Advanced Alloy Development

AUSC Manufacturing Cost Analysis

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Disclaimer

Attribution

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About Me

Michael Verti

- **National Energy Technology Laboratory**
  - *Deloitte Consulting*: onsite support contractor
  - R&D and Technology Commercialization Strategy
- **New Pig Corporation**
  - Director, New Product Development & Product Strategy
  - Agile Product Development, Human-centered design, Web-as-lab strategies
- **Kennametal Inc**
  - Strategic Technology Manager
  - New-to-company technology and market
    - Advanced Manufacturing
    - High-performance Materials

Advanced Ultrasupercritical (AUSC)

Next generation power generation

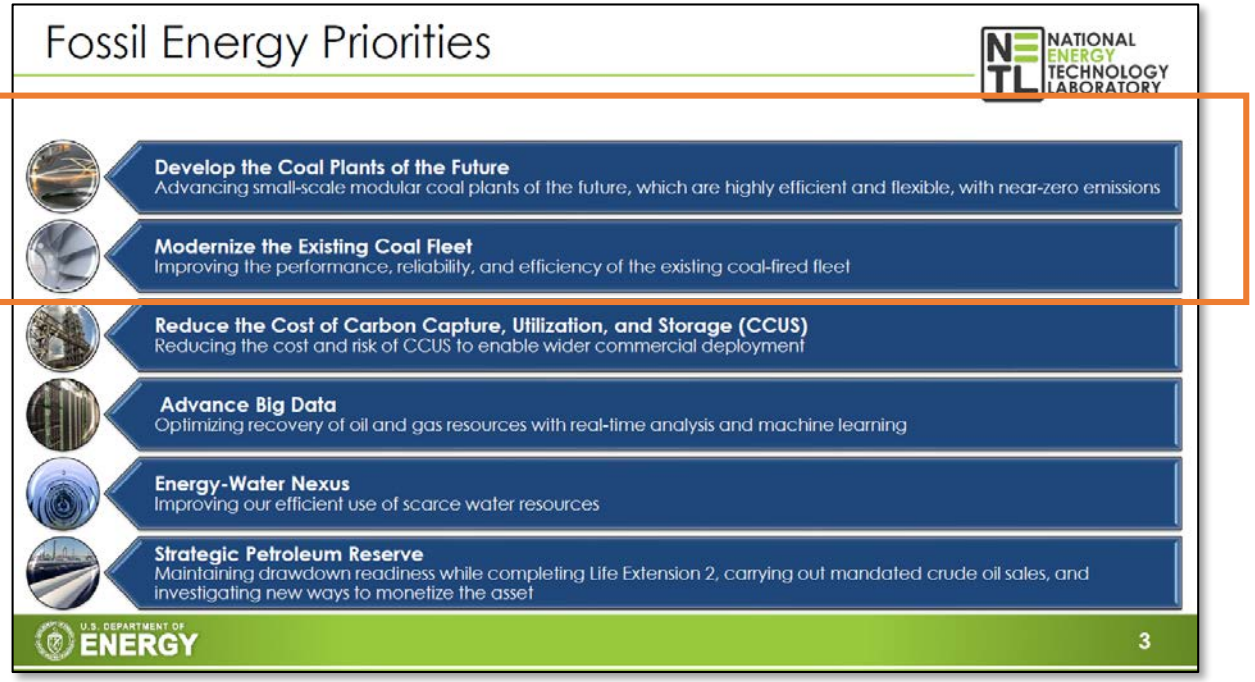
	Subcritical	Supercritical (SC)	Ultra-supercritical (USC)	Advanced Ultra-supercritical (AUSC)
Net Plant Efficiency (HHV)	35%	38%	>42%	>45%
Steam Conditions	2400 psig 535 – 550 °C	>3600 psig 550°C	>3600 psig 600°C	4000 - 5000psig 700 - 760°C

AUSC power plants require less coal per megawatt-hour, leading to lower emissions, higher efficiency and lower fuel costs per megawatt

Source: https://www.netl.doe.gov/sites/default/files/2017-11/Crosscutting_20150429_0830A_EIO.pdf

AUSC: Well-Aligned with DOE Goals

New technology improves energy efficiency & lowers emissions



NETL Mission:

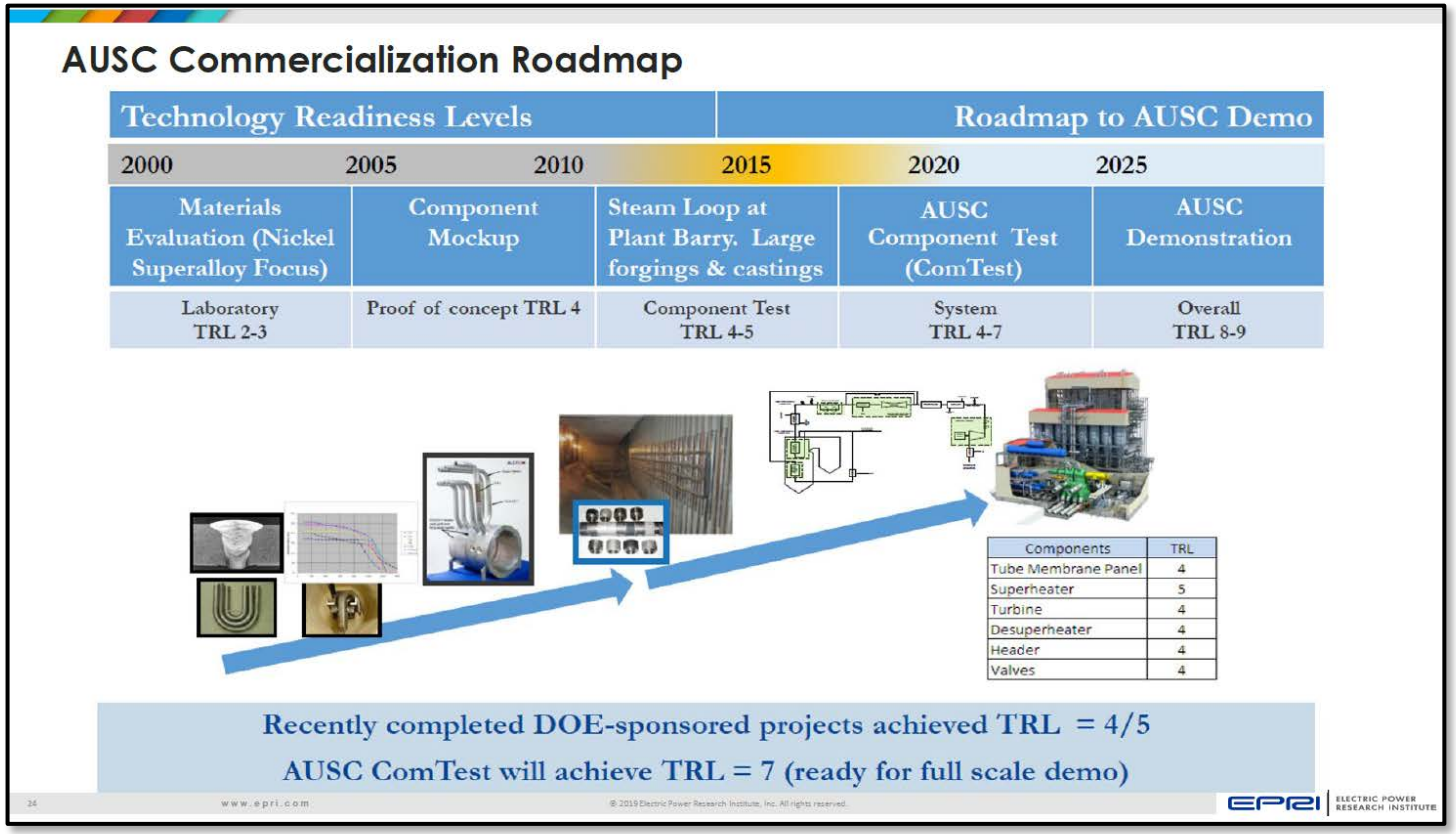
Discover, integrate and mature technology solutions to enhance the Nation's energy foundation and protect the environment for future generations:

- Effective resource management
- Efficient energy conversion
- Environmental sustainability

The commercialization of AUSC power generation technology will benefit the environment and reduce energy costs compared to existing coal-fired power generation plants

DOE Investing in AUSC Supply Chain

ComTest Program Working Towards AUSC Demo



ComTest Program

- Led by Energy Industries of Ohio (EIO)
- Actively focused on establishing a capable domestic supply chain of nickel superalloy AUSC components:
  - Boiler headers, tubing assemblies
  - Turbine rotors, nozzle carrier
- Alloys:
  - Inconel 740H
  - Haynes 282

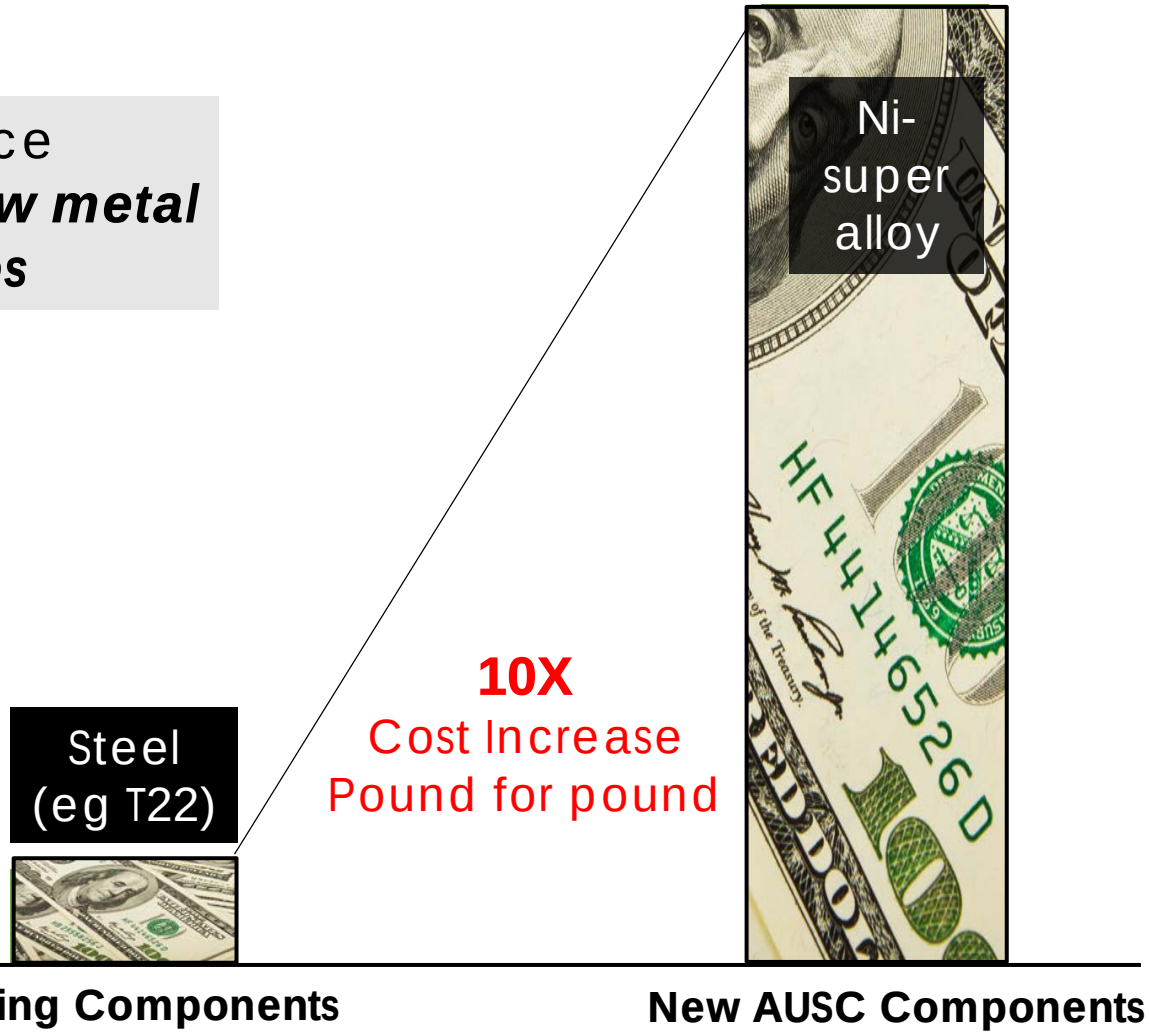
Commercialization Challenges

Enabling technology is required to bring AUSC to market

Advanced Ultrasupercritical steam conditions force large plant ***components to be fabricated from new metal alloys to withstand the temperatures and pressures***

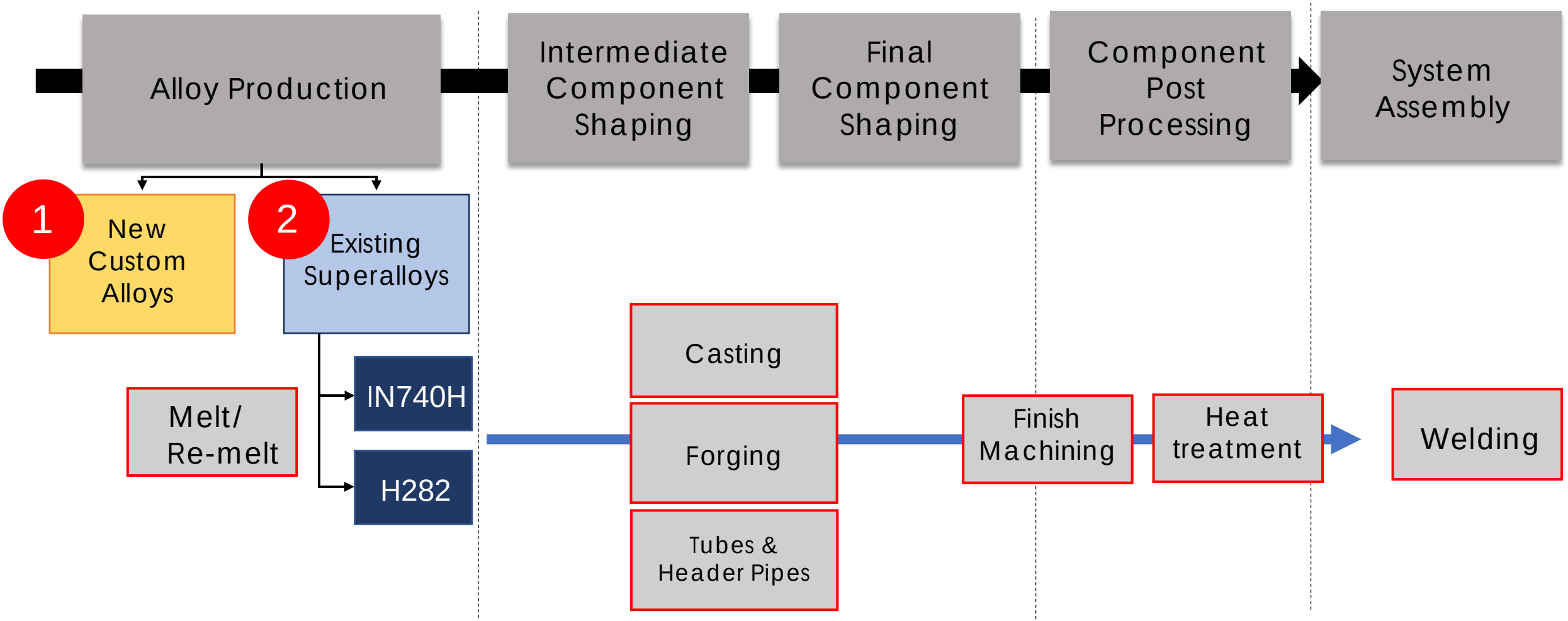
Challenges:

- TECHNICAL: Establishing a capable manufacturing processes needed to manufacture these large superalloy components
- ECONOMIC: Making technology available at a cost that ensures market adoption



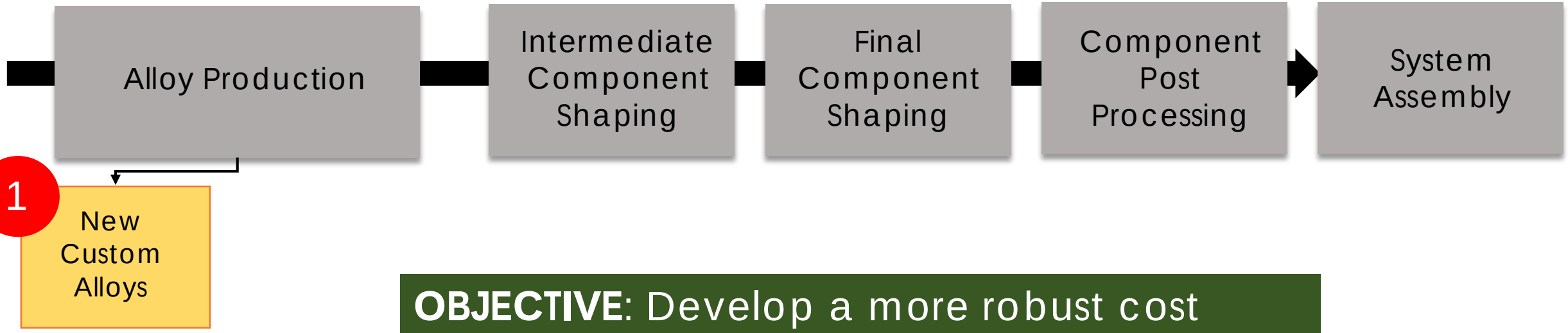
AUSC Component Fabrication

Goal: Identify opportunities to reduce cost in the supply chain



Path 1: Alloy Design Cost Estimation

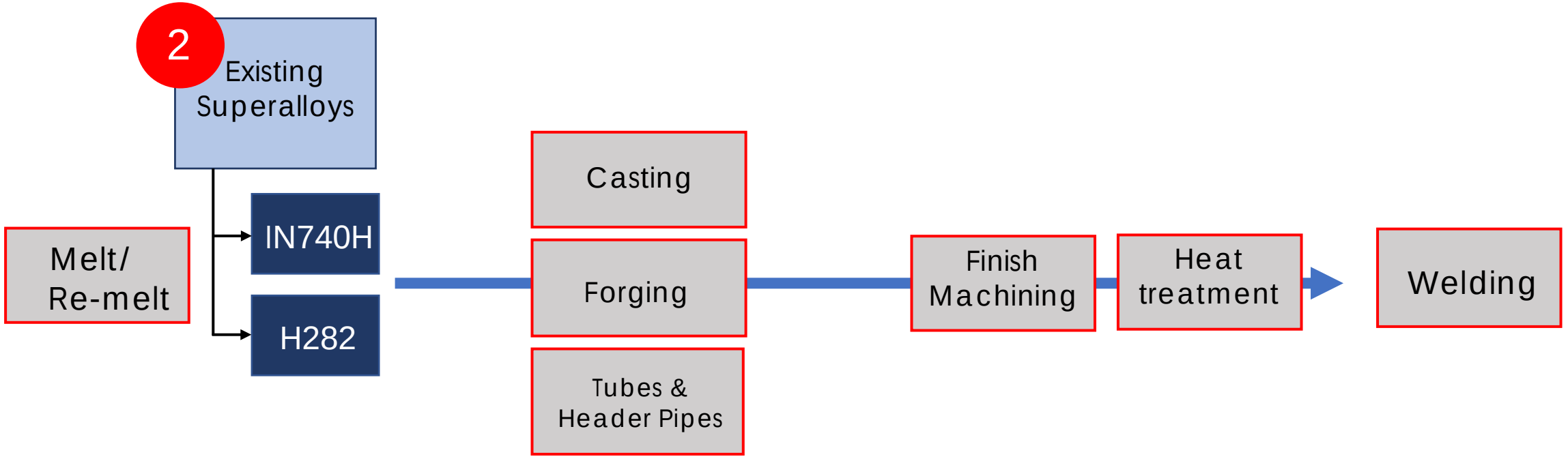
Understanding tradeoffs between cost and performance



OBJECTIVE: Develop a more robust cost model to help guide alloy development by making cost trade-offs in alloy composition more apparent

Path 2: Existing Alloy Fabrication

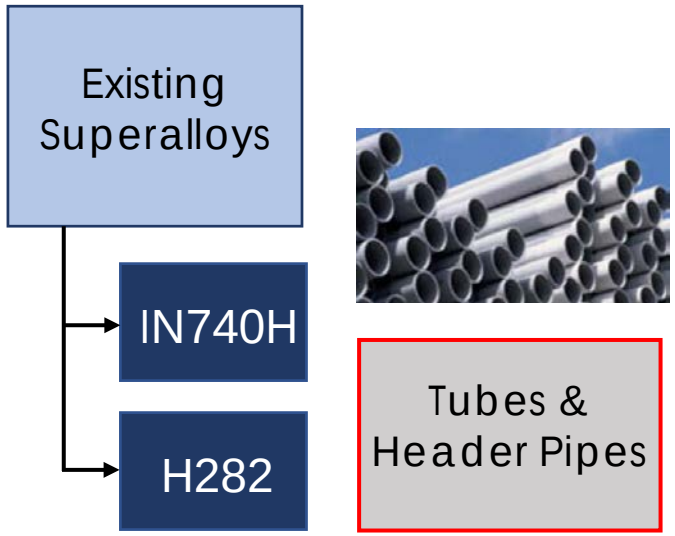
Identify cost and technical challenges related to IN740 & H282



OBJECTIVE: Identify the major sources of cost in the production process of existing AUSC superalloy component designs

Cost Reduction Opportunities

Large-sized tubular components represent biggest opportunity

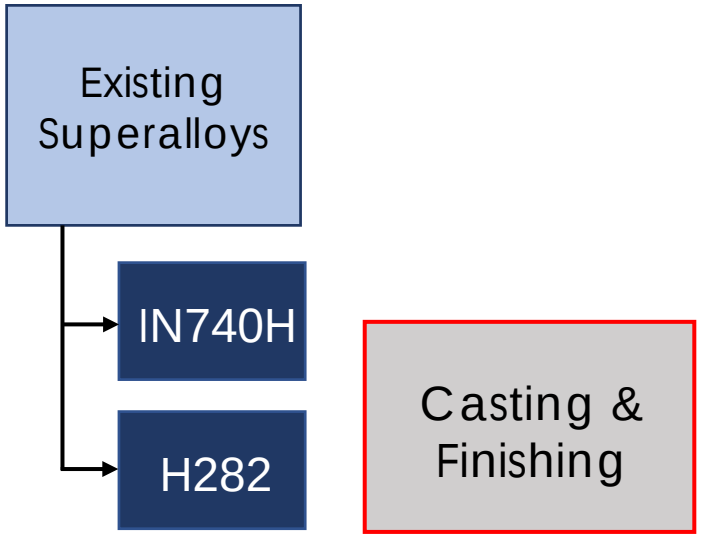


- Tubular components represent the largest share of superalloy parts in AUSC plant designs – *roughly 60-70%*
- The large size and diameter/wall thickness ratio present challenges for conventional extrusion methods
- Only one domestic fabricator with large enough extrusion press
- Cost reduction and sourcing flexibility could be achieved with seam-welded tube and pipe

Seam-welded pipes and tubes will reduce cost, but must overcome industry reluctance to adopt due to product failure concerns

Cost Reduction Opportunities

Near-net shaped fabrication methods may reduce cost



Valve body sand casting performed by Haynes International as part of the ComTest program:

- ½ of the valve body:
  - Pour size: 17,500 lbs
  - Component size: 6,000 lbs

Nearly 3x pour weight to final weight

- Potential to use alternative fabrication methods like powder metallurgy for greater efficiency?

Additive manufacturing or other near-net shape powder metallurgy production methods may yield cost savings compared to casting

Cost Reduction Opportunities

Field sites uncover technology challenges

- Known AUSC Ni-superalloy components technology development challenges:
  - Larger size components
  - Welding dissimilar materials
- Uncovering new challenges: Going from test to field trials
- ComTest project plans AUSC demonstration by 2025
- Opportunities to test and learn sooner?

New challenges will not be known until components are fabricated and tested in field sites at system-integration stage

Summary

Facilitating AUSC technology adoption

- The goal of our work is to uncover opportunities for focused R&D activity to lower the cost of nickel superalloy components
- Initial research conducted with industry interview uncovered three potential areas for DOE investment for IN740H & H282 alloys:
    1. **Seam-welded tubing**: Demonstrate fabrication and risk assessment & testing
    2. **Near-net shape production** methods leveraging PM and/or AM
    3. **System-level testing**: Identify and fund the fabrication and testing of components in comparable environments
- **New alloy development**: Longer term. Continue development of tools to help researchers understand trade-offs between alloy design and cost