OVERVIEW REPORT

DOE/NETL Clean Coal Research Program Crosscutting Technology Research Program FY2015 Peer Review Meeting

Pittsburgh, Pennsylvania
August 24-28, 2015

ASM INTERNATIONAL

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OVERVIEW REPORT
CLEAN COAL RESEARCH PROGRAM
CROSSCUTTING TECHNOLOGY RESEARCH PROGRAM
FY2015 PEER REVIEW MEETING

Pittsburgh, Pennsylvania
August 24 - 28, 2015

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DISCLAIMER

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INTRODUCTION AND BACKGROUND

The Crosscutting Technology Research program serves as an essential multidisciplinary program providing technologies and tools that benefit existing power generation systems and advanced energy systems including carbon capture and storage. For the technologies and tools that are of interest to the Crosscutting Technology Research program, the maturation of the technology may span technology readiness levels (TRLs) 2–6 with novel concepts being developed and demonstrated at appropriate levels and transitioned, as appropriate, to programs within the Office of Fossil Energy (FE) or to industry. Examples of technology development suitable for transition include harsh environment sensors, high-performance structural materials, and multiphase flow and simulation based tools. In many cases, technologies and tools are transitioned to the appropriate program(s) within the FE and NETL's Strategic Center for Coal (SCC). Consistent with this research and development (R&D) path, CTR serves as the lead program to incubate novel concepts and to foster the growth of those concepts that hold the potential to benefit fossil-energy-based power systems.

The Crosscutting Technology Research program is currently funding the development of a broad portfolio of crosscutting technologies that have the potential to provide step-change improvements in both cost and performance as compared to current state-of-the-art systems. The execution of the program is primarily through cost-shared R&D in collaboration with universities, national laboratories, and industry. There are five key technologies within the Crosscutting Technology Research program:

- Sensors and Controls
- Simulation-Based Engineering
- High-Performance Materials
- Water Management R&D
- Innovative Energy Concepts

These areas support the overall goals of the Clean Coal and Carbon Management Research Programs (CCCMRP) and help provide valuable research support to each of the other subprogram areas (i.e., Advanced Energy Systems, Carbon Capture, Carbon Storage, and Supercritical Carbon Dioxide [sCO_2] Cycles).

The deployment of Crosscutting Technologies Research technologies will provide benefits when applied to existing technologies and will be integral to application within the next generations of new energy technologies providing pathways to improved efficiency and lower capital and operating costs. These technologies have been prioritized to support CCCMRP and meet their goals for application targets.

For the Fiscal Year (FY) 2015 Crosscutting Technology Research Program Peer Review, projects were selected from the Sensors and Controls Key Technology Area and the High-Performance Materials Key Technology Area.

SENSORS AND CONTROLS

The goal for the Sensors and Controls Key Technology is to make available new classes of sensors and measurement devices to increase the efficiency and accuracy that manage complexity; permit low-cost, robust monitoring; and enable real-time optimization of fully integrated, highly efficient power-generation systems. Pathways toward this goal include development of sensors capable of monitoring key parameters (e.g., temperature, pressure, and gas compositions) while operating in harsh environments with real-time online analytical evaluation and measurement capabilities. Research in the area of advanced sensor manufacturing is being conducted to determine the feasibility of constructing embedded sensors into such devices as turbine blades, boiler walls, piping, and tubing. Together these pathways provide a holistic approach that can bring about value and derive benefits for existing systems leading to important contributions toward realizing the goals of transformational systems. A complementary pathway is focused on the development of advanced process control including research in self-organizing information networks and distributed intelligence for process control and decision making.

The Sensors and Controls Key Technology addresses barriers and challenges associated with the operation of existing power plants and advanced energy systems. The motivation for conducting R&D in the sensors and controls area is based on the following technical drivers:

- Explores system upgrades using low-cost, high-benefit technologies that enhance large-scale equipment performance and reliability.
- Explores existing sensor technology potential for operations under harsh-environmental conditions associated with current and future energy conversion processes.
- Boosts efficiency of existing facilities and contributes to high reliability of emerging systems.
- Supports other power-generation technologies and related infrastructures by providing the foundation for actionable information, intercommunication across infrastructures, and intra-communication within a highly integrated, large-scale power plant.
- Makes operation of future ultraclean energy plants possible by providing novel control architectures designed to manage nonlinear dynamic systems with high levels of integration and rapid response to system changes.
- Enables new paradigms in plant and asset management beyond traditional process control by offering a novel sensor and control system that can embed intelligent sensors at various levels to monitor, in real time, asset condition, system performance, and plant operation through a computational architecture that self-organizes data and information and takes action at a time scale faster than that of the current capability.

Implementation of the Sensors and Controls Key Technology has been shown to increase efficiency and lower emissions of existing coal-fired power plants. The implementation of improved monitoring technology also affords better insight into the condition of equipment and process upsets and therefore contributes to an increase in the reliability, availability, and maintainability of operating systems. Additionally, the Sensors and Controls Key Technology directly impacts carbon dioxide (CO_2) emissions from large-scale plants to increase efficiency, heat rate, and fuel utilization—thus reducing the amount of CO_2 produced per unit of power generated. For each 1 percent increase in heat rate for a 500-megawatt (MW) coal-fired power plant, over 30 tonnes of CO_2 can be avoided without any significant retrofit to plant equipment or components. These improvements can be implemented on existing power plants to derive immediate benefit for the nation. While these contributions may only have an incremental impact relative to capture technologies, these changes are significantly less expensive and are easily maintained over long-term operation of the power system.

Sensors technology is focused on measurement systems and approaches suitable for harsh environments. The utilization of fossil fuels in an environmentally benign manner requires the conversion of the fuel and the generation of steam to take place at high temperatures and pressures with tight control over the conditions at which the targeted performance goals are achieved. These conditions can include temperatures that extend up to 2,900 °F (1,600 °C) and pressures up to 1,000 pounds per square inch (psi) (7 megapascal [MPa]) on the fuel side and up to 1,400 °F (760 °C) and 5,000 psi (35 MPa) on the steam side. The harsh conditions are compounded by a highly corrosive and erosive process environment, leading to significant failure of commercially available instrumentation. Given the challenges, the primary driver is a science-based approach to improve measurement technology, which includes consideration of advanced materials, novel sensor designs, and sensor packaging that addresses practical implementation issues.

Controls development centers around self-organizing information networks and distributed intelligence for process control and decision making. These new technologies are designed to benefit both existing and advanced power systems such that meaningful improvements can be made with respect to their efficiency and availability. As generational and transformational systems mature, sensors and controls will serve as an essential and enabling technology to operate these systems under conditions where optimal performance is balanced with reliability. The future envisioned is one in which automation technology will work alongside human operators, controlling equipment and processes as designed, while also helping users make and implement decisions and assess derived optimizations in real time. This will be achieved by new computational tools that ingest sensor data and analytical inputs, and generate a steady stream of control signals while simultaneously providing decision-making support.

HIGH-PERFORMANCE MATERIALS

The goal for this research is to develop new materials that will enable the next generation of fossil fuel power-generation technologies to operate at higher pressures and temperatures to achieve increased efficiency and lower operating costs. These new materials will need to sustain their superior properties for lifetimes up to 30 years in extreme environments. This research covers the entire realm of materials design and manufacturing. The High-Performance Materials Key technology leverages the funding available in the University Coal Research and Historically Black Colleges and Universities programs to maximize the extensive amount of materials research required. This is to ensure that the materials technology necessary to meet the technical performance and market-based goals are achieved for the Advanced Energy Systems technologies.

The High-Performance Materials Key Technology recognizes that materials research can be cost-effectively conducted at a basic level and then transferred to the appropriate research focus area as the technology progresses for specific performance evaluation. As the technology progresses to deployment, research efforts may be transferred to the appropriate program for continued funding and management. Moreover, because materials are in many cases the primary enabler of a technology’s performance, the benefits of materials can be measured by the benefits of the technology achieving its performance goal.

A goal of the High-Performance Materials Key Technology includes shortening material development timelines to facilitate FE goals. Experimental and computational investigations cut across many scientific and technological disciplines to address materials requirements for all fossil-energy systems. To bridge the gap between basic and applied research, “breakthrough” concepts are pursued to develop materials with unique thermal, chemical, and mechanical capabilities. High-Performance Materials has two basic parts. The first is the computational materials portion (design) and the second is actual material development (manufacture, testing, and qualification). The computational materials effort focuses on a predictive computational framework that accelerates the development of materials and utilizes multiscale computational materials modeling methods with focused validation experiments. Utilization of these techniques is expected to reap many benefits, including rapid alloy design, improved manufacture, better simulation of an alloy’s environmental and mechanical performance, and extended component life. This is true for both the design of structural and functional materials that are research focus areas of this key technology. As these material designs are developed, advanced manufacturing concepts, another research focus area, can be applied to produce the component parts from these materials at potentially lower cost than using conventional technologies.

Office of Management and Budget Requirements

In compliance with requirements from the Office of Management and Budget, DOE and NETL are fully committed to improving the quality of research projects in their programs. To aid this effort, DOE and NETL conducted an FY2015 Crosscutting Technology Research Program Peer Review Meeting with independent technical experts to assess ongoing research projects and, where applicable, to make recommendations for individual project improvement.

In cooperation with Leonardo Technologies, Inc., ASM International convened a panel of leading academic and industry experts on August 24–28, 2015, to conduct a five-day peer review of selected Crosscutting Technology Research program research projects supported by NETL.

Overview of Office of Fossil Energy Crosscutting Technology Research Program Research Funding

The total funding of the 12 projects reviewed, over the duration of the projects, is $15,811,059. The funding and duration of the 12 projects that were the subject of this Peer Review are provided in Table 1.

TABLE 1. CROSSCUTTING TECHNOLOGY RESEARCH PROGRAM PROJECTS REVIEWED

SENSORS AND CONTROLS KEY TECHNOLOGIES

Reference Number	Project No.	Title	Lead Organization	Total Funding		Project Duration	
				DOE	Cost Share	From	To
1	FWP-AL-14-450-011	Sensors and Controls (Engineering of Complex Systems)	Ames National Laboratory	$1,935,000	$0	10/1/2014	9/30/2019
2	FE0012299	Additive Topology Optimized Manufacturing with Embedded Sensing	United Technologies Corporation	$1,186,160	$296,540	10/1/2013	9/30/2016
3	FE0012274	Reduced Mode Sapphire Optical Fiber and Sensing System	Virginia Polytechnic Institute and State University	$1,500,000	$375,000	1/1/2014	12/31/2016
4	FE0012321	Investigation of "Smart Parts" with Embedded Sensors for Energy System Applications	University of Texas at El Paso	$913,362	$237,532	10/1/2013	9/30/2016
5	FE0012383	Smart Refractory Sensor Systems for Wireless Monitoring of Temperature, Health and Degradation of Slagging Gasifiers	West Virginia University Research Corporation	$1,280,304	$336,809	10/1/2013	9/30/2016
6	FE0012302	Evolving Robust and Reconfigurable Multi-Objective Controllers for Advanced Power Systems	Oregon State University	$1,120,255	$280,967	10/1/2013	9/30/2016

HIGH-PERFORMANCE MATERIALS KEY TECHNOLOGIES

Reference Number	Project No.	Title	Lead Organization	Total Funding		Project Duration	
				DOE	Cost Share	From	To
7	FE0024027	Modeling Long-Term Creep Performance for Welded Nickel-Based Superalloy Structures for Power Generation Systems	General Electric Company	$499,755	$149,952	10/1/2014	9/30/2016
8	FE0024054	Computational Design and Performance Prediction of Creep-Resistant Ferritic Superalloys	University of Tennessee	$500,000	$126,681	10/1/2014	9/30/2016
9	FE0024120	Predicting the Oxidation/ Corrosion Performance of Structural Alloys in Supercritical CO_2	Electric Power Research Institute	$1,697,647	$424,095	10/1/2013	3/31/2016
10	FEAA114	Advanced Alloy Design Concepts for High Temperature Fossil Energy Applications	Oak Ridge National Laboratory	$304,000	$0	6/1/2014	9/30/2016
11	FWP-2012.04.01	Innovative Process Technologies - Subtask 3.4 Computational Aspects in Alloy Design & Life Prediction	National Energy Technology Laboratory Office of Research and Development	$2,022,000	$0	10/1/2011	9/30/2015
12	FE0024014	Benefits of Hot Isostatic Pressure/ Powdered Metal (HIP/PM) and Additive Manufacturing (AM) to Fabricate Advanced Energy System Components	Energy Industries of Ohio Inc.	$500,000	$125,000	10/1/2014	9/30/2016

OVERVIEW OF THE PEER REVIEW PROCESS

The U.S. Department of Energy (DOE), the Office of Fossil Energy (FE), and the National Energy Technology Laboratory (NETL) are fully committed to improving the quality and results of their research projects. To support this goal, in fiscal year (FY) 2015, ASM International was invited to provide an independent, unbiased, and timely peer review of selected projects within the DOE Office of Fossil Energy's Crosscutting Technology Research program. The peer review of selected projects within the Crosscutting Technology Research program was designed to comply with requirements from the Office of Management and Budget.

On August 24–28, 2015, ASM International convened two panels (four panel members for Sensors and Controls and five panel members for High-Performance Materials) of eight leading academic and industry experts to conduct a five-day peer review of 12 research projects supported by the NETL Crosscutting Technology Research program (each panel reviewed six projects). Throughout the peer review meeting, these recognized technical experts provided recommendations on how to improve the management, performance, and overall results of each research project.

In consultation with NETL, who chose the 12 projects (six Sensor and Controls Key Technology projects and six High-Performance Materials Key Technology projects) for review, ASM International selected an independent peer review panel, facilitated the peer review meeting, and prepared this report to summarize the results.

ASM International performed this project review work as a subcontractor to prime NETL contractor Leonardo Technologies, Inc.

Pre-Meeting Preparation

Several weeks before the peer review, each project team submitted a project technical summary and a draft final PowerPoint slide deck they would present at the peer review meeting. Additionally, the appropriate federal project manager provided the project management plan and other relevant materials, including quarterly and annual reports (if applicable), and published journal articles (if applicable) that would help the peer review panel evaluate each project. The panel received all of these materials prior to the peer review meeting via a secure and confidential peer review SharePoint site, which enabled the panel members to fully prepare for the meeting with the necessary project background information to thoroughly evaluate the projects.

To increase the efficiency of the peer review meeting, a pre-meeting orientation teleconference/WebEx was held with the review panel and ASM International support staff four weeks prior to the meeting to review the peer review process and allow for the Technology Manager and Division Director of the Crosscutting Technology Research program to provide an overview of the program goals and objectives.

Peer Review Meeting Proceedings

At the meeting, each research team made an uninterrupted 30-minute PowerPoint presentation that was followed by a 45-minute question-and-answer session with the panel and a 60-minute panel discussion and evaluation of each project. The time allotted for project presentation, the question-and-answer session, and the panel discussion was dependent on the individual project's complexity, duration, and breadth of scope. To facilitate a full and open discourse of project-related material between the project team and the panel, all sessions were limited to the panel, ASM International personnel, and DOE-NETL personnel and contractor support staff. The closed sessions ensured open discussions between the principal investigators and the panel. Panel members were also instructed to hold the discussions that took place during the question-and-answer session as confidential.

The panel discussed each project to identify and come to consensus on the project strengths, project weaknesses, and recommendations for project improvement. The panel designated all strengths and weaknesses as "major" or "minor" and ranked recommendations from most to least important. The consensus strengths and weaknesses served as the basis for determining the overall project score in accordance with the Rating Definitions and Scoring Plan of the Peer Review Evaluation Criteria Form.

To facilitate the evaluation process, Leonardo Technologies, Inc. offered the panel laptop computers that were preloaded with Peer Review Evaluation Criteria Forms for each project, as well as the project materials that the panel members were able to access via SharePoint prior to the peer review meeting.

Peer Review Evaluation Criteria

At the end of the group discussion for each project, the panel came to consensus on an overall project score. The panel assigned a consensus score for each project, based on the following definitions (the panel was welcome to assign any integer value ranging from 0 to 10):

- Excellent (10)
- Highly Successful (8)
- Adequate (5)
- Weak (2)
- Unacceptable (0)

The Rating Definitions that informed scoring decisions are included in Appendix B of this report.

NETL completed a Technology Readiness Assessment of its key technologies in 2014. The technology readiness level (TRL) of projects assessed in 2014 was provided to the panel prior to the peer review meeting. These assessments enabled the panel to appropriately score the review criteria within the bounds of the established scope for each project. Appendix C describes the various levels of technology readiness used in 2014.

SUMMARY OF KEY FINDINGS

This section summarizes the overall key findings of the 12 projects evaluated at the FY2015 Crosscutting Technology Research Program Peer Review.

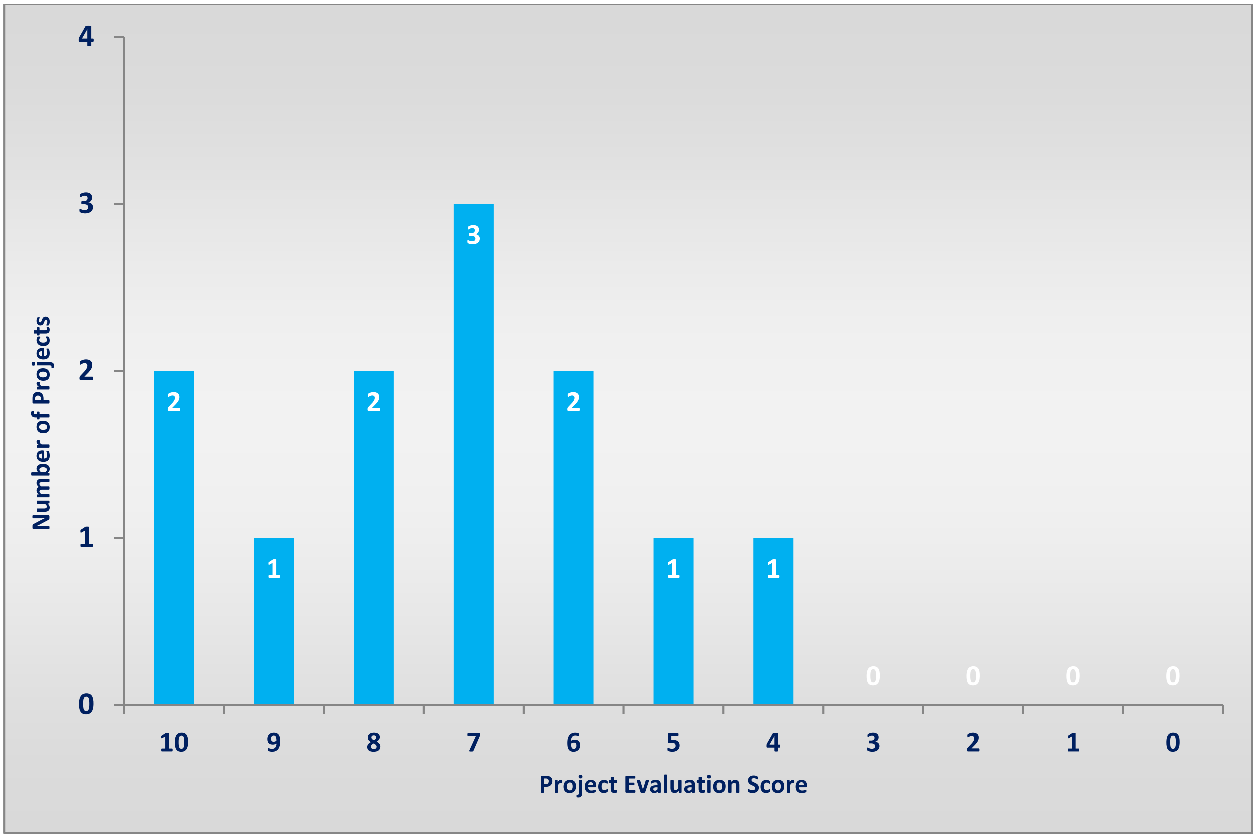
Overview of Project Evaluation Scores

The panel assigned a consensus score for each project, based on the following definitions (the panel was welcome to assign any integer value ranging from 0 to 10):

- Excellent (10)
- Highly Successful (8)
- Adequate (5)
- Weak (2)
- Unacceptable (0)

While it is not the intent of this review to directly compare one project with another, a rating of 5 or higher indicates that a specific project was viewed as at least adequate by the panel. The number of projects given each project evaluation score is shown in Figure 1.

FIGURE 1. CROSSCUTTING TECHNOLOGY RESEARCH PROGRAM PEER REVIEW PROJECT EVALUATION SCORES



PROJECT SYNOPSES

For more information on the Crosscutting Technology Research program and project portfolio, please visit the NETL website: http://www.netl.doe.gov/research/coal/crosscutting.

01: FWP-AL-14-450-011
SENSORS AND CONTROLS (ENGINEERING OF COMPLEX SYSTEMS)

Mark Bryden and Richard LeSar, Ames National Laboratory

Technology Readiness Level: 2	***DOE Funding:*** $1,935,000
Duration: 10/01/2014 – 09/30/2019	***Cost Share:*** $0

The goal of this project is to demonstrate the framework and tools needed to create detailed systems models that enable policy, engineering, and operational decisions for advanced fossil energy systems. Specifically, this project is focused on using the Hyper project at NETL as a platform to demonstrate (1) federated model sets as a decentralized approach to coordinating the exchange of information between independently developed autonomous models and (2) user interaction tools that support assembly, decision making, exploration, design, engineering, and other critical tasks related to the Hyper system with these federated model sets. These tools will then be extended to other fossil energy challenges.

02: FE0012299
ADDITIVE TOPOLOGY OPTIMIZED MANUFACTURING WITH EMBEDDED SENSING

Joseph Mantese, United Technologies Corporation

Technology Readiness Level: 2	***DOE Funding:*** $1,186,160
Duration: 10/01/2013 – 09/30/2016	***Cost Share:*** $296,540

This project will attempt to seamlessly embed a suite of sensors into an industrial gas turbine airfoil, thereby demonstrating additive manufacturing as a relevant process (when guided by physics-based models) for next generation gas turbines. The resulting “smart part” will: maintain its structural integrity, be remotely powered and sensed, and provide real-time diagnostics when coupled to a Health-Utilization-Monitoring System.

03: FE0012274
REDUCED MODE SAPPHIRE OPTICAL FIBER AND SENSING SYSTEM

Dan Homa, Virginia Polytechnic Institute and State University

Technology Readiness Level: 2	***DOE Funding:*** $1,500,000
Duration: 01/01/2014 – 12/31/2016	***Cost Share:*** $375,000

The real-time, accurate, and reliable monitoring of temperatures at distributed locations can further revolutionize technologies such as the unique integrated gasification combined cycle configuration of turbines and the ultra-super critical steam cycle designs. The proposed sapphire fiber waveguide design will overcome the harsh environment challenges that severely limit the integration of mature optical fiber sensing technologies in new power plant control systems. A new modal reduction waveguide design will take advantage of the high temperature stability and corrosion resistance of sapphire and result in a paradigm shift in ultra-high temperature sensing. A novel and precise etching technique will significantly reduce (>50%) the mode volume in a robust and truly unique sapphire.

04: FE0012321
INVESTIGATION OF "SMART PARTS" WITH EMBEDDED SENSORS FOR ENERGY SYSTEM APPLICATIONS

Yirong Lin, University of Texas at El Paso

Technology Readiness Level: 3	***DOE Funding:*** $913,362
Duration: 10/01/2013 – 09/30/2016	***Cost Share:*** $237,532

This research project aims to optimize advanced 3-D manufacturing processes for embedded sensors in energy system components, characterizing the performance and properties of these smart parts, and assessing the feasibility of applying these parts in harsh energy system environments. Specific project objectives are to (1) fabricate energy system related components with embedded sensors, (2) evaluate the mechanical properties and sensing functionalities of the smart parts with embedded piezo ceramic sensors, and (3) assess in-situ sensing capability of energy system parts. This research effort will not only contribute to designing and fabricating parts, but also to determining the smart part's durability, repeatability, and stability by testing it in realistic energy environments.

05: FE0012383
SMART REFRACTORY SENSOR SYSTEMS FOR WIRELESS MONITORING OF TEMPERATURE, HEALTH AND DEGRADATION OF SLAGGING GASIFIERS

Edward Sabolsky, West Virginia University Research Corporation

Technology Readiness Level: 2	***DOE Funding:*** $1,280,304
Duration: 10/01/2013 – 09/30/2016	***Cost Share:*** $336,809

The goal of this project is to demonstrate a high-temperature sensor concept for the monitoring of reaction conditions and health within slagging coal gasifiers. The technology will include the development of a smart refractory brick, which will contain embedded temperature, strain/stress, and spallation sensors throughout the volume of the refractory brick. The project will also develop a method to interconnect the sensors to the reactor exterior, where the sensor signals will be processed by low-power electronics and transmitted wirelessly to a central processing hub. The data processing and wireless transmitter hardware will be specifically designed to be isolated (with low power consumption) and will be adaptable to future implementation of energy-harvesting strategies for extended life. The collected data will be used for model-based estimation of refractory degradation, which can help to monitor the health of the refractory in real time.

06: FE0012302
EVOLVING ROBUST AND RECONFIGURABLE MULTI-OBJECTIVE CONTROLLERS FOR ADVANCED POWER SYSTEMS

Kagan Tumer, Oregon State University

Technology Readiness Level: 2	***DOE Funding:*** $1,120,255
Duration: 10/01/2013 – 09/30/2016	***Cost Share:*** $280,967

This work will focus on deriving, implementing, and testing bio-mimetic control and multi-objective optimization algorithms that promote robust and reconfigurable performance in an advanced power system. The long-term objective of the proposed work is to provide a comprehensive solution to the scalable and robust multi-objective control of an advanced power system where no detailed system model is required for real-time control.

07: FE0024027
MODELING LONG-TERM CREEP PERFORMANCE FOR WELDED NICKELBASE SUPERALLOY STRUCTURES FOR POWER GENERATION SYSTEMS

Chen Shen and Monica Soare, General Electric Company

Technology Readiness Level: 2	***DOE Funding:*** $499,755
Duration: 10/01/2014 – 09/30/2016	***Cost Share:*** $149,952

The goal of this project is to model long-term creep performance for nickel-base super alloy weldments in high temperature power generation systems. The project will use physics-based modeling methodologies and algorithms for predicting alloy properties in heterogeneous material structures. The modeling technology developed will provide a more efficient and accurate assessment of a material's long-term performance compared with current testing and extrapolation methods. This modeling technology will accelerate development and qualification of new materials in advanced power generation systems. The modeling methodology will be demonstrated on a gas turbine combustor liner weldment of Haynes H282 precipitate-strengthened nickel-base super alloy.

08: FE0024054
COMPUTATIONAL DESIGN AND PERFORMANCE PREDICTION OF CREEP-RESISTANT FERRITIC SUPERALLOYS

Peter Liaw, University of Tennessee

Technology Readiness Level: 4	***DOE Funding:*** $500,000
Duration: 10/01/2014 – 09/30/2016	***Cost Share:*** $126,681

The objectives of this research are: (1) to develop and integrate modern computational tools and algorithms, i.e., predictive first-principles calculations, computational-thermodynamic modeling, and meso-scale dislocation-dynamics simulations, to design high-temperature alloys for applications in FE power plants; and (2) to understand the processing-microstructure-property-performance links underlying the creep behavior of novel ferritic alloys strengthened by hierarchical coherent B2/L21 precipitates.

09: FE0024120
PREDICTING THE OXIDATION/CORROSION PERFORMANCE OF STRUCTURAL ALLOYS IN SUPERCRITICAL CO_2

John Shingledecker, Electric Power Research Institute

Technology Readiness Level: 3	***DOE Funding:*** $1,697,647
Duration: 10/01/2013 – 03/31/2016	***Cost Share:*** $424,095

The technical goal of this project is to develop an oxidation/corrosion model to predict the performance of structural alloys as a function of oxide growth rate and tendency for scale exfoliation in supercritical CO_2 (sCO_2) in severe operating environments at high temperatures. This goal will be accomplished through (1) short-term isothermal lab-scale oxidation/corrosion tests in high-pressure (200 atmosphere [atm] or higher) and high-temperature (650-750ºC) sCO_2; (2) characterization of the oxide scales on the exposed samples, determination of the oxide scale growth, and exfoliation kinetics; and (3) modeling of the process of oxide growth and exfoliation with and without heat-flux, and application of the model to actual tube geometries. A longer-term exposure on a relevant geometry will also be conducted as a confirmatory test for the developed model. Using the model results, recommendations will be made for structural materials selection for alloys in high-temperature sCO_2 environments.

10: FWP-FEAA114
ADVANCED ALLOY DESIGN CONCEPTS FOR HIGH TEMPERATURE FOSSIL ENERGY APPLICATIONS

Yukinori Yamamoto, Oak Ridge National Laboratory

Technology Readiness Level: 2-3	***DOE Funding:*** $304,000
Duration: 06/01/2014 – 09/30/2016	***Cost Share:*** $0

The goal of this project is to identify and apply breakthrough alloy design concepts and strategies for incorporating improved creep strength, environmental resistance, and weldability into the classes of alloys intended for use as heat exchanger tubes in fossil-fueled power generation systems at higher temperatures than is possible with currently available alloys. Technical objectives are (1) temperature capabilities that are 50-200ºC higher (for both mechanical properties and environmental compatibility) than those of the existing ferritic-martensitic steels, austenitic steels, and Nickel-base alloys; and (2) provide cost-effective new alloys by the use of less expensive elemental additions as well as inexpensive processing routes.

11: FWP-2012.04.01
INNOVATIVE PROCESS TECHNOLOGIES - SUBTASK 3.4 COMPUTATIONAL ASPECTS IN ALLOY DESIGN & LIFE PREDICTION

David Alman and Jeffrey Hawk, National Energy Technology Laboratory

Technology Readiness Level: 2	***DOE Funding:*** $2,022,000
Duration: 10/01/2011 – 09/30/2015	***Cost Share:*** $0

Continue development of existing computational models (e.g., oxidation) by adding realistic complexity to simulate alloy oxidation kinetics in relevant FE combustion (i.e., air- and oxy-fired) and working fluid (e.g., sCO_2) environments. The primary focus will be on predicting long-term oxidation kinetics that would establish criteria for "end of life" in specific alloy systems. Doing so will allow either higher temperatures to be achieved for current systems at existing stress levels or higher stress levels within components at existing temperatures for current systems.

More importantly, research will continue on developing computational models and associated algorithms that can be used to simulate continuous evolutionary improvements within the microstructure for critical features that govern microstructural stability and mechanical performance (i.e., austenitic matrix and strengthening phases in nickel superalloys, austenitic matrix of stainless steels, generalized face centered cubic (FCC) and body centered cubic (BCC) metallic structures, and specific 9% chromium (Cr) martensitic-ferritic steels). The goal is to extend life at current power system conditions and also gain sufficient awareness of what excursions outside normal operating conditions can do to a material, and account for these excursions within the life models by integrating microstructural evolution with microstructural and mechanical property information to more precisely define microstructure-mechanical "end of life" criteria for specific alloy systems. Being able to do so will enable better power plant management by accounting for microstructural changes within the material in real time as the material ages due to temperature and stress.

12: FE0024014
BENEFITS OF HOT ISOSTATIC PRESSURE/POWDERED METAL (HIP/PM) AND ADDITIVE MANUFACTURING (AM) TO FABRICATE ADVANCED ENERGY SYSTEM COMPONENTS

Nancy Horton and Roy Sheppard, Energy Industries of Ohio, Inc.

Technology Readiness Level: N/A	***DOE Funding:*** $500,000
Duration: 10/01/2014 – 09/30/2016	***Cost Share:*** $125,000

This project will demonstrate how tailoring Hot Isostatic Pressure of Powdered Metal (HIP/PM) coupled with advances in Additive Manufacturing (AM) (also known as 3D printing or 3DP and used interchangeably herein) has specific, measurable benefits for fabricating advanced energy (AE) system components. Three new methods of manufacturing advanced alloys will be pursued: 1) Directly built AM parts; 2) AM cans for HIP/PM; and 3) AM cans produced in the final part material. The project will utilize binderjet technology, the fastest metal 3DP technique on the market, coupled with an alloy specific sintering profile to produce a sufficiently dense part for final HIP. The project will use Haynes alloy A-282, a high nickel material capable of withstanding the severe operating environments required in AE systems and other cross-cutting environments including aerospace. The goal will be to validate AM (combining 3DP & HIP) as a viable method of producing A-282 components, while providing key information about cost, manufacturing challenges/opportunities and lead-times when compared to other methods including HIP/PM and casting.

APPENDIX A: ACRONYMS AND ABBREVIATIONS

Acronym or Abbreviation	Definition
3DP	3D printing
AE	advanced energy
AM	additive manufacturing
atm	atmosphere
BCC	body centered cubic
CCC	Copyright Clearance Center
CCCMRP	Clean Coal and Carbon Management Research Program
CO_2	carbon dioxide
Cr	chromium
CTR	Crosscutting Technology Research
DOE	U.S. Department of Energy
FCC	face centered cubic
FY	fiscal year
HIP	hot isostatic pressure
IPO	Independent Professional Organization
LTI	Leonardo Technologies, Inc.
MPa	megapascal
MW	megawatt
NETL	National Energy Technology Laboratory
PM	powdered metal
psi	pounds per square inch
R&D	research and development
RD&D	research, development, and demonstration
SCC	Strategic Center for Coal
sCO_2	supercritical CO_2
TRL	technology readiness level

APPENDIX B: PEER REVIEW EVALUATION CRITERIA FORM

PEER REVIEW EVALUATION CRITERIA AND GUIDELINES

U.S. DEPARTMENT OF ENERGY (DOE)
NATIONAL ENERGY TECHNOLOGY LABORATORY

Peer Review Title:	
Dates:	
Project Title:	
Performer:	
Name of Peer Reviewer:	

The following pages contain the criteria used to evaluate each project. Each criterion is accompanied by multiple characteristics to further define the topic. Each Reviewer is expected to independently assess the provided material for each project, considering the Evaluation Criteria on the following page. Prior to the meeting, the Reviewers will independently create a list of strengths and weaknesses for each project based on the materials provided. To assist Reviewers in capturing their thoughts both before and during the meeting, an optional form is attached at the end of this document.

At the meeting, the Facilitator and/or Panel Chairperson will lead the Peer Review Panel in identifying consensus strengths, weaknesses, overall score, and prioritized recommendations for each project. The consensus strengths and weaknesses shall serve as a basis for the determination of the overall project score in accordance with the Rating Definitions and Scoring Plan detailed on the following page.

A **strength** is an aspect of the project that, when compared to the evaluation criterion, reflects positively on the probability of successful accomplishment of the project's goals and objectives.

A **weakness** is an aspect of the project that, when compared to the evaluation criterion, reflects negatively on the probability of successful accomplishment of the project's goals and objectives.

Consensus strengths and weaknesses shall be characterized as either "major" or "minor" during the panel's consensus discussion at the meeting. For example, a weakness that presents a significant threat to the likelihood of achieving the project's stated technical goals and supporting objectives should be considered "major," whereas relatively less significant opportunities for improvement are considered "minor."

A **recommendation** shall emphasize an action that will be considered by the project team and/or DOE to be included as a milestone for the project to correct or mitigate the impact of weaknesses, or expand upon a project's strengths. A recommendation should have as its basis one or more strengths or weaknesses. Recommendations shall be *ranked* from most important to least, based on the major/minor strengths/weaknesses.

EVALUATION CRITERIA	
1	**Degree to which the project, if successful, supports the program's near- and/or long-term goals** • Clear project performance and/or cost/economic* objectives are present, appropriate for the maturity of the technology, and support the program goals. • Technology is ultimately technically and/or economically viable for the intended application.
2	**Degree of project plan technical feasibility** • Technical gaps, barriers and risks to achieving the project performance and/or cost objectives* are clearly identified. • Scientific/engineering approaches have been designed to overcome the identified technical gaps, barriers and risks to achieve the project performance and/or cost/economic objectives*.
3	**Degree to which progress has been made towards the stated project performance and cost/economic* objectives** • Milestones and reports effectively enable progress to be tracked. • Reasonable progress has been made relative to the established project schedule and budget.
4	**Degree to which the project plan-to-complete assures success** • Remaining technical work planned is appropriate, in light of progress to date and remaining schedule and budget. • Appropriate risk mitigation plans exist, including Decision Points if appropriate.
5	**Degree to which there are sufficient resources to successfully complete the project** • There is adequate funding, facilities and equipment. • Project team includes personnel with needed technical and project management expertise. • The project team is engaged in effective teaming and collaborative efforts, as appropriate.

* Projects that do not have cost/economic objectives should be evaluated on performance objectives only.

RATINGS DEFINITIONS AND SCORING PLAN

The Panel will be required to assign a consensus score to the project, after strengths and weaknesses have been agreed upon. Intermediate whole number scores are acceptable if the panel feels it is appropriate. The overall project score must be justified by, and consistent with, the identified strengths and weaknesses.

RATING DEFINITIONS	
10	**Excellent -** Several major strengths; no major weaknesses; few, if any, minor weaknesses. Strengths are apparent and documented.
8	**Highly Successful -** Some major strengths; few (if any) major weaknesses; few minor weaknesses. Strengths are apparent and documented, and outweigh identified weaknesses.
5	**Adequate -** Strengths and weaknesses are about equal in significance.
2	**Weak -** Some major weaknesses; many minor weaknesses; few (if any) major strengths; few minor strengths. Weaknesses are apparent and documented, and outweigh strengths identified.
0	**Unacceptable -** No major strengths; many major weaknesses. Significant weaknesses/deficiencies exist that are largely insurmountable.

APPENDIX C: TECHNOLOGY READINESS LEVEL DESCRIPTIONS

Research, Development, and Demonstration (RD&D) projects can be categorized based on the level of technology maturity. Listed below are nine (9) TRLs of RD&D projects managed by the NETL. These TRLs provide a basis for establishing a rational and structured approach to decision-making and identifying performance criteria that must be met before proceeding to the next level.

TRL	DOE-FE Definition	DOE-FE Description
1	Basic principles observed and reported	Lowest level of technology readiness. Scientific research begins to be translated into applied R&D. Examples include paper studies of a technology's basic properties.
2	Technology concept and/or application formulated	Invention begins. Once basic principles are observed, practical applications can be invented. Applications are speculative and there may be no proof or detailed analysis to support the assumptions. Examples are still limited to analytic studies.
3	Analytical and experimental critical function and/or characteristic proof of concept	Active R&D is initiated. This includes analytical and laboratory-scale studies to physically validate the analytical predictions of separate elements of the technology (e.g., individual technology components have undergone laboratory-scale testing using bottled gases to simulate major flue gas species at a scale of less than 1 scfm).
4	Component and/or system validation in a laboratory environment	A bench-scale prototype has been developed and validated in the laboratory environment. Prototype is defined as less than 5% final scale (e.g., complete technology process has undergone bench-scale testing using synthetic flue gas composition at a scale of approximately 1–100 scfm).
5	Laboratory-scale similar-system validation in a relevant environment	The basic technological components are integrated so that the system configuration is similar to (matches) the final application in almost all respects. Prototype is defined as less than 5% final scale (e.g., complete technology has undergone bench-scale testing using actual flue gas composition at a scale of approximately 1–100 scfm).
6	Engineering/pilot-scale prototypical system demonstrated in a relevant environment	Engineering-scale models or prototypes are tested in a relevant environment. Pilot or process-development-unit scale is defined as being between 0 and 5% final scale (e.g., complete technology has undergone small pilot-scale testing using actual flue gas composition at a scale equivalent to approximately 1,250–12,500 scfm).
7	System prototype demonstrated in a plant environment	This represents a major step up from TRL 6, requiring demonstration of an actual system prototype in a relevant environment. Final design is virtually complete. Pilot or process- development-unit demonstration of a 5–25% final scale or design and development of a 200–600 MW plant (e.g., complete technology has undergone large pilot-scale testing using actual flue gas composition at a scale equivalent to approximately 25,000–62,500 scfm).
8	Actual system completed and qualified through test and demonstration in a plant environment	The technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include startup, testing, and evaluation of the system within a 200–600 MW plant CCS/CCUS operation (e.g., complete and fully integrated technology has been initiated at full-scale demonstration including startup, testing, and evaluation of the system using actual flue gas composition at a scale equivalent to approximately 200 MW or greater).
9	Actual system operated over the full range of expected conditions	The technology is in its final form and operated under the full range of operating conditions. The scale of this technology is expected to be 200–600 MW plant CCS/CCUS operations (e.g., complete and fully integrated technology has undergone full-scale demonstration testing using actual flue gas composition at a scale equivalent to approximately 200 MW or greater).

APPENDIX D: MEETING AGENDA

AGENDA

FY15 Crosscutting Research Peer Review
August 24 – 28, 2015
Sheraton Station Square
Pittsburgh, PA

Monday, August 24, 2015 – Ellwood Room

7:00 – 8:00 a.m.	**Registration – 2nd Floor Foyer**
8:00 – 8:45 a.m.	**Peer Review Panel Kickoff Session – Sensors and Control Key Technology** Open to National Energy Technology Laboratory (NETL) and ASM International staff only - NETL and ASM International Welcome - Role of Panel Chair - Peer Review Process Overview - Meeting Logistics
8:45 – 9:15 a.m.	**Technology Manager/Office of Program Performance & Benefits (OPPB) and Panel Q&A** Open to NETL and ASM International staff only - Crosscutting Research Technology Manager – Bob Romanosky, NETL - OPPB
9:15 – 9:30 a.m.	**BREAK**
9:30 – 10:00 a.m.	**01 – Project # FWP-AL-14-450-011** – Sensors and Controls (Engineering of Complex Systems) *Mark Bryden and Richard LeSar* - **Ames National Laboratory**
10:00 – 10:45 a.m.	Q&A
10:45 – 12:00 p.m.	Discussion
12:00 – 1:00 p.m.	**Lunch (on your own)**
1:00 – 1:30 p.m.	**02 – Project # FE0012299** - Additive Topology Optimized Manufacturing with Embedded Sensing *Joe Mantese* - **United Technologies Corporation**
1:30 – 2:15 p.m.	Q&A
2:15 – 3:30 p.m.	Discussion

Tuesday, August 25, 2015 – Ellwood Room

7:00 – 8:00 a.m.	**Registration – 2nd Floor Foyer**
8:00 – 8:30 a.m.	**03 – Project # FE0012274 –** Reduced Mode Sapphire Optical Fiber and Sensing System *Dan Homa* - **Virginia Polytechnic Institute and State University**
8:30 – 9:15 a.m.	Q&A
9:15 – 10:15 a.m.	Discussion
10:15 – 10:30 a.m.	**BREAK**
10:30 – 11:00 a.m.	**04 – Project # FE0012321** – Investigation of "Smart Parts" with Embedded Sensors for Energy System Applications *Yirong Lin* - **University of Texas at El Paso**
11:00 – 11:45 a.m.	Q&A
11:45 – 12:45 p.m.	Discussion
12:45 – 1:45 p.m.	**Lunch (on your own)**
1:45 – 2:15 p.m.	**05 – Project # FE0012383** – Smart Refractory Sensor Systems for Wireless Monitoring of Temperature, Health and Degradation of Slagging Gasifiers *Edward Sabolsky* - **West Virginia University Research Corporation**
2:15 – 3:00 p.m.	Q&A
3:00 – 4:00 p.m.	Discussion

Wednesday, August 26, 2015 – Ellwood Room

7:00 – 8:00 a.m.	**Registration – 2nd Floor Foyer**
8:00 – 8:30 a.m.	**06 – Project # FE0012302** – Evolving Robust and Reconfigurable Multi-Objective Controllers for Advanced Power Systems *Kagan Tumer* **– Oregon State University**
8:30 – 9:15 a.m.	Q&A
9:15 – 10:15 a.m.	Discussion
10:15 – 10:30 a.m.	**BREAK**
10:30 – 11:30 a.m.	**Wrap-up Session**
11:30 – 12:30 p.m.	**Lunch (on your own)**
12:30 – 1:15 p.m.	**Peer Review Panel Kickoff Session – High Performance Materials Key Technology** Open to National Energy Technology Laboratory (NETL) and ASM International staff only - NETL and ASM International Welcome - Role of Panel Chair - Peer Review Process Overview - Meeting Logistics
1:15 – 1:45 p.m.	**Technology Manager/Office of Program Performance & Benefits (OPPB) and Panel Q&A** Open to NETL and ASM International staff only - Crosscutting Research Technology Manager – Bob Romanosky, NETL - OPPB
1:45 – 2:00 p.m.	**BREAK**

2:00 – 2:30 p.m.	**07 – Project # FE0024027** – Modeling Long-Term Creep Performance for Welded Nickel-Base Superalloy Structures for Power Generation Systems *Chen Shen and Monica Soare* - **General Electric Company**
2:30 – 3:15 p.m.	Q&A
3:15 – 4:30 p.m.	Discussion

Thursday, August 27, 2015 – Ellwood Room

7:00 – 8:00 a.m.	**Registration – 2nd Floor Foyer**
8:00 – 8:30 a.m.	**08 – Project # FE0024054** – Computational Design and Performance Prediction of Creep-Resistant Ferritic Superalloys *Peter Liaw* - **University of Tennessee**
8:30 – 9:15 a.m.	Q&A
9:15 – 10:15 a.m.	Discussion
10:15 – 10:30 a.m.	**BREAK**
10:30 – 11:00 a.m.	**09 – Project # FE0024120** – Predicting the Oxidation/Corrosion Performance of Structural Alloys in Supercritical CO_2 *John Shingledecker* - **Electric Power Research Institute**
11:00 – 11:45 a.m.	Q&A
11:45 – 12:45 p.m.	Discussion
12:45 – 1:45 p.m.	**Lunch (on your own)**
1:45 – 2:15 p.m.	**10 – Project # FWP-FEAA114** – Advanced Alloy Design Concepts for High Temperature Fossil Energy Applications *Yukinori Yamamoto* - **Oak Ridge National Laboratory**
2:15 – 3:00 p.m.	Q&A
3:00 – 4:00 p.m.	Discussion

Friday, August 28, 2015 – Ellwood Room

7:00 – 8:00 a.m.	**Registration – 2nd Floor Foyer**
8:00 – 8:30 a.m.	**11 – Project # FWP-2012.04.01** – Innovative Process Technologies - Subtask 3.4 Computational Aspects in Alloy Design & Life Prediction *Jeffrey Hawk and David Alman* - **National Energy Technology Laboratory**
8:30 – 9:15 a.m.	Q&A
9:15 – 10:15 a.m.	Discussion
10:15 – 10:30 a.m.	**BREAK**
10:30 – 11:00 a.m.	**12 – Project # FE0024014** – Benefits of Hot Isostatic Pressure/Powdered Metal (HIP/PM) and Additive Manufacturing (AM) to Fabricate Advanced Energy System Components *Nancy Horton and Roy Sheppard* - **Energy Industries of Ohio Inc.**
11:00 – 11:45 a.m.	Q&A
11:45 – 12:45 p.m.	Discussion
12:45 – 1:45 p.m.	**Working Lunch - Wrap-up Session**

APPENDIX E: PEER REVIEW PANEL MEMBERS

Sensors and Controls Key Technologies

Michael von Spakovsky, Ph.D. – Panel Chair

Dr. von Spakovsky has over 28 years of teaching and research experience in academia and over 17 years of industry experience in mechanical engineering, power utility systems, aerospace engineering and software engineering. He received his B.S. in Aerospace Engineering in 1974 from Auburn University and his M.S and Ph.D. in Mechanical Engineering in 1980 and 1986, respectively, from the Georgia Institute of Technology. While at Auburn he worked for three and a half years at NASA in Huntsville, Alabama and from 1974 to 1984 and from 1987 to 1989 worked in the power utility industry first as an engineer and then as a consultant. From 1989 to 1996, Dr. von Spakovsky worked as both an educator and researcher at the Swiss Federal Institute of Technology in Lausanne, Switzerland where he led a research team in the modeling and systems integration of complex energy systems and taught classes in the thermodynamics of indirect and direct energy conversion systems (including fuel cells).

In January of 1997, Dr. von Spakovsky joined the Mechanical Engineering faculty at Virginia Tech as Professor and Director of the Energy Management Institute (now the Center for Energy Systems Research). He teaches undergraduate and graduate level courses in thermodynamics and intrinsic quantum thermodynamics, kinetic theory and the Boltzmann equation, fuel cell systems, and energy system design. His research interests include computational methods for modeling and optimizing complex energy systems, methodological approaches (with and without sustainability and uncertainty considerations) for the integrated synthesis, design, operation, and control of such systems (e.g., stationary power systems, grid/microgrid/producer/storage and district heating/cooling networks, high performance aircraft systems), theoretical and applied thermodynamics with a focus on intrinsic quantum thermodynamics applied to nanoscale and microscale reactive and non-reactive systems, and fuel cell applications for both transportation and centralized, distributed, and portable power generation and cogeneration. He has published widely in scholarly journals, conference proceedings, etc. (over 220 publications) and has given talks, keynote lectures, seminars and short courses (e.g., on fuel cells and intrinsic quantum thermodynamics) worldwide. Included among his various professional activities and awards is *Senior member of the AIAA*; *Fellow of the ASME*; the *2014 ASME James Harry Potter Gold Medal*; the *2012 ASME Edward F. Obert Award*; the *2005*, *2008*, and *2012 ASME Advanced Energy Systems Division (AESD) Best Paper Awards*; the *ASME AESD Lifetime Achievement Award*; former Chair of the *Executive Committee* for the ASME AESD, elected member of Sigma Xi and Tau Beta Pi, Associate Editor of the *ASME Journal of Fuel Cell Science and Technology*, and former Editor-in-Chief (11-year tenure) and now Honorary Editor of the *International Journal of Thermodynamics*.

Ching-Fong (Chris) Chen, Ph.D.

Dr. Chen graduated from the University of Michigan in 1987 with a Ph.D. degree in Materials Science and Engineering. His dissertation was on the high temperature mechanical properties of Si_3N_4 for gas turbine applications. He has more than 26 years of experience in ceramic powder synthesis, powder processing, ceramic forming, sintering/hot pressing/hot isostatic pressing, machining/polishing, metallization, and characterizations; Dr. Chen is a scientist within the materials science and technology division of LANL. While working at LANL he successfully led a DNDO and a NA-22 project in developing a transparent polycrystalline gamma detector. He was also a PI of a LANL internal funded project to developed a transparent polycrystalline

Spinel ($MgAl_2O_4:Ce^{3+}$), which resulted in one publication and one patent. He has also been a PI of several program including catalyst for metal air battery, additive manufacturing, specialty functional material, and signature sensing. Prior to joining LANL, Dr. Chen was the Director of Technology with MER Corporation. He had won 5 phase I and 2 phase II programs in developing several advanced materials and detectors. From 1998–2001, he was the process control manager of Brush Wellman, Inc. There he was responsible for processing control, process improvement, and materials development. From 1990-1996, he was the advanced ceramics manager with LECO Corp. His responsibility was to develop advanced ceramics and commercialize the products. He oversaw the product development, marketing information, and sale. From 1987-1990, Dr. Chen was the advanced ceramic research manager with Keramont Corp, where he was responsible for AlN and transparent polycrystalline AlON ceramics.

Prabir Dutta, Ph.D.

The four active areas of research in Professor Dutta's group are: (1) Microporous Materials Synthesis (examining the synthesis of microporous materials in novel environments such as reverse micelles); (2) Photochemistry in Microporous Materials (the architecture of microporous materials, in particular, zeolites being exploited to assemble photochemical assemblies that can promote the use of light to generate useful chemicals, as in the production of hydrogen and oxygen from water); (3) Harsh Environment Sensors (high temperature sensors appropriate for use in harsh environments, as in automotive exhausts for detecting gases, such as carbon monoxide, hydrocarbons, nitrogen oxides, are being developed; and (4) Toxicity of Mineral Fibers (the basis of toxicity of mineral fibers, such as asbestos, are being developed via studies of model zeolitic fibers with rat lung macrophages).

Prabir K. Dutta received his B.S. degree in Chemistry from Calcutta University in 1972 and a M.S. degree from Indian Institute of Technology, Kanpur in 1974. In 1978, he received his Ph.D. degree in Chemistry from Princeton University. After a year of post-doctoral study at Princeton and four years of industrial research at Exxon Research and Engineering Company, he joined The Ohio State University as Assistant Professor. He was promoted to Associate Professor in 1988, and to Professor of Chemistry in 1992. Since 1998, he has been the Robert K Fox Professor of Chemistry. He was named Distinguished University Professor in 2010. He has received several research and teaching awards, including a Society for Applied Spectroscopy Award in 1993, Ohio State Distinguished Scholar Award in 2000 and a Teaching Award in 2000. He is also currently the Deputy Director of the multidisciplinary NSF-funded center, Center for Industrial Sensors and Measurements in the College of Engineering with responsibility for directing the basic research program in ceramic sensors. Professor Dutta was the Department Chair from 2003 through 2007.

Eric Taleff, Ph.D.

Dr. Taleff specializes in the mechanical behavior and the thermo-mechanical processing of structural materials, with emphasis on processing-microstructure-property relationships. His current research interests include the ductility of Al-Mg alloys at elevated temperatures, including superplasticity and superplastic alloys, and processing-microstructure-property relationships in hypereutectoid steels, particularly for high-strength wire applications. The Taleff Research Group works in these and other areas related to structural materials. Dr. Taleff was a member of the faculty of the Department of Aerospace Engineering and Engineering Mechanics from 1995 until 1998, and since 1998 has been a member of the faculty of the Department of Mechanical Engineering. He is an active member in the Minerals, Metals & Materials Society, ASM International, and American Society of Professional Engineers professional societies. He has received several awards and honors, including: 1998 Faculty Excellence Award for the AEEM Department; 1998 Young Leader Internship of the Minerals, Metals & Materials Society; and 1997 National Science Foundation Faculty Early Career Development (CAREER) Award; 2001 Texas Excellence Teaching Award for the Cockrell School of Engineering from the Ex-Students' Association and the Cabinet of College Councils; and the 2001 Cockrell School of Engineering Award for Outstanding Engineering Teaching by an Assistant Professor, sponsored by Lockheed-Martin. He became the Faculty Advisor for Pi Tau Sigma, the National Honorary Mechanical Engineering Society in 2003. In 2005 he received the Charlotte Maer Patton Centennial Fellowship in Engineering. Dr. Taleff is also a member of the University of Texas Materials Institute.

High-Performance Materials Key Technologies

Michael von Spakovsky, Ph.D. – Panel Chair

Michael von Spakovsky has more than 18 years of teaching and research experience in academia and over 17 years of industry experience in mechanical engineering, power utility systems, aerospace engineering, and software engineering. In January of 1997, Dr. von Spakovsky joined the Mechanical Engineering faculty at Virginia Polytechnic Institute and State University as Professor and director of the Energy Management Institute (now the Center for Energy Systems Research). He teaches undergraduate and graduate level courses in thermodynamics, kinetic theory, fuel cell systems, and energy system design.

Prior to teaching at the Virginia Polytechnic Institute and State University, Professor Spakovsky worked at the National Aeronautics and Space Administration; in the power utility industry, first as an engineer and then as a consultant; and as both an educator and researcher at the Swiss Federal Institute of Technology in Lausanne, where he led a research team in the modeling and systems integration of complex energy systems and taught classes in the thermodynamics of indirect and direct energy conversion systems.

His research interests include computational methods for modeling and optimizing complex energy systems, methodological approaches for the integrated synthesis, design, operation, control, and diagnosis of such systems (stationary power as well as, for example, high performance aircraft systems), theoretical and applied thermodynamics with a focus on the unified quantum theory of mechanics and thermodynamics, and fuel cell applications for both transportation and distributed power generation.

Professor von Spakovsky has been a contributing author of more than 170 publications, including articles in scholarly journals and conference proceedings, and has given talks, seminars, and short courses (e.g., on fuel cells) worldwide. Included among his various professional activities and awards is membership in the American Institute of Aeronautics and Astronautics, fellow of the ASME, member of the Executive Committee for the ASME's Advanced Energy Systems Division, elected member of Sigma Xi and Tau Beta Pi, associate editor of the International Journal of Fuel Cell Science and Technology, editor-in-chief of the International Journal of Thermodynamics, and chairman of the executive committee for the International Center of Applied Thermodynamics. He holds a B.S. in aerospace engineering from Auburn University, and an M.S. and Ph.D. in mechanical engineering from the Georgia Institute of Technology.

Minking K. Chyu, Ph.D.

Dr. Chyu is chair of the Department of Mechanical Engineering and Materials Science and the Leighton Orr Endowed Professor of Engineering at the University of Pittsburgh. Dr. Chyu's primary research focus is thermo-fluid issues related to power and propulsion system, material processing, microsystem technology, transport phenomena, energy and power systems, gas turbines, and fuel cells. Major projects he has conducted include convective cooling of gas turbine airfoils, thermal control of rotating machinery, thermal measurement and imaging techniques, and transport phenomena in adaptive flow control and fabrication of microstructures.

Dr. Chyu has received numerous honors and awards, including a DOE-NETL Faculty Fellow from 2007 to the present, associate fellow of the American Society of Aeronautics and Astronautics (2005), ASME Engineer of the year Award (2002), and DOE Advanced-Turbine-System Faculty Fellow (1998–1999). Dr. Chyu is also a fellow of ASME, a member of the Heat Transfer Technical Committee in Gas Turbines (K-14), and an advisory board member of the

Center for Advanced Energy and Environment, National Tsing Hua University in Taiwan. Dr. Chyu served as Associate Editor of the ASME Journal on Heat Transfer, served on NSF Propane Review Panels from 2003 to 2005, and is a member of the Scientific Council for the International Centre for Heat and Mass Transfer. Dr. Chyu has over 70 publications and over 100 symposium and conference papers, has been conference chair or organizer of nearly 30 conferences, served as an invited lecturer on more than 40 occasions, has won over 30 grants, and has graduated 12 Ph.D. and 20 M.S. students.

Dr. Chyu received a B.S. in nuclear engineering at the National Tsing Hua University in Taiwan, a M.S. in applied mechanics at the University of Cincinnati, and a Ph.D. in mechanical Engineering from the University of Minnesota.

Kester D. Clarke, Ph.D.

Dr. Kester is a staff member and technical lead for deformation/thermal processing and fabrication of metals in the Materials Science and Technology division, Metallurgy (MST-6) group, at Los Alamos National Laboratory. He has over 10 years' experience working in materials engineering positions in national laboratory, consulting, and industry settings. His research interests include development of materials, material fabrication processes, and the use of experimental and modeling methods to examine the effect of material processing history and microstructure on mechanical properties and performance. He is active in the Association for Iron and Steel Technology (AIST), ASM International, and The Minerals, Metals, & Materials Society (TMS) and currently serves as chair of the AIST Metallurgy – Processing, Products and Applications Technology committee, chair of the Los Alamos Chapter of ASM International, secretary of the TMS Shaping & Forming committee, and as a member of the TMS/ASM Nuclear Materials and TMS/ASM Phase Transformations committees. He earned Ph.D. ('08) and M.S. ('02) degrees in Metallurgical and Materials Engineering from the Colorado School of Mines, a B.S. ('00) in Materials Science and Engineering from Wayne State University, and a B.A. ('94) in Psychology from Indiana University.

Wayne Huebner, Ph.D.

Dr. Wayne Huebner is a Professor of Ceramic Engineering, and the Chairman of the Materials Science and Engineering Department at the Missouri University of Science and Technology in Rolla, MO. Prior to this position he served as the Vice Provost for Research from 2001–2007. The author of over 100 papers, monographs, and book chapters, he has been actively involved in the preparation and characterization of electronic ceramics. Much of his research is focused on the use of dielectrics, ionic and mixed conductors, piezoelectrics, electrostrictive materials for multilayer capacitors, solid oxide fuel cells, gas separation membranes, and phased linear array transducers for intravascular imaging. He has graduated 10 Ph.D. students and 15 M.S. students. Huebner has received S&T's Faculty Excellence Award five times, the Outstanding Teacher Award four times, and was named the Outstanding Faculty Member in Ceramic Engineering five consecutive years. He has been a continuous member of the Electronics Division of American Ceramic Society since 1983, serving in many capacities including all offices of the Ceramic Educational Council, an organizer of various symposia, and Associate Editor of the Journal of the ACS. Dr. Huebner received his B.S and Ph.D. in ceramic engineering from the University of Missouri-Rolla.

Richard Wenglarz, Ph.D.

Richard Wenglarz is a consultant for advanced energy systems, particularly related to gas turbines. His energy system experience includes about 23 years at major energy companies and, most recently, 10 years at the South Carolina Institute for Energy Studies (SCIES) at Clemson University.

At SCIES, Dr. Wenglarz was Manager of Research for the University Turbine Systems Research program organized as a consortium of government, industry, and about 110 member universities. Working with an industrial review board of up to 17 member companies (e.g., General Electric, ExxonMobil, British Petroleum, Siemens, etc.), he was responsible for defining request for proposal research objectives, evaluating and selecting university proposals to accomplish the objectives, and overseeing the university research projects awarded throughout the nation. He also oversaw workshops to disseminate the results of the university research to Government, industry, and academia.

Prior to SCIES, Dr. Wenglarz held research and project management positions over about 23 years related to advanced turbine systems at Rolls Royce/Allison Gas Turbine Company and Westinghouse Research and Development Center. He managed a program that successfully demonstrated an Allison 501 gas turbine with first-stage ceramic vanes at an Exxon natural gas processing plant. He also conducted numerous plant economic analyses for the DOE/Allison Advanced Turbine System and the DOE/Allison Direct Coal Fired Turbine System Program. In addition, Dr. Wenglarz was responsible for developing and evaluating turbine flow path protection approaches from deposition, erosion, and corrosion for the Allison Direct Coal Fired Turbine Program and at Westinghouse. He also managed the Allison internal research and development program for coal fuels and the DOE/Allison Component Screening Program, both directed to developing a technology base for direct coal fueled turbines.

Dr. Wenglarz has authored over 80 publications and has delivered invited presentations at the Von Karman Institute for Fluid Dynamics (Belgium), Yale University, UK Central Electricity Research Laboratories, Cambridge University, the Kentucky Energy Cabinet Laboratories, 8th Liege Conference on Materials for Advanced Power Engineering (Belgium), and the Sultzer Metco Gen 5 Ceramics Consortium. He also developed and presented a course segment on turbine corrosion and deposition at the DOE sponsored short course “Impact of Synfuels and Hydrogen Fuels Relevant to Gas Turbine Development.” Dr. Wenglarz received B.S. and M.S. degrees from the University of Illinois, and a Ph.D. from Stanford University, all in engineering mechanics.