Committee on Advanced Technologies for Gas Turbines
Second Meeting
February 7-8, 2019

Beckman Center of the National Academies
Huntington Room
100 Academy Way
Irvine, CA 92617
949-721-2200

AGENDA

Complete Draft, Open Sessions (as of Jan 29, 2019)

Meeting Goal--Open Sessions

Explore potential for high-risk, high-payoff research to substantially accelerate improvements to gas turbines for aviation propulsion, high-power industrial applications (generation of electricity and steam), and the oil and gas industry.

Potential Research Areas Relevant to the Statement of Task (see last page of agenda):

R1. Novel thermodynamic cycles
R2. System and component integration
R3. Design for advanced manufacturing (e.g., additive manufacturing)
R4. Digital twins
R5. Materials and coatings
R6. Thermal management and component cooling
R7. Condition based overhaul and maintenance (sensors, analytics, and inspection)
R8. Combustion (e.g., flexible fuels)
R9. High-fidelity integrated simulation (including experimentation)
R10. Product development cycle time
R11. Safe operation of pipeline turbines with hydrogen fuel

Future Technical Trends. It is assumed that these technologies will rapidly advance through 2030 and beyond:

T1. Inexpensive, large scale computational capabilities
T2. Highly autonomous systems
T3. Advanced additive manufacturing capabilities

Future Market Scenario. It is assumed that the following changes will come to pass by 2030:

M1. Highly distributed networks of smaller power generation stations
M2. Greater emphasis on low CO2 emissions (e.g., more electric aircraft)
M3. More renewable energy, increasing the need for more flexible gas turbines (i.e., able to accommodate rapid changes in demand)
M4. More-capable international competitors
M5. Greater demand for LNG and LNG transportation
M6. Greater demand for CO2 pipelines
M7. Changing formulation of natural gas (addition of hydrogen)

Thursday, February 7

Open Session

Time	Duration Hrs : Min		
7:15 AM	0:30	Breakfast available in dining room	
7:45 AM	0:10	Welcome and Introductions	Ed Crow and Tresa Pollock, Co-chairs Alan Angleman, Study Director

Panel 1. Novel Thermodynamic Cycles and Gas Turbine System and Component Integration

Focus Questions for Panel 1: Assuming that the future technical trends (specified above) continue and the future market scenario comes to pass . . . What high-risk, high-payoff research related to novel thermodynamic cycles and gas turbine system and component integration has the greatest potential for substantially accelerating improvements to the performance of gas turbines (in terms of efficiency, life cycle cost, and/or other parameters)? What would be the advantages and disadvantages of placing greater emphasis on component integration at early stages of the design process? What aggressive goals should be established for these research projects and what state of development could these research projects achieve by 2030? The gas turbine applications of interest are aviation propulsion, high-power industrial applications (generation of electricity and steam), and the oil and gas industry.

Time	Duration Hrs : Min		
7:55 AM	0:10	Introduction and Overview of Applicable Gas Turbines	Moderators: Tim Lieuwen and John Gülen, Committee Members
8:05 AM	0:40	Opening remarks by each panelist (10 minutes each)	Panelists: 1. Chris Perullo, Ga Tech 2. Fred Schauer, AFRL 3. Raub Smith, GE Power 4. Geo Richards, DOE National Energy Technology Laboratory
8:45 AM	1:10	General Discussion	
9:55 AM	0:15	Break	

Panel 2. Simulation, Experimentation, and Digital Twins

Focus Questions for Panel 2: Assuming that the future technical trends (specified above) continue and the future market scenario comes to pass . . . What high-risk, high-payoff research related to high-fidelity simulation, related experimentation, and digital twins has the greatest potential for substantially accelerating improvements to the performance of gas turbines (in terms of efficiency, life cycle cost, and/or other parameters)? What aggressive goals should be established for these research projects and what state of development could these research projects achieve by 2030? The gas turbine applications of interest are aviation propulsion, high-power industrial applications (generation of electricity and steam), and the oil and gas industry.

Time	Duration Hrs : Min		
10:10 AM	0:10	Introduction and Overview of Applicable Gas Turbines	Moderator: Parviz Moin and Allister James, Committee Members
10:20 AM	0:50	Opening remarks by each panelist (10 minutes each)	Panelists: 1. Gianluca Iaccarino, Stanford 2. Bob Lucht, Purdue 3. Jayaprakash Natarajan, GE Power 4. David Furrer, P&W 5. Ron Adrian, Arizona State University
11:10 AM	1:20	General Discussion	
12:30 PM	0:45	Lunch	
1:15 PM	0:30	Safe Operation of Pipeline Turbines with Hydrogen Fuel: Presentation	Doug Rawlins, Solar Turbines
1:45 PM	0:30	Safe Operation of Pipeline Turbines with Hydrogen Fuel: Discussion	

Panel 3. Advanced Manufacturing

Focus Questions for Panel 3: Assuming that the future technical trends (specified above) continue and the future market scenario comes to pass . . . What high-risk, high-payoff research related to advanced manufacturing has the greatest potential for substantially accelerating improvements to the performance of gas turbines (in terms of efficiency, life cycle cost, and/or other parameters)? What aggressive goals should be established for these research projects and what state of development could these research projects achieve by 2030? The gas turbine applications of interest are aviation propulsion, high-power industrial applications (generation of electricity and steam), and the oil and gas industry.

Time	Duration Hrs : Min		
2:15 PM	0:10	Introduction and Overview of Applicable Gas Turbines	Moderators: Chuck Ward and John Gülen, Committee Members
2:25 PM	1:00	Opening remarks by each panelist (10 minutes each)	Panelists: 1. Kevin Sheehan, Siemens (remote) 2. Behrang Poorganji, GE Additive Manufacturing 3. Shreyes Melkote, Ga Tech 4. Doug Rawlins, Solar Turbines 5. Jesse Boyer, P&W 6. Todd Palmer, Penn State
3:25 PM	0:15	Break	
3:40 PM	1:35	General Discussion	
5:15 PM		Adjourn for the day	

Friday February 8
Open Session

Time	Duration Hrs : Min		
7:30 AM	0:30	Breakfast available in meeting room	
8:00 AM	0:10	Welcome and Introductions	Ed Crow and Tresa Pollock, Co-chairs

Panel 4. User Perspectives

Focus Questions for Panel 4: **What are your perspectives on the potential research areas, future technical trends, and future market scenario specified above?** What items would you suggest adding, deleting, or changing? What high-risk, high-payoff research has the greatest potential for substantially accelerating improvements to the performance of gas turbines of interest to you? For panelists from electrical utilities: How do you anticipate accommodating the need to integrate ever increasing amounts of renewable energy into the electrical grid?

Time	Duration Hrs : Min		
8:10 AM	0:15	Introduction and Overview of Applicable Gas Turbines	Moderator: Tim Lieuwen, Committee Member
8:25 AM	0:40	Opening remarks by each panelist (10 minutes each)	Panelists: 1. Tracy Cook, Southern Company Power 2. Vinod Kallianpur, Samsung C&T 3. Sal DellaVilla, SPS, Inc. 4. Taryn Riley, Siemens
9:05 AM	1:00	General Discussion	
10:05 AM	0:15	Break	
10:20 AM	0:40	General Discussion, Continued	
11:00 AM	0:45	DOE Perspective on Future Technical Trends, Future Market Scenario, and Potential Research Areas Relevant to the Statement of Task	Rich Dennis, DOE
11:45 AM	1:00	Lunch	
12:45 PM		End of Open Session	

Statement of Task:

The National Academies of Sciences, Engineering, and Medicine will convene an ad hoc committee to identify high-priority opportunities for improving and creating advanced technologies that can be introduced into the design and manufacture of gas turbine engines to substantially accelerate improvements to performance (e.g., efficiency and life cycle cost). The committee will determine the state of development that could be achieved by 2030. Gas turbine applications of particular interest are as follows:

- combined cycle gas turbines to generate electrical power, such as:
  - -- large, stationary turbines to power the electrical grid
- simple cycle gas turbines to generate electrical and mechanical power, such as:
  - -- large, stationary turbines to power the electrical grid
  - -- stationary turbines of various sizes to support oil and gas production and transmission
- gas turbines for commercial and military aircraft propulsion

The priority of specific advanced technologies shall be based on their breadth of application, the degree of improvement for individual applications, the timeliness with which the technologies could be matured, and other factors to be determined by the committee. The scope of the study shall include compressors, combustion systems, expanders, bearings, seals, instrumentation, and digital twins (i.e., virtual copies of operational gas turbines). In identifying high-priority opportunities for developing advanced technologies of interest, the committee shall consider the performance of current gas turbines and gas turbine components for the applications listed above, the state of the art of relevant manufacturing technologies, and ongoing efforts to develop advanced manufacturing technologies.

The following information is provided for any members of the general public who may be in attendance:
This meeting is being held to gather information to help the committee conduct its study. This committee will examine the information and material obtained during this, and other public meetings, in an effort to inform its work. Although opinions may be stated and lively discussion may ensue, no conclusions are being drawn at this time and no recommendations will be made. In fact, the committee will deliberate thoroughly before writing its draft report. Moreover, once the draft report is written, it must go through a rigorous review by experts who are anonymous to the committee, and the committee then must respond to this review with appropriate revisions that adequately satisfy the Academy's Report Review committee and the chair of the NRC before it is considered an NRC report. Therefore, observers who draw conclusions about the committee's work based on today's discussions will be doing so prematurely. Furthermore, individual committee members often engage in discussion and questioning for the specific purpose of probing an issue and sharpening an argument. The comments of any given committee member may not necessarily reflect the position he or she may actually hold on the subject under discussion, to say nothing of that person's future position as it may evolve in the course of the project. Any inference about an individual's position regarding findings or recommendations in the final report are therefore also premature.