Combined-Cycle Turbomachinery (P79)

Robert Steele
Program Manager

John Scheibel
Technical Executive

Leonard Angello, Dale Grace
Principal Technical Leaders

Jose Marasigan, Bobby Noble
Senior Technical Leaders

Generation Advisory Meeting
Orlando, Florida

September 13, 2016
Always be Careful at the Beach
Another Danger: Back to School – Safety Tips for Motorists

- Most bus-related accidents are with pedestrians
  - 4 to 7 years old
  - Within 10 ft of bus is most dangerous area
  - Hit by the bus or a motorist
- All 50 state laws:
  - Stop both ways on undivided road
  - Stop behind stopped bus on divided road
- Yellow flashing lights – Alert
- Red flashing lights - Stop
- Children are UNPREDICTABLE!
Introduce Change in Co-Chair

Welcome Robert LaRoche!

- BSME at University of Arizona
- 32 years at Salt River Project Agricultural Improvement and Power
- Registered PE since 1990
- Serving as gas Turbine Specialist since 2001
- Serving as SRP EPRI Advisor on gas turbines since 2003
- Served as Chairman of GE 7FA User Group in 2015
- Current member of GE 7FA User Group Steering Committee
# Monday Agenda – Major Upgrades of F-Class Gas Turbines

<table>
<thead>
<tr>
<th>TIME</th>
<th>TOPIC</th>
<th>PRESENTER</th>
</tr>
</thead>
<tbody>
<tr>
<td>12:00 p.m.</td>
<td>Lunch – Kingston Hall</td>
<td></td>
</tr>
<tr>
<td>1:00 p.m.</td>
<td>Introduce the topic and background information</td>
<td>John Scheibel, EPRI</td>
</tr>
<tr>
<td>1:15 p.m.</td>
<td>Overview of historical path of major gas turbine upgrades</td>
<td>Leonard Angello/Dale Grace, EPRI</td>
</tr>
<tr>
<td>1:45 p.m.</td>
<td>Utility experiences with gas turbine upgrades</td>
<td>P79 utility member representatives</td>
</tr>
<tr>
<td></td>
<td>- What is their approach</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- What models have they upgraded</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Lesson learned</td>
<td></td>
</tr>
<tr>
<td>2:30 p.m.</td>
<td>Afternoon Break</td>
<td></td>
</tr>
<tr>
<td>3:00 p.m.</td>
<td>Utility experiences with gas turbine upgrades</td>
<td>P79 utility member representatives</td>
</tr>
<tr>
<td></td>
<td>- What is their approach</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- What models have they upgraded</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Lesson learned</td>
<td></td>
</tr>
<tr>
<td>3:30 p.m.</td>
<td>Update on P79 evaluation of the GE 7FA AGP upgrade</td>
<td>Robert Dewey, Turbine Technology International</td>
</tr>
<tr>
<td>4:30 p.m.</td>
<td>KEPCO Hot Gas Path Facility and Blade Life Assessment</td>
<td>Choi, Woosung, KEPRI</td>
</tr>
<tr>
<td>5:00 p.m.</td>
<td>Final summary comments</td>
<td>John Scheibel, EPRI</td>
</tr>
<tr>
<td>5:15 p.m.</td>
<td>Adjourn</td>
<td></td>
</tr>
<tr>
<td>6:30 p.m.</td>
<td>P79 Advisors and EPRI Staff Dinner</td>
<td>All (location to be determined)</td>
</tr>
</tbody>
</table>
## Tuesday Agenda – Program Meeting

<table>
<thead>
<tr>
<th>TIME</th>
<th>TOPIC</th>
<th>PRESENTER</th>
</tr>
</thead>
<tbody>
<tr>
<td>7:00 a.m.</td>
<td>Breakfast – Kingston Hall</td>
<td>Rob Steele, EPRI</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Robert LaRoche, SRP</td>
</tr>
<tr>
<td>8:00 a.m.</td>
<td>Welcome and Introductions</td>
<td>Rob Steele, EPRI</td>
</tr>
<tr>
<td>8:20 a.m.</td>
<td>Program updates and planning</td>
<td>Erik Verloop, Bin Zhou, FM Global</td>
</tr>
<tr>
<td>8:45 a.m.</td>
<td>Provide perspective on current issues and opportunities</td>
<td>Scott Keller, PSM</td>
</tr>
<tr>
<td>9:20 a.m.</td>
<td>Recent changes at Power Systems Manufacturing</td>
<td></td>
</tr>
<tr>
<td>10:00 a.m.</td>
<td>Morning Break</td>
<td></td>
</tr>
<tr>
<td>10:30 a.m.</td>
<td>Roundtable</td>
<td>ONLY power producing P79 members</td>
</tr>
<tr>
<td>11:45 a.m.</td>
<td>2016 Member Satisfaction Survey</td>
<td>John Hutchinson, EPRI</td>
</tr>
<tr>
<td>12:00 p.m.</td>
<td>Lunch – Kingston Hall</td>
<td></td>
</tr>
<tr>
<td>1:00 p.m.</td>
<td>Report out - Peaking Gas Turbine session in Scottsdale</td>
<td>Jose Marasigan, EPRI</td>
</tr>
<tr>
<td>1:20 p.m.</td>
<td>Present new 2017 projects for voting</td>
<td>P79 Staff</td>
</tr>
<tr>
<td>2:30 p.m.</td>
<td>Afternoon Break</td>
<td></td>
</tr>
<tr>
<td>3:00 p.m.</td>
<td>Present new 2017 projects for voting</td>
<td>P79 Staff</td>
</tr>
<tr>
<td>4:10 p.m.</td>
<td>New Plant Development – Louisville meeting</td>
<td>Dale Grace, EPRI</td>
</tr>
<tr>
<td>4:30 p.m.</td>
<td>Wrap up and action items</td>
<td></td>
</tr>
<tr>
<td>5:00 p.m.</td>
<td>Adjourn</td>
<td>Rob Steele, EPRI</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Robert LaRoche, SRP</td>
</tr>
<tr>
<td>6:30 p.m. – 8:00 p.m.</td>
<td>Reception</td>
<td>Open to attendees and their guests</td>
</tr>
</tbody>
</table>
2016 P79 Membership (37 organizations)

- Ansaldo Energia S.p.A. (Italy)
- Alliant Energy
- Arkansas Electric Cooperative
- Austin Energy
- Comision Federal de Electricidad (Mexico)
- Consolidated Edison
- Doosan Heavy Industries (Korea)
- DTE Electric Company
- Duke Energy
- ENEL S.p.A. (Italy)
- Energy Future Holdings
- ENMAX (Canada)
- Entergy Services
- Exelon
- FM Global
- Gas Natural SDG, S.A. (Spain)
- Great River Energy
- Hawaiian Electric
- Hoosier Energy Rural Electric Coop
- Iberdrola, S.A. (Spain)
- Korea Electric Power (Korea)
- LG&E and KU Energy
- Lincoln Electric System
- Los Angeles Dept of Water and Power
- Nebraska Public Power District
- New York Power Authority
- Oglethorpe Power
- Ontario Power Generation
- Public Service Enterprise Group
- Salt River Project
- Sarawak Energy Berhad (Malaysia)
- Southern Company
- Sunflower Electric Power
- Tennessee Valley Authority
- Tri-State Generation and Transmission
Program Items for Discussion during the Day

- Non-utility P79 members
- Multi-year planning
- When and how to present ongoing work
- Budgets and new project voting
Non-Utility P79 Members
Non-Utility P79 Members

- Ansaldo Energia S.p.A. (Italy)
- Power Systems Manufacturing (owned by Ansaldo)
- Doosan Heavy Industries and Construction Co (Korea)
- FM Global
- Potentially other non-utility organizations ……..
  - Gas turbine OEMs
  - Engineering consulting
  - Repair shops
  - Monitoring and instrumentation manufacturers

Develop a strong and appropriate working relationship with each company
Multi-year Planning
EPRI Annual Research Portfolio (ARP)
Project Development and Prioritization Process for Programs

Move program towards a detailed and well organized two-year planning cycle
Survey Advisors each October for Next Year Projects

2016 Program 79 Research Projects Survey

Dear Program 79 Participant,

This is the evaluation exercise for Program 79 research projects for 2016. It is important and relevant to your organization. B. 2010 projects is available on the Program 79 Cockpit and attached to this survey, with the appropriate staff in your organization before completing the survey.

Your response to the Project Evaluation Survey is requested by Friday, Oc

If you have any questions, please contact Rob Steele.

Together... Shaping the Future of Electricity.
Research Areas of Focus

- Gas Turbine Component Life Extension
- Gas Turbine and CC Plant Monitoring
- Steam Turbine and Generators in CC Plants
- CC Plant Integration
- New CC Plant Designs, Cycles, Upgrades
- Gas Turbine Innovation and Advancement
# Multi-Year Planning for Each Technical Area of Focus

<table>
<thead>
<tr>
<th>Orientation</th>
<th>Solving Defined Issues</th>
<th>Preparing for Change in Market Conditions</th>
<th>Shaping Future Options with Enabling Technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Duration</strong></td>
<td>1-2 years</td>
<td>2-3 years</td>
<td>4+ years</td>
</tr>
<tr>
<td><strong>Approach</strong></td>
<td>Applying existing tools and background R&amp;D results</td>
<td>Adaptation, development, &amp; demonstration</td>
<td>Long term research &amp; development</td>
</tr>
</tbody>
</table>
Program 79 Planning Matrix

Equipment Oriented:

- Gas Turbine
  - Hot Section/Combustor *(Atlanta, 2014)*
  - Compressor *(Chicago, 2015)*
  - Rotor *(Ft Worth, 2015)*
- Steam Turbine/Generator *(Chicago, 2015)*

Plant Oriented:

- Monitoring *(Atlanta, 2014)*
- Plant Emissions *(Chicago, 2015)*
- New Plants/Upgrades *(Atlanta, 2014)*
- Flexible Operations *(Chicago, 2015)*
- Capacity and Thermal Performance *(Scottsdale, 2016)*

Inter-Program ties to P88, P65, P87, P73, P194
Identify Gas Turbine Champions Among P79 Advisors

- Gas Turbine Models
- Frame
- Aeroderivative
- User Groups
- Service Bulletins
- Upgrades
When and How to Present Ongoing Work?
Project Status Updates (PSU)

*Relatively new feature on Cockpits*

- Information on current program research
- Located on Project Status Updates tab on Program Cockpit
- Issued Quarterly

### Project Status Updates

<table>
<thead>
<tr>
<th>Projects</th>
<th>Funding Type</th>
<th>Published</th>
<th>Scope</th>
<th>Budget</th>
<th>Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td>NDE for Boiler and Piping Components</td>
<td>Base Funded</td>
<td>Jun-2016</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
</tr>
<tr>
<td>NDE Methods of Detection of Early Stages</td>
<td>Base Funded</td>
<td>Jul-2016</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
</tr>
<tr>
<td>Guided Wave for Wall Loss and Cracking</td>
<td>Base Funded</td>
<td>Jun-2016</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
</tr>
<tr>
<td>Acoustic Emission Monitoring of Damaged</td>
<td>Base Funded</td>
<td>Jul-2016</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
</tr>
<tr>
<td>NDE for Detection of Axially Oriented</td>
<td>Base Funded</td>
<td>Jun-2016</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
</tr>
<tr>
<td>Corrosion Fatigue Controlled Circulation</td>
<td>Base Funded</td>
<td>Jul-2016</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
</tr>
</tbody>
</table>
# P79 Members Recommended Topics for 2016 Monthly Webcasts

<table>
<thead>
<tr>
<th>MONTH</th>
<th>Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>JULY</td>
<td>- Have more fleet wide discussions regarding new TILs and service bulletins issued by the OEM's. <em>GE 7FA ROTOR TIL #1972</em></td>
</tr>
<tr>
<td>SEPT</td>
<td>- Recommend discussing GE Advanced Gas Path Upgrades.</td>
</tr>
<tr>
<td>MAY</td>
<td>- Capital and Maintenance Actions to Improve CC Plant Heat Rate.</td>
</tr>
<tr>
<td>MARCH</td>
<td>- Provide updates on CT Health monitoring.</td>
</tr>
<tr>
<td>OCT</td>
<td>- Generator (P-65) maintenance and monitoring overview.</td>
</tr>
<tr>
<td>AUG</td>
<td>- PMBD refresher with an overview of the new features.</td>
</tr>
<tr>
<td>NOV</td>
<td>- Overview of the SCR Testing Protocol work done last year.</td>
</tr>
<tr>
<td></td>
<td>- Performance of SCRs for simple cycle F class gas</td>
</tr>
</tbody>
</table>
## Monday Afternoon Sessions at Advisory Meetings

<table>
<thead>
<tr>
<th>Year</th>
<th>Topic and/or Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>Tour Lodi Siemens Flex 30 plant</td>
</tr>
<tr>
<td>2014</td>
<td>Compressor and combustor monitoring / Georgia Tech lab tour</td>
</tr>
<tr>
<td>2015</td>
<td>Advanced combustion systems</td>
</tr>
<tr>
<td>2015</td>
<td>Single crystal materials</td>
</tr>
<tr>
<td>2016</td>
<td>O&amp;M of simple cycle peaking gas turbines</td>
</tr>
<tr>
<td>2016</td>
<td>Major upgrades of F-class gas turbines</td>
</tr>
</tbody>
</table>

**How should we use the Advisory Meetings for reviewing ongoing work?**
Budgets and New Project Voting
EPRI Funding Allocation

EPRI Membership Funds

- 25% Self-Directed Funds
- 15% Technology Innovation & Demonstration
- 60% Base Program

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EPRI Base Program Funding Allocation

P79 Base Program Funds

- General Program Maintenance
- Internal Program Technical Support
- Ongoing Multi-year Project Support
- New Votable Project Support

Advisors have been asked to vote on the “NEW” projects each year
# P79 New Votable Projects Allocations in 2014-2017

<table>
<thead>
<tr>
<th>Year</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>R&amp;D Contracting Budget</td>
<td>$1.25 M</td>
<td>$1.29 M</td>
<td>$1.10 M</td>
<td>$1.21 M (est)</td>
</tr>
<tr>
<td>New Project Budget</td>
<td>$880 K</td>
<td>$535 K</td>
<td>$675 K</td>
<td>$697 K (est)</td>
</tr>
<tr>
<td>Percentage</td>
<td>70%</td>
<td>41%</td>
<td>61%</td>
<td>58% (target)</td>
</tr>
</tbody>
</table>

**Target $700 K for new projects in 2017 for R&D contracts**
FM Global Presentation
PSM Presentation
Roundtable Discussion
Topics for Discussion

- Introduce yourself
  - name, company, location, responsibility
- Technical issues and events since last Advisory Meeting
- Changes in dispatch of GT and CC assets
- Future additions of GT and CC assets
- Additional topics for discussion
Member Satisfaction Survey 2016
Your Input is Critical…

*Promote open communication... help us understand...*

✔ What’s important to you…
✔ What we do well…
✔ Where we can improve…
✔ How well are we listening…

The quality of a member’s experience is key to a healthy collaborative …
## Improvement Initiatives

<table>
<thead>
<tr>
<th>Category</th>
<th>Initiative</th>
<th>Timeframe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research and Development</td>
<td>• Project Overview Forms</td>
<td>Implemented 2015</td>
</tr>
<tr>
<td></td>
<td>• Project Status Updates</td>
<td></td>
</tr>
<tr>
<td>Tech Transfer</td>
<td>• Executive Summary for Technical Reports</td>
<td>Implemented 2016</td>
</tr>
<tr>
<td>Simplification</td>
<td>• On-line Pricing for Supplementals</td>
<td>Implemented 2016</td>
</tr>
<tr>
<td>Website</td>
<td>• New Search Engine</td>
<td>Implemented 2016</td>
</tr>
<tr>
<td></td>
<td>• Member Center Improvements</td>
<td></td>
</tr>
</tbody>
</table>

Listening and Responding to the Feedback of our Members
### Title
**10,665 results found for coal**

### Category
- Research (4,866)
- EPRI Publications (4,754)
- Events (1,591)

### Sector
- Generation (4,317)
- Environment (2,872)
- Nuclear (691)
- Power Delivery & Utilization - Distribution & Utilization (643)
- Power Delivery & Utilization - Transmission (779)

### Type
- Technical Results (4,597)
- Issues & Overviews (428)
- Newsletters (178)
- Supplemental Projects (48)
- Corporate (32)

### Event Type
- Meeting or Workshop (144)
- Webcast (11)
- Advisory Meeting (13)

### Websites
- Member Center (3,987)
- Collaboration Websites (556)
- EPRI Public Websites (120)
- METT Central (102)

### Implementation Category
- REFERENCE (97)
- CATEGORY 2 (39)

---

**New Search Engine**

- Find information faster
- Updated, intuitive interface
- Full text search
- Improved graphics
- Enhanced results
## P79 Improvement Actions in 2016

<table>
<thead>
<tr>
<th>Improvement Opportunity</th>
<th>Program Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact of research on improving my business</td>
<td>• Continue to strengthen the monthly webcasts, offer a deep dive technical session during Advisory meetings, conduct site tours, provide one-on-one exchanges and meetings</td>
</tr>
<tr>
<td>Format in which research results are delivered</td>
<td>• Adding executive summaries, Re-issuing condensed versions, conducting deep dive webcasts, providing PPT slides</td>
</tr>
<tr>
<td>Proactive research planning (e.g., results ready when needed)</td>
<td>• Program 79 continues to strengthen the multi-year planning with annual evaluation of the Strategic Objectives that were initiated in 2013</td>
</tr>
<tr>
<td></td>
<td>• Establish consistent and relevant inter-program projects and activities</td>
</tr>
<tr>
<td>Ease of finding information on EPRI website</td>
<td>• The Institute is implementing improvement initiatives to improve search engine (see sector slide)</td>
</tr>
<tr>
<td>Relevance of mailings/e-mails to your specific needs</td>
<td>• Increase direct contact with advisors to more fully understand their needs and issues. Request further explanation to improve the EPRI response both at the Institute level and at the Program level</td>
</tr>
</tbody>
</table>
2016 Member Satisfaction Survey Form

Key components:

1. Who you are
   *without a name and organization, we can’t count your input!*

2. Number of years you have been an Advisor

3. How we’re doing

4. How you assess EPRI value

5. Key improvement in ease of doing business

6. Value you have received from this Program
# 2016 Member Satisfaction Survey Form

### Key components:

7. Rate each statement based on how satisfied you are

8. Rank the top 5 statements as indicated in the instructions

9. Would you recommend EPRI

10. If you are not satisfied with us in any area, please tell us why

---

**For each of the statements below, please rate your satisfaction and, using the far right column, please rank the top five aspects of the EPRI experience that are most important to you. Rank them in order from 1=highest to 5=lowest. Only rank 5 of the statements.**

<table>
<thead>
<tr>
<th>Statement</th>
<th>Highly Satisfied</th>
<th>Satisfied</th>
<th>Neutral</th>
<th>Dissatisfied</th>
<th>Highly Dissatisfied</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Information provided by EPRI about resources available to members</td>
<td></td>
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<tr>
<td>2. Ability to actively participate through membership in the program</td>
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<tr>
<td>3. Understanding your role as an advisor</td>
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<tr>
<td>4. Understanding of EPRI’s collaborative business model</td>
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<tr>
<td>5. Leverage received from the collaborative model</td>
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<tr>
<td>6. Ease of contracting with EPRI</td>
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<tr>
<td>7. The program’s strategic priorities and directions</td>
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<tr>
<td>8. Your ability to provide feedback on research priorities</td>
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<tr>
<td>9. Quality of research results</td>
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<tr>
<td>10. Impact of research on improving my business</td>
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<tr>
<td>11. Relevance of research carried out by the program</td>
<td></td>
<td></td>
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<tr>
<td>12. Pervasiveness of research planning (e.g., results ready when needed)</td>
<td></td>
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<tr>
<td>13. Technical staff expertise</td>
<td></td>
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<td>14. Adherence to stated timelines</td>
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<tr>
<td>15. Effectiveness of program management</td>
<td></td>
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<tr>
<td>16. Communication of R&amp;D project status</td>
<td></td>
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<tr>
<td>17. Thought leadership</td>
<td></td>
<td></td>
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<tr>
<td>18. Ease of understanding content of research results</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19. Format in which research results are delivered</td>
<td></td>
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<tr>
<td>20. Quality of advisory meeting content</td>
<td></td>
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<tr>
<td>21. Quality of oral/written presentations (i.e., material presented)</td>
<td></td>
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<tr>
<td>22. Frequency of communications from EPRI to members (e.g., news and updates)</td>
<td></td>
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</tr>
<tr>
<td>23. Relevance of e-mails/mails to your specific needs</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24. Responsiveness to member feedback</td>
<td></td>
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<tr>
<td>25. Ease of finding information on EPRI website</td>
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<tr>
<td>26. Helpfulness of information on EPRI website</td>
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</tr>
</tbody>
</table>

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Would you recommend EPRI to a colleague or peer?

- [ ] Definitely Would
- [ ] Probably Would
- [ ] Might or Might Not
- [x] Would Not
- [ ] Definitely Would Not

To help us better understand your concerns, for any statement with a rating of 3 or lower, please provide an explanation or example which led you to that rating.
Report Since Scottsdale Peaking Gas Turbine Session
Recap of Scottsdale Monday Afternoon Session
Operations and Maintenance of Simple Cycle Peaking Gas Turbines

- Several presentations on topic including:
  - For legacy units,
    - O&M issues, e.g., blade rock
    - Possible upgrades, e.g., valves, control system, purge credit, combustion
  - For aeroderivatives,
    - O&M issues, LM6000 HPC S3-5 edge of contact failure
    - Actual upgrades, e.g., control system
Recap of Scottsdale Monday Afternoon Session
Operations and Maintenance of Simple Cycle Peaking Gas Turbines

- Key takeaways from presentations and discussion:
  - General concern over legacy turbines as well as aeroderivatives
  - We should be doing something to improve the O&M of these turbines
  - But what?
Actions since Scottsdale

- Included a research project in 2017 P79 Research Portfolio
  - Life Extension of Vintage Combustion Turbines. Intended for:
    - Base program-funded projects
    - Vintage frames but can also include aeroderivatives
- Formed Vintage CT Working Group
Vintage CT Working Group

- **Motivation**
  - Current base program mostly focused on O&M of newer frames

- **Objectives**
  - Provide a forum where owners of vintage CTs and peaking plants can share current issues
  - Identify existing EPRI work/products that may be relevant
  - Identify potential new work that is of interest to the group

- **CT model scope**
  - LM2500, LM6000, Frame 5, Frame 6, Frame 7, SW 501D
Vintage CT Working Group

- Initial meeting on Monday morning, September 12, 2016
  - Purpose:
    - Stimulate discussions
    - Identify issues that EPRI can assist with
    - Chart a path forward for the working group
  - Meeting summary
P79 2017 Proposed Projects and Activities
# New 2017 P79 Votable Projects

<table>
<thead>
<tr>
<th>Project Manager</th>
<th>Topic</th>
<th>Joint Programs</th>
<th>P79 R&amp;D Contractor Budget</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lenny</td>
<td>Assessment of Combined SCR/CO Catalyst Concept</td>
<td>P73/P79/P88/P194</td>
<td>$60K (2017) $60K (2018)</td>
</tr>
<tr>
<td>Dale</td>
<td>Combined-cycle Steam Turbines: Research Initiative</td>
<td>P65/P79</td>
<td>$80K (2017)</td>
</tr>
</tbody>
</table>

**TOTAL P79 BUDGET ESTIMATES**

## Hot Section Plan: Ongoing, 2017 Proposed

<table>
<thead>
<tr>
<th>Solving Defined Issues</th>
<th>Prepare for Market Changes</th>
<th>Shaping Future Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repair Guideline: Updates</td>
<td>Repair Guideline: New Models</td>
<td>Embedded Sensing (TI Project)</td>
</tr>
<tr>
<td>Repair Shop Capabilities</td>
<td>Single Crystal Degradation/Repair (TI Project)</td>
<td>Transpiration Cooling Design</td>
</tr>
<tr>
<td>Rejuvenation Heat Treatments</td>
<td>Advanced Gas Path Upgrades</td>
<td>Ceramic Matrix Composites</td>
</tr>
<tr>
<td>HGP Related Performance Losses (See Performance Strategy)</td>
<td>Low-K TBC (TI project)</td>
<td>Steam-cooled Component Designs</td>
</tr>
<tr>
<td>Extend repair limits and life</td>
<td>Advanced Repair Technology</td>
<td>Advanced Sealing Techniques</td>
</tr>
<tr>
<td>Parts/Damage Tracking</td>
<td>Alternative Parts</td>
<td>Beyond 3D Flowpath</td>
</tr>
<tr>
<td>Failure/Damage Investigations</td>
<td></td>
<td>Additive Manufacturing/3D Printing</td>
</tr>
<tr>
<td>NDE Techniques</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Extending Blade Repair Limits

- **Issue:** Hot section blade scrap out due to excessive tip and platform damage

- **Objective:** Re-examine repair guideline practices; establish technical basis for extending tip/platform restoration limits

- **Approach:** Review S-O-A shop practices; Process, NDE and testing procedures to qualify extended repairs

- **Deliverable:** Technical Update in 2018 (18 month), Update Repair Guidelines

- **Funding:** $175K

Extend EPRI Repair Guideline blade tip and platform "conservative" restoration limits
EPRI Blade Repair Guideline: Current Limits

“The limit for welding at the blade tip is squealer wall restoration only. The squealer platform (cover plate) itself may be removed and replaced, however, unless specifically approved otherwise weld repair below the squealer platform is not allowed.”

“Platform weld repairs are limited to 6.3mm (0.25 inch) maximum depth, and shall not extend into airfoil platform fill radius.”
Blade Tip Restoration

- Weld repair processes:
  - Manual Gas Tungsten Arc (GTA) or Laser Clad
  - Robotic GTA or Plasma Arc
  - SWET elevated temperature GTA
- Filler material choice: oxidation vs strength
- Rebuilding internal cooling channel partitions
- Cover plate attachment: electron beam or laser fusion welding
Blade Platform Restoration

- Repair process options:
  - Gas Tungsten Arc weld on edges, may extend further on platform end edges
  - Laser clad repair extending near airfoil fillet
  - Filler material choice
  - High strength braze
Extended Repair Limit Qualification

- Review S-O-A shop practices and related field experience
- Use scrap parts from EPRI parts inventory and seek other material for test repairs
- Solicit repair shops to perform tip and platform repairs
  - Possibly leverage member repair activity
- Establish repair integrity:
  - High strength
  - External/internal defect acceptance
  - Structural analysis used as acceptance baseline
Advanced NDE for Airfoil Structural Integrity

- **Issue:** Structural Integrity of turbine and compressor airfoils
- **Objective:** Develop an advanced NDE solution that highlights indications or structurally defective airfoils that could lead to catastrophic failure
- **Approach:** Investigate Process Compensated Resonance Testing (PRCT) for detecting structural defects through changes in resonant frequencies
- A parts resonant frequencies can foretell a parts structural integrity
- Change in resonant frequency is proportional to the change in part stiffness, and severity of its structural integrity
- Defective and defect-free blade samples are used to train software algorithm
- Algorithms monitor differences across a parts resonance frequency relationship predicting structural changes
- Individual airfoil structural changes are monitored throughout its useful life
- **Deliverable:** Technical Update 2017-2018
- **Funding:** $160K
Process Compensated Resonance Testing - Overview

Resonant Inspection is an ideal NDT method because the measurement correlates directly to part strength

- Resonant Frequencies determined by dimensions and material properties of “whole part”
  \[ f_r \sim \sqrt{\frac{k}{m}} \]
  \( f_r \) = resonant frequency
  \( k \) = stiffness (elastic properties e.g., Young’s Modulus)
  \( m \) = mass (dimensions, density)

- Structural Defect = Strength reduction caused by degraded material properties or dimensional variation
  - Degree of resonant frequency change is proportional to defect severity

- PCRT can significantly reduce inspection time
A structural defect reduces part stiffness causing a proportional shift in resonant frequency.
Process Compensated Resonance Testing

- Simple resonance analysis insufficient for defect detection since unacceptable and acceptable patterns are interlaced
- PCRT system measures multiple resonance responses developing pattern recognition algorithms
- Acceptable parts & variation characterizes
- PCRT currently used for long term monitoring of aerospace turbine blade Structural Health
Turbine Blade Over-Temperature Evaluation

- **Case 1: Delta TechOps**
  - JT8D-219 commercial engines prone to over-temperature incidents
  - Standard FAA procedure, cut up one randomly selected blade for MET analysis
  - If test blade passes, all blades are assumed to be flight worthy
  - If blade showed signs of heat damage, all 64 blades are removed from service and discarded – costing hundreds of thousands of dollars
  - In 2008, Delta TechOps was given six months to come up with a better process
  - PCRT offers increased sensitivity to defects, less engine down time and reduced waste
  - PCRT was added in 2009 for prescreening over-temperature blades
  - FAA approved PCRT in 2010
  - Reduced Engine Inspection Costs by Nearly $2M Annually
Classification of CF6-80A Blades

- **Case 2:**
  - Blades manufactured with brazed-in inverted tip cap
  - Several service failures and numerous in flight shutdowns increasing
  - After an undetermined amount of cycles braze diffusion line is weakened by service stresses
  - Weakened area is prime location for axially crack propagation when part under load
  - Once crack is surface breaking corrosive elements attack exposed material leading to complete tip separation
  - PCRT classifies suspect blades for CR evaluation
# GT/CC Plant Monitoring Plan: Ongoing, 2017 Proposed

<table>
<thead>
<tr>
<th>Solving Defined Issues</th>
<th>Prepare for Market Changes</th>
<th>Shaping Future Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaluate commercial packages</td>
<td>Optimize monitoring system configurations</td>
<td>Advanced sensors</td>
</tr>
<tr>
<td>Support utilities with combustion dynamics monitoring (CDM) algorithm implementation</td>
<td>Collect field, exercise and refine CDM combustor fault diagnostics matrixes</td>
<td>Advanced Analytics</td>
</tr>
<tr>
<td>Pinging Protocol to Assess Operational Risks in Gas Turbine Compressors</td>
<td>Exercise field monitoring options</td>
<td>GT exhaust temperature pattern recognition</td>
</tr>
<tr>
<td>On-line gas turbine performance monitoring software development</td>
<td>Combustor Auto-tuning (See Emissions Management Strategy )</td>
<td>Improved life prediction models</td>
</tr>
<tr>
<td>Gas Turbine Combustion Dynamics Training &amp; Reference Guide (See GT/CC Plant Emissions Plan)</td>
<td>Sensor health detection monitoring capability</td>
<td>Model-based controls</td>
</tr>
<tr>
<td>Air filtration performance field testing</td>
<td>Compressor Blade Health Monitoring (BHM) (See Compressor Reliability Strategy)</td>
<td>Acoustic Impact Monitoring (See Compressor Reliability Strategy)</td>
</tr>
</tbody>
</table>
Gas Turbine Combustion Dynamics Training & Reference Guide

- **Issue:** Risk of combustor hardware damage or failure as well as trips due to lean blow out
- **Objective:** Give background training on combustion dynamics, review monitoring methods, relate combustion dynamics behavior to gas turbine operation, and overview why/how tuning effects operation
- **Approach:** Partner with EPRI member(s) to identify needs and develop report/web application
- **Deliverable:** Tech Report 2017/Web App 2018
- **Funding:** $50K P108 / $50K P79
Combustion Dynamics

- Single largest issue associated with development of low NO$_X$ GT’s
- Designs make systems susceptible to large amplitude acoustic pulsations
- CD happen for a reason, question to answer – Why?
Mechanism of Combustion Instabilities

- Pressure (acoustics) and heat release oscillations can be coupled
- Combustion in acoustically confined chamber
- Harmonics can create severe damage to liners, transition pieces, connecting tubes, etc.
- Instabilities are non-linear & can be triggered by any number of events

- Aim to give insights to determine if:
  - Sensor Issues
  - Tuning Problem
  - Possible Combustor Hardware Damage
Proposed Guide/Training Outline

- Introduction: Combustion Dynamics (CD) & Monitoring
- Overview Sensor Types/Failure Mechanisms
- Discuss Tuning/Autotuning effects on understanding CD
- Detail GT Hardware Failures & Detection from CD

Deliverables:
- Technical Report for 2017
- Web App developed from Report for 2018
Pinging Protocol to Assess Operational Risks in Gas Turbine Compressors

**Issue:** Compressor failures have recently plagued GE units; Includes 7FA, 7EA, 6B Units
- Blade/Vane cracking
- Blade/Vane “clashing”

Methodologies are needed to proactively detect compressor hardware distress.

**Objective:** Develop a remote inspection capability to assess the blade/vane liberation risk of compressor stages 2 through 5.

**Approach:** Adapt EPRI’s snake robot technology for gas turbine compressor application. Investigate ability to perform inspection and pinging analysis.

**Deliverable:** Technical update on lab study in 2017; Field Testing in 2018

**Funding:** Lab Study ~ $100 K, Field Test ~ $100 K

[Link to image: http://www.cij-online.com/frame-6bs-under-the-microscope-cracking-of-s1-stator-vanes-liberated-s17-vanes/]
Pinging Test Equipment

1. Crystal Instruments: CoCo 80 Handheld Dynamic Signal Analyzer
2. Excitation Hammer
3. Accelerometer w/ Wax
4. Microphone

Equipment and Software Cost ~ $20,000
Basic Setup

- Install accelerometer with wax near S1 tip
- Microphone was positioned by hand near S1 blade of interest
- Bin and sample rate chosen with frequency resolution ~0.2Hz and Nyquist frequency > 500Hz
  - Allows for no more than 5sec sample time

Note: Luminant only used microphone and could perform test on one unit (with setup) in approximately 4 hrs
Adaption of Snake Robot for GT Compressor Application

- **Key Adaptation Steps**
  - Miniaturize mechanical design
  - Update camera and controls
  - Add remote solenoid-type striking devise
  - Add microphone
  - Other

- **Approach:**
  - Snake attached to upstream blade or vane pings downstream blade/vane and records response via integrated microphone
  - Data recorded remotely using portable signal analyzer
## GT/CC Emissions Management Plan: Ongoing, 2017

<table>
<thead>
<tr>
<th>Solving Define Issues</th>
<th>Prepare for Market Changes</th>
<th>Shaping Future Options</th>
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</thead>
<tbody>
<tr>
<td><strong>Generic GT Cycle Deck:</strong> Addressing De-rated Base Load Power and Emissions on Aging DLN Gas Turbines (Jointly funded with P68, P69 &amp; P194)**</td>
<td>Low Load &amp; Minimum Load Optimization Guidelines (See Flex Opts Strategy)</td>
<td>Assess Next Generation DLN Combustor Designs (See New Plant Strategy)</td>
</tr>
<tr>
<td><strong>SCR/CO Catalyst System O&amp;M Guide Update</strong> (Jointly funded with P88 &amp; P73)</td>
<td>Environmental Control Handbook Update (See New Plant Strategy; Jointly funded with P88 &amp; P73)</td>
<td>DLN Combustor Auto-Tuning Demonstration</td>
</tr>
<tr>
<td><strong>Collect Field Data to Improve CDM Combustor Fault Diagnostics</strong> (See Monitoring Strategy)</td>
<td>DNL Tuning Guidelines</td>
<td>Combined SCR/CO Catalyst Demonstration (Jointly funded with P88 &amp; P73)</td>
</tr>
<tr>
<td><strong>SCR/CO Catalyst Testing Protocol</strong></td>
<td>Repair Guideline: New Models (See Hot Section Strategy)</td>
<td>Advanced Sensors for Monitoring and Control</td>
</tr>
<tr>
<td></td>
<td>Model-based controls</td>
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</tbody>
</table>
Generic GT Cycle Deck: Addressing De-rated Base Load Power and Emissions on Aging DLN Gas Turbines

- **Issue:** Many DLN gas turbines that have been through multiple hardware repair cycles have base load de-ratings result in/from power output reductions and NOx emissions above design values
- **Objective:** Develop analytical tools to identify corrective actions to mitigate the circumstances which contribute to poor power output & emissions performance
- **Approach:** Develop a GT simulation model capable of diagnosing base load de-ratings
- **Deliverable:** Software – 2016
- **Funding:** $200K; Shared with Program 194
Generic GT Cycle Deck: Addressing De-rated Base Load Power and Emissions on Aging DLN Gas Turbines

**Issue:**

- Many 7FAs that have been through multiple hardware repair cycles have base load de-ratings even though new technology hardware should result in higher power output
- Additionally, NOx emissions for many of these units have increased above their 9 ppm design value
- Data from one site with high NOx indicates that a 1 ppm reduction in NOx comes at the cost of 2 MW in base load output

[Graph showing the relationship between NOx and combustion reference temperature]
7FA Cycle Deck Tool Overview

- Cycle Deck Tool
  - Faster root cause analysis and independent of OEM

- Typical Inputs
  - Stage 1 nozzle info
  - $\Delta p$ on impingement sleeve
  - Area of nozzles
  - Etc…

- Typical Outputs
  - Power Output
  - NOx
  - Firing Temp
  - Mass Flow Rate
  - Etc…
Proposed User Interface

 AEPRM System
Input Files
Sensitivity File: C:/AEPRM/Amasing_Accuracy.xls
Measurement Input File: C:/Data/Site#10/Base Load 01152016.xls
Baseline Data File: C:/Data/Site#10/New Base Load 01152016.xls

Demo Main Input Screen

AEPRM Root Cause Selection Screen
Root Cause Possibilities:
- Fan Erosion
- Fan Corrosion
- HPC Erosion
- HPC Corrosion
- HP Frame Leak
- HPT Erosion S/N
- HPT Erosion S/B

Demo Root Cause Selection Screen

AEPRM Measurement Delta Selection Screen
Measurement Δ’s to use:
- Select All
- Select None

Demo Measurement Delta Cause Selection Screen
Assessment of Combined SCR/CO Catalyst Concept

**Issue:** Combined SCR/CO catalyst concept recently introduced; independent evaluation needed
- CO catalyst downstream of SCR catalyst
- Simplifies NH3 injection (direct aqueous injection at engine outlet)
- May also reduce ammonia slip

**Objective:** Assess performance and deactivation

**Approach:** Lab-scale parametric study followed by full-scale *in situ* deactivation study

**Deliverable:** Technical update on lab study in 2016; deactivation results in 2018

**Funding:** Lab Study ~ $75 K, Deactivation Study ~ $150-200K; Shared with Programs 88 and 73
Combined SCR/CO Catalyst Concept: Lab Study

**Apparatus**
- Bench reactors

**Scope of Tests**
- NOx reduction, CO oxidation and NH3 oxidation performance evaluations
- Comparison to traditional SCR and CO catalysts
- Sensitivities (temperature, area velocity, CO effects on $K_{NOx}$, NOx effects on CO oxidation, etc.)
Combined SCR/CO Catalyst Concept: Full-Scale Deactivation Study

**Test Site**
- Existing unit with combined SCR/CO catalyst installed, or
- Install small section of combined SCR/CO cassettes in larger traditional catalyst bed

**Test Approach**
- *In situ* techniques to measure $K_{\text{NO}_x}$ and CO oxidation over a two year period
# Capacity and Thermal Performance Plan: Ongoing, 2017

<table>
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<th>Solving Defined Issues</th>
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<tbody>
<tr>
<td>Inlet air filter performance and life cycle costs</td>
<td></td>
<td>New/improved capacity enhancement technologies</td>
</tr>
<tr>
<td>Gas turbine performance analysis and training</td>
<td>Gas turbine upgrades and downstream impacts (shared with New Plants/Upgrades area)</td>
<td>Energy storage (shared with New Plants/Upgrades area)</td>
</tr>
<tr>
<td>GT/CC Performance Analysis Tool for Next Day Revenue Optimization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plant monitoring, audit procedures and performance recovery</td>
<td>Improved instrumentation</td>
<td>Field-test new plant hardware and procedures</td>
</tr>
<tr>
<td>Modifications &amp; actions to improve plant performance and methods to quantify value</td>
<td>Auxiliary power reduction</td>
<td>Steam turbine performance degradation (shared with Steam Turbine/ Generator area)</td>
</tr>
<tr>
<td>Experience sharing and networking</td>
<td>HSRG fouling reduction (shared with Emissions area)</td>
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</tr>
</tbody>
</table>
GT/CC Performance Analysis Tool for Next Day Revenue Optimization

- **Issue:** Ability to predict future GT/CC performance for bidding on power production
- **Objective:** Extend current GTPA tool to predict future performance based on prior available data
- **Approach:** Update GTPA algorithms to perform performance prediction; Implement standard trending and forecasting algorithms
- **Deliverables:**
  - Gas Turbine Revenue Tool - 2017
  - Combined Cycle Revenue Tool – 2018
- **Funding:** $100K; Shared with Programs 88 and 194
Current GTPA Capabilities

Current Capabilities

- Correct performance data to standard day for trending
- Assist end users in identifying anomalous behavior
  - Recoverable degradation
  - Non-recoverable degradation

Proposed Enhancements

- Automated trending and anomaly detection
- Enhance calculations to perform prediction in addition to reconciliation
- Forecasting of plant performance on local and seasonal basis
Example Output

- Provide long term (seasonal) and short term (weekly) forecasting
- Provides additional information to assist with outage and maintenance planning decisions
- Also provides ability to better predict available output for revenue optimization

Forecast and trend:
- Power output
- Heat rate
- Compressor efficiency
- Inlet and exhaust pressure drops
Extend to Combined Cycle Performance Prediction

- Extending GTPA to include combined cycles can take two paths…
  - Correction curve approach to capture general condenser limitations, steam turbine valve leakage, and HRSG fouling issues
  - More detailed model capable of identifying deeper issues
### CC Steam Turbine and Generator Plan *(Ongoing)* (2017 Proposed)

<table>
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<th>Shaping Future Options</th>
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</thead>
<tbody>
<tr>
<td>Procurement guideline and specification (New Plants/Upgrades Area)</td>
<td><em>Reduce cycling damage from more frequent starts and higher ramp rates</em></td>
<td>Higher temperature and supercritical steam cycles</td>
</tr>
<tr>
<td>Identify main causes of steam turbine and generator unavailability</td>
<td>New machine design characteristics and upgrades (New Plants/Upgrades Area)</td>
<td>Improved seals/packing for longer term performance gains</td>
</tr>
<tr>
<td>Reduce risk of generator failures, improve maint.</td>
<td>Monitor blades, control/stop valves, rotor dynamics</td>
<td>Life estimation and life extension</td>
</tr>
<tr>
<td>Major maintenance costs (New Plants/Upgrades Area)</td>
<td>Root cause failure analyses</td>
<td></td>
</tr>
<tr>
<td>Reliability and maintainability improvements</td>
<td>Improve low load operation</td>
<td></td>
</tr>
</tbody>
</table>
Combined Cycle Steam Turbines: Research Initiatives

Proposed Projects for 2017 (cost shared P65/P79)

Proposed Project Option #1:

CCST Main Steam Valve Reliability and Maintainability Improvements

- **Issue:** CCST main steam valves – significant reliability issues especially on units with cycling operation; valves not designed for ease of maintenance

- **Objective:** Extend the knowledge base of specific CCST main steam valve designs and provide practical solutions for improved maintenance and retrofit solutions

- **Approach:** Review several of the most common valve designs in CC applications, gather information on reliability, design weaknesses, maintainability issues, and identify modifications that could be implemented on internals, including improved material selections

- **Deliverable:** Technical Report, December 2017 (P79 cost estimate: $80K)
Combined Cycle Steam Turbines: Research Initiatives
Proposed Projects for 2017 (cost shared P65/P79)

Proposed Project Option #2:
CCST Warming Blankets for HP/IP Shell Heating

- **Issue:** Requirements for improved control of the HP/IP shell temperature especially during transient operation in order to limit the thermo-mechanical fatigue damages to the equipment associated with the unit start-up/shut-downs

- **Objective:** Review the available heating blankets technologies which can be applied to the CCST applications, provide operational benefits and identify areas for improvement

- **Approach:** Gather operating experience from industry leaders, survey commercial technology, describe design and application limitations. Focus on how heating blankets reduce startup time and reduce cyclic damage in general.

- **Deliverable:** Technical Report, December 2017 (P79 cost estimate: $80K)
Combined Cycle Steam Turbines: Research Initiatives
Research Areas under Consideration for the Long Term (after 2017)

- **Research Focus**: Address different aspects of cycling in relation to the thermomechanical fatigue damage and the influence of cycling to the existing operational and maintenance practices:
  
  - Numerical modeling of rotor and shell geometries (heat transfer and stress) to demonstrate effects of various startup and cooldown profiles, impact of insulation, heating blankets, hot air injection – use model to explore operational improvements
  
  - Controls improvements incorporating turbine stress analyzer systems, describing how they work, inputs, outputs. Review methods for estimating rotor temperatures during transients based on shell temperature. Explore new sensor schemes to improve accuracy of turbine component online stress determination.
  
  - Guidance on inspection intervals when subject to cold, warm, hot starts (i.e. EOH factors). Guidance on condition-based assessment of extending maintenance intervals.
New Plant Development Working Group
New Plant Development Working Group

- **Issue**
  - Leverage EPRI members’ knowledge and plant development experience for mutual benefit

- **Objectives**
  - Communicate and share approach, best practices and lessons learned
  - New generation planning, project development, execution/construction, startup and upgrades

- **Focus**
  - New gas-fired combined-cycle plants
  - New simple-cycle gas turbine and reciprocating engine plants
  - Capacity/efficiency upgrades
New Plant Development Working Group

- **Approach**
  - Facilitate an open exchange among utility planning and project development professionals and industry participants
  - Share information on new projects and major upgrade planning, specification, procurement, construction and commissioning

- **Activities**
  - User presentations, discussions, plant visits, webcasts. Future meetings may include invited speakers (EPCs and/or OEMs)
  - Recommendations for program R&D deliverables

- **Next Meeting**
  - March/April 2016
  - Atlanta, Georgia (tentative)
  - Cost: No charge to EPRI utility members
Power Plant Development Life Cycle

- Production Cost Modeling
- Interconnect Agreements
- Cost Estimates
- Execution Approach
- Detailed Engineering
- Project Completion
- Site Selection
- Conceptual Design
- Optimization Analyses
- Contracting Strategy
- Construction / Construction Management
- Load Forecasts
- Fuel Supply Agreements
- Permitting / Licensing
- Project Planning & Controls
- Startup / Commissioning
- Evaluation of Alternatives
- Plant Design Basis
- Project Schedule
- Procurement Strategy
- Procurement
- Operator Training

Generation Planning → Project Development → Project Execution

EPRI Report # 3002007410
Louisville Meeting – New Plant Development

Full Day Meeting, May 25

- Participation
  - 18 utility attendees from 12 companies,
    10 utility presentations, various subjects

- Key Recurring Themes
  - Renewables penetration, CTCC plant flexibility
  - Equipment maintenance access
  - Gas pipeline, electrical transmission costs
  - Project financials, regulated market PUCs
  - O&M staffing, cross-training
  - Planning risks, project optimization
Louisville Meeting – New Plant Development

Half Day Site Meeting, May 26

- LG&E Cane Run CC Plant Tour
  - 2x1 SGT6-5000F5ee, Siemens STG, Vogt HRSG
  - COD: June 2015

- Design basis
- Construction lessons learned
- O&M experience

Big thanks to LG&E-KU for making the tour and briefing memorable and informative!
Final Comments of the Day
Propose Same Survey Approach for 2017 Research Projects

## 2015 Program 79 Research Projects Survey

Indicate the relevance and importance of each proposed project to your organization (1 being not important and 5 being very important)

### P79.001 - Plant Wide Integration

<table>
<thead>
<tr>
<th>Project</th>
<th>1 (Not Important)</th>
<th>2</th>
<th>3 (Important)</th>
<th>4</th>
<th>5 (Very Important)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital and Maintenance Actions to Improve Combined-Cycle Plant Heat Rate</td>
<td></td>
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<tr>
<td>Operational and Control Strategies for Reducing Steam Turbine Damage from Cycling of Combined-Cycle Plants</td>
<td></td>
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<tr>
<td>SCR and CO Catalyst System O&amp;M Guideline for Gas Turbines and Combined-Cycle Plants</td>
<td></td>
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<tr>
<td>Protocol for SCR and CO Catalyst Testing for Gas Turbines and Combined-Cycle Applications</td>
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</tbody>
</table>

### P79.002 - Life Assessment/Risk Management

<table>
<thead>
<tr>
<th>Project</th>
<th>1 (Not Important)</th>
<th>2</th>
<th>3 (Important)</th>
<th>4</th>
<th>5 (Very Important)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotor NDE: Field Rabbet UT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SX (Single Crystal) Hot Section Degradation and Repair</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

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Advisor Assignments Following Orlando

- Safe travels home!
- Review the proposed 2017 projects
- Collect technical ideas and issues from your technical staff
- Coordinate between your Generation Program Advisors (P79, P88, P65, P87, etc.)
- Be prepared for:
  - 2017 survey sent out in October
  - Return survey results by November
  - 2017 projects confirmed by December
Concluding Action Items

- Review action items
- Closing comments from attendees
- Closing comments from EPRI staff
- Adjourn
Good-bye Orlando … Travel Safe !
Together…Shaping the Future of Electricity
EPRI Event App
Download the
“EPRI Events” Meeting App!

Search for EPRI Events
Login – genf16
URL - https://event.crowdcompass.com/gen-adv-council

Confirmation number required to access materials – see registration desk or welcome letter
Generation Meeting App Features

• Find the time and place for your meetings
• Access
  • Meeting Agendas
  • Meeting presentations and materials
  • Speaker biographies
  • EPRI documents
  • Hotel maps
  • List of nearby restaurants
• Link to site for things to do and see in Orlando
Smart Device App Home Page

Access Materials:
Click on the three lines at the top to log into the app
- See welcome letter for registration ID or visit the Registration Desk
- Some programs and Council materials are restricted to members ONLY

Welcome:
- General meeting information
- EPRI Antitrust Guidelines
- Future advisory meetings through 2017

Schedule:
- Meeting times and places
- Agendas
- Presentations and other materials
Schedule Page

Full Week Schedule of Events

- Meeting times and places
- Agendas
- Presentations and other materials

Schedule at a Glance

Schedule by Day

Schedule by Track (Research Areas)

Program Agendas

All Program Agendas
Event Extras Page

Log in for more features!

Generation Advisory and Sect...

My Items
- My Schedule
- My Messages
- My Contacts
- My Notes

Event Guide
- Welcome Gen Advisors
- Safety Information
- Schedule
- New Advisors
- Crowd Compass

Login for access to meeting materials
Confirmation code is in welcome email or at registration desk

My personal schedule
Project Update Information on Cockpit
Project Overview Forms

- Located on Projects tab of Program Cockpit
- Describe projects currently taking place and future 2017 research

### Project Overviews

All Project Overviews | Portfolio 2017 Project Overview

---

**Projects**

<table>
<thead>
<tr>
<th>Title</th>
<th>Funding Type</th>
<th>Published</th>
<th>Portfolio Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application of Lifting Calculator - Lifting of Soft</td>
<td>Base Funded</td>
<td>09-Jun-2016</td>
<td>2017</td>
</tr>
<tr>
<td>Assessment of Eddy Current Arrays for Replac</td>
<td>Base Funded</td>
<td>08-Jun-2016</td>
<td>2017</td>
</tr>
<tr>
<td>Assessment of Eddy Current Arrays for Detection</td>
<td>Base Funded</td>
<td>08-Jun-2016</td>
<td>2017</td>
</tr>
<tr>
<td>Boiler Tube Failure Application</td>
<td>Base Funded</td>
<td>09-Jun-2016</td>
<td>2017</td>
</tr>
<tr>
<td>Component Specific Testing</td>
<td>Base Funded</td>
<td>20-Jun-2016</td>
<td>2017</td>
</tr>
<tr>
<td>Damage from Cycling of Supercritical Power</td>
<td>Base Funded</td>
<td>09-Jun-2016</td>
<td>2017</td>
</tr>
</tbody>
</table>
Example Project Overview Form

- Title
- Estimated Budget
- Start Date
- Duration
- Key Research Question
- Objective
- Approach
- Deliverables

Project Overview
Back to Project List
Advanced Approaches to Flow Accelerated Corrosion Control

| Project Lead: Mike Caravaggio, 704-595-2569; mcariavaggio@epri.com |

<table>
<thead>
<tr>
<th>Budget/Funding</th>
<th>Target Start Date</th>
<th>Anticipated Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016 - $125-175K</td>
<td>01/2016</td>
<td>12 Months</td>
</tr>
</tbody>
</table>

Key Research Question
Component damage associated with flow accelerated corrosion (FAC) is often very localized and isolated. The subtle variations in the environmental conditions (chemistry) are not identifiable as contributory to significant changes in the corrosion rate. Due to the confined nature of the corrosion activity, measurement of the results of the corrosion through techniques such as corrosion product transport or physical inspection are insensitive to reaction kinetics. Treatment regimens to mitigate corrosion activity are principally focused on establishing corrosion potentials which favor stabilization of the metal or metallic anode, however, reliable measurement of the corrosion rate in actual FAC or simulated conditions of localized attack resulting from FAC are typically unavailable.

Electrochemical corrosion measurements at condensate/feedwater temperatures with a probe assembly designed to promote a mode of corrosion (e.g., oriented to simulate FAC) have been established using various techniques in laboratory test loops. The adaptation of these techniques to an online probe providing a real-time measurement of corrosion potential may permit for improved cycle chemistry monitoring and corrosion control.

Direct measurement of actual or simulated conditions would be beneficial in assessing the risk of upset condition of contamination or loss of chemical control and the corrosion hazards to operating conditions. Commercial development of in-situ monitoring of corrosion rates will provide not only improved guidance, but an essential measurement of the cycle chemistry control.

Objective
Demonstrate enhanced FAC corrosion control under various conditions applying newly developed EPRI FAC Probes.

Approach
This project will further previous laboratory and field work performed by EPRI in the development of a new FAC corrosion monitoring probe. The anticipated applications include monitoring FAC in HRSG economizers and in conventional boiler feedpump associated piping.

Anticipated Deliverables

Technical Report
**Project Status Updates (PSU)**

- Information on current program research
- Located on Project Status Updates tab on Program Cockpit
- Issued Quarterly

**Project Status Updates**

<table>
<thead>
<tr>
<th>Projects</th>
<th>Funding Type</th>
<th>Published</th>
<th>Scope</th>
<th>Budget</th>
<th>Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td>NDE for Boiler and Piping Components</td>
<td>Base Funded</td>
<td>Jun-2016</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
</tr>
<tr>
<td>NDE Methods of Detection of Early Stages</td>
<td>Base Funded</td>
<td>Jul-2016</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
</tr>
<tr>
<td>Guided Wave for Wall Loss and Cracking</td>
<td>Base Funded</td>
<td>Jun-2016</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
</tr>
<tr>
<td>Acoustic Emission Monitoring of Damaged</td>
<td>Base Funded</td>
<td>Jul-2016</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
</tr>
<tr>
<td>NDE for Detection of Axially Oriented</td>
<td>Base Funded</td>
<td>Jun-2016</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
</tr>
<tr>
<td>Corrosion Fatigue Controlled Circulation</td>
<td>Base Funded</td>
<td>Jul-2016</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
</tr>
</tbody>
</table>
Example Project Status Update

- Title
- Description
- Key Activities
- Project Status
- Project Issues/Resolutions
- Deliverables

Project Status Updates
Back to Project List
Phase Transition Zone - Filming Amines
Published: Jun 2015 * Print Report
Manager: Michael Carrawaggio, (704) 595-2599, mcarravaggio@epri.com

- SCOPE - Green: Green - No change in scope (key activities or deliverables) since last update.
- BUDGET - Green: Green - Project funding and spending are in line with the project plan.
- SCHEDULE - Green: Green - Project's key activities or deliverables are on or ahead of schedule.

Description
To control the corrosion mechanisms in the PTZ, researchers will evaluate the filming amine application in a simulated environment and the effectiveness of this the filming amine abating with oxycondensates and liquid film sampling devices near the PTZ. The early condensate/liquid film sampling devices will simulate actual conditions in the PTZ, resulting from a variety of filming amine propert formate decomposition products. The project will use sacrificial test strips to measure success. Resulting data will be used to quantify the benefit or risk of these steam chemistries compared.

Key Activities

<table>
<thead>
<tr>
<th>Activity Name</th>
<th>Short Description</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Update PTZ Testing Rig</td>
<td>The rig will be updated to allow for the addition of filming amines</td>
<td>May 30, 2015</td>
</tr>
<tr>
<td>Test Train</td>
<td>Tests utilizing filming amines conducted</td>
<td>April 30, 2016</td>
</tr>
</tbody>
</table>

Status
Contract in place.
Testing commenced July 18, 2015 - two filming amines have been tested to date.
The Neutralizing Amino PTZ final report has been issued.
Interim Report is published for Filming Amines if covers 2 of 4 commercially available products.
Final testing has been delayed due to issues with rig, testing expected to complete this summer.

Issues / Resolution
Issues with chemical injection system are being trouble shot currently.

Deliverables

<table>
<thead>
<tr>
<th>Number</th>
<th>Name</th>
<th>Date</th>
<th>Status</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>36030069103</td>
<td>Control of Corrosion in the Steam Turbine Phase Transition Zone (PTZ) Using Filming Amines</td>
<td>Published</td>
<td>Green</td>
<td>Technical Results</td>
</tr>
</tbody>
</table>
New Search Engine

Find information faster

Updated, intuitive interface

Full text search

Improved graphics

Enhanced results
Sign up for TIP Emails

- Select EPRI program cockpits of special interest
- Weekly or biweekly
- Program cockpit updates
  - Meetings & webcasts
  - Project Updates
- New product announcements
- Links are direct to member center
- Questions email tip@epri.com

<table>
<thead>
<tr>
<th>Number</th>
<th>Name</th>
<th>Funding</th>
<th>Favorite</th>
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<tbody>
<tr>
<td>63</td>
<td>Boiler Life and Availability Improvement Program</td>
<td></td>
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<tr>
<td>64</td>
<td>Boiler and Turbine Steam and Cycle Chemistry</td>
<td></td>
<td></td>
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<tr>
<td>65</td>
<td>Steam Turbine Generators and Auxiliary Systems</td>
<td></td>
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<tr>
<td>66</td>
<td>Fossil Fleet for Tomorrow</td>
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<td></td>
</tr>
<tr>
<td>68</td>
<td>Instrumentation, Controls and Automation</td>
<td></td>
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<tr>
<td>69</td>
<td>Maintenance Management and Technology</td>
<td></td>
<td></td>
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<tr>
<td>71</td>
<td>Combustion and Coal Quality Impacts</td>
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<tr>
<td>73</td>
<td>Post-Combustion NOX Control</td>
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<tr>
<td>75</td>
<td>Integrated Environmental Controls</td>
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<tr>
<td>77</td>
<td>Continuous Emissions Monitoring</td>
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<tr>
<td>79</td>
<td>Combined Cycle Turbomachinery</td>
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<tr>
<td>81</td>
<td>Fossil Materials and Repair</td>
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<tr>
<td>88</td>
<td>Combined Cycle HRSG and Balance of Plant</td>
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<tr>
<td>104</td>
<td>Generation Maintenance Applications Center (GenMAC)</td>
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<tr>
<td>108</td>
<td>Operations Management and Technology</td>
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<tr>
<td>105</td>
<td>CO2 Capture, Utilization and Storage</td>
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<td>105</td>
<td>Water Management Technology</td>
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<td>103</td>
<td>Renewable Generation</td>
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<tr>
<td>104</td>
<td>Heat Rate Improvement</td>
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</tbody>
</table>
Advisor Responsibilities
**Program Advisory Structure and Roles**

**Program Advisor**
- Liaison/primary interface to an EPRI program for your organization
- Identify new research needs and project opportunities
- Help scope new projects (base and supplemental)
- Assist with annual research prioritization process
- Help identify Project Advisors within your organization based upon subject matters and skill sets
- Communicate research results within your organization
- Provide feedback to EPRI program management regarding program improvement opportunities
- Attend Program Advisory Committee meetings; participate in Program Advisory committee teleconferences/webcasts
- Help your organization maximize your value from program participation
Project Advisory Structure and Roles

Project Advisors
- Help with project objectives, scope, schedules, results, etc.
- Serve as a technical subject matter expert relating to project
- Review progress and results of project; provide feedback and guidance
- Participate in periodic teleconferences/webcasts
- Contribute to technical reports/updates as a technical reviewer/editor
- Contribute to software developments as a product tester
- Serve as a project champion for your organization
- Assist with communication of project results within your organization