# High Temperature Additive Architecture for 65% Efficiency

### DE-FE0031611

# **GE Gas Power**

PI: Richard DiCintio PM: Sharon Swede Key Contributors: Ben Lacy, Srikanth Kottilingam, Brad VanTassel, Evan Dozier, Tim Moricca

UTSR Project Review Meeting San Diego, CA September, 2022







This material is based upon work supported by the Department of Energy under Award Number **DE-FE0031611** 

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

**GE INFORMATION** - The information contained in this document shall not be reproduced without the express written consent of GE. If consent is given for reproduction in whole or in part, this notice and the notice set forth on each page of this document shall appear in any such reproduction. This presentation and the information herein are provided for information purposes only and are subject to change without notice. NO REPRESENTATION OR WARRANTY IS MADE OR IMPLIED AS TO ITS COMPLETENESS, ACCURACY, OR FITNESS FOR ANY PARTICULAR PURPOSE. All relative statements are with respect to GE technology unless otherwise noted.

# Successful History of GE-NETL Partnership Leads to World Record Performance



### 57% to 64%+ Combined Cycle Efficiency in 15 years!





- Impact of Additive at GE
- Industrial Gas Turbine Terminology
- Phase I Objectives
- Phase II Key Technology Activities
- Phase II Next Steps



# Impact of Additive at GE



#### Performance

- Removes traditional mfg. constraints
- Enables "near surface" cooling & Cooling air reduction



### Speed to Market

- Model to part directly
- Quick prototypes
- ~18 month cycle



### Cost

- Eliminate casting tooling
- Metal only where needed
- Reduction of component counts

### Improving state-of-the-art

#### Processing sciences





#### Alloys





#### Design





# Advanced Manufacturing Works – Greenville, SC

### Merging design and manufacturing technology to deliver better products



### Additive

- >20,000 parts shipped
- 1<sup>st</sup> GT parts produced/fielded

### Ceramics

- 1<sup>st</sup> fielded CMCs
- Thermal coatings

### **Process optimization**

- Automation/CMT/Digital
- HGP Special Processes
- Reduced cost and lead time



# Industrial Gas Turbine Terminology





# **Turbine Vane Conventional Cooling Fundamentals**

#### Internal Cooling Flow Circuit



#### Surface/External Film Cooling





# Project Objectives & Technical Approach

## **Overall Objective**

Develop a feasible conceptual design for advanced additive turbine inlet components that enable 65% CC efficiency through analytical methods and feature print trials.

### **Technical Approach**

### Phase I – Discovery (July 2018 – January 2020)

- Generate advanced wall architecture and airfoil concepts enabled by additive manufacturing
- Identify and evaluate additive methods and materials that enable desired geometry through coupon print trials
- Down select a primary concept and additive method/material plus a backup to carry forward into potential Phase II project
- Develop test plan for Phase II execution

#### Phase II - Demonstration (January 2020 - Sept 2024)

- Generate high efficiency component design, enabled by additive manufacturing, using state of the art tools and methods
- Demonstrate manufacturing readiness level for additive manufacturing modalities through extensive print trials and post print inspection
- Validate individual wall architecture and cooling concepts with laboratory environment testing
- Demonstrate technology readiness level for component design at representative gas turbine conditions in combustion validation rig



# Program Objectives: Phase I – Discovery



Program focus will be on high-temperature alloys, new additive modalities, geometry enabled by additive, and manufacturing capability



# Phase II Key Technology Activities

Phase II Activities

- 1) Cooling Technology
  - > Initial scope of thermal correlations for additive cooling features completed
  - Additional scope identified
- 2. Wall Architecture Technology Bench Testing
  - Correlations of model to printed feature size for different additive modalities
  - Flow testing of cooling features, total and by feature
- 3. Additive Process Capability and Control
  - Powder removal demonstrated repeatedly on production viable designs
  - Progressing towards repeatability demonstration/ dimensional control
- 4. Additive Material Properties
  - Evaluating properties for several modalities
- 5. Detailed Design
  - Iterations on heat transfer and structural mechanical









Additively Printed Airfoils

Additively Printed End walls





Detailed Design - Heat Transfer and Structural



# Phase II Next Steps

#### **Optimization for a Viable Commercial Product**

- Demonstrated Manufacturing Repeatability of selected additive printing modalities and associated processes
- Completion of material property characterization including optimization of grain size
- High temperature validation of optimized design
  - Detailed design of rig underway to support testing in 2024
  - Numerous test samples to be tested



# Questions?

