# Information Age Technology for Power Generation Project Development

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## Introduction

The electric power industry is growing increasingly competitive, both domestically and internationally. Electricity suppliers vie intensely for customers, and project developers aggressively bid to furnish new generating units. Successful projects must meet not only the needs of the customer (wholesale or retail) and environmental criteria, but also result in satisfactory financial return for the participating parties. The site-specific nature of each project and the many possible business and technology scenarios make it costly for developers to effectively balance unit performance, capital cost, competitive positioning, and return on investment.

At the same time, less than one project in 50 is ever completed, while more than 100 proposals may be submitted for each potential project. Bidders are under pressure to reduce proposal development costs by duplicating prior designs or choosing between standard vendor designs. However, taking this step often leads to proposals that satisfy none of the parties' interests.

To compete in today's global market, the project developer must be able to more quickly, accurately, and cost-effectively address the unique requirements of each project opportunity. To accomplish this, developers must graduate from the cumbersome process of preparing separate performance and cost estimates, based on information provided by multiple sets of vendors; and feeding that information into a spreadsheet environment to execute a detailed financial analysis.

A new class of decision-support technologies has been developed to meet the needs of the current proposal development environment—technologies that fully integrate the process of unit performance analysis, cost estimating, and financial analysis. In the early 1990s, the Electric Power Research Institute (EPRI) recognized the need to combine technical and economic decision-making into one software package. In response, EPRI sponsored development of the SOAPP (State-of-the-Art Power Plant) suite of products, created to support development of new electric generating plants and the upgrading and repowering of existing units.

The centerpiece of the SOAPP software family is the SOAPP WorkStations. Each WorkStation fully automates the plant design process: generating heat and material balances, equipment sizing, drawings, cost estimates, construction schedules and financial analysis based on user-selected equipment, site, environmental, fuel, and economic criteria. The integration of technical and financial analysis with advanced automation enables the user to make business and technical decisions conjointly, rather than independently as in the past. SOAPP tailors equipment selection and process design to project-specific criteria so the user can evaluate the design over a range of likely scenarios, striking the best balance between risk and reward.

The following paper presents a brief overview of the SOAPP products, their capabilities, and three case studies demonstrating how CSW Energy has utilized SOAPP to help keep its project development business competitive.

## The SOAPP Products

SOAPP is a suite of interactive software products that enables the user to access the most current information on power plant technology alternatives, to evaluate selected alternatives in a site-specific context, and to integrate technology selections into a conceptual plant design and financial analysis, all from a desktop personal computer. Two types of SOAPP products have been developed: Technology Modules and WorkStations.

SOAPP Technology Modules are interactive, multimedia tools that provide background and technical information, support decision-making, and train engineers in new technologies. They can be utilized for comparing and assessing performance, costs, and installation schedules of existing and emerging plant technologies. For decision support, SOAPP modules combine the traditional features of a multimedia encyclopedia with interactive technical and economic modeling, including dynamic graphing.

SOAPP WorkStations are integrated, calculational products that enable the user to input basic design and economic criteria, select an appropriate technology configuration, and evaluate the resulting conceptual plant design. Input for the WorkStation is divided into four data groups (Figure 1).

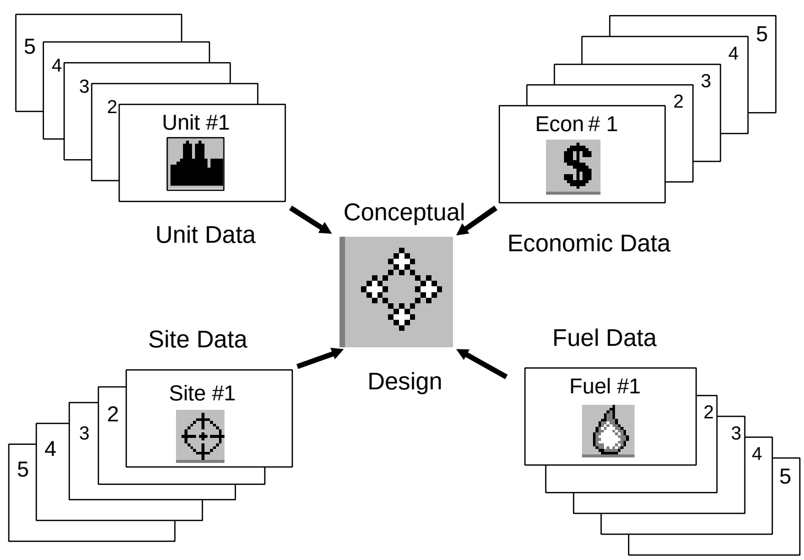
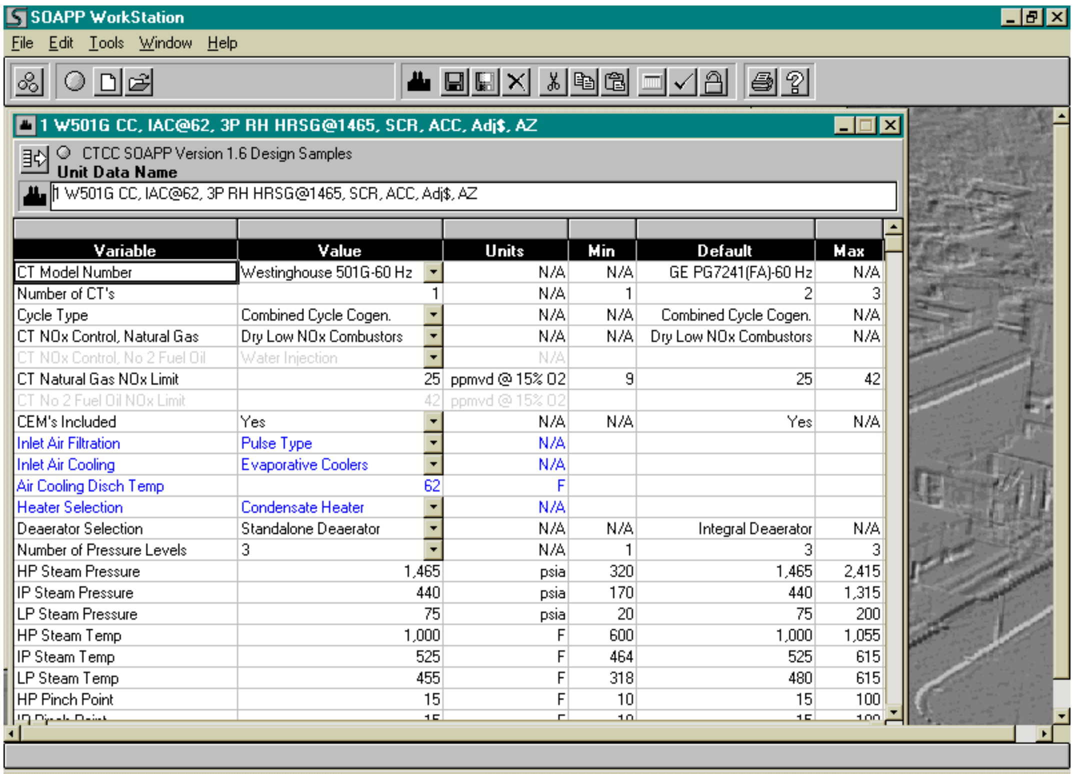



*Figure 1: User Input Structure*

The Unit Data group allows the user to input specific key design attributes of the unit. For the SOAPP–CT WorkStation, the user starts with the selection of the combustion turbine (CT) model, selecting from a database of more than 63 commercially available 50 and 60 Hz models, ranging in size from 20 MW to 220 MW. Simple cycle, combined cycle, and cogeneration cycles can be configured. Based on the CT selected, a default configuration is available if desired; otherwise the user can configure each major equipment item and select process design conditions separately. Figure 2 illustrates some of the variables in the Unit Data group.




| Variable | Value | Units | Min | Default | Max |
|---|---|---|---|---|---|
| CT Model Number | Westinghouse 501G-60 Hz | N/A | N/A | GE PG7241(FA)-60 Hz | N/A |
| Number of CT's | 1 | N/A | 1 | 2 | 3 |
| Cycle Type | Combined Cycle Cogen. | N/A | N/A | Combined Cycle Cogen. | N/A |
| CT NOx Control, Natural Gas | Dry Low NOx Combustors | N/A | N/A | Dry Low NOx Combustors | N/A |
| CT NOx Control, No 2 Fuel Oil | Water Injection | N/A | | | |
| CT Natural Gas NOx Limit | 25 | ppmvd @ 15% O2 | 9 | 25 | 42 |
| CT No 2 Fuel Oil NOx Limit | 42 | ppmvd @ 15% O2 | | | |
| CEM's Included | Yes | N/A | N/A | Yes | N/A |
| Inlet Air Filtration | Pulse Type | N/A | | | |
| Inlet Air Cooling | Evaporative Coolers | N/A | | | |
| Air Cooling Disch Temp | 62 | F | | | |
| Heater Selection | Condensate Heater | N/A | | | |
| Deaerator Selection | Standalone Deaerator | N/A | N/A | Integral Deaerator | N/A |
| Number of Pressure Levels | 3 | N/A | 1 | 3 | 3 |
| HP Steam Pressure | 1,465 | psia | 320 | 1,465 | 2,415 |
| IP Steam Pressure | 440 | psia | 170 | 440 | 1,315 |
| LP Steam Pressure | 75 | psia | 20 | 75 | 200 |
| HP Steam Temp | 1,000 | F | 600 | 1,000 | 1,055 |
| IP Steam Temp | 525 | F | 464 | 525 | 615 |
| LP Steam Temp | 455 | F | 318 | 480 | 615 |
| HP Pinch Point | 15 | F | 10 | 15 | 100 |

*Figure 2: Unit Data Group*

The Site Data group consists of ambient conditions (temperature, elevation, etc.), environmental criteria (emissions limits), site conditions (seismic zone, cooling water conditions, etc.), and certain site-specific cost and economic inputs.

The Fuel Data group defines the available fuels and fuel usage. Primary and secondary fuels are defined, along with a secondary fuel usage factor.

The Economic Data group contains the information required to perform the capital and operation and maintenance (O&M) cost estimates, and the financial analyses. There are approximately 33 inputs subdivided into the following groups:

- Time frame (commercial operating date, book life, tax life, etc.)
- Evaluation basis (current or constant dollar analysis)
- Operating basis (capacity factor)
- Escalation rates

- Unit value costs
- Tax/insurance rates
- Capital structure (common and preferred equity, debt, and investment tax credit)

The WorkStation allows the user to define multiple sites, economic scenarios, unit configurations, and fuel types.  Any combination of input data groups can be selected to form a conceptual plant design.  Once selected and associated together as a conceptual design, the performance, cost, and financial analyses are fully automated (Figure 3).  The user has a wide variety of deliverables from which to choose (Figure 4).

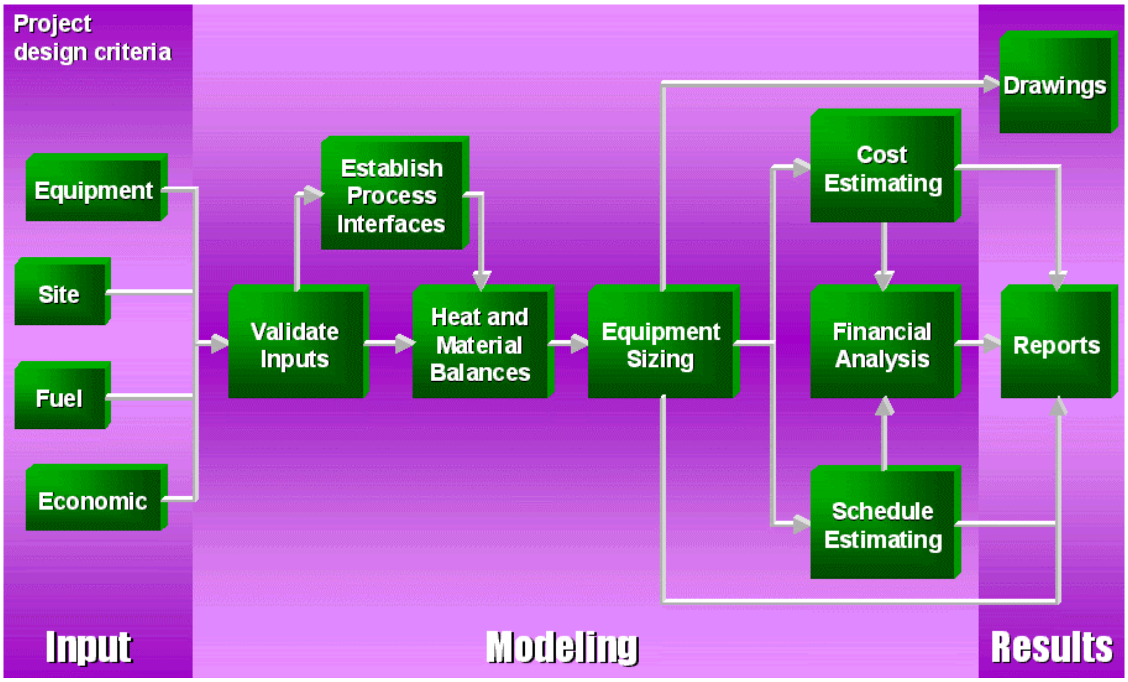



*Figure 3: Automated Conceptual Design within the SOAPP–CT WorkStation*

Upon selecting a deliverable, the WorkStation performs two validation procedures.  The first validates each individual data set, while the second validates the four data sets as a whole.  This ensures that the site, unit, fuel, and economic data are complete sets of information, and verifies that the selected data sets form an allowable plant configuration.  When errors or incompatibilities are identified, the user receives a general notification and may then scan through the data.  Problem inputs are highlighted in red, and when the user points the cursor at the input line, the WorkStation provides an explanation of the problem.

When the user has an error-free set of inputs, the WorkStation automatically performs heat and material balances, sizes equipment, and generates the selected deliverable.  The WorkStation provides a complete customized set of preliminary design documents.  Drawings generated by the WorkStation are in standard DXF format.  The user has the option of viewing the drawings in the WorkStation or exporting it directly to any standard commercial CAD package.  Reports can be printed directly from the WorkStation or pasted into text documents or spreadsheets.

The WorkStation integrates performance, cost, and financial analysis capabilities into one product, combining them with a flexible data input structure.  This allows the user to optimize the plant design to technical and financial criteria, and assess it against project and market uncertainties.  Because so

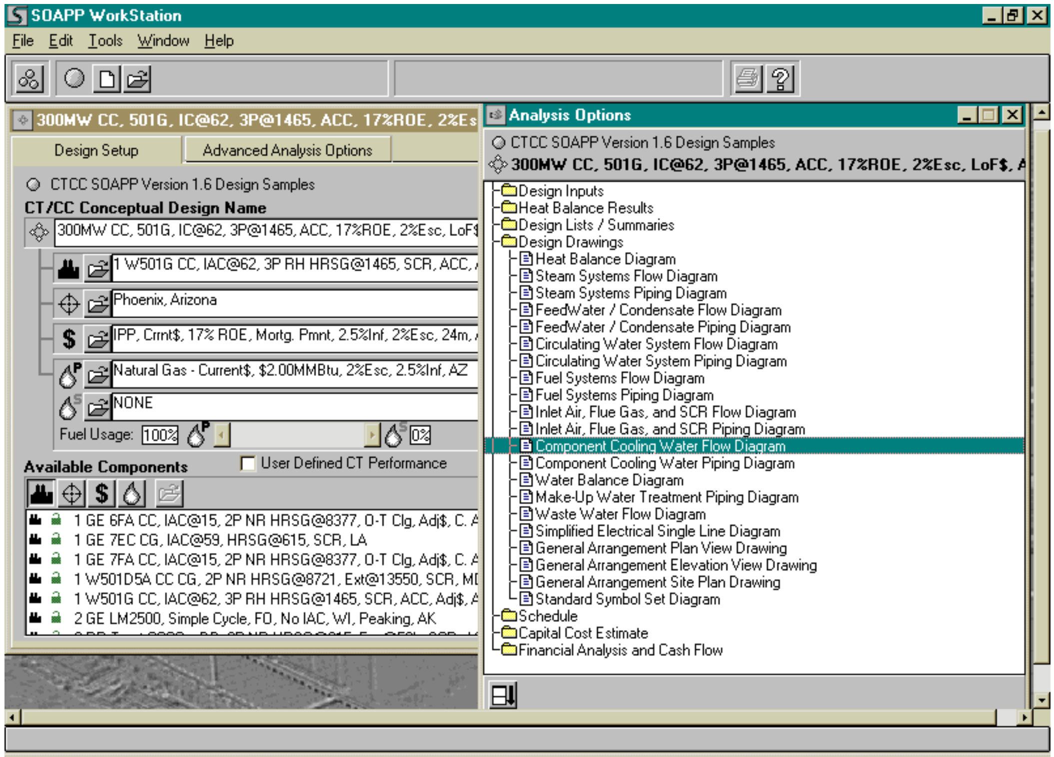



*Figure 4: SOAPP–CT WorkStation Deliverables*

many project-specific site and financial variables interact with the design, no one parameter can be used to judge the optimum solution for any particular project. "What if" scenarios provide an invaluable tool for evaluating the impacts of key design decisions on overall project performance.

Significant opportunities for reducing bus bar generating costs, increasing net income, and reducing risk are left untapped in many developed projects. These possibilities are created by the complex, often hidden interactions of site conditions, economic and market factors, and financial strategies with the cost-benefit relationships of equipment, process, and plant design. Because of the SOAPP–CT WorkStation's ability to handle the dynamics of these complex interactions, project developers can now begin to take advantage of these opportunities. The key to uncovering the opportunities lies in using the SOAPP–CT WorkStation to experiment with a wide variety of equipment choices and design criteria selection over the range of expected economic, market, and financial conditions. The combination providing the optimal project financial performance will emerge from this investigation.

Figure 5 illustrates the potential impact of this approach to the financial performance of a developed project. The starting point for this analysis was a fairly typical 300 MWe combined cycle plant design, firing natural gas 95% of the time with fuel oil as a backup 5% of the time. For the purposes of illustration, this example has been simplified by keeping many of the plant components constant, such as the combustion turbine model and configurations of the condensate and cooling systems, and by conducting the analysis for only one set of economic and financial parameters. The starting design featured a three-pressure heat recovery steam generator (HRSG) at 1465 psi with reheat; inlet air cooling by ammonia liquid overfeed to 60°F; and combustion turbine $NO_X$ control that uses dry low $NO_X$ combustors when firing natural gas, and water injection when burning fuel oil.

As illustrated in Figure 5, the economics of this project favor higher steam pressures, with an increase of the HRSG high pressure steam to 2400 psi yielding the greatest improvement in net cash flow to equity. Further analysis using the SOAPP–CT WorkStation demonstrated that changes to the design steam conditions, including higher pinch points and approaches, yield an even greater improvement in net cash flow to equity. Next, examination of the amount of inlet air cooling with this improved steam cycle show an expected "bathtub curve" effect, with the optimal design point, from the standpoint of maximizing net cash flow to equity, occurring at 57°F. Although fuel oil will be fired only 5% of the time, a design switch from water injection to steam injection when firing fuel oil makes a slight, unexpected improvement in the projected financial performance of the project. Finally, changing the type of inlet air cooling to mechanical chillers results in yet another increase in the net cash flow to equity. *[Note: the jump in the curves in Figure 5 in the year 2013 corresponds to the point at which all principal of the project financing has been paid.]*

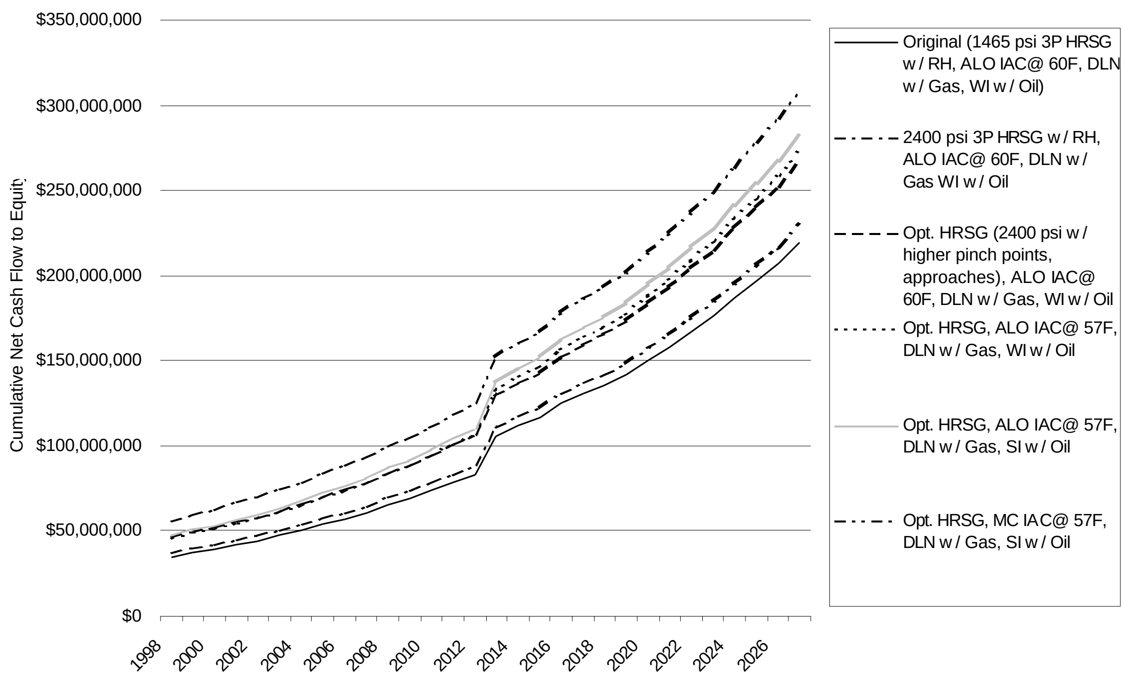



*Figure 5: Optimizing Project Design to Maximize Project Return*

As illustrated by Figure 5, the profitability of a project can be increased, in some cases quite significantly, by tailoring equipment technology selection and design criteria to the project's business environment. The increase in profitability both improves the return on equity (ROE) and increases the margin on revenues, reducing the equity holders' risk of not attaining their minimum acceptable ROE. The increased margin can serve as a supplementary hedge against unforeseen costs, lower-than-expected revenues, and other project risks. Project developers and/or owners who conduct this analysis early and update it throughout the development process will have the opportunity to fully attain higher margins through equipment technology and design criteria selection. Optimization analyses, such as the process described for Figure 5, should be performed or updated at each of the following stages of project development:

- Definition of project needs
- Establishment of proposal strategy, including teaming
- Preliminary design

In a competitive process, these analyses should be revisited any time improved information on the project site, market, and/or business conditions are available, ensuring that any changes to the proposal are responsive to the competitive situation.

## Case Studies: CSW, Energy, Inc.

CSW Energy (CSWE) and CSW International (CSWI) are the non-utility power generation subsidiaries of Central and South West Corporation, based in Dallas, Texas. CSWE/CSWI acquires, owns, develops, constructs, operates, and maintains power production facilities of 50 MW and larger both in the United States and internationally.

CSWE has been making use of SOAPP since its release in 1994. Initially, the software functioned largely in the engineering department as a combustion turbine (CT) technology reference tool. However, the team increasingly utilized SOAPP for a variety of projects as they recognized that the WorkStation could significantly reduce proposal development schedules and improve quality of output. Engineers are performing more work more quickly, accurately, and creatively, spending 50% more time working directly on engineering projects instead of administrative and information processing tasks. Every division with which the team works has noted the improved quality of work from the engineering group during the past three years.

### Altamira Simple Cycle Cogeneration Power Project
### Tamaulipas, Mexico

At the end of 1995, CSWE partnered with a Mexican industrial group to develop that country's first large-scale independent cogeneration project. The new plant is to deliver steam to Petrocel and Temex and supply electrical power to Petrocel, Temex, Indelpro, Pecten, and several other industrial companies.

*Figure 6: Altamira Cogeneration Project*

To meet the process steam requirements of the project's industrial users, an immediate analysis of the project's scope was needed, as well as all data, specifications, and materials for the Request for Proposal (RFP) needed to bid the engineering, procurement, and construction (EPC) contract. Based on the industrial partners' schedule, which was already well advanced, CSWE was given a fast-track development timeline, with plant construction to begin in mid-1996—just six months away—and unit startup scheduled for the first quarter of 1998. This required that the project be defined and the RFP for the EPC contract be prepared in four to six weeks, rather than the usual two or three months; and that plant construction take 18 months instead of the standard two years or more. The project scope included laying a gas pipeline and building the onsite electrical distribution system and interconnections with Mexico's Comision Federal de Electricidad (CFE).

CSWE's development team relied on several SOAPP features to respond to this compressed schedule. As part of the project definition stage, engineers used the SOAPP–CT WorkStation to help define the scope of the project, and develop RFP documents and specifications. As the first step, a key decision needed to be made. Should the new plant be an 80 MW facility, which would meet the electrical and steam requirements of the project's industrial users; or should CSWE risk the expense of installing a 120 MW unit, which would make the plant more cost-effective if partners could be found?

CSWE engineers using the SOAPP–CT WorkStation input all specific data for the Altimira project, including the specialized requirements for both steam and electricity production, Mexican emissions standards, site-specific data, and various other factors. They utilized these data to create multiple "what if" scenarios, comparing several combustion turbine models to evaluate process designs. The two best options were selected from this process. The team then performed a more detailed analysis of the finalists, creating supporting documentation to compare cost and performance factors on SOAPP templates.

Based on this analysis, CSWE made the decision to invest in the larger unit—a wise choice, as it turned out. Enough new partners have been found that ways are already being sought to increase power output from Altimira's pending 120 MW facility.

Drawings generated from the SOAPP–CT WorkStation were then used as the basis for preliminary flow and process instrument drawings. A 3D plot plan and plant rendering were also created from the SOAPP site drawing. In some cases, such as designing interior layouts for plant buildings, engineers started with dimensions recommended by the SOAPP analysis. Within these dimensions—a two-story building—they created customized designs for a control room, switchgear room, maintenance facility, office spaces, etc. Developing their own designs based on SOAPP's recommendations, engineers created new interior models which were added to the in-house drafting library as a standard for future plants.

SOAPP's flow and process instrument diagrams and 3D plot plan features made the development team's drafting department far more productive throughout the project. Drafting productivity increased by 50% as a result of being able to work directly from SOAPP's wire frame diagrams and drawings. It had previously taken a week to complete heat balance drawings and a plot plan. With SOAPP, engineers were able not only to finalize these, but also to include additional project data such as flow diagrams and 3D drawings. It was noted that the work was generally of higher quality despite the compressed schedule.

Once the Altimira conceptual design was finalized, the SOAPP data files were combined with CSWE's in-house specifications and edited to form the project scope for developing the EPC RFP. The output from the SOAPP–CT WorkStation served as the basis for the actual plant design, while equipment lists, equipment sizing data, and drawings served as templates to help create a full and complete RFP package. The team accessed the SOAPP equipment lists to fine-tune the RFP specifications, referring back to the software for recommendations on structural design components, pumps, balance of plant equipment and major pipe sizes.

Using SOAPP as a decision-support tool for the Altimira project enabled CSWE to more fully define the project and a full scope of supply, which had several important advantages:

CSWE was able to improve the accuracy of its capital costs estimate: The two lowest EPC bids received were within 2% of the CSWE estimated price, and these were within just a few thousand dollars of each other.

The high-impact business decision (whether to install a 80 MW or a 120 MW unit), based on accurate models and well-documented support, made the Altimira venture still more cost-effective.

With only six weeks of preparation time, SOAPP saved CSWE about 200 man-hours and 20% of the normal proposal development budget.

The measure of a proposed development project is in how well construction costs match the projections. To date, the Altimira project, now under construction, is currently ahead of schedule and within budget. As one engineer said, “SOAPP allowed us to ask better questions, enabling us to know the project better and scope it far more accurately.”

### Northwest Regional Power Facility

CSWE and a local developer applied for site certification to the State of Washington for a new power production facility, which would serve a large rural area in the eastern part of the state. As originally conceived, this was a 914 MW combined cycle plant using four F-class combustion turbines, with a heat rejection system based on mechanical draft cooling towers. During the environmental permitting process, state authorities raised questions regarding the new plant’s proposed technologies. Over the following two years, CSWE prepared reports and responses to hundreds of questions regarding various alternatives for the project.

The chief issue at stake was the plant’s demand on the local water table. Concerned about the amount of water required for this type of wet cooling process, officials asked CSWE to present alternate configurations for a number of different heat rejection systems, such as dry cooling technologies using air cooled condensers or once-through cooling. CSWE was also required to create a plan based on pumping water from a river 15 miles away from the site.

CSWE needed to rapidly develop a series of reports and alternative scenarios in response to such questions, sometimes as many as ten per month. The project development team—working with an environmental specialist and his staff, as well as numerous outside consultants—utilized SOAPP as a major resource for information to create these responses.

Accessing the SOAPP–CT Technology Module on Heat Rejection Systems, the project development team explored configurations based around a dry cooling system (Figure 7). Such a plan differed markedly from the original proposal, requiring a larger, more complex facility and consequent higher costs. Engineers utilized the SOAPP–CT Technology Modules’ performance information, equipment lists, and cost estimating features to explore a series of plant alternatives. From this in-house resource, they obtained current information on equipment specifications and prices, which would previously have been obtained by personally contacting many different vendors.

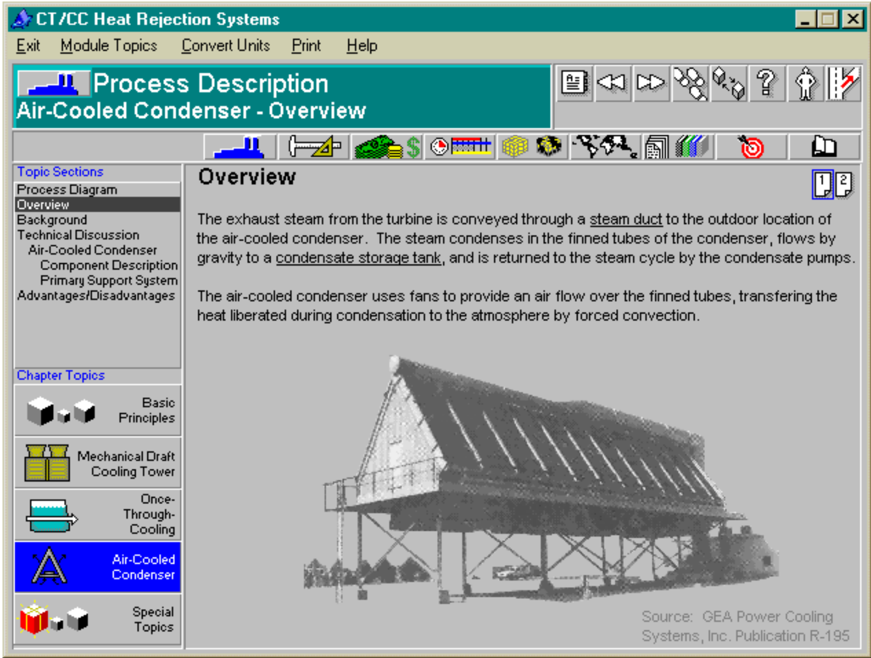



*Figure 7: SOAPP–CT Technology Module on Heat Rejection Systems—Process Description Chapter*

SOAPP was then used to run "what if" scenarios showing the features of the various dry cooling alternatives (Figure 8). Drawings of final options were downloaded to an Auto-CAD file and rendered for the state's consideration.

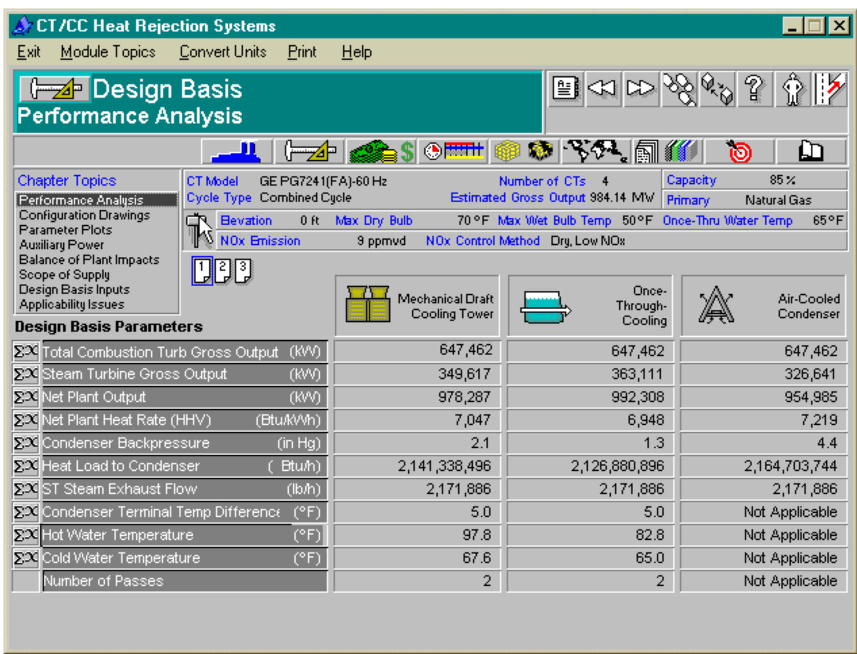



*Figure 8: SOAPP–CT Technology Module on Heat Rejection Systems—Design Basis Performance Analysis (Typical}*

Estimated costs were also developed for the proposed water-pumping scheme, using the SOAPP templates as guidelines for producing the information. It was demonstrated through cost comparison analysis that pumping equipment installation and construction of a 15-mile pipe (which would have to be six feet in diameter), as well as the cost of electricity for running the pumps, would be prohibitively expensive.

The two-year review process culminated in a full state environmental review, as part of which CSWE committed to a dry cooling process alternative. Since the conceptual design of this new configuration had already been developed using the SOAPP–CT WorkStation, project engineers were informed on the new systems and their requirements. They were therefore in a position to move forward at once to complete the project scope.

The environmental permitting process in many states can present a major challenge to keeping a power production project on schedule. Using SOAPP as an information resource and as a tool to produce fast overviews of possible alternatives enabled CSWE to promptly and regularly respond to state concerns regarding the Northwest Regional Power Facility. This had several advantages to CSWE:

- By utilizing SOAPP as a readily available information resource to explore a wide variety of alternative plant configurations, CSWE saved approximately $50,000 in consultants' fees.

- The project schedule was kept moving throughout the environmental permitting process, despite an unusual number of questions and concerns from state authorities.

- Lines of communication with the state were kept open by CSWE's ability to respond to the questions raised promptly and with complete and accurate information.

- When the final decision was made to alter the proposal to the new dry cooling configuration, much of the process engineering had already been done, and the fully scoped project is currently ready to move on to the RFP stage.

### Everett Delta Power Project

In February 1994, CSWE submitted a bid for the Everett Delta Power Project for the Snohomish Public Utility District in the State of Washington. At this time, the facility was planned as a 248 MW combined cycle cogeneration plant powered by a GE 7221 F-class turbine, generating approximately 35,000 pounds/hour of saturated steam for an industrial user.

Due to various delays, the project was still under consideration in the summer of 1996. By this time the plant's configuration had been considerably rethought, and it was being developed with two industrial partners as a 228 MW combined cycle cogeneration plant, powered by a GE 7231 F-class turbine, and generating a far greater amount of saturated steam at 190,000 pounds/hour. Many personnel involved with the project had also departed or recently joined the project, both within CSWE and among local utility and city officials. Because of the changes which had taken place over two-and-a-half years, it was necessary to provide a detailed update to everyone involved with the Everett Delta Project.

It is CSWE's practice to generate periodic project status reports to keep old and new project team members, company executives, and partners informed. Developers felt that a thorough report at this point in the Everett Delta Project would clarify many major issues and be an asset to ongoing planning. CSWE engineers decided to utilize the SOAPP–CT WorkStation methodology and the SOAPP–CT Report Tool as a template to create this detailed written analysis.

SOAPP's capital cost summary feature had already been used for the previous three years as a basis for the project's annual executive review. To create the Everett Delta Technical Reference Guide, engineers accessed SOAPP reports laying out the plant's revised design basis, design impact summaries, equipment list, motor list, and other data; as well as summaries of capital costs, CT performance data, fuel transportation data, and HRSG water steam conditions. Utilizing these and other SOAPP features as guidelines, a detailed project profile was produced in three to four weeks.

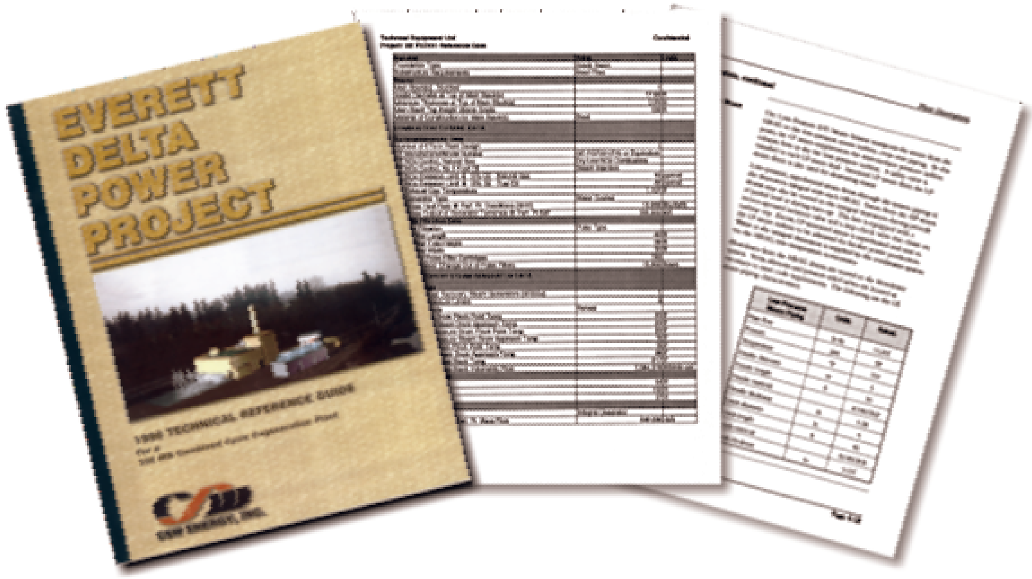



*Figure 9: CSWE's Project Guide*

The Guide turned out to be an even greater asset to the Everett Delta Project than had been expected. It has been heavily utilized both by technical personnel and by state authorities, and serves as a convenient resource during planning meetings and public presentations. The Reference Guide continues to be kept up-to-date; information saved within the SOAPP software may be quickly accessed for revision and pasted into a Microsoft® Excel® Worksheet or a Word® Document. As new information becomes available, CSWE edits the SOAPP reports to reflect the latest project status.

Developing a power project can be a long and protracted process. Many times, it will only come to fruition after several years have passed. Being able to produce an accurate, detailed, and easily updated report on the status of the Everett Delta Project gave CSWE several advantages:

- SOAPP provided CSWE engineers with a new methodology for disseminating information to project participants, raising the standard of data quality and assuring consistent presentation of information.

- The Everett Delta Project Reference Guide for the first time provided a centralized focus of project information that may be utilized over a long period and despite any project revisions. CSWE now plans to use SOAPP templates to maintain status reports on many of its power projects.

- Lines of communication within the Everett Delta Project improved as partners, executives, and engineers became better informed. Having the Guide available as a handy reference has made discussions more productive and effective.

- Time delays caused by repetitive information gathering by state and city officials and other outside authorities were eliminated by putting these parties on a regular Reference Guide update list.

## Conclusion

To compete in today's global market, developers must make use of every available tool to quickly, accurately, and cost-effectively produce proposals that address each project's unique requirements. SOAPP is the only product currently available that consistently supports a wide variety of power project development functions. CSWE's employment of SOAPP in these three cases demonstrates some of the advantages to be gained when the software becomes an integral part of an organization's infrastructure. CSWE's engineering and generation groups also utilize SOAPP for such roles as:

- serving as a training resource for younger engineers;
- supporting the development of detailed, high quality proposals under compressed schedules;
- creating customized reference cases that demonstrate CSWE's capabilities to potential customers.

When CSWE first began using SOAPP, a few engineers worried that this advanced technology might eventually replace them. After working with the product for several months, it became evident that SOAPP was a valuable tool for these same engineers, enhancing creativity while significantly improving productivity. CSWE is now examining additional ways to take advantage of the SOAPP products' capabilities throughout the organization.



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