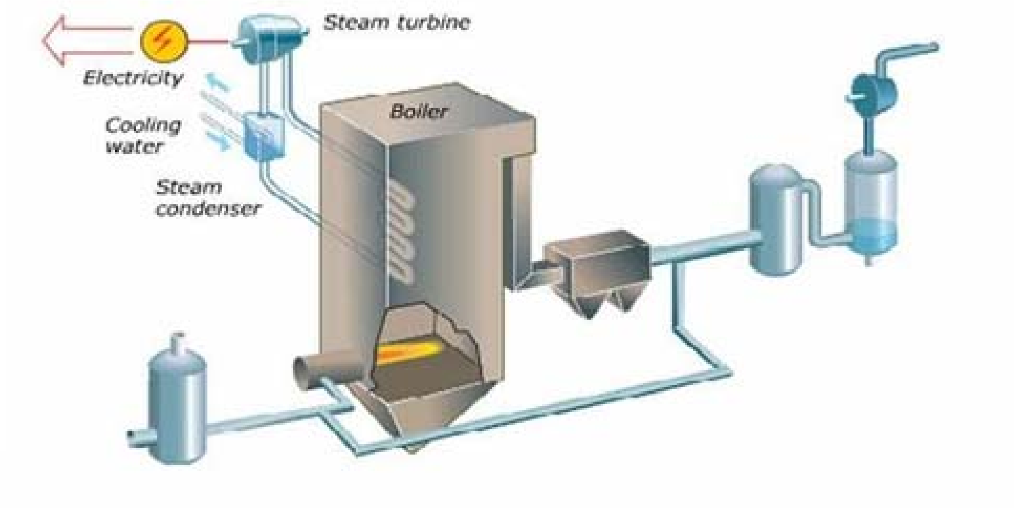
Current USC R&D Efforts

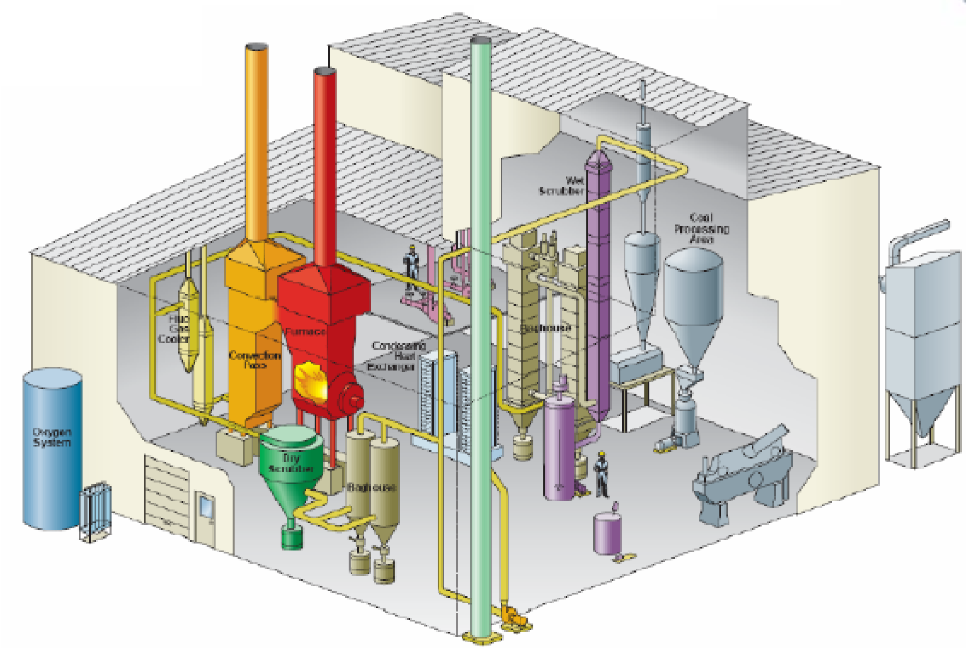
- Current technology for U.S. Boilers
  - Typical subcritical = 540 °C
  - Typical supercritical = 593 °C
  - Most advanced supercritical = ~610 °C
- Advanced ultrasupercritical (USC) DOE goal for boiler and turbine materials capable of:
  - 760 °C (1400 °F)
  - 5,000 psi (35 MPa)
  - Oxygen firing
- Ultrasupercritical plant advantages:
  - Higher efficiency - 45 to 47% HHV
  - Decreased emissions - ~ 20%
  - CO_2 capture ready with oxy-firing
- Meeting these targets requires:
  - The use of new materials
  - Novel uses of existing materials

USC Steam Boiler

- material evaluation and process development
- long-term material properties evaluation
- long-term degradation of materials due to fabrication processes
- microstructural evolution of alloys
- modeling of materials
- fundamental and applied materials research to address all materials issues related to using these alloys at 760 °C

Oxy-fired Materials

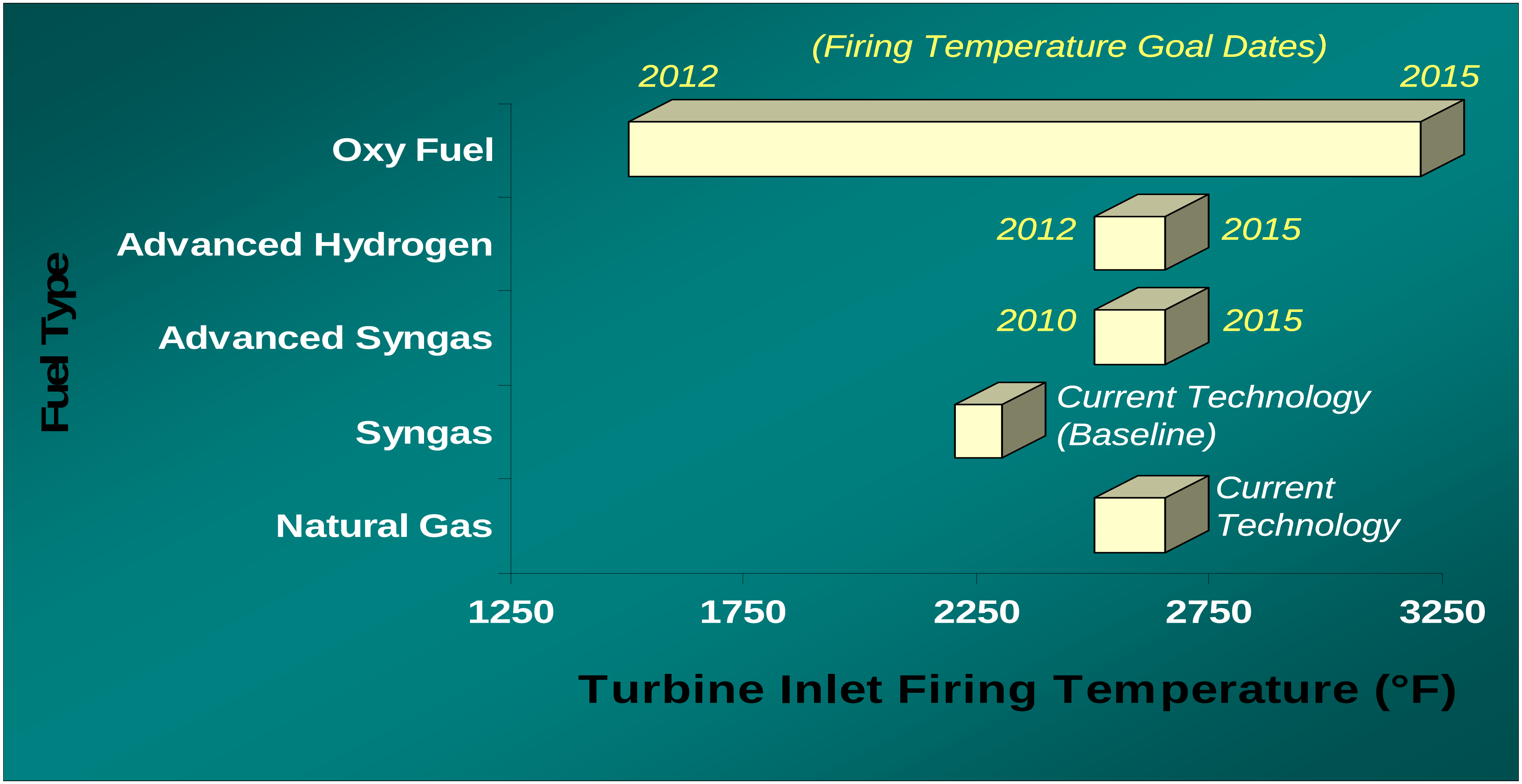




Materials Performance in CO2 and CO2-Steam Environments

- **Evaluate oxidation/corrosion performance of metallic structural alloys in pure CO2 and in CO2-steam environments over a wide temperature range**
- **Establish the kinetics of scaling and internal penetration, if any, and develop correlations for long term performance**
- **Identify viable alloys for structural and gas turbine applications**
- **Evaluate the influence of exposure environment on the mechanical properties (especially creep, fatigue, and creep-fatigue) of the candidate alloys**

Turbines



(Firing Temperature Goal Dates)
2012
2015
Oxy Fuel
Advanced Hydrogen
2012
2015
Advanced Syngas
2010
2015
Syngas
Current Technology
(Baseline)
Natural Gas
Current
Technology
Fuel Type
1250
1750
2250
2750
3250
Turbine Inlet Firing Temperature (°F)

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