United States Advanced Ultra-Supercritical Component Test Facility for 760°C Steam Power Plants

ComTest Project

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IEA Clean Coal Centre
3rd Workshop on AUSC Power Plant
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Goals: The A-USC ComTest Project will lead to…

- **Higher efficiency** for new and existing fossil fuel plants
  - 10% above today's new state-of-the-art coal power plants, and
  - 25% above that of the average power plants in the U.S. existing fleet
- **Lower emissions** (NOx, SOx, CO_2)
- **Minimized risk** for utilities desiring to build A-USC plants
- Support for design of **A-USC steam turbine** at 760ºC
- Accelerated development of U.S. domestic **supply chain** for advanced materials and components
- **Validation of technology** applicable to fossil, nuclear, sCO2, and renewable power generation options, all targeted by the U.S. DOE NETL Cross-Cutting Research Technology Program

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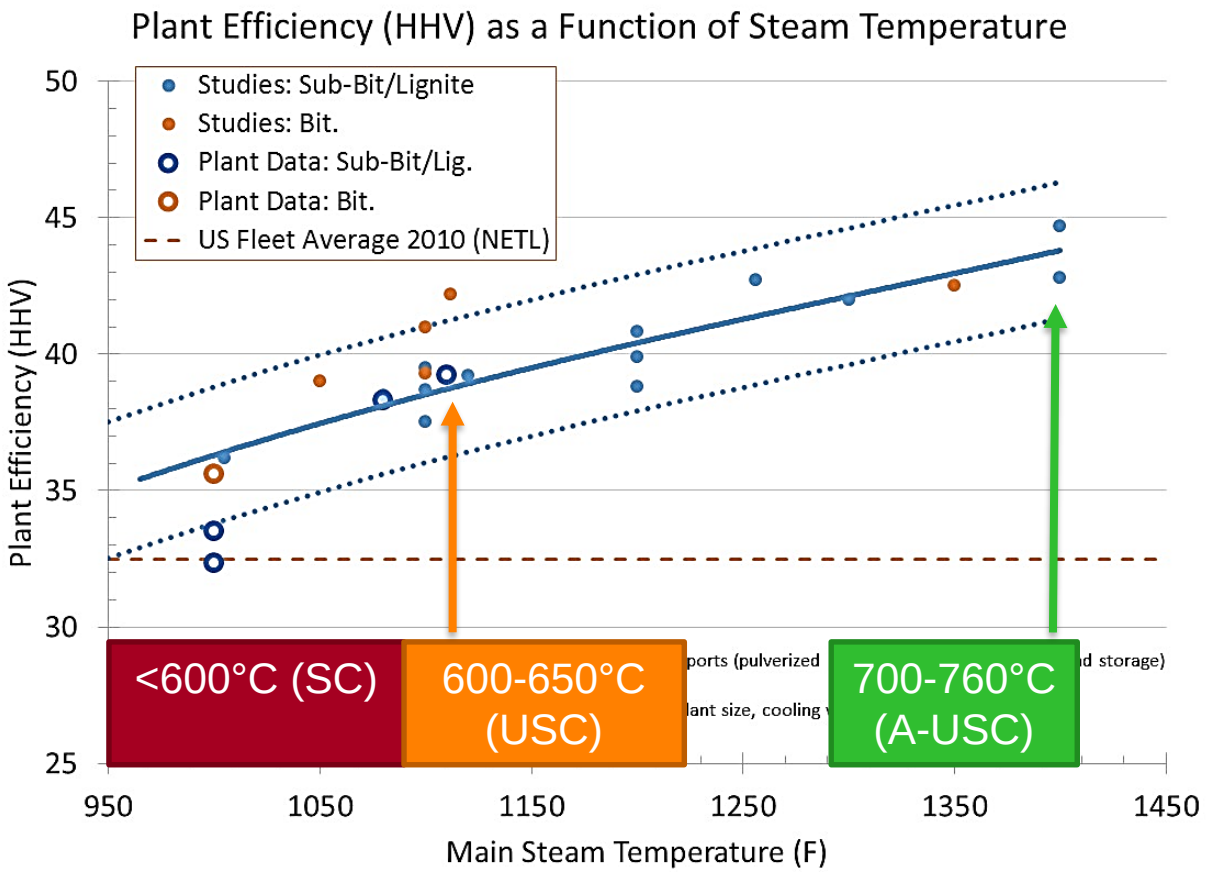
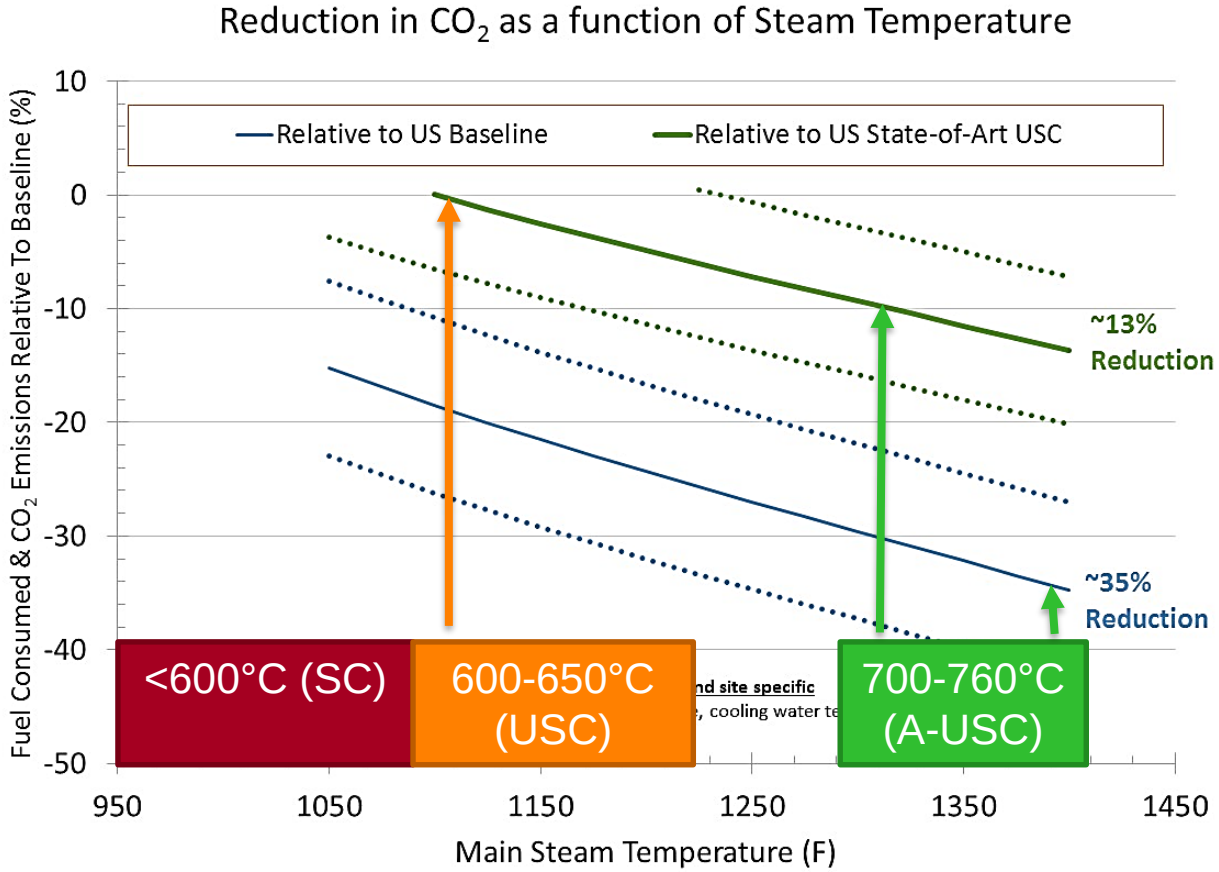
Motivation for A-USC Coal-Fired Power Plants





<u>Increased Efficiency is a Least Regret Strategy for CO_2 Reduction</u>

Studies show A-USC = 10-35% reduction in CO_2 compared to current plants

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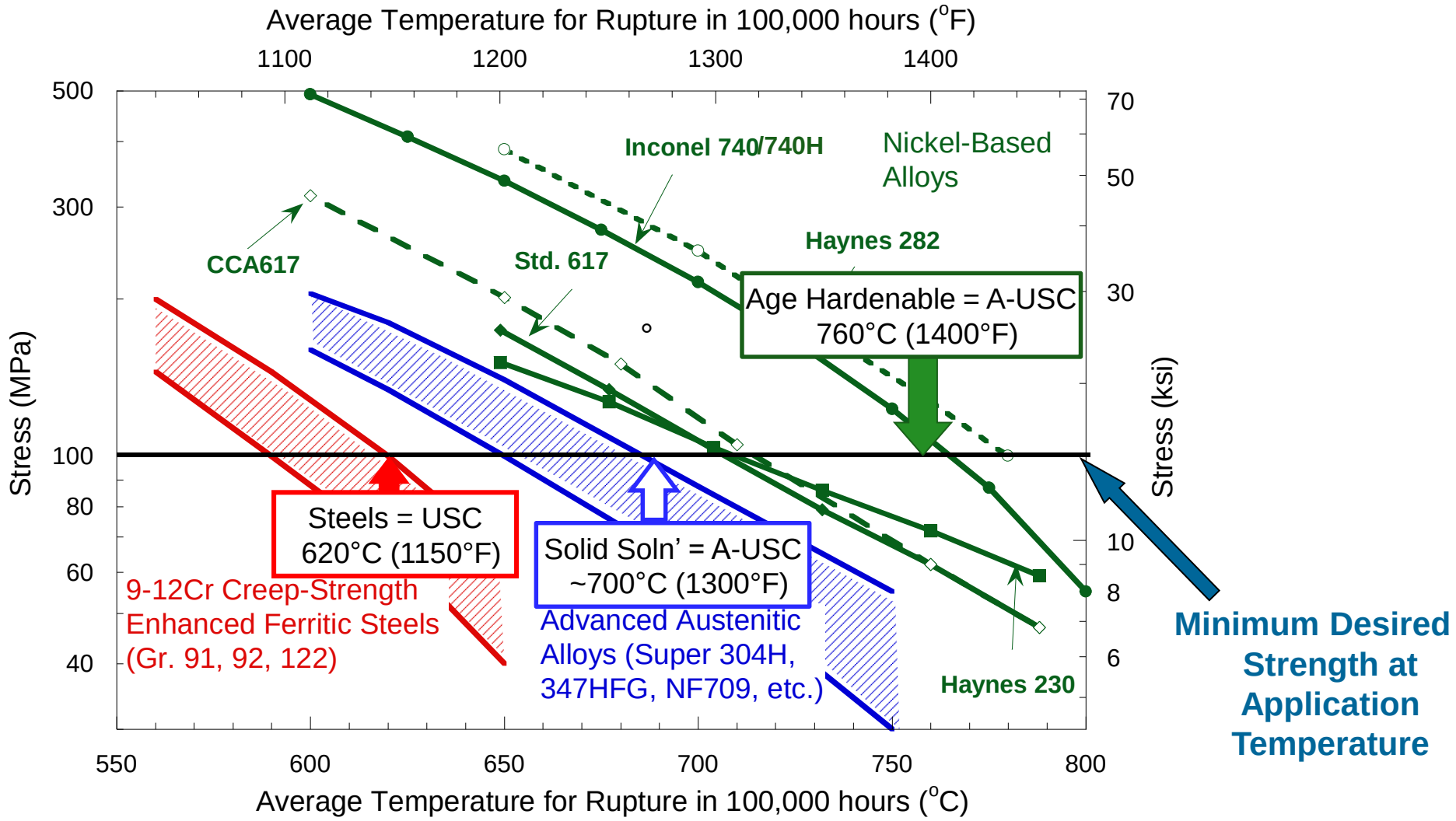
Materials Limit the Current Technology:

Today's State-of-the-Art (USC) Coal-Fired Power Plants are defined by steel technology



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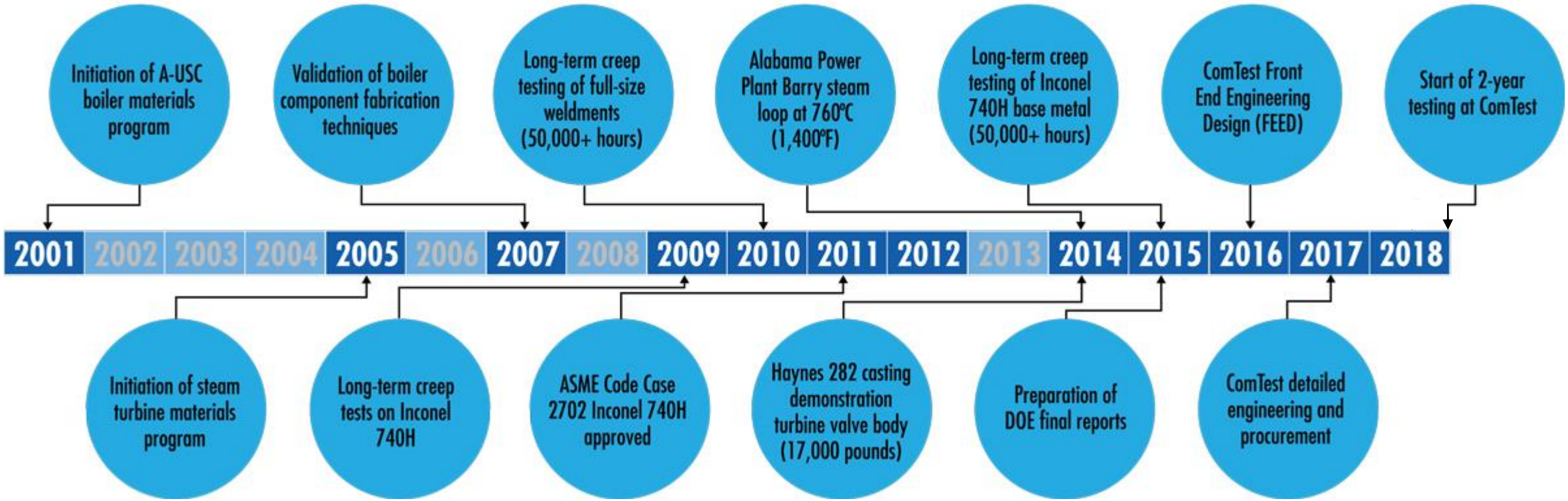
History of A-USC Materials Programs in U.S. ComTest is the Next Step for A-USC Technology



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Background of A-USC Materials Programs

- Present work builds upon 15-year effort supported by U.S. Department of Energy, Ohio Coal Development Office, and industry participants
  - Boiler Materials for Advanced Ultra-supercritical Coal Power Plant
    - DOE Contract: DE-FG26-01NT41175
    - OCDO Grant: CDO-D-05-02(A)
  - Materials for Advanced Ultra-supercritical Steam Turbines
    - DOE Contract: DE-FE0000234
    - OCDO Grant: CDO-D-05-02(B)

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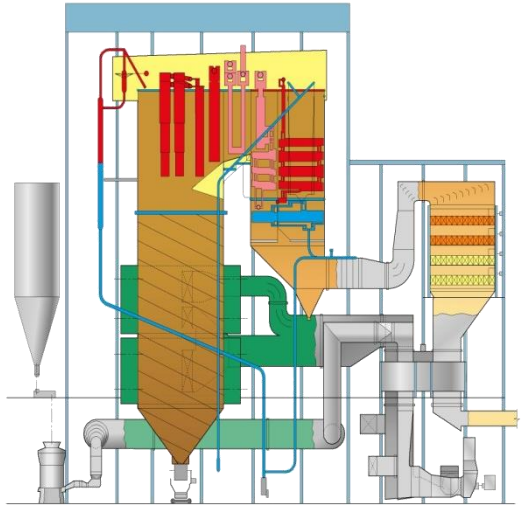
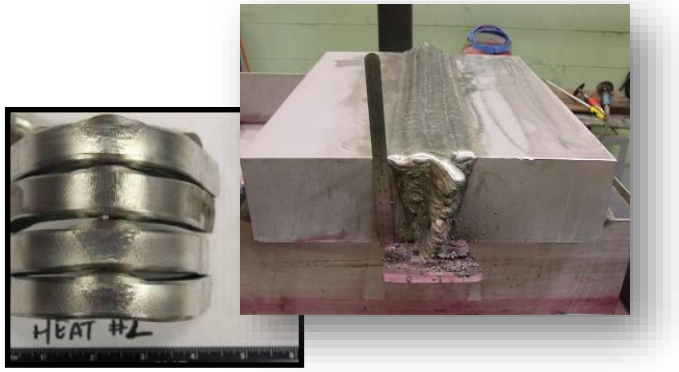
Tasks Completed in A-USC Materials Programs

General design studies show favorable economics



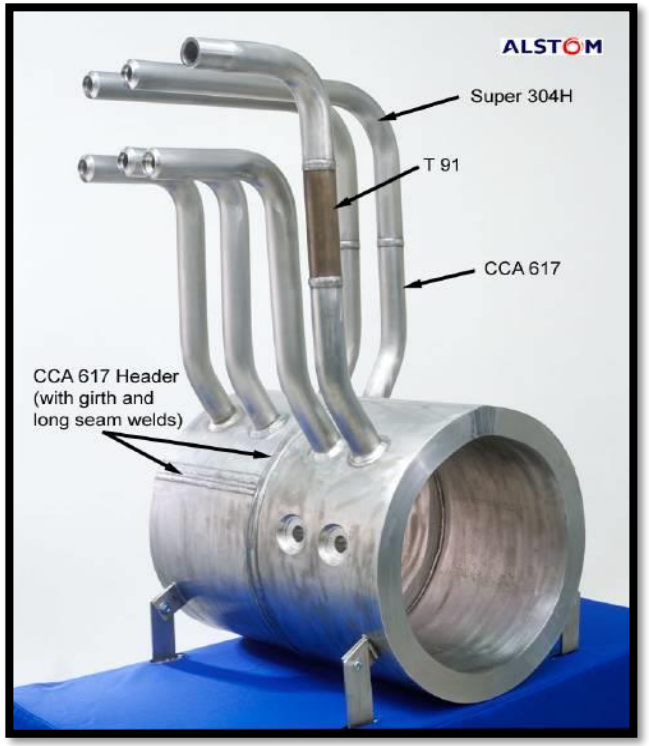
Steam-Side Oxidation



Welding Technology Developments

Fireside Corrosion (High-Sulfur Coal & In-Plant Testing)

Fabrication Processes



Turbine Component Scale-up

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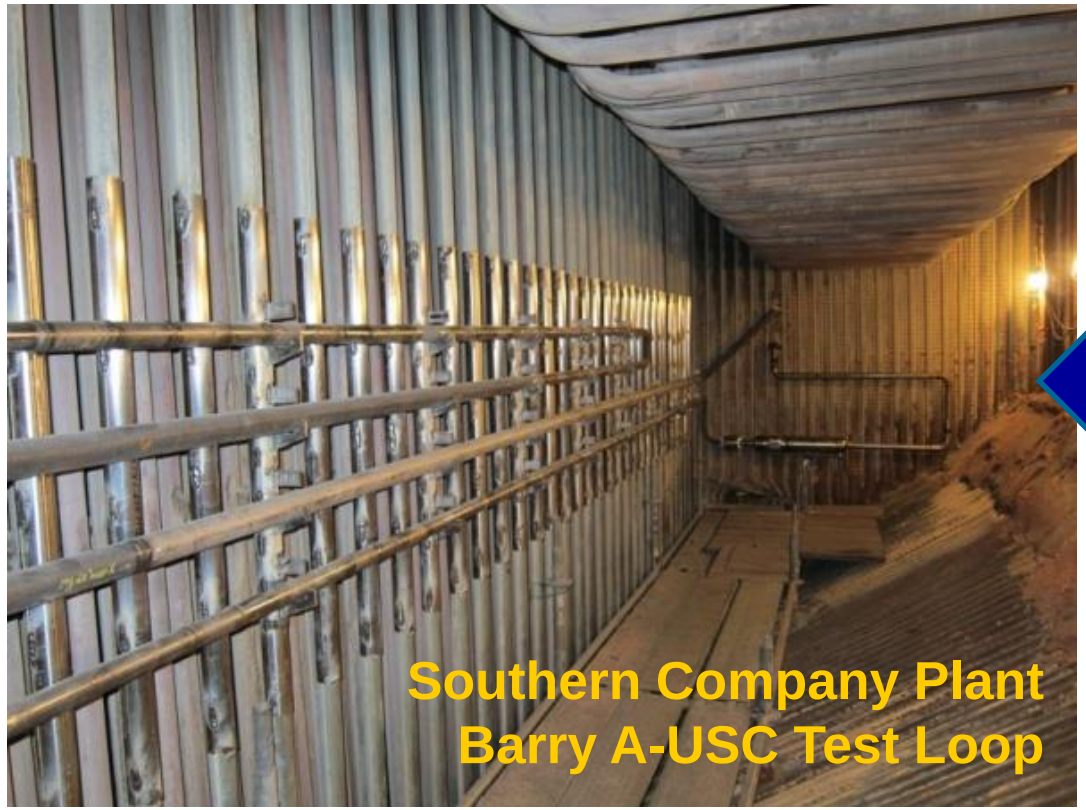
Successes: In-Plant Testing at 760°C (1400°F) Operating Steam Corrosion Test Loop



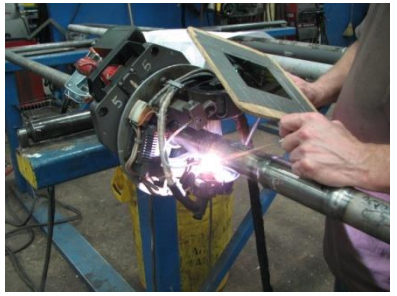
- Phase 1
  - Laboratory testing & air-cooled probes in boiler
  - Steam-cooled loop (high S coal)
- 2nd Steam Loop
  - **World's first steam loop operating at 760°C (1400°F)**
  - **Removed from service after 33months with >16,000hrs in operation**
  - **Evaluations = little to no wastage**

Materials included:

740H, CCA617, HR6W, Super 304H, Coating, Overlays, and Others

Fabrication in Alstom Chattanooga TN shop

Prior to Welding



Being Welded

After Assembly

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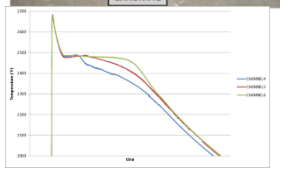
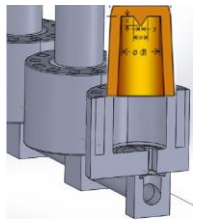
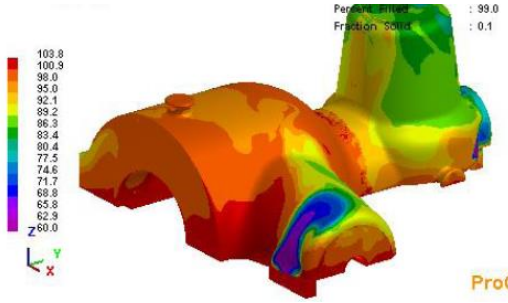
Producing the World's Largest Haynes 282 Alloy Casting Capability

- Casting simulation developed
- Cooling rate and secondary dendrite arm spacing predictions validated
- Modeling used to design valve body casting







NDE (Surface & X-ray) = Excellent Quality

~2700kg (6,000lb) ½ Valve body (simulate full-size valve)

Casting successful (17,500lb pour)

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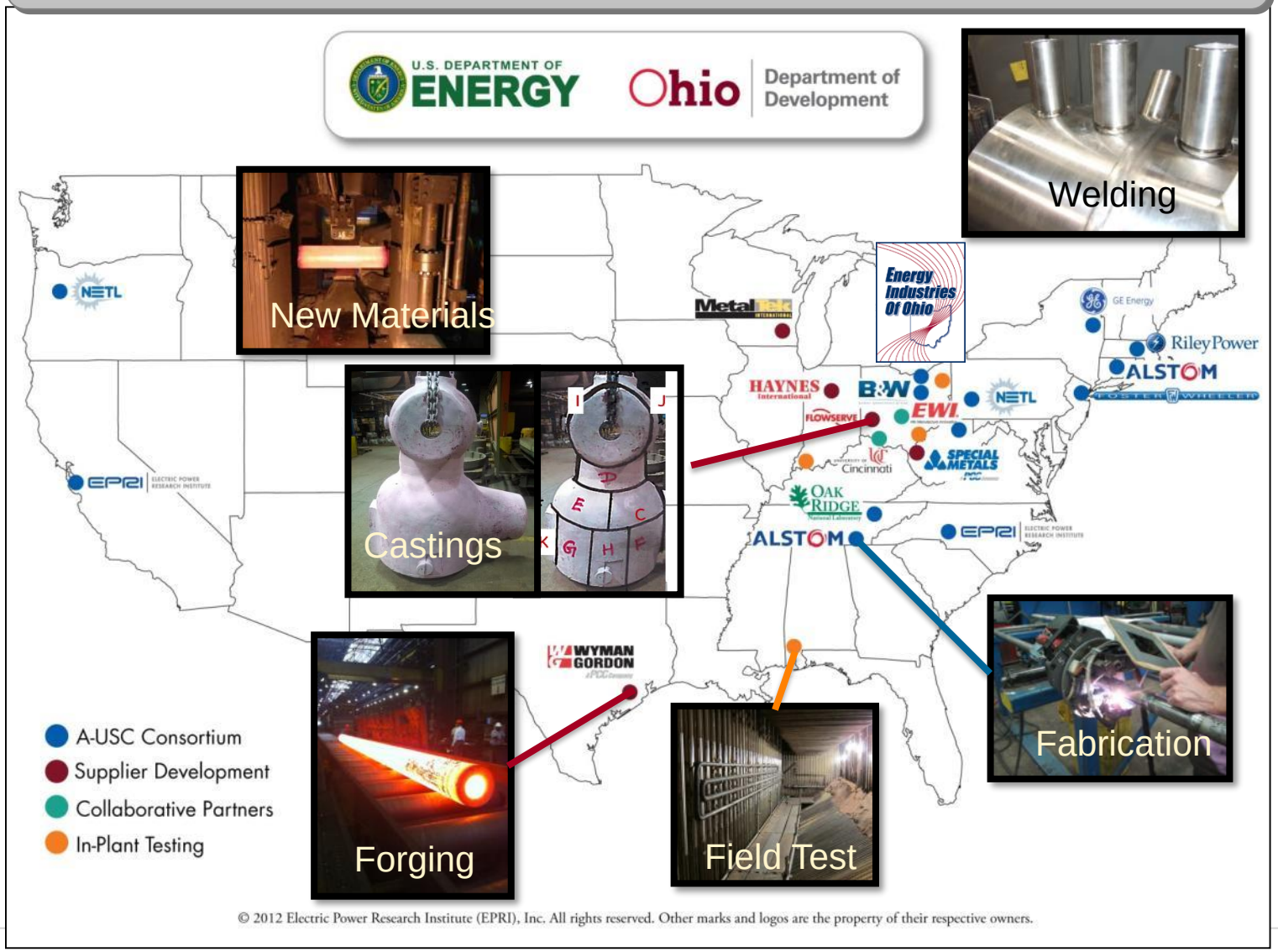
Next Step… Building Upon Prior Work

Federal – State – National Laboratory – Non Profit – For Profit
Cost Sharing Consortium



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15 Years

ComTest

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ComTest Project Team

Team Member	Funder	Role
US DOE NETL	✓	Funder
OCDO (Ohio)	✓	Funder
EIO		Prime Contractor & Administration
EPRI	✓	Technical Lead
GE	✓	Supply of Main Components
AECOM		EPC Contractor
Southern Company		Host Site Owner

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ComTest Utility Advisory Committee

- Help to shape and guide the project
- Prioritize work scope
- Ensure key technical needs are met
- Collaborate
- Provide host site access

Current Members
Southern Company
AEP
Duke
FirstEnergy
Tri-State

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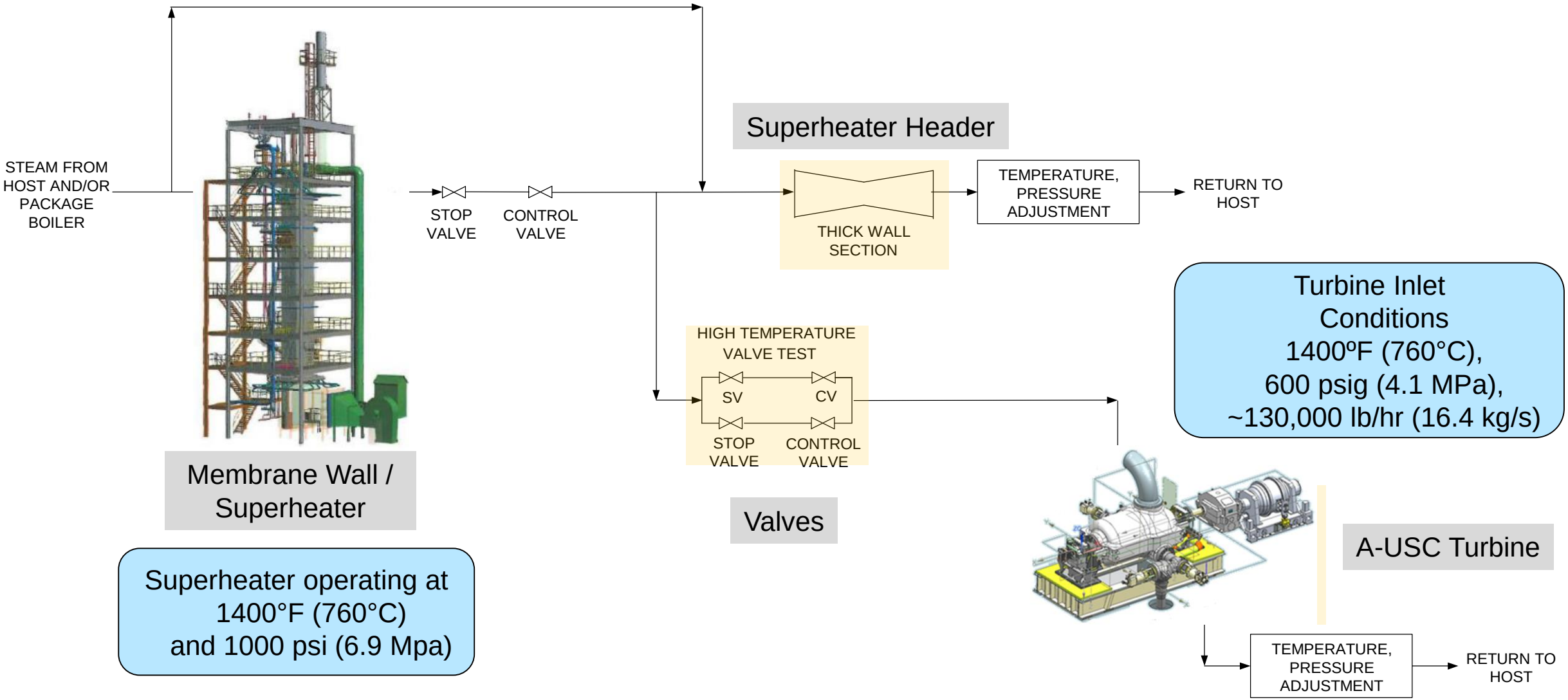
Earlier ComTest Pilot Plant Testing Schematic



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Evolution of ComTest Project

- GE/Alstom merger
  - Allowed incorporation of design information and intellectual property not previously available to the individual entities
  - Learned that additional steam turbine design and operational testing was unnecessary
  - Achieved significant project cost reductions
- Greater focus on defining fabrication methods and costs for steam turbine components and associated supply chain

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Project Scope Changes

- GE concluded that the full construction and operational testing of an A-USC ComTest steam turbine was not necessary to confidently design a commercial scale A-USC steam turbine
  - White paper prepared by GE explains pivot
- GE recommended alternative focus for turbine components
  - Full-size turbine component manufacturing demonstration (825-MW IP turbine)
    - Rotor forging
    - Nozzle carrier (inner casing) casting
  - No testing or fabrication of the main stop & control valve at full temperature conditions within ComTest
    - Synergy with the US-DOE sCO_2 STEP project – same valve casing design
- Operational testing to focus on superheater component and other valves
  - Optimizing testing scope for Phase 2 activities

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Cross-cutting Applicability to sCO2 Power Cycles

- sCO2 Brayton power cycles share common materials, forgings and castings with A-USC technology.
- Synergies exist between ComTest and US-DOE's Supercritical Transformational Electric Power (STEP) project that will demonstrate a pilot scale supercritical CO2 (sCO2) test facility.
- The STEP program will use a main stop and control valve that is essentially the same as the MSCV contemplated for the A-USC ComTest project.
  - Demonstrate manufacture of large Haynes 282 alloy valve body
  - Operate valve in sCO2 environment, at similar temperatures to A-USC

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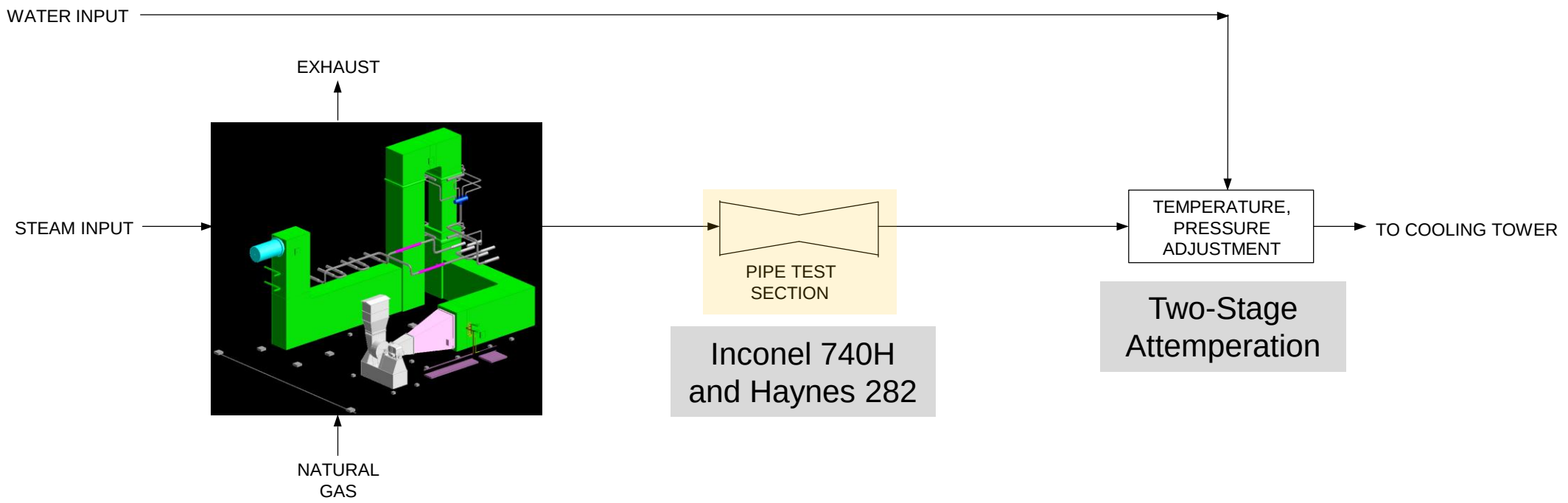
Current ComTest Pilot Plant Testing Schematic



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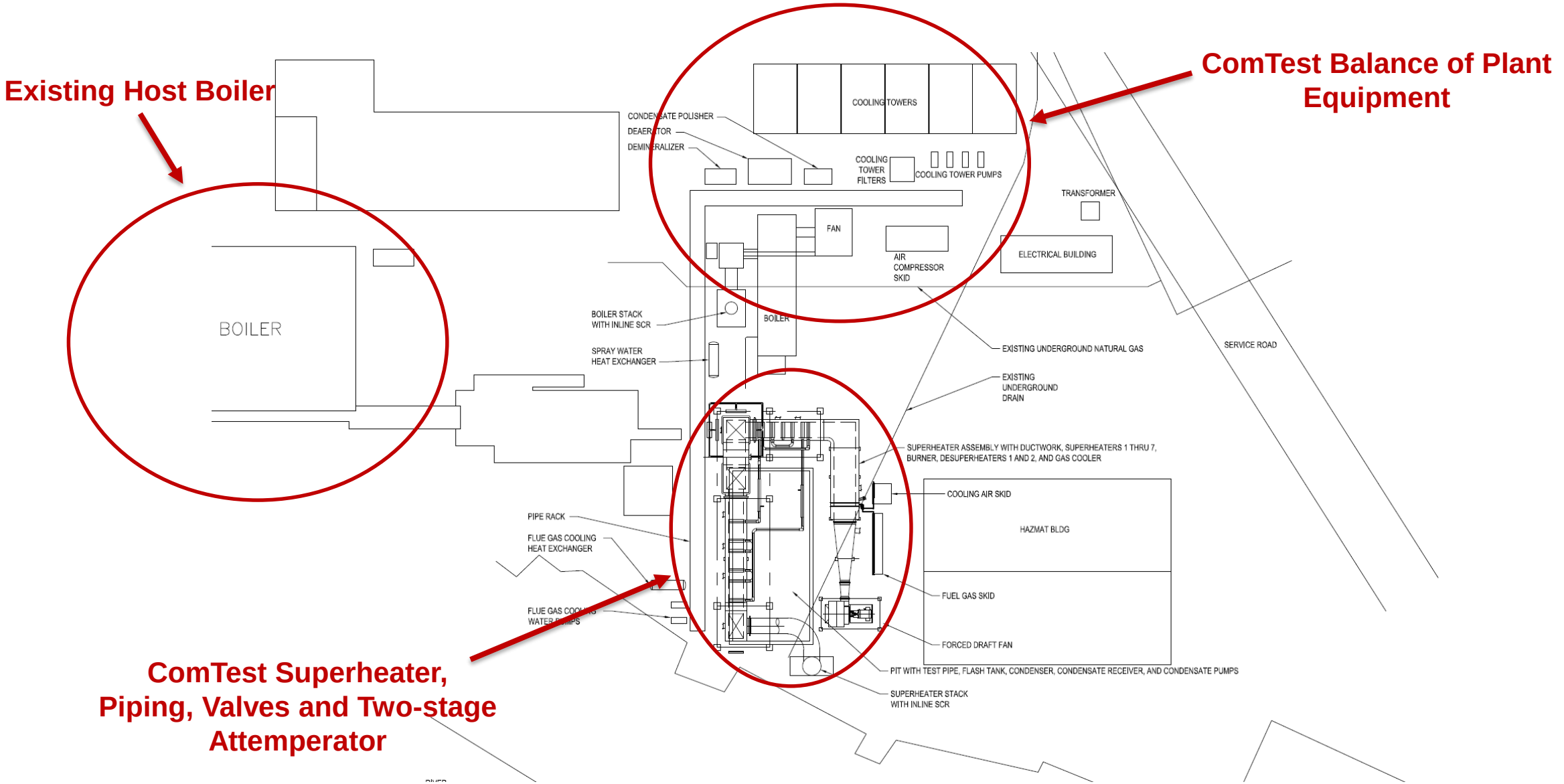
ComTest Equipment Layout at Host Site



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Accomplishments

- Evaluated multiple potential host sites
- Identified viable host sites (Ohio and Alabama)
- Optimized project scope – Closed budget gap
- Completed Pre-FEED and FEED tasks
- Prepared preliminary capital cost estimates
- Worked with suppliers to develop supply chain
- Developed 8,000+ hour test plan
- Started Detailed Engineering effort

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Next Steps

- Complete Detailed Engineering effort
  - Phase 2 budgets (+/- 5%)
  - Develop procurement specifications for equipment
  - Finalize testing scope for host site
- Confirm funding sources for Phase 2 cost share
- Confirm supply chain and fabrication methods
- Construct ComTest components and facility
- Operate pilot plant
- Conduct evaluations and report results

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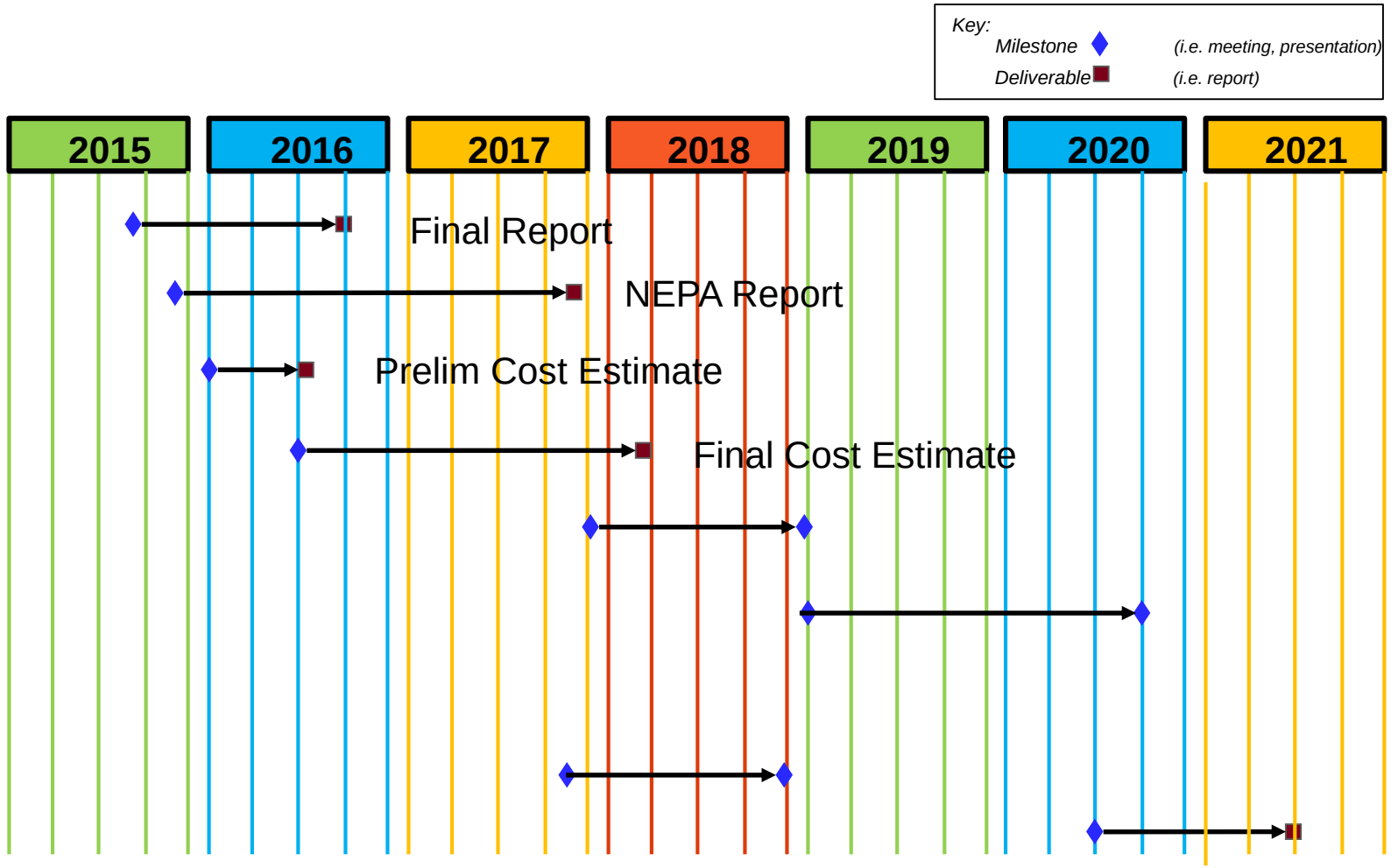
A-USC ComTest Schedule

- Pre-FEED
- NEPA
- FEED
  - Detailed Engineering
  - Procurement & Construction
- Operation
  - Membrane Wall & SH, Outlet Header & Valves
  - ST Fabrication Development
  - Evaluation & Reporting



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