# Materials for Advanced Ultra-supercritical Steam Turbines - Advanced Ultra-supercritical Component Demonstration

**DOE Contract Number DE-FE0025064**

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Energy Industries Of Ohio

# Goals: The A-USC ComTest Project will lead to…

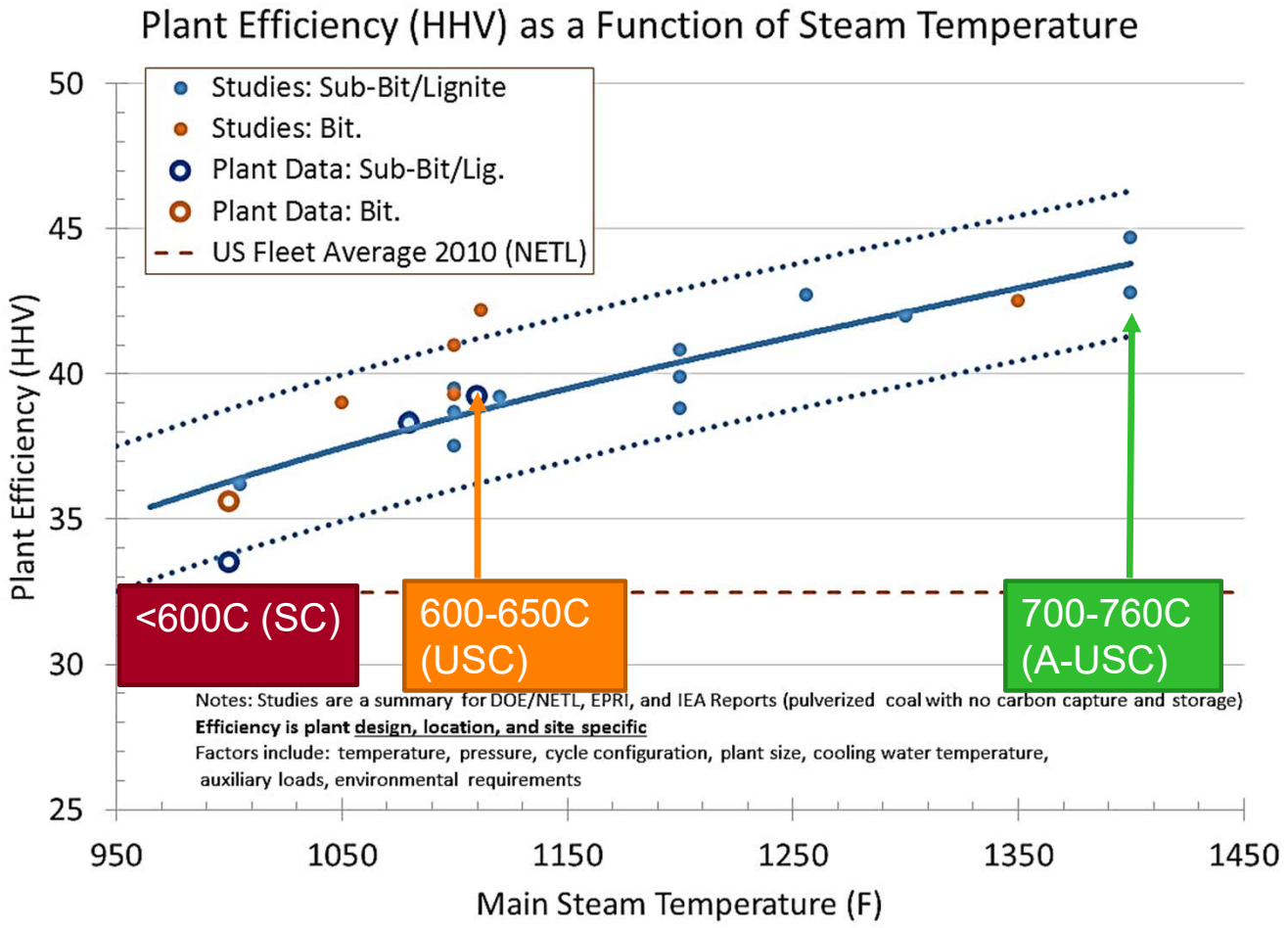
- **Higher efficiency** for new and existing fossil fuel plants
  - 10% above today's new state-of-the-art coal power plants, and
  - 25% above that of the average power plants in the U.S. existing fleet
- **Lower emissions** (NOx, SOx, $CO_2$)
- **Minimized risk** for utilities desiring to build A-USC plants
- Fabrication of **full scale components** (850 MWe) for 760ºC
- Accelerated development of domestic **supply chain** for advanced materials and components (greenfield & retrofit)
- **Validation of technology** applicable to multiple fossil, nuclear, and renewable power generation options, all targeted by the U.S. DOE NETL Cross-Cutting Research Technology Program

# Presentation Outline

- Background
- ComTest Project Overview
  - Project Objective
  - Phase I
  - Phase II
- Status and Schedule

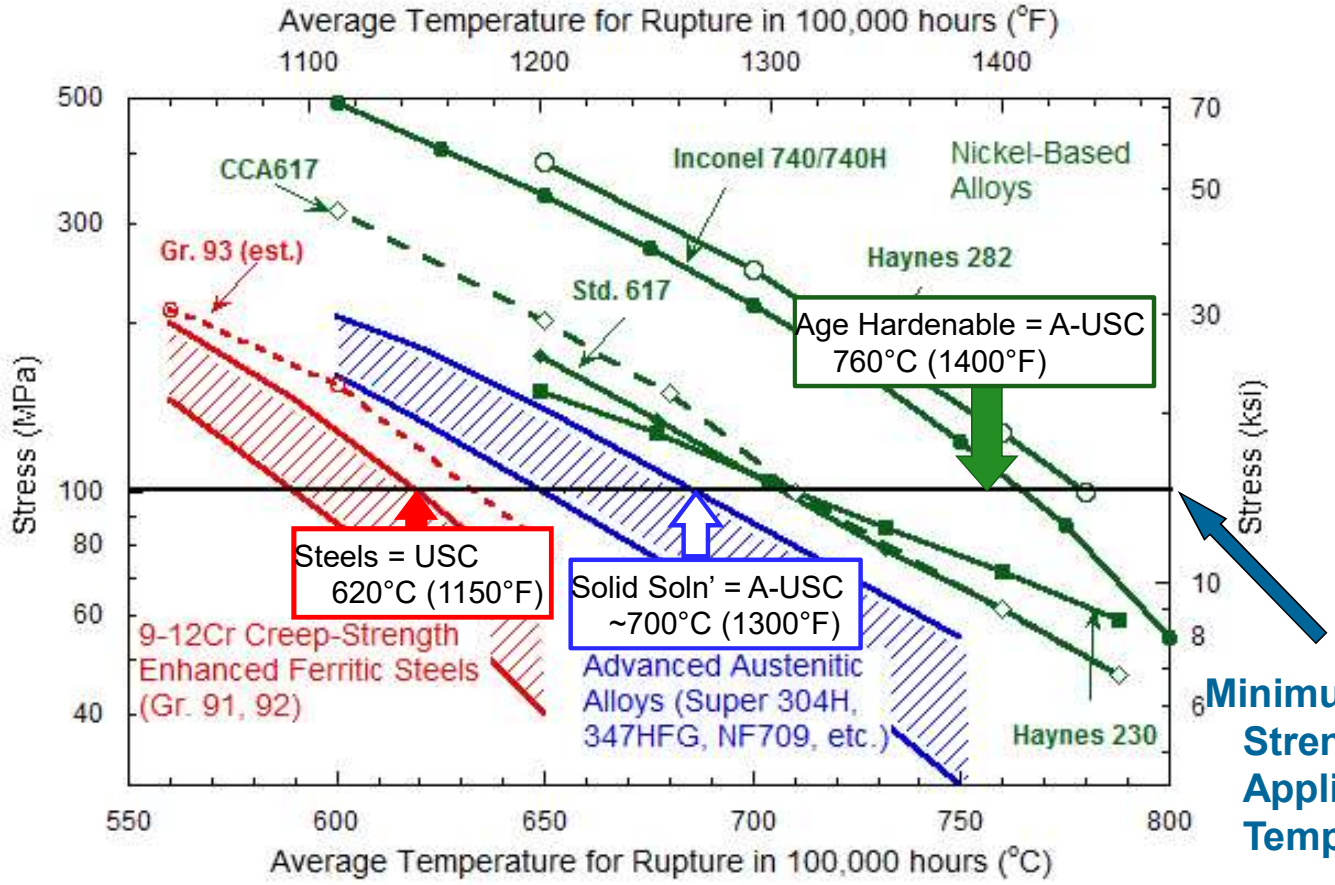
# Background

# Increasing Steam Conditions to Dramatically Improve Efficiency



# Materials Limit the Current Technology

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

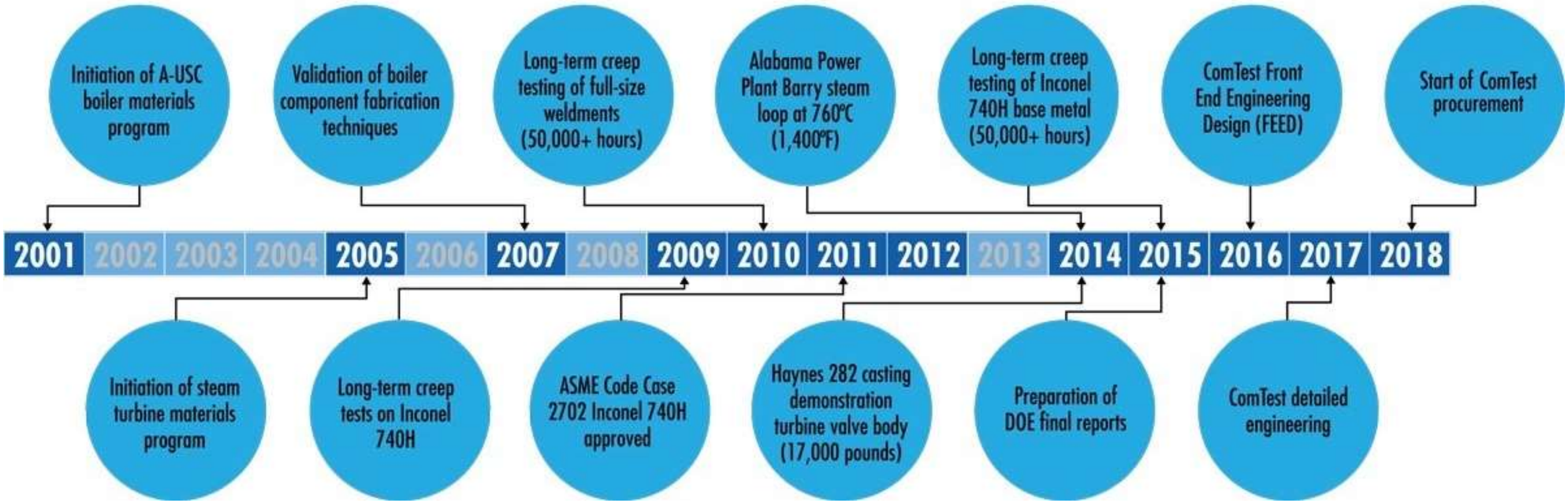



**Minimum Desired Strength at Application Temperature**

# Background of A-USC Materials Programs

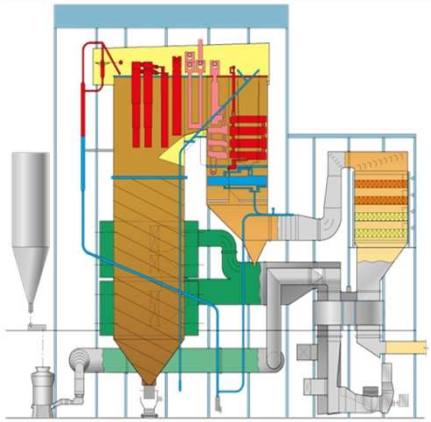
- Present work builds upon 15-year effort supported by U.S. Department of Energy, Ohio Coal Development Office, and industry participants
  - Boiler Materials for Advanced Ultra-supercritical Coal Power Plant
    - DOE Contract: DE-FG26-01NT41175
    - OCDO Grant: CDO-D-05-02(A)
  - Materials for Advanced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

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



# Tasks Completed in Prior A-USC Materials Programs

General design studies show favorable economics



Steam-Side Oxidation


Welding Technology Developments

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

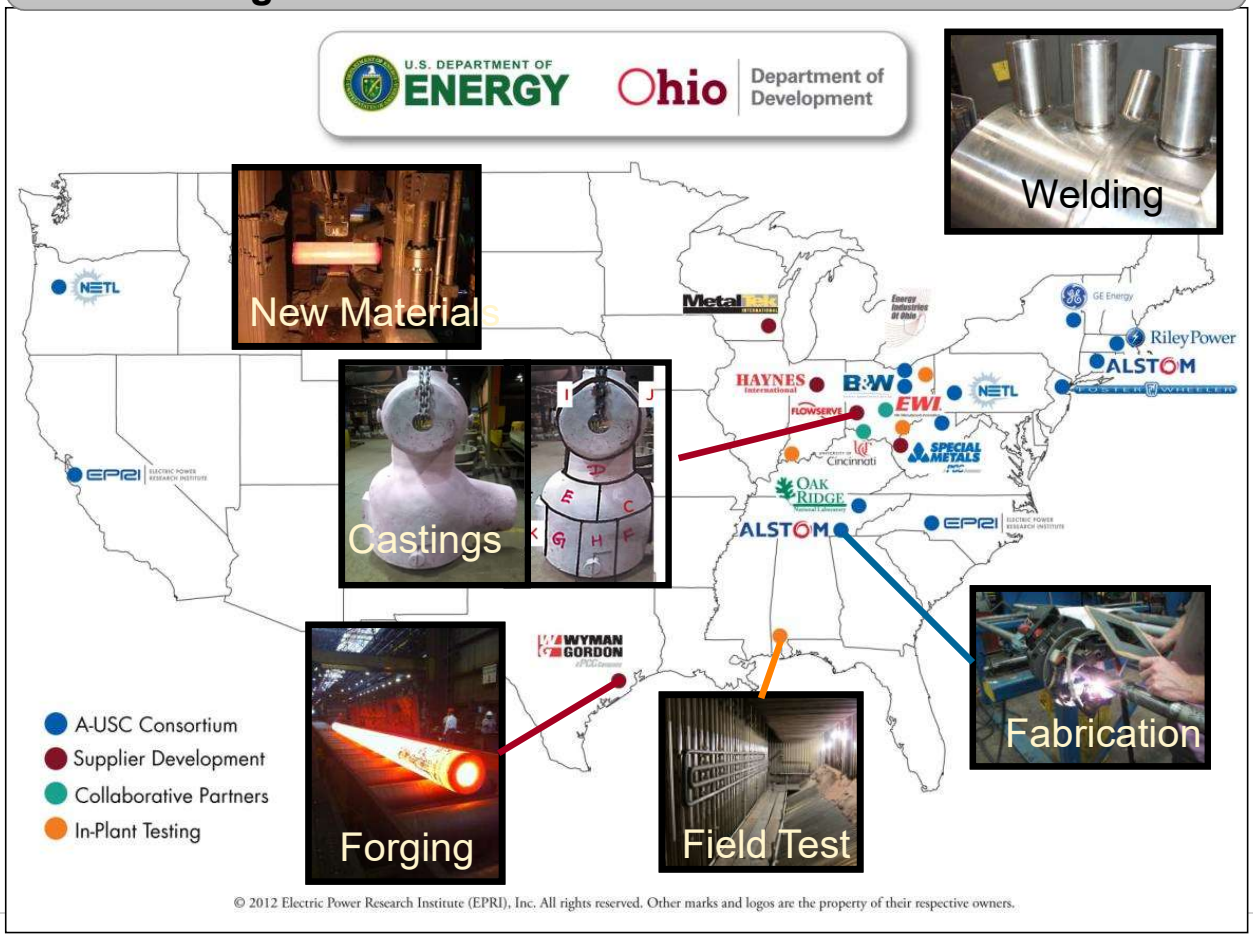
Fabrication Processes



Turbine Component Scale-up

# Next Step… Building Upon Prior Work

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




**15 Years**

**ComTest**





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# ComTest Project Overview

# Main Objective of ComTest Project

U.S. Department of Energy (DOE) funded consortium, industry, and other partners, together with EPRI technical leadership, have concluded that the primary **remaining step** necessary to prepare A-USC technology for **demonstration** in a commercial-scale power plant (new or retrofit) is to build **full-scale** (800-850 MWe) versions of **selected components**.

# Accomplishments – Phase I

- Evaluated host sites for test facility
- Identified viable host sites (Ohio and Alabama)
- Completed Pre-FEED and FEED tasks
- Prepared preliminary capital cost estimates
- Worked with suppliers to develop supply chain
- Determined that operational testing of the steam turbine and AUSC superheater were not required
- Revised scope of Phase II to focus on demonstrating production capability readiness (fabrication & supply chain)
- Completed Detailed Engineering effort for new scope

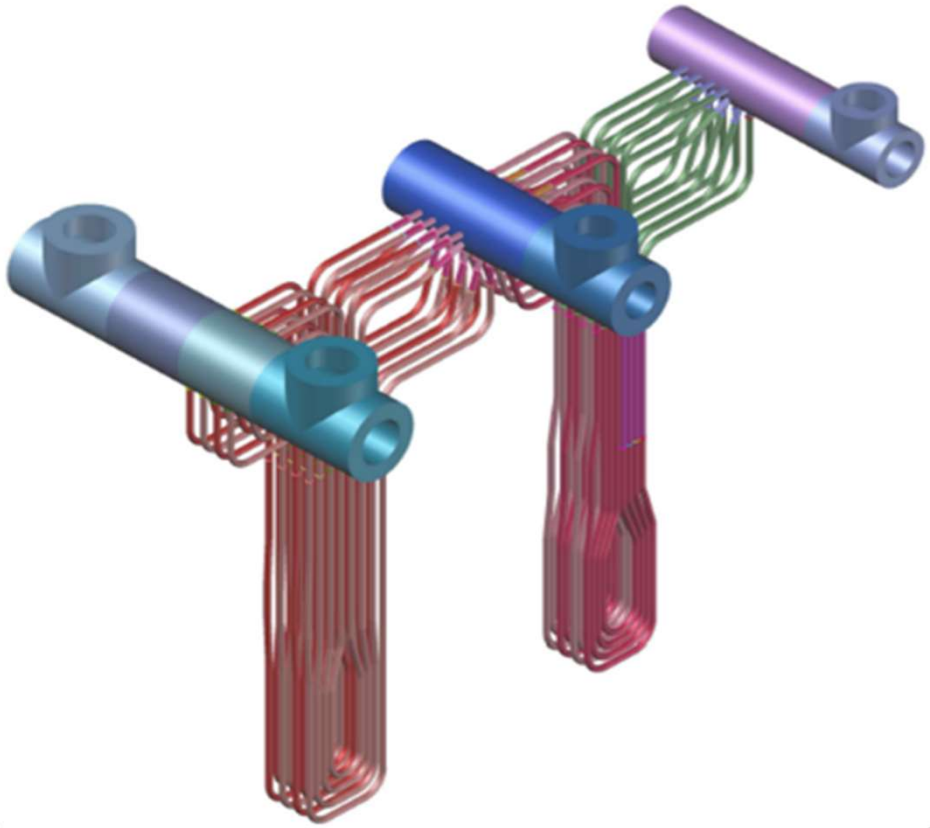
# Materials to be Included – Phase II

- Inconel 740H (tubes, pipes, forgings)
- Haynes 282 (tubes, pipes, castings, forgings)
- Grade 91/92 (membrane panels)
- SAVE12AD (pipe/header)
- HR6W (tubes, pipe/header)
- Sanicro 25 (tube)
- TP347H, and Super 304H for lower temperatures
- Inconel 617 for safe ends on HR6W tubing

# Boiler Component Scope – Phase II

- Procure materials for fabrication into A-USC components and sub-assemblies
- Fabricate A-USC boiler and superheater components and sub-assemblies (membrane panels, SH/RH tubes, headers, pipes)
- Fabricate forged components for
  - AUSC steam piping system – Wye and Tee (Inconel 740)

**A-USC Superheater / Reheater Assembly**
**(Image provided by Alstom Power / GE)**



# Steam Turbine & Valve Component Scope – Phase II

- Procure materials for fabrication into A-USC components and sub-assemblies
- Fabricate a cast steam turbine nozzle carrier casing (Haynes 282)
- Fabricate steam turbine rotor forging (Haynes 282 )
- Fabricate pressure relief and steam turbine bypass valves (Haynes 282)
  - Include testing, intended to obtain ASME Code approval for these valves.

**Nozzle Carrier Casting**
**(Image provided by GE Power)**

# Testing and Analysis Scope – Phase II

- Perform mechanical properties tests and metallurgical analyses of specimens obtained from the A-USC components and sub-assemblies
  - Tensile, fatigue, creep rupture, creep-fatigue, notch sensitivity, fracture toughness, impact testing, and microstructural evaluation
- Perform a techno-economic analysis (TEA) of an A-USC power plant
  - Update the capital costs and Cost of Electricity

# Fabrication Processes to be Developed – Phase II

- Bending of a heavy wall nickel alloy pipe
- Field erection simulation
  - Waterwall panel butt welds (with PWHT) and longitudinal seam welds (without PWHT)
- Field repair simulation
  - Inconel 740H and Haynes 282 thick wall piping – circumferential welds of fittings and plugs
  - Grade 92 tube membrane panel repair – simulated “Dutchman” repair when inserting panel openings
  - Evaluation of strength of PWHT vs non-PWHT welds in 740H
  - Determine ability to weld repair and to use innovative repair options such as weld overlay cladding of water walls as a field weld repair

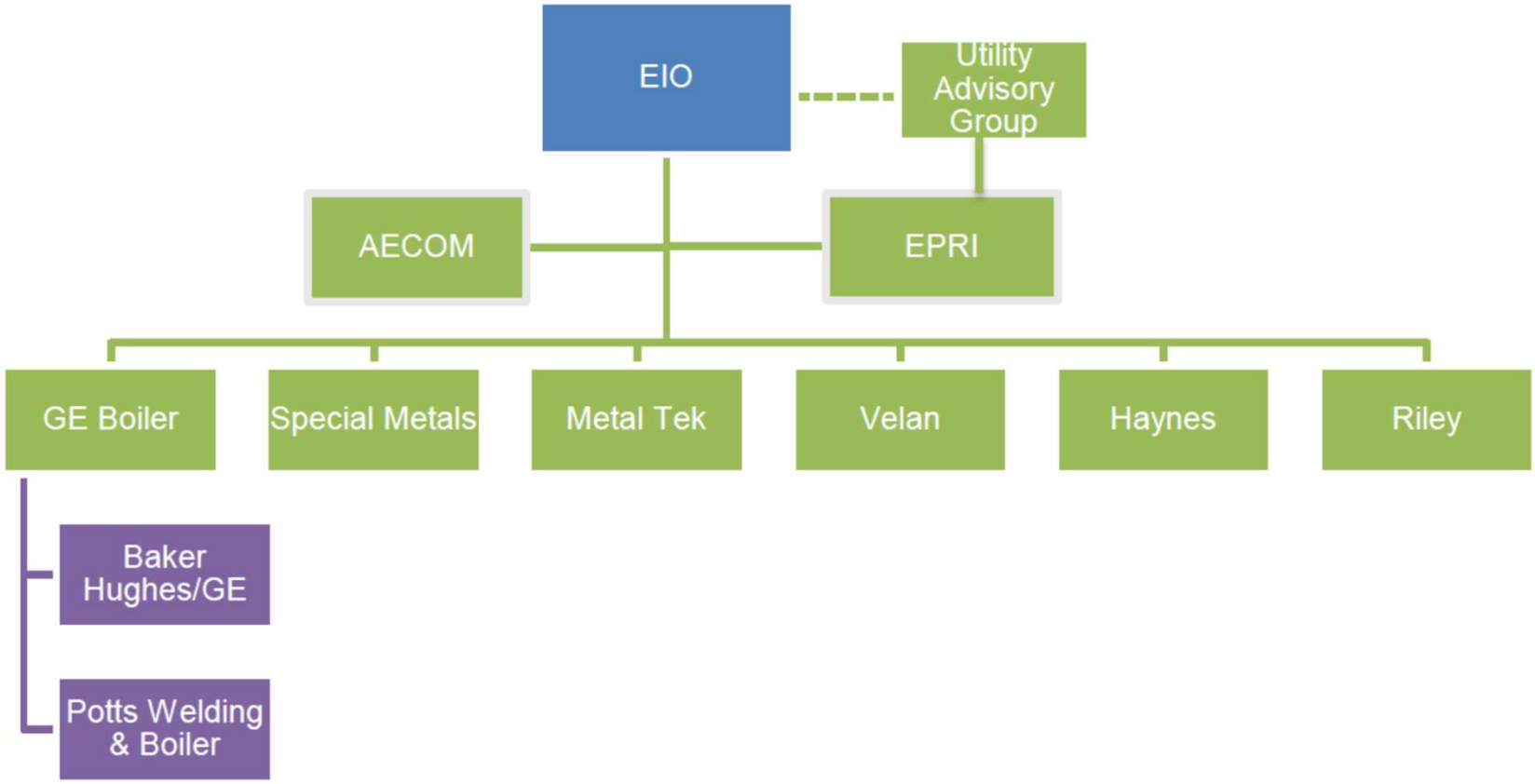
# ASME Code Case Development – Phase II

- Overpressure protection that would allow an alternative to a spring activated PRV at the superheater outlet
- Expand ASME B16.34 to allow bolted flange design at high temperatures
- Revision of the Case 2902 for Inconel 740H, to permit the use of SMAW as a permissible welding process
- Permit use of wrought forms of H282 in AUSC power plants
- Develop an ASME Code Case for the cast version of H282

# ComTest Project Team – Phase II

| Team Member | Funder | Role |
|---|---|---|
| US DOE NETL | ✓ | Funder |
| EIO | | Prime Contractor & Administration |
| EPRI | ✓ | Technical Lead & Testing |
| GE | | Boiler Components, Valves |
| RILEY/BTA | | Boiler Components, Overlays |
| AECOM | | Costs for Techno-Economic Study |
| VELAN | ✓ | Valves (Fabrication & ASME Test) |
| SPECIAL METALS | ✓ | Pipe, Tubing, Forging Material |
| METALTEK | ✓ | Casting |
| HAYNES | ✓ | Pipe, Tubing, Casting |

# ComTest Project Organization – Phase II



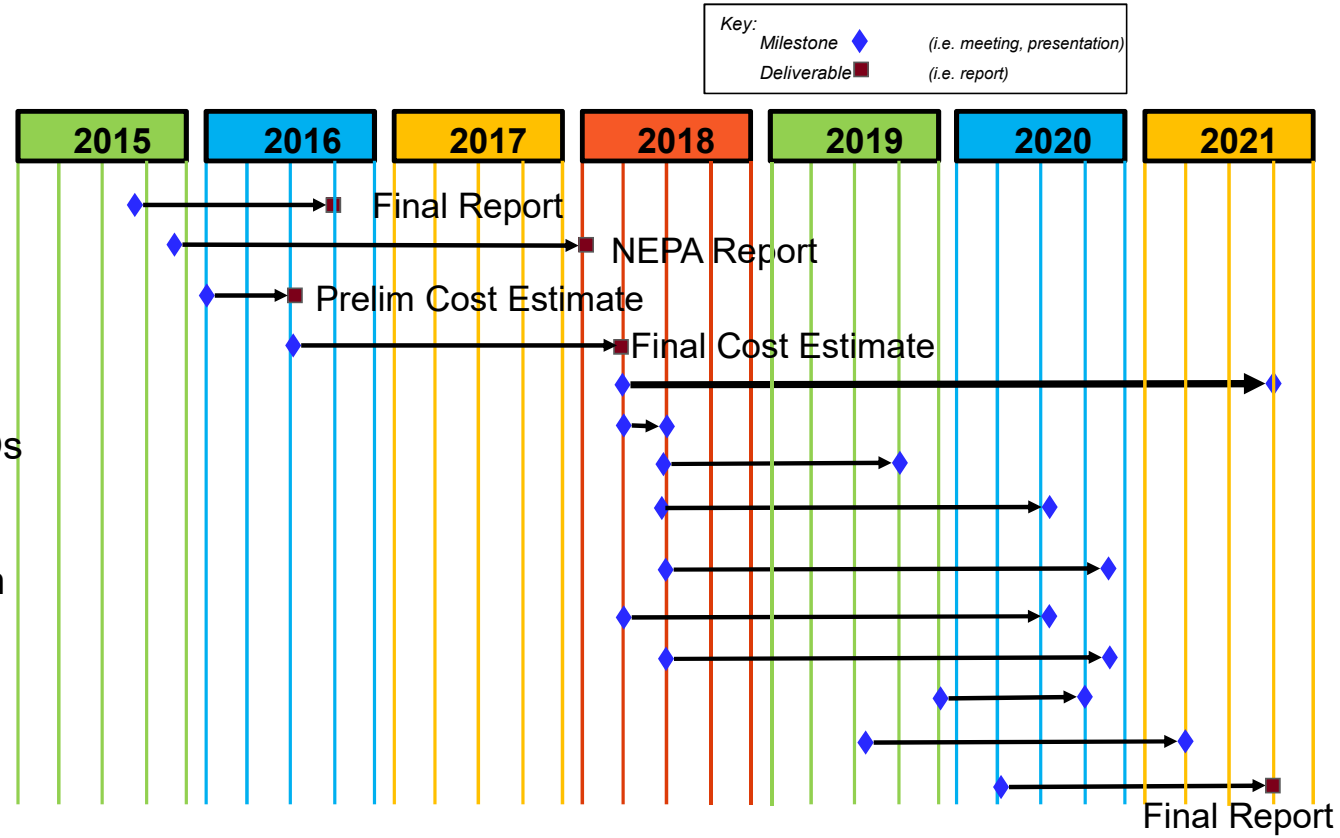
# Status and Schedule

# Current Status and Next Steps

- Phase I work has been completed
- Prepared draft of Final Report for Phase I
- Phase II Decision Point Application being evaluated
- Awaiting Phase II award
- Establish subcontracts
- Procurement of materials for components and sub-assembly fabrication
- Fabricate full scale components
- Confirm supply chain and fabrication methods
- Metallurgical testing and techno-economic analysis

# ComTest Schedule (Revised March 2018)

- **Phase I**
  - Pre-FEED
  - NEPA
  - FEED
  - Detailed Engineering
- **Phase II**
  - Negotiations, Subawards & POs
  - Turbine Rotor Forging
  - Nozzle Carrier Casting
  - Valve Testing / NB Qualification
  - Superheater Component Fab.
  - Pipe Forgings and tube trials
  - Techno-Economic Study
  - Metallurgical Testing
  - Evaluation & Reporting



# A-USC ComTest Project Support Acknowledgement

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