

## MODERNIZATION TECHNOLOGY ASSESSMENT

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| MTA Number                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | MTA-EN-006-R1                                                                                                                                                                                                                                                                                                                                                                                     |  |  |
| Title                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                   |  |  |
| Improved Thermal Performance Through Data Validation and Reconciliation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                   |  |  |
| Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                   |  |  |
| <p>Nuclear plants perform Core Thermal Power (CTP) calculations to ensure the plant is operating within the licensed thermal limitations at all times. The CTP calculation uses various instrument inputs, the most significant input being feedwater flow measurements. It is common for feedwater flow measurement devices, such as venturists, to experience fouling, which results in erroneous flow measurement inputs to the CTP calculation. As a result, the calculated CTP may be greater than the actual core power, forcing the plant to operate underpowered. Data Validation and Reconciliation (DVR) can be used to reconcile instrument values and reduce the uncertainty in the CTP calculation.</p> <p>DVR software models use statistical analysis of various plant instruments to solve for error values in measurements of feedwater flow and CTP. The DVR results can be used to support calibration of plant instruments to help reduce underpower operation and to support the transition from time-based maintenance to condition-based maintenance of feedwater flow components and systems. Under the 10 CFR 50.59 process, DVR can be used for power recovery, with a potential recoverable MW range from approximately 3 to 5 MWe per unit. The potential recoverable MW may be greater depending on the extent the plant is already incurring CTP losses due to feedwater measures.</p> <p>A Topical Report (TR) on the use of DVR for measurement uncertainty recapture (MUR) is currently under NRC review, and plants may implement DVR for MUR once this TR is approved. Current MUR uprates are based on the use of ultrasonic flow meters (UFMs) for feedwater measurement. Implementation of DVR can provide equivalent or more accurate measurement than UFMs and, therefore, replace UFMs to support MUR. Plants that pursue a MUR uprate as a result of implementing DVR for CTP calculations can expect a potential recoverable MW range from 12-18 MWe per unit. The use of DVR for MUR is not currently in the scope of this MTA.</p> |                                                                                                                                                                                                                                                                                                                                                                                                   |  |  |
| Benefits                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                   |  |  |
| Benefits Estimate                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Level 1 – Savings are less than \$1 million per year, per unit. Estimated savings range from approximately \$600K-\$1M per year, per unit depending on the recoverable MWe. Savings are largely driven by the price of power based on the market and time of year.                                                                                                                                |  |  |
| Benefits Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <ul style="list-style-type: none"><li>• Reduce vulnerability to single point measurement errors.</li><li>• Reduce uncertainty in CTP calculation.</li><li>• Recover power losses due to errors in feedwater flow measurements.</li><li>• Reduce labor hours by supporting the transition to condition-based maintenance for required equipment inspections and instrument calibrations.</li></ul> |  |  |
| Costs and Schedule                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                   |  |  |
| Cost                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Level 3 – Implementation cost is less than \$1 million per unit. Costs range from \$200K-\$500K per unit, with the higher cost including the design change process to use DVR for power recovery. The ongoing costs for software licensing, model maintenance, and data analysis labor are approximately \$10K-\$30K per year.                                                                    |  |  |
| Schedule                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Less than six months per unit. DVR can be installed online and takes a few months to develop each model.                                                                                                                                                                                                                                                                                          |  |  |

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| Scope Context                                                                                                                                                                                                                                                                                                                                               | <p>Per unit.</p> <p>Initial implementation costs include purchase of software from the vendor, training, IT labor, and engineering labor to utilize the software. Ongoing costs include the cost of the software licensing, the costs associated with maintenance of the DVR model, and the labor costs associated with the data analysis.</p>                                                                                                                                                                                                                                                                |
| <b>Risks</b>                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| <p>There is a regulatory risk if a unit is taken above CTP limits if DVR is implemented for power recovery. During the planning phase, plants should leverage the implementation guidance to ensure they are outfitted with the proper instrumentation for the DVR software, noting that the more data input for the DVR model, the better the results.</p> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| <b>Administrative Items</b>                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| Date                                                                                                                                                                                                                                                                                                                                                        | 12/14/2021                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Functional Area Where Benefits Will Be Realized                                                                                                                                                                                                                                                                                                             | <p>Engineering</p> <p>Operations</p> <p>Maintenance</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Reference Implementation Guidance                                                                                                                                                                                                                                                                                                                           | <p>Program on Technology Innovation: Evaluation of Data Reconciliation Methods for Power Recovery (EPRI <a href="#">3002005345</a>)</p> <p>Using Data Validation Techniques to Evaluate the Impact of Chemical Addition at Nuclear Power Plants: Effects of Polyacrylic Acid and Online Noble Metal Injections on Steam Side Parameters (EPRI <a href="#">3002013194</a>)</p> <p>Guidance for Implementing a Data Validation and Reconciliation Program at Nuclear Power Plants (EPRI <a href="#">3002013197</a>)</p> <p><a href="#">2020 TIP Award</a> Data Validation and Reconciliation (ID: 13344057)</p> |
| Industry SME                                                                                                                                                                                                                                                                                                                                                | <p>EPRI – Kurtis Crytzer</p> <p>Contact: <a href="mailto:NuclearPlantMod@epri.com">NuclearPlantMod@epri.com</a></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Previous Implementation                                                                                                                                                                                                                                                                                                                                     | This improvement has been implemented at several nuclear plants. Please contact the EPRI SME for additional information.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Implementation Enablers                                                                                                                                                                                                                                                                                                                                     | <p>The proper plant instrumentation must be installed prior to implementation of DVR. It is expected that most plants will already have the proper instrumentation installed as a part of the current balance-of-plant heat cycle measurements. See Reference Implementation Guidance for guidance on how to validate the proper instrumentation is installed.</p>                                                                                                                                                                                                                                            |

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| SWEEP Score                            | <ul style="list-style-type: none"> <li>• Cost – Level 3 – Implementation cost is less than \$1 million per unit. Costs range from \$200K-\$500K, with the higher cost including the design change process to use DVR for power recovery. The ongoing costs for software licensing, model maintenance, and data analysis labor are approximately \$10K-\$30K per year.</li> <li>• Savings – Level 1 – Savings are less than \$1 million per year, per unit. Estimated savings range from \$600K-\$1M per year, per unit depending on the recoverable MWe. Savings are largely driven by the price of power based on the market and time of year.</li> <li>• Payback – Level 2 – Payback period is greater than one year but less than five years. Payback period is typically around 2 years.</li> <li>• Technical Readiness – Level 3 – This technology has already been implemented at a nuclear site for power recovery.</li> <li>• Licensing Readiness – Level 3 – No regulatory changes are required for implementation. Use of DVR for MUR is currently under review by the NRC. Utilities can implement DVR for power recovery under 10 CFR 50.59 process.</li> <li>• Implementation Proficiency – Level 3 – The technology can be implemented by all sites, regardless of digital experience.</li> </ul> |
| Applicability                          | <p>All reactor types</p> <p>All geographic regions</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| Keywords                               | DVR; core thermal power; CTP calculation; feedwater flow; power recovery                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Business Case Analysis Cross-Reference | Plant Modernization Business Case: Improved Thermal Performance Through Data Validation and Reconciliation: Cost-Benefit Analysis of DVR Analysis for Power Recovery or Measurement Uncertainty Recapture Uprates (EPRI <a href="http://www.epri.com/nuclearplantmod">3002019845</a> )                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |

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