NATIONAL ENERGY TECHNOLOGY LABORATORY

FY21 CROSSCUTTING (SENSORS, CONTROLS, AND NOVEL CONCEPTS) PEER REVIEW OVERVIEW REPORT

August 16, 2021

U.S. DEPARTMENT OF ENERGY | NATIONAL ENERGY TECHNOLOGY LABORATORY

DISCLAIMER

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INTRODUCTION AND BACKGROUND

The Crosscutting (Sensors, Controls, and Novel Concepts) Program aims to improve fossil energy power generation with sensors, distributed intelligent control systems, and increased security. Advanced sensors and controls provide pivotal insights into optimizing plant performance and increasing plant reliability and availability. The National Energy Technology Laboratory (NETL) tests and matures novel sensor and control systems that are operable in coal-fired power plants, capable of real-time measurements, improve overall plant efficiencies, and allow for more effective ramp rates. Given the crosscutting nature of sensors and controls, these enabling technologies also benefit natural gas and biomass co-fired power generation, combined cycle power plants, hydrogen production and utilization, carbon management systems, and other harsh environment applications.

The current energy landscape is experiencing a greater energy mix than ever before. Technological advances enable renewable energy sources to penetrate the grid, which forces existing infrastructure to switch from a traditional baseload operational profile to a load-following profile. Load following poses a challenge to the fossil-based power generation fleet because the systems and materials of construction were not originally designed to endure fast ramp rates, low load operation, and more frequent cold starts. Operators are increasingly turning to sensors, controls, and monitoring and diagnostic tools to better enable flexible operations and predict component failures.

The Crosscutting (Sensors, Controls, and Novel Concepts) Program explores advances within, and the integration of technologies across, the following primary research areas:

- Harsh Environment Sensors—Sensor research investigates a range of advanced manufacturing techniques to develop novel prototype technologies that may be used to conduct new measurements and determine the feasibility of incorporating sensors with condition-based monitoring algorithms to predict component failure; anticipate maintenance needs; and reduce plant downtime. Sensors and controls lead to improved infrastructure while reducing operations and maintenance (O&M) costs. Crosscutting research is helping determine optimal sensor placement, allowing for optimal characteristic readings, such as temperature, pressure, fluid composition, and the state of materials. The information informs operators of plant health and process performance in real time.
- Advanced Controls and Cyber Physical Systems—Controls research advances the accuracy of physics-based and data analytics-driven distributed intelligence systems for process control and automation. The ability to monitor key plant parameters and align results in real time with self-organizing information networks can enable decision-makers to improve the operational efficiency during challenging transient conditions, increase plant availability and dispatch, tighten environmental control, and improve plant revenue profiles. Cyber-physical approaches are used at NETL to explore the complex interactions of power generation subsystems, as well as to improve the control of plant components.
- Novel Concepts—As a part of greater efforts to achieve a carbon pollution-free power sector by 2035 and net-zero emissions by 2050, other novel/emerging technologies will be developed to support energy applications that will prove essential to an equitable, clean energy future. These activities are focused on technology maturation and transfer into the

marketplace. Recent efforts include projects focused on cybersecurity, quantum information sciences (QIS), and direct power extraction.

Office of Management and Budget and U.S. Department of Energy Requirements

In compliance with requirements from the Office of Management and Budget and in accordance with the U.S. Department of Energy (DOE) Strategic Plan, DOE and NETL are fully committed to improving the quality of research projects in their programs by conducting rigorous peer reviews. DOE and NETL conducted a Fiscal Year 2021 (FY21) Crosscutting (Sensors, Controls, and Novel Concepts) Peer Review Meeting with independent technical experts to offer recommendations to strengthen projects during the period of performance and assess the projects' Technology Readiness Level (TRL) progression. KeyLogic, an NETL site-support contractor, convened a panel of four academic and industry experts[*] on July 7-9, 2021, to conduct a peer review of five research projects.

[*] Please see "Appendix D: Peer Review Panel Members" for detailed panel member biographies.

TABLE 1. CROSSCUTTING (SENSORS, CONTROLS, AND NOVEL CONCEPTS) PEER REVIEW – PROJECTS REVIEWED

Project Number	Title	Lead Organization	Total Funding		Project Duration	
			DOE	Cost Share	From	To
FE0031640	Operational Technology Behavioral Analytics	Southern Company Services Inc.	$249,985	$72,909	10/01/2018	09/30/2021
FE0031751	Generation Plant Cost of Operations and Cycling Optimization Model	National Rural Electric Cooperative Association (NRECA)	$1,510,400	$500,000	10/01/2019	03/31/2022
FE0031763	Deep Analysis Net with Causal Embedding for Coal Fired Power Plant Fault Detection and Diagnosis	General Electric (GE) Company	$1,999,837	$499,959	09/01/2019	08/31/2021
FE0031753	Hybrid Analytics Solution to Improve Coal Power Plant Operations	Expert Microsystems, Inc.	$791,693	$197,923	10/01/2019	09/30/2021
FE0031768	Boiler Health Monitoring using a Hybrid First Principles-Artificial Intelligence Model	West Virginia University (WVU) Research Corporation	$1,984,135	$524,811	09/01/2019	08/31/2022
Peer Review Evaluation: During TRL-based evaluations, the independent panel offers recommendations and assesses the projects' technology readiness for work at the current TRL and the planned work to attain the next TRL.			$6,536,050	$1,795,602		
			$8,331,652			

OVERVIEW OF THE PEER REVIEW PROCESS

Peer reviews are conducted to help ensure that the Office of Fossil Energy and Carbon Management's (FECM) research program, implemented by NETL, is in compliance with requirements from the Office of Management and Budget and in accordance with the DOE Strategic Plan and DOE guidance. Peer reviews improve the overall quality of the technical aspects of research and development (R&D) activities, as well as overall project-related activities, such as utilization of resources, project and financial management, and commercialization.

KeyLogic convened a panel of four academic and industry experts to conduct a peer review of five research projects supported by the Crosscutting (Sensors, Controls, and Novel Concepts) Program. Throughout the peer review meeting, these recognized technical experts offered recommendations to strengthen the projects during the remaining period of performance and provided feedback on the projects' technology readiness for work at the current TRL and the planned work to attain the next TRL. KeyLogic selected an independent Peer Review Panel, facilitated the peer review meeting, and prepared this report to summarize the results.

Pre-Meeting Preparation

Before the peer review, each project team submitted a Project Technical Summary (PTS), project presentation, and a Technology Maturation Plan (TMP) to facilitate TRL evaluation. The Federal Project Manager (FPM) provided the Project Management Plan (PMP), the latest quarterly report, and supplemental technical papers as additional resources for the panel. The panel received these materials prior to the peer review meeting, which enabled the panel members to fully prepare for the meeting with the necessary background information to thoroughly evaluate the projects.

To increase the efficiency of the peer review meeting, multiple pre-meeting orientation teleconference calls were held with NETL, the Peer Review Panel, and KeyLogic staff to review the peer review process and procedures, evaluation criteria, and project documentation, as well as to allow for the Technology Manager to provide an overview of the program goals and objectives.

Peer Review Meeting Proceedings

At the meeting, each project performer gave a presentation describing the project. The presentation was followed by a question-and-answer session with the panel and a closed panel discussion and evaluation. The time allotted for the presentation, the question-and-answer session, and the closed panel discussion was dependent on the project's complexity, duration, and breadth of scope.

During the closed sessions of the peer review meeting, the panel discussed each project to identify strengths, weaknesses, and recommendations in accordance with the Peer Review Evaluation Criteria. The panel offered a series of prioritized recommendations to strengthen the projects during the remaining period of performance and offered an evaluation of TRL progression.

SUMMARY OF KEY FINDINGS

This section summarizes the overall key findings of the projects evaluated at the FY21 Crosscutting (Sensors, Controls, and Novel Concepts) Peer Review Meeting. The panel concluded that the peer review provided an excellent opportunity to comment on the relative strengths and weaknesses of each project. The presentations and question-and-answer sessions provided additional clarity to complement the pre-meeting documentation. The peer review also provided an insight into the range of technology development and the relative progress that has been made by the project teams. The technical discussion enabled the panel to contribute to each project's development by identifying core issues and by making constructive, actionable recommendations to improve project outcomes. The panel generated 28 recommendations for NETL management to review and consider.

The projects were well received by the panel, primarily in terms of the status of technology development and the inclusion of the various participants and expertise within the project teams to execute the work scope. The teams include representation from academia and industry—specifically partnerships with power plants that (for example) provide real plant data to develop and validate models. The panel confirmed that the projects are aligned with DOE's near- and/or long-term goals and demonstrated noteworthy progress and accomplishments within their respective work scope and budgets. The panel also noted that the projects accurately represented their TRL and demonstrated an understanding of the work needed to continue their progression along the technology development pathway. The project teams demonstrated noteworthy examples of the integration of different technologies, a necessary feature to advance TRL, but more work is needed to make their respective process(es) more iterative.

The panel expressed a concern that the projects are using neural networks when simpler approaches may be available for consideration. There is a significant trend in this space that artificial intelligence (AI) is a "silver bullet" that can solve any problem and/or address gaps, but there are other areas of engineering and computer science available that are worthy of heightened attention and consideration by the project teams. Given the level of data and machine learning (ML) presented, the panel expected more rigorous statistical analysis from the project teams. With that said, the panel did express that the project teams are using the right tools to execute their work scope and the neural network approaches are in line with their expectations. Finally, the panel indicated that these projects would be more impactful if their data were made publicly available (while acknowledging the apparent sensitives with proprietary data). Data availability in the public arena can contribute to the establishment of benchmarks and these data are both needed and difficult to acquire (e.g., time series data from real-world systems). With respect to additional research considerations for DOE to pursue, the panel offered that a research effort to define a digital twin would be helpful and impactful.

Evaluation of Technology Readiness Level Progression

At the meeting, the panel assessed the projects' readiness to start work towards the next TRL based on a project's strengths, weaknesses, recommendations, issues, and concerns. For the various projects subject to review, the panel found that the projects were on track to attaining their respective planned end-of-project TRL based on achievement of the project goals as planned and addressing the panel recommendations.

- Project FE0031640 has not attained TRL 3. To attain TRL 3, Project FE0031640 should complete analytical and laboratory-scale studies to physically validate the analytical predictions of the Operational Technology Behavioral Analytics (OTBA) technology.
- Project FE0031751 has attained TRL 3. Upon achievement of review panel recommendation 3 (i.e., completing an analysis on how accurate the neural network is as a surrogate model), the project shall attain TRL 4. Upon completion of review panel recommendations 1, 2, and 4 (i.e., expanding the reliability analysis formulation, quantifying the impact of the uncertainties in the balance equations and the direct measurement uncertainties on cost predictions and the training of the neural network, and determining the root cause of the bimodal operation in 2015 data), Project FE0031751 shall attain TRL 5.
- Project FE0031763 has attained TRL 4. Upon achievement of review panel recommendation 1 (i.e., performing a rigorous statistical analysis) and development of online versions of their models ready for integration with an existing system, Project FE0031763 shall attain TRL 5. The completion of review panel recommendations 2 and 3 (i.e., developing a process to correctly annotate new data from new plants/systems and developing a process for model retraining) would result in attaining TRL 6.
- Project FE0031753 has not attained TRL 6. To attain TRL 6, Project FE0031753 should implement review panel recommendations 1 and 2 (i.e., including the quantification of additional alerts or the avoidance of false positives and quantifying why the hybrid approach prediction is better than the advanced pattern recognition [APR] prediction alone). Upon demonstrating an actual system prototype in a relevant environment and implementation of review panel recommendation 3 (i.e., evaluating the impact of continually updating model parameters), Project FE0031753 shall attain TRL 7.
- Project FE0031768 has attained TRL 4. Following completion of review panel recommendations 2 and 3 (i.e., completing a rigorous statistical analysis of the new methodology and determining whether the AI model is improving predictions from their baseline model), Project FE0031768 shall attain TRL 5. Following completion of review panel recommendation 1 (i.e., ensuring installation of the instrumented dutchman on a coal-fired plant and the later removal and evaluation of the material changes observed), the project shall attain TRL 6.

PROJECT SYNOPSES

For more information on the Crosscutting (Sensors, Controls, and Novel Concepts) Program and project portfolio, please visit the NETL website: https://netl.doe.gov/coal/sensors-and-controls.

FE0031640

OPERATIONAL TECHNOLOGY BEHAVIORAL ANALYTICS

SOUTHERN COMPANY SERVICES INC.

Project Description: The goal of the project is to normalize various forms of machine data to enhance analytics and machine learning (ML) to more robustly detect cyberattacks on generation, transmission, and distribution systems. Captured data will provide a baseline of the environment that will be utilized to generate analytical trends, patterns, and discovered behavior of devices/processes.

FE0031751

GENERATION PLANT COST OF OPERATIONS AND CYCLING OPTIMIZATION MODEL

NATIONAL RURAL ELECTRIC COOPERATIVE ASSOCIATION

Project Description: The National Rural Electric Cooperative Association (NRECA), in collaboration with Great River Energy (GRE), Purdue University, and Pacific Northwest National Laboratory (PNNL), has undertaken a project to develop resources and tools that allow utilities to determine the costs of operating their large coal boilers at reduced capacity. The resource will allow large coal boilers to cycle safely to provide enhanced resiliency and reliability while utility systems accommodate increased penetration of renewable resources, such as wind, solar photovoltaics, or other small generators.

FE0031763

DEEP ANALYSIS NET WITH CAUSAL EMBEDDING FOR COAL FIRED POWER PLANT FAULT DETECTION AND DIAGNOSIS

GENERAL ELECTRIC COMPANY

Project Description: General Electric (GE) Company, in collaboration with Electric Power Research Institute (EPRI) and Southern Company Services Inc., (SC) is developing a novel end-to-end trainable artificial intelligence (AI)-based multivariate time-series learning system for flexible and scalable coal power plant fault detection and root-cause analysis (i.e., diagnosis), known as Deep Analysis Net with Causal Embedding for Coal-fired power plant Fault Detection and Diagnosis (DANCE4CFDD).

FE0031753

HYBRID ANALYTICS SOLUTION TO IMPROVE COAL POWER PLANT OPERATIONS

EXPERT MICROSYSTEMS, INC.

Project Description: The goal of this project is to develop, demonstrate, and commercialize a new real-time monitoring approach (i.e., the Hybrid Analytics Solution) to improve coal plant operations. This hybrid analytics software tool will provide real-time information on the relationship between plant operational data (e.g., measured temperatures, pressures, flow rates) and the plant performance and reliability. The hybrid analytics solution will integrate machine learning (ML)-based data analytics with thermal analysis in a manner that enables increased accuracy and scope of the thermal analysis, resulting in an improved ability of the data analytics to monitor changes affecting plant operations.

FE0031768

BOILER HEALTH MONITORING USING A HYBRID FIRST PRINCIPLES-ARTIFICIAL INTELLIGENCE MODEL

WEST VIRGINIA UNIVERSITY RESEARCH CORPORATION

Project Description: The project will develop and validate a first-principles model for the superheater/reheater, develop a Bayesian machine learning (ML) model for tube external and internal heat transfer resistance, develop a Gaussian radial basis function (RBF) network model for the subrecipient's existing physics-based models (i.e., TULIP/BLISS), enhance the capabilities of TULIP/BLISS, and develop a health monitoring framework that leverages the hybrid model.

APPENDIX A: PEER REVIEW EVALUATION CRITERIA

Peer reviews are conducted to ensure that the Office of Fossil Energy and Carbon Management's (FECM) research program, implemented by the National Energy Technology Laboratory (NETL), is compliant with the U.S. Department of Energy (DOE) Strategic Plan and DOE guidance. Peer reviews improve the overall quality of the technical aspects of research and development (R&D) activities, as well as overall project-related activities, such as utilization of resources, project and financial management, and commercialization.

In the upcoming NETL peer review, a significant amount of information about the projects is covered in a short period. For that reason, NETL has established a set of guidelines for governing the meeting.

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 all the provided material for each project prior to the meeting and engage in discussion to generate feedback for each project during the meeting.

NETL Peer Review – Technology Readiness Level-Based Evaluation

At the meeting, the Facilitator leads the Peer Review Panel in assessing a project's readiness to start work towards the next Technology Readiness Level (TRL) based on a project's strengths†, weaknesses‡, recommendations, issues, and concerns.

A recommendation emphasizes an action that is considered by the project team and/or DOE to correct or mitigate the impact of weaknesses, expand upon a project's strengths, or progress along the technology maturation path (TRL-based evaluation). A recommendation has as its basis one or more strengths or weaknesses. Recommendations are ranked from most important to least, based on the major/minor strengths/weaknesses.

† 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 goal(s) 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 goal(s) and objectives.

NETL Peer Review Evaluation Criteria
1. Degree to which the project, if successful, supports the U.S. Department of Energy (DOE) Program's near- and/or long-term goals.
• Program goals are clearly and accurately stated. • Performance requirements[1] support the program goals. • The intended commercial application is clearly defined. • The technology is ultimately technically and economically viable for the intended commercial application.
2. Degree to which there are sufficient resources to successfully complete the project.
• There is adequate funding, facilities, and equipment. • Project team includes personnel with the needed technical and project management expertise. • The project team is engaged in effective teaming and collaborative efforts, as appropriate.
3. Degree of project plan technical feasibility.
• Technical gaps, barriers, and risks to achieving the performance requirements are clearly identified. • Scientific/engineering approaches have been designed to overcome the identified technical gaps, barriers, and risks to achieve the performance requirements. • Remaining technical work planned is appropriate considering progress to date and remaining schedule and budget. • Appropriate risk mitigation plans exist, including Decision Points when applicable.
4. Degree to which progress has been made towards achieving the stated performance requirements.
• The project has tested (or is testing) those attributes appropriate for the next Technology Readiness Level (TRL). The level of technology integration and nature of the test environment are consistent with the aforementioned TRL definition. • Project progress, with emphasis on experimental results, shows that the technology has, or is likely to, achieve the stated performance requirements for the next TRL (including those pertaining to capital cost, if applicable). • Milestones and reports effectively enable progress to be tracked. • Reasonable progress has been made relative to the established project schedule and budget.
5. Degree to which an appropriate basis exists for the technology's performance attributes and requirements.
• The TRL to be achieved by the end of the project is clearly stated[2]. • Performance attributes for the technology are defined[2]. • Performance requirements for each performance attribute are, to the maximum extent practical, quantitative, clearly defined, and appropriate for and consistent with the DOE goals as well as technical and economic viability in the intended commercial application.
6. The project Technology Maturation Plan (TMP) represents a viable path for technology development beyond the end of the current project, with respect to scope, timeline, and cost. *(This criterion is not applicable to a recommendations-based evaluation)*
[1] If it is appropriate for a project to not have cost/economic-related performance requirements, then the project is evaluated on technical performance requirements only. [2] Supported by systems analyses appropriate to the targeted TRL.

APPENDIX B: DOE TECHNOLOGY READINESS LEVELS

The following is a description of U.S. Department of Energy (DOE) Technology Readiness Levels (TRLs).

Relative Level of Technology Development	Technology Readiness Level	TRL Definition	Description
System Operations	TRL 9	Actual system operated over the full range of expected mission conditions	The technology is in its final form and operated under the full range of operating mission conditions. Examples include using the actual system with the full range of wastes in hot operations.
System Commissioning	TRL 8	Actual system completed and qualified through test and demonstration	The technology has been proven to work in its final form and under expected conditions. In almost all cases, this Technology Readiness Level (TRL) represents the end of true system development. Examples include developmental testing and evaluation of the system with actual waste in hot commissioning. Supporting information includes operational procedures that are virtually complete. An Operational Readiness Review (ORR) has been successfully completed prior to the start of hot testing.
	TRL 7	Full-scale, similar (prototypical) system demonstrated in relevant environment	This represents a major step up from TRL 6, requiring demonstration of an actual system prototype in a relevant environment. Examples include testing full-scale prototype in the field with a range of simulants in cold commissioning (1). Supporting information includes results from the full-scale testing and analysis of the differences between the test environment, and analysis of what the experimental results mean for the eventual operating system/environment. Final design is virtually complete.
Technology Demonstration	TRL 6	Engineering/pilot-scale, similar (prototypical) system validation in relevant environment	Engineering-scale models or prototypes are tested in a relevant environment. This represents a major step up in a technology's demonstrated readiness. Examples include testing an engineering-scale prototypical system with a range of simulants (1). Supporting information includes results from the engineering-scale testing and analysis of the differences between the engineering-scale, prototypical system/environment, and analysis of what the experimental results mean for the eventual operating system/environment. TRL 6 begins true engineering development of the technology as an operational system. The major difference between TRL 5 and 6 is the step-up from laboratory scale to engineering scale and the determination of scaling factors that will enable design of the operating system. The prototype should be capable of performing all the functions that will be required of the operational system. The operating environment for the testing should closely represent the actual operating environment.

Relative Level of Technology Development	Technology Readiness Level	TRL Definition	Description
Technology Development	**TRL 5**	Laboratory-scale, similar system validation in relevant environment	The basic technological components are integrated so that the system configuration is similar to (matches) the final application in almost all respects. Examples include testing a high-fidelity, laboratory scale system in a simulated environment with a range of simulants (1) and actual waste (2). Supporting information includes results from the laboratory scale testing, analysis of the differences between the laboratory and eventual operating system/environment, and analysis of what the experimental results mean for the eventual operating system/environment. The major difference between TRL 4 and 5 is the increase in the fidelity of the system and environment to the actual application. The system tested is almost prototypical.
Technology Development	**TRL 4**	Component and/or system validation in laboratory environment	The basic technological components are integrated to establish that the pieces will work together. This is relatively "low fidelity" compared with the eventual system. Examples include integration of ad hoc hardware in a laboratory and testing with a range of simulants and small-scale tests on actual waste (2). Supporting information includes the results of the integrated experiments and estimates of how the experimental components and experimental test results differ from the expected system performance goals. TRL 4–6 represent the bridge from scientific research to engineering. TRL 4 is the first step in determining whether the individual components will work together as a system. The laboratory system will probably be a mix of on hand equipment and a few special purpose components that may require special handling, calibration, or alignment to get them to function.

Relative Level of Technology Development	Technology Readiness Level	TRL Definition	Description
Research to Prove Feasibility	TRL 3	Analytical and experimental critical function and/or characteristic proof of concept	Active research and development (R&D) is initiated. This includes analytical studies and laboratory-scale studies to physically validate the analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative tested with simulants (1). Supporting information includes results of laboratory tests performed to measure parameters of interest and comparison to analytical predictions for critical subsystems. At TRL 3 the work has moved beyond the paper phase to experimental work that verifies that the concept works as expected on simulants. Components of the technology are validated, but there is no attempt to integrate the components into a complete system. Modeling and simulation may be used to complement physical experiments.
Research to Prove Feasibility / Basic Technology Research	TRL 2	Technology concept and/or application formulated	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. Supporting information includes publications or other references that outline the application being considered and that provide analysis to support the concept. The step up from TRL 1 to TRL 2 moves the ideas from pure to applied research. Most of the work is analytical or paper studies with the emphasis on understanding the science better. Experimental work is designed to corroborate the basic scientific observations made during TRL 1 work.
Basic Technology Research	TRL 1	Basic principles observed and reported	This is the lowest level of technology readiness. Scientific research begins to be translated into applied R&D. Examples might include paper studies of a technology's basic properties or experimental work that consists mainly of observations of the physical world. Supporting Information includes published research or other references that identify the principles that underlie the technology.

1 Simulants should match relevant chemical and physical properties.

2 Testing with as wide a range of actual waste as practicable and consistent with waste availability, safety, as low as reasonably achievable (ALARA), cost, and project risk is highly desirable.

Source: U.S. Department of Energy, "Technology Readiness Assessment Guide." Office of Management. 2011.

APPENDIX C: MEETING AGENDA

FY21 Crosscutting (Sensors, Controls, and Novel Concepts) Peer Review
July 7-9, 2021
Virtual Meeting

**** All times Eastern ****

Day 1 – Wednesday, July 7, 2021

10:00 – 10:30 a.m.	Peer Review Panel Kickoff Session *DOE HQ/NETL, KeyLogic Peer Review Support Staff, and Panel Members Attend* - Facilitator Opening, Review Panel Introductions, NETL Welcome, Peer Review Process and Meeting Logistics
10:30 – 11:15 a.m.	Project FE0031640 – Operational Technology Behavioral Analytics *Clifton Black* – Southern Company Services Inc.
11:15 – 12:00 p.m.	Question-and-Answer Session
12:00 – 12:30 p.m.	LUNCH
12:30 – 2:00 p.m.	Closed Discussion (Peer Review Panel Evaluation) *DOE HQ/NETL and KeyLogic Peer Review Support Staff Attend as Observers*
2:00 – 2:15 p.m.	BREAK
2:15 – 3:00 p.m.	Project FE0031751 – Generation Plant Cost of Operations and Cycling Optimization Model *Anantha Narayanan* – National Rural Electric Cooperative Association (NRECA)
3:00 – 3:45 p.m.	Question-and-Answer Session
3:45 – 4:00 p.m.	BREAK
4:00 – 5:30 p.m.	Closed Discussion (Peer Review Panel Evaluation) *DOE HQ/NETL and KeyLogic Peer Review Support Staff Attend as Observers*
5:30 p.m.	Adjourn

**** All times Eastern ****

Day 2 – Thursday, July 8, 2021

10:00 – 10:10 a.m.	Kickoff Session
10:10 – 10:55 a.m.	Project FE0031763 – Deep Analysis Net with Causal Embedding for Coal Fired Power Plant Fault Detection and Diagnosis *Feng Xue* – General Electric (GE) Company
10:55 – 11:40 a.m.	Question-and-Answer Session
11:40 – 12:10 p.m.	LUNCH
12:10 – 1:40 p.m.	Closed Discussion (Peer Review Panel Evaluation) *DOE HQ/NETL and KeyLogic Peer Review Support Staff Attend as Observers*
1:40 – 1:55 p.m.	BREAK
1:55 – 2:40 p.m.	Project FE0031753 – Hybrid Analytics Solution to Improve Coal Power Plant Operations *Randall Lee Bickford* – Expert Microsystems, Inc.
2:40 – 3:25 p.m.	Question-and-Answer Session
3:25 – 3:40 p.m.	BREAK
3:40 – 5:10 p.m.	Closed Discussion (Peer Review Panel Evaluation) *DOE HQ/NETL and KeyLogic Peer Review Support Staff Attend as Observers*
5:10 p.m.	Adjourn

**** All times Eastern ****

Day 3 – Friday, July 9, 2021

11:30 – 11:40 a.m.	Kickoff Session
11:40 – 12:25 p.m.	Project FE0031768 – Boiler Health Monitoring using a Hybrid First Principles-Artificial Intelligence Model *Debangsu Bhattacharyya* – West Virginia University Research Corporation
12:25 – 1:10 p.m.	Question-and-Answer Session
1:10 – 1:25 p.m.	BREAK
1:25 – 2:55 p.m.	Closed Discussion (Peer Review Panel Evaluation) *DOE HQ/NETL and KeyLogic Peer Review Support Staff Attend as Observers*
2:55 – 3:40 p.m.	Peer Review Panel Wrap-up Session and Discussion *DOE/NETL and KeyLogic Peer Review Staff Attend*
3:40 p.m.	Adjourn

APPENDIX D: PEER REVIEW PANEL MEMBERS

FY21 Crosscutting (Sensors, Controls, and Novel Concepts) Peer Review
July 7-9, 2021
Virtual Meeting

Travis Desell, Ph.D.

Dr. Travis Desell is an Associate Professor specializing in Data Science, housed in the Department of Software Engineering in the B. Thomas Golisano College of Computing and Information Sciences (GCCIS) at the Rochester Institute of Technology (RIT). His research focuses on the application of machine learning (ML) to large-scale, real-world datasets using high-performance and distributed computing, with an emphasis on developing systems for practical scientific use. He is interested in the intersection of evolutionary algorithms and neural networks, or "neuro-evolution," where evolutionary algorithms are used to automate and optimize the design of neural network architectures. Dr. Desell is actively developing the Evolutionary eXploration of Augmenting Convolutional Topologies (EXACT) and Evolutionary eXploration of Augmenting Memory Models (EXAMM, formerly known as EXALT) algorithms, which are hosted on GitHub. He has also been a main contributor in the development of both the compiler and runtime of SALSA and SALSA Lite, a programming language based on the actor model of computation; SALSA enables the development of concurrent and transparently distributed applications by following actor semantics.

Dr. Desell has produced numerous journal articles, conference and workshop proceedings, and technical reports, and has offered nearly 30 public talks. He earned his B.S., M.S., and Ph.D. from Rensselaer Polytechnic Institute (RPI).

Ronald Griebenow, P.E.

Ronald Griebenow is an Executive Consultant for Woyshner Services Company, Inc. He has more than 30 years of experience in power plant reliability, performance improvement, and operations training for the electric power industry. Mr. Griebenow spent more than nine years as a Director with GP Strategies Corporation, primarily in a business development role helping to define and implement equipment condition and plant performance monitoring and diagnostic projects. He was also one of the instructors for GP's Performance Knowledge Series training courses and managed several large performance improvement projects. Mr. Griebenow joined GP Strategies through the acquisition of Performance Consulting Services (PCS), where he was the President and a co-founder. PCS specialized in engineering support, training, and software products directed toward increasing plant performance and availability, optimizing manpower usage, and reducing overall operating costs.

In addition to his responsibilities for corporate management and business development for PCS, Mr. Griebenow spent eight years on contract to the Electric Power Research Institute (EPRI) as the Director of EPRI's Fossil Plant Simulator and Training Center. His responsibilities included development and management of the Center, management of EPRI fossil plant simulator and training projects, and technology transfer to EPRI member utilities. Mr. Griebenow received a B.S. in Mechanical Engineering from the University of Idaho. He is a member of the American Society of Mechanical Engineers (ASME), a member of ASME's Committee for Certification of Operators of High Capacity Fossil Fuel Fired Plants and the Performance Test Codes (PTC) 100 Standards

Committee, and a registered Professional Engineer in the state of South Carolina.

Aaron Hussey, P.E.

Aaron Hussey is the principal for Integral Analytics' business and consulting activities with an emphasis on power industry implementation of advanced pattern recognition (APR) models and analytics software design and prototyping. Current responsibilities include APR model development and program implementation for Ontario Power Generation (OPG) monitoring & diagnostic center under contract to WSC, Inc., assessment of critical sensors using a failure modes and effects analysis (FMEA) for large electric generators under contract to EPRI, and various analytics software design and prototyping efforts for software vendors and electric utilities covering nuclear, fossil-fuels, and hydroelectricity. Before founding Integral Analytics, Mr. Hussey's responsibilities included the implementation of predictive analytic models for Duke Energy's 11-unit fleet of nuclear power plants, Tennessee Valley Authority's (TVA) fossil-, hydro-, and nuclear-generating units, and South Carolina Electric & Gas (SCE&G) VC Summer nuclear site. Prior to that, he fulfilled various roles over more than nine years at the Electric Power Research Institute, focusing on instrumentation and controls (both nuclear and non-nuclear) research including project management for the Fleet-Wide Monitoring Interest Group.

Michael von Spakovsky, Ph.D.

Dr. Michael von Spakovsky has more than 30 years of teaching and research experience in academia and more than 20 years of industry experience in mechanical engineering, power utility systems, aerospace engineering, and software engineering. He received his B.S. in Aerospace Engineering from Auburn University and his M.S. and Ph.D. in Mechanical Engineering from the Georgia Institute of Technology. Dr. von Spakovsky has worked at the National Aeronautics and Space Administration (NASA) in Huntsville, Alabama and in the power utility industry, first as an engineer and then as a consultant. 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).

Dr. von Spakovsky is currently a part of 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 been published widely in scholarly journals and conference proceedings (more than 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 American Institute of Aeronautics and Astronautics (AIAA); Fellow of the American Society of Mechanical Engineers (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 Electrochemical Energy Conversion and Storage; and former Editor-in-Chief (11-year tenure) and now Honorary Editor of the International Journal of Thermodynamics.