

SOAPP-CT O&M Cost Estimator—Version 3.5

Advanced Capabilities for Estimating CT/CC Plant O&M Costs

Palo Alto, CA January 23, 2007: EPRI has released the latest version of the SOAPP-CT O&M Cost Estimator, a spreadsheet software tool for calculating operating and maintenance costs, developing a cash flow projection, and providing a present value analysis for combustion turbine-based simple cycle and combined cycle projects. Using this tool, the incremental cost per start or per hour can be determined, depending on the type of service intended for the unit.

The SOAPP-CT O&M Cost Estimator provides the framework and cost items to determine O&M costs for specific plant equipment configurations and duty cycles. The user specifies key inputs such as CT manufacturer, cycle type, duty cycle, and plant net output, and then either accepts a series of default values or provides specific inputs for detailed cost categories. Risk mitigation input options include original equipment manufacturer (OEM) extended warranty, maintenance contract (i.e. LTSA), boiler & machinery breakdown insurance, property insurance, and business interruption insurance. The user may also choose from several optional Monte Carlo simulation options.

The spreadsheet generates a cash flow projection of O&M costs for use in a pro forma financial analysis, and provides both a present value and annualized analysis of costs, with and without risk mitigation alternatives. Scheduled maintenance outage rates and cost data for the GE 7FA, 7EA, 6B, 6FA, 9FA, 9E, ALSTOM/ABB GT11N2, GT13E2, GT24B, GT26B, Siemens-Westinghouse 501D5A, 501FD2, 501G, Siemens V84.2, V94.2, V84.3A2, V94.3A2, and Mitsubishi M501F3, M701F3, M501G and M701G models are included. The costing framework can be applied to any heavy-duty model using either Equivalent Operating Hours (EOH) maintenance intervals or those based on both starts and hours. Statistical unscheduled outage data is also incorporated for the GE 7FA and SW 501F and is scaled for other models. By considering outage and cost information probabilistically, the user can quantify the degree to which risk mitigation alternatives decrease economic risks and change the average costs of a CT project. Estimates based on self-directed maintenance can then be compared with estimates incorporating risk mitigation options, including long-term maintenance contracts.

New Features in Version 3.5 include:

- **Improved Modeling of Five-Stage Turbines.** Up to five rows of blades and vanes plus HP outlet guide vanes, can now be modeled explicitly with fallout estimates for each row (applicable to ALSTOM GT13E2, GT24B/GT26B models).
- **Improved Maintenance Interval Flexibility.** The user may now eliminate Combustion Inspection events if desired when modeling combustor hardware that is repaired/replaced at the Hot Gas Path Inspection (HGPI) interval (i.e. GE 24k combustor hardware).
- **Siemens-Westinghouse 501G Maintenance Costs.** A new model-specific cost sheet for the 501G (60 Hz) contains estimates for component costs, in addition to the existing 501FD2 and 501D5A model sheets with updated costs.
- **Mitsubishi M501G and M701G Maintenance Costs.** New model-specific cost sheets for the M501G (60 Hz) and M701G (50 Hz) include estimates for component costs, in addition to the existing M501F3 (60 Hz) and M701F3 (50 Hz) model sheets. The algorithm for maintenance intervals of Mitsubishi Heavy Industries machines (on the Maintenance Inputs sheet) determines the annual Equivalent Operating Hours (EOH) and Equivalent Starts (ES) based on overall user inputs. The MHI EOH calculation includes a non-linear consideration of weighted starts.
- **Updated Costs for Other Models.** Component costs for other models have been updated based on current estimates of nominal "list" prices and market conditions. Miscellaneous O&M costs have been updated throughout to 2006 estimates.
- **Currency Conversion Enhancements.** Additional input and output sheets now have preferred currency conversion. Output sheets and charts are now displayed in the preferred currency and their formatting has been enhanced.
- **Other Refinements.** Combustion turbine variable maintenance costs per factored hour (per factored start for starts-based maintenance) are provided on the summary sheet. The Users Manual has been updated with additional information on the software program flow and descriptions of inputs and usage. The user can specify the component names of other parts on the CT model-specific input sheets. The number of part-load starts is now a user input on the Input Summary page. The valid range for the project economic life is expanded to a range of 5 to 40 years.

Features Added in Previous Versions:

- **Siemens V84.2, V94.2 and V94.3A Maintenance Costs.** New model-specific cost sheets for the V84.2 (60 Hz), V94.2 (50 Hz) and V94.3A (50 Hz) engines are provided with preliminary estimates for component costs, in addition to the existing V84.3A model sheet.
- **General Electric 6B, 9E and 9FA Maintenance Costs.** New model-specific cost sheets for the 6B (50/60 Hz), the 6FA (50/60 Hz), the 9E (50 Hz) and 9FA (50 Hz) engines are provided with estimates for component costs. In addition, the existing 7EA and 7FA component costs are updated.
- **Alstom GT13E2, GT24B and GT26B Maintenance Costs.** New model-specific cost sheets for the GT13E2 (50 Hz), the GT24B (60 Hz) and GT26B (50 Hz) engines are provided with preliminary estimates for component costs, in addition to the existing GT11N2 model sheet.
- **Custom Model Sheets.** New custom model sheets were added for use in estimating other combustion turbine models. When the OEM selected is General Electric, Siemens-Westinghouse or Mitsubishi, the Custom (H & S) sheet is used. When Siemens KWU or ALSTOM (Linear EOH) is selected, the "Custom (Linear EOH)" sheet is used. When ALSTOM (Elliptical EOH) is selected, the elliptical method is applied and "Custom (Elliptical EOH)" sheet inputs, or the GT24B or GT26B sheets can be selected.
- **Currency Conversion.** For most inputs and outputs, the user can now work in their preferred currency, selected on the Input Summary sheet. Defaults provide initial guidance of conversion factors, but the user should apply the most current conversion rate for their currency per U.S. dollar.
- **Component Repair and Replacement Cost Details.** The new "Maint Cost Detail" output sheet provides quarterly costs for repair and replacement on a component-by-component basis, giving greater visibility to the buildup of costs included in the "Quarterly" sheet. These costs are shown with escalation and currency conversion applied. A new "Model Summary" output sheet also restates the inputs in the selected model-specific sheet with currency conversion applied.
- **Other Refinements.** When the user selects a CT model from the Input Summary, the relevant model-specific sheet becomes available for user input and other unrelated model-specific sheets are hidden. Maintenance inspection intervals and user adjustment factors are now located on each model-specific input sheet. In the Operations Inputs sheet, a line item is available for other fixed, non-operating auxiliary power costs such as capacity charges, if desired to be included by the user.
- **Fallout Rates.** Fallout rates for blades and vanes are now applied to each repair interval. A method is described to save simulation runs and restore them at a later date without rerunning the simulation. Annual O&M services and materials costs are now summarized separately depending on whether they are operations or maintenance-related.
- **O&M Estimates for Existing Plants.** The SOAPP-CT O&M Cost Estimator was modified to allow estimates of O&M on a "going forward" basis. For existing units that have run for a period of time and have perhaps already had maintenance inspections, the user can enter the accumulated factored hours and

factored starts for “aged parts” on a component type basis, as well as factored hours and starts since the last inspection of each type. The SOAPP-CT O&M Cost Estimator then uses this information as a starting point for estimating maintenance intervals and parts repair and replacement intervals, in the same method as for new plants.

- **Insurance Premium Revisions.** The methodology and cost estimates for Boiler and Machinery Insurance (i.e.. Machinery Breakdown) and for the associated Business Interruption Insurance were significantly reworked to provide more accurate default estimates based on current market conditions and industry input. Insurance is an important part of technical risk mitigation, providing an indication of the risk perceived by the insurers and their response to market conditions.
- **Property Insurance.** Premium estimates for property insurance, with and without additional business interruption coverage, were added as default values. Property coverage insures against a broad range of property damage exposures including fire, explosions, floods, earthquakes and other perils. Property Insurance covers not only the process equipment but also support equipment and buildings.
- **Maintenance Intervals Refinements.** A user override feature was added to the Quarterly Inputs sheet to provide improved scheduling of Major Inspections for certain unique circumstances. The User can specify the minimum time interval following the Hot Gas Inspection prior to a Major Inspection. In circumstances where the maintenance interval is a mixture of starts-limited and hours-limited intervals (a condition that can occur with GE and Siemens-Westinghouse algorithms, depending on inspection limits), a Major Inspection (starts limited) could occur shortly after a Hot Gas Path Inspection (hours limited). A provision has been added such that the Hot Gas Inspection is redefined as a Major Inspection if it would have occurred within several quarters time frame. This approach provides a more rational cost estimate and approach to maintenance scheduling.
- **Siemens-Westinghouse 501D5A, 501FD2 and V84.3A2 Maintenance Costs.** Model-specific maintenance estimates now includes the 501D5A and V84.3A(2) machines, as well as an update to the 501F costs. Initial default values for parts costs and life based on factored hours and starts (or equivalent operating hours, as applicable) can be adjusted on model-specific input sheets. Any ALSTOM/ABB, General Electric, Siemens KWU or Siemens-Westinghouse machine can be modeled using the framework provided. In addition, vendor-specific algorithms for maintenance intervals have been updated.
- **Additional Enhancements.** CT Parts Rotation Sparing can now accept any number of spares, up to the number of CTs being considered, to provide more flexibility in the sparing decisions. Quarterly escalation factors are now readily available for use with the user-defined maintenance cost and contract cost adders. Additional Maintenance Contract types are available, such as repair-only, labor-only or replacement parts-only contracts, inclusion of steam turbine maintenance, etc. Cash Flow sheets now include greater details, such as display of repair costs and replacement costs separately.
- **Rotation Sparing.** The user can choose which parts are subject to rotation. When selected, procurement of replacement parts is accelerated to the time of the first repair cycle. Removed parts are repaired and used in a later repair cycle in the same machine or another machine (“roll-in, roll-out”). The timing of

procurement of replacement parts and parts repair based on rotation sparing is therefore accelerated, which affects the cash flow and present value economic analysis. Rotation sparing is often utilized for cyclic and baseload plants which require high availability.

- **Quarterly Analysis.** A quarterly calendar basis is provided for scheduled CT maintenance intervals and inspection/overhaul costs. Present value calculations are based on costs assigned quarterly, providing a finer resolution to changes in operating scenarios for sensitivity analysis. Factored hours and starts can be modified per quarter if desired to fine-tune inspection intervals.
- **Repair Fallout.** Parts replacement costs due to fallout during the repair cycle are rigorously calculated throughout the project life based on a user-specified fallout rate. In addition, the user specifies the extent that repairs must be made before deciding that the parts must be scraped and replaced prematurely.
- **Maintenance Intervals and Parts Life.** Additional flexibility is provided in defining the frequency of inspections and CT parts life. The user may modify factored hours and starts intervals for Combustion Inspections, Hot Gas Path Inspections and Major Overhauls. Timing of inspections is determined based on cumulative factored hours (and starts as applicable) since the last inspection. Parts repair/replacement timing is also determined based on cumulative factored hours (and starts) since the last repair or replacement. The timing of costs for repair or replacement is assigned to a maintenance event so as not to exceed its defined life based on hours and starts.
- **User-defined Costs.** Additional user-defined CT maintenance costs for variable parts/materials and labor, either capital or expense categories, can be entered on a quarterly basis for self-performed maintenance. Additional user-defined costs associated with maintenance contracts can also be assigned on a quarterly basis.
- **GE 7EA and ALSTOM GT 11N2 Maintenance.** Model-specific maintenance now includes the GE 7EA and ALSTOM GT 11N2 machines, in addition to the GE 7FA and S-W 501F machines. Initial default values for parts costs and life based on factored hours and starts (or equivalent operating hours, as applicable) can be adjusted on model-specific input sheets. Any ALSTOM/ABB, General Electric, Siemens KWU or Siemens-Westinghouse machine can be modeled using the framework provided.
- **Capital and Expense Categories.** Scheduled CT maintenance estimates now include user selection of the tax category (capital or expense) for parts replacement, repair and labor. Selections are made on the model-specific cost input sheets for each part category. Costs are summarized by category on the cash flow summary sheets.
- **Cost Updates.** Default O&M costs are updated, including parts replacement and repair costs for the GE 7FA and S-W 501F machines. Maintenance algorithms are updated based on current OEM publications.

The SOAPP-CT O&M Cost Estimator requires Microsoft Excel 2000 or later, operating under Microsoft Windows 2000 or later. The SOAPP-CT O&M Cost Estimator can be used as a standalone product or in conjunction with the SOAPP-CT WorkStation.

The SOAPP-CT O&M Cost Estimator was developed by the SOAPP Team at EPRI. For more information on the SOAPP-CT O&M Cost Estimator, please contact Todd Nordgren by phone at 1.817.295.5167 or by e-mail at tnordgren@epri.com.

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