Section 11

PEPCO'S EARLY PLANNING FOR A PHASED COAL GASIFICATION COMBINED-CYCLE PLANT

Steven Scherer, P.E.

Potomac Electric Power Company
1900 Pennsylvania Ave., N.W.
Washington, D.C. 20068

PEPCO'S EARLY PLANNING FOR A PHASED COAL GASIFICATION COMBINED CYCLE POWER PLANT

BY

STEVEN M. SCHERER

ABSTRACT

This paper presents a review of Potomac Electric Power Company (PEPCO) activities which led to a decision in late 1984 that a coal gasification combined cycle (GCC) power plant very probably can be developed for service on PEPCO's system in the 1990's, in place of conventional pulverized coal-fired technology as the Company's next generating plant addition. The principal activities leading to the PEPCO GCC decision were the Company's 1983 Energy Plan Study, 1983/84 Phased GCC Evaluation and 1985 Construction Budget Review. The paper also provides an overview of PEPCO's Flexible Expansion Strategy (FLEXS), the plan which is being implemented to provide the new GCC generating capacity, when required, at the lowest mix of cost, schedule and technical risk. The FLEXS plan is based on a phased GCC plant with a nominal net generating capacity of about 360 MW. The first phase of the plant, a combustion turbine, is currently scheduled to be in-service in 1995, and preliminary planning and feasibility studies for the unit have begun.

ACKNOWLEDGMENTS

The author would like to thank Ms. N. Lee Beavers and Mr. W. O. "Bud" Disney for their assistance in the preparation of this paper.

PEPCO'S EARLY PLANNING FOR A PHASED GASIFICATION COMBINED CYCLE POWER PLANT

BY

STEVEN M. SCHERER

INTRODUCTION

The Potomac Electric Power Company (PEPCO) provides electric service to over 500,000 customers (almost two million people) in a compact 643 square mile service area in metropolitan Washington, D. C. This area includes all of the Nation's Capitol, most of Montgomery and Prince George's counties in Maryland, and about 10 percent of Arlington County, Virginia. PEPCO also sells electricity to the Southern Maryland Electric Cooperative, which serves a 1,150 square mile service area in Southern Maryland.

PEPCO owns and operates six generating stations, and is a joint owner in one other station. These facilities have a total summer net generating capacity of approximately 5,375 MW. Of this, over 3,000 MW are base-load designed coal-fired units. The stations are operated as part of the Pennsylvania-New Jersey-Maryland Interconnection (PJM). During the past year the Company experienced record peak demands for electricity of 4,490 MW in the summer (+4.9% over 1983) and 3,437 MW in the winter (+9.4% over 1984). For the next decade the anticipated growth in summer peak demand is expected to be about 1% to 2% a year.

Other 1984 Company highlights include record energy sales; increased earnings per share, dividends and stock value; and a decline in the average price per kilowatt hour.

To continue the excellent 1984 results, PEPCO's corporate objective is to meet future energy supply obligations by providing reliable electric service at the lowest cost, under the range of uncertain future conditions which include load growth, fuel prices, inflation, cost of capital and environmental regulation. A major activity in achieving the corporate objective is the Energy Plan Study, which is performed every two years. These studies develop, analyze and integrate the available supply (for example, generation) and demand (for example, energy use management) options in plans which meet the Company's objective.

The following is a summary of PEPCO's 1983 Energy Plan Study. This study included the Company's first preliminary analysis of a phased coal gasification combined cycle (GCC) power plant. The 1983 Study was the first activity in the process which led to the decision in late 1984 that a GCC power plant very probably can be developed for service on PEPCO's system in the 1990's, in

place of conventional pulverized coal-fired technology, as the Company's next generating plant addition.

Other major activities in the process were the Company's 1983/84 Phased GCC Evaluation and 1985 Construction Budget Review, both covered later in this paper. Also included is an overview of PEPCO's Flexible Expansion Strategy (FLEXS), the plan being implemented to provide the new GCC generating capacity, when needed, at the lowest mix of cost, schedule and technical risk.

1983 ENERGY PLAN STUDY

The purpose of the 1983 Energy Plan Study was to recommend approaches for PEPCO to take toward meeting future demand and energy needs. The Study developed and evaluated alternative energy plans that met PEPCO's energy supply obligations for the period 1983 to 1995. Specifically, it focused on plant life upgrade strategies (PLUS) and energy use management (EUM). It also examined conventional and advanced generating technologies and capacity/energy transactions. The results of the Study served as the basis for a number of Company decisions in late 1983 including: (1) moving ahead with PLUS and EUM programs which in turn permitted deferment of the next generating plant addition to 1995 or beyond, and (2) improving future planning flexibility by exploring advanced generating techniques which might become suitable for implementation in the mid-1990's.

The generating technologies evaluated in the 1983 Study were classified into two groups based on technical feasibility. The first group included conventional pulverized coal-fired (PC) generating units with flue gas desulfurization systems and combustion turbines for peaking duty. The second group included potential advanced generating technologies for installation after 1995.

The recommendation regarding advanced generating technologies was to continue studying options that offer capital and operating cost improvements, are smaller or suitable for phased implementation, provide greater schedule and fuel flexibility, and are environmentally acceptable. A related recommendation was to continue to pursue responsible plant permitting and siting reforms with the objectives of trying to shorten the duration and simplify the complex licensing process.

While numerous advanced generating technologies are tracked by PEPCO for energy plan studies, only those nearing demonstration or commercialization, and considered to have the potential to be implemented for the next plant additions are formally evaluated. At the time of the 1983 Study, construction of the Cool Water GCC demonstration project had not been completed and the concept remained technically unproven. However, GCC was considered by PEPCO to have many potential benefits, including being the first new coal-fired generating technology which might be available for the next plant addition. Therefore, GCC was included in the Study in order to better define its potential benefits and determine if further study was warranted.

The economic evaluation of alternatives in an Energy Plan Study uses comparisons of cumulative present worth of incremental revenue requirements (CPWIRR) to address the Company's objective of providing service at the lowest cost. To develop the CPWIRR, both production costing and incremental revenue requirements models are used. Production operating and maintenance expenses, including fuel costs, are calculated using the PROMOD III model. The PEPCO

ECON model is used to calculate the annual incremental revenue requirements associated with both production and capital costs.

The expansion plans resulting from the implementation of PEPCO's EUM and PLUS programs identified the need for additional generating capacity of approximately 100 MW per year, beginning in 1995.

To better define the potential GCC benefits the 1983 Study compared a 1995 PC unit in a PC expansion plan (Table 1) with a phased GCC power plant in a GCC/PC expansion plan. In the GCC/PC plan the 1995 PC unit was replaced with a 360 MW phased GCC power plant (Table 2).

Table 1
1983 Energy Plan Study
PC Expansion Plan

Year In-Service	PC Additions
1995	300 MW
1998	300 MW
2001	500 MW
2006	500 MW
2011	500 MW

Table 2
1983 Energy Plan Study
Phased GCC Power Plant

Year In-Service	Phased GCC Addition
1995	Phase 1: 108 MW Advanced Combustion Turbine
1996	Phase 2: 108 MW Advanced Combustion Turbine
1997	Phase 3: 144 MW Steam Bottoming Cycle and Coal Gasification Plant

The GCC power plant was developed with the assistance of the Electric Power Research Institute (EPRI). The plant was based on the Cool Water design, but included 2200°F advanced combustion turbines. A minimum of other advanced components were used and only radiant gas cooler heat recovery incorporated. Additional complexities to allow for more flexible plant operation were excluded. Plant performance was based on an 88°F ambient condition.

A comparison of the economic impacts of the plans is summarized in Table 3.

Table 3
1983 Energy Plan Study
Comparison of Economic Impacts 1983 - 2012
CPWIRR 1/83 $'s x 10^6

	Fuel and O&M	New Plant	Totals
PC Plan	7,701	2,309	10,010
GCC/PC Plan	7,687	2,174	9,861
GCC Benefits	14	135	149

Since GCC was treated as a mature technology in the Study, the results do not take into account additional cost and performance uncertainties associated with this advanced concept. However, the results do demonstrate the potential cost benefits that may occur, particularly the capital cost advantages accruing from the deferred capital expenditures in a phased GCC plan. Not quantified, but noted in the results, were other potential GCC benefits including: better planning flexibility through smaller capacity increments, potentially greater fuel flexibility and improved environmental performance compared to a PC unit. It also stated that because GCC is a new technology not yet demonstrated on a commercial scale, PEPCO cannot formally consider it in a long-range plan. Therefore, while GCC showed considerable potential, the resulting base plan from the 1983 Study included PLUS, EUM and a 300 MW PC unit in 1995.

With the favorable GCC results in the 1983 Energy Plan Study, it was determined that additional analysis was warranted, and work was begun in late 1983. A summary of that work, PEPCO's 1983/84 Phased GCC Evaluation follows.

1983/84 Phased GCC Evaluation

The objectives of the 1983/84 Phased GCC Evaluation were to compare the following two cases in order to better define the potential benefits of a GCC capacity addition and to recommend areas for future study.

Case 1: Conventional PC capacity additions
Case 2: Case 1 with the first PC capacity addition replaced with a phased GCC power plant

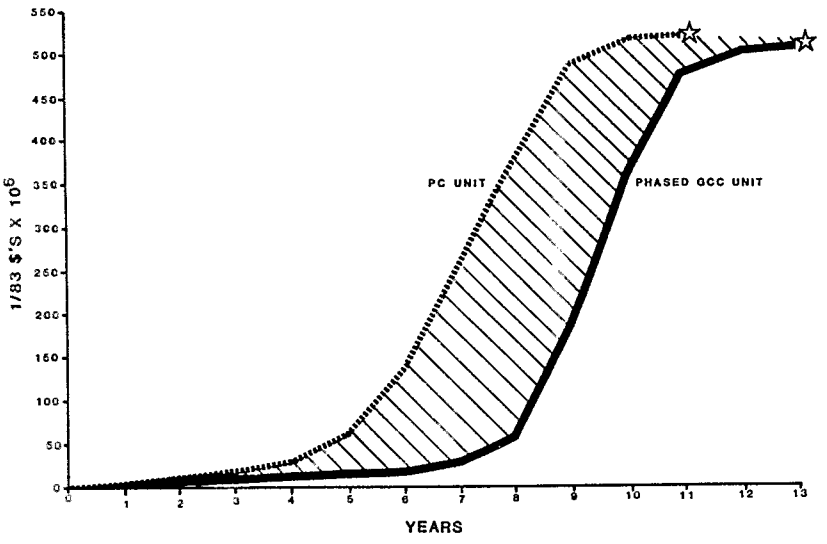
While the basis for this evaluation was the same as the 1983 Study, all assumptions, data and procedures were reviewed and updated by PEPCO, as necessary. Again, the three phase, 360 MW GCC power plant was used (Table 2). However, in this analysis, the GCC power plant was evaluated against a comparably sized (360 MW) PC unit. The units common to both cases were a 300 MW PC unit in 1998 and 500 MW PC units in 2001, 2006 and 2011. For case 1, the PC case, the 360 MW PC unit was assumed to go in-service in 1995.

As in the 1983 Energy Plan Study, the operation and maintenance cost data used assumed that the GCC power plant had slightly better availability, operating costs and heat rate than the comparably sized PC unit. This was expected because of the modular design of the GCC power plant, the high efficiency of combined cycles and no requirement for flue gas scrubbers.

The capital cost estimates were made in January 1983 dollars; were based on mature technology; included all owner, switchyard and interconnection costs; and a 10% allowance for inaccuracies and minor changes. Not included in the capital cost estimates were land, AFUDC and initial fuel inventories. A comparison of the capital cost estimate cash flows (Figure 1) shows one of the potential significant advantages of the phased GCC concept: deferred cash flow.

FIGURE 1

360 MW UNIT CASH FLOWS



As in PEPCO's Energy Plan studies, the modeling techniques used in this evaluation were PROMOD III and ECON. A comparison of the economic impacts of the cases is summarized in Table 4:

Table 4
1983/84 Phased GCC Evaluation
Comparison of Economic Impacts 1983 - 2012
CPWIRR 1/83 $'s x 10^6

	Fuel and O&M	New Plant	Total
Case 1 (PC UNITS)	7,660	2,357	10,017
Case 2 (GCC/PC UNITS)	7,679	2,246	9,925
GCC Benefits	-19	111	92

The evaluation identified the following benefits of the phased GCC concept:

- Provides a better match to load growth
- Defers capital expenditure
- Increases planning flexibility
- Reduces dollar commitment risk
- Has a CPWIRR benefit of $92 million in January 1983 dollars

The results of the evaluation also identified issues for future study, including:

- Development of better combined cycle modeling. The combined cycle production cost models currently available are too simplistic to capture representative costs of a GCC power plant.
- Evaluation of a range of design alternatives, such as supplementary firing of the heat recovery steam generators during summer operation.
- Comparison of current and advanced combustion turbines.
- Sensitivity analyses on the cost and performance estimates.
- Adding a four phase GCC power plant. The first two combustion turbines phases remain unchanged. Phase 3 is the steam bottoming plant only and phase 4 the gasification plant.

A summary of PEPCO's 1983/84 Phased GCC Evaluation was presented in mid-1984 at a Utility Coal Gasification Association (UCGA) meeting. This summary has served as the basis for much of the current UCGA/EPRI GCC Phasing Study. PEPCO is participating in that study, and some results should be available in late 1985.

As noted previously, PEPCO's GCC studies identified that current production cost modeling for GCC plants was inadequate. This has resulted in an EPRI contract to PEPCO, related to the UCGA/EPRI GCC Phasing Study, to develop the needed production cost modeling software. This work is being performed in conjunction with Energy Management Associates (EMA), the owner of PROMOD III, and should be completed by mid-1985. The new modeling capability will significantly improve our ability to quantify more accurately the costs and benefits of the GCC concept.

With the continuing favorable results, it was determined that additional study of the GCC option was warranted in preparation for PEPCO's 1985 Construction Budget review.

1985 Construction Budget Review

PEPCO's annual Construction Budget review includes the next year's budget and a 10-year budget forecast. In 1981 a project was approved to initiate licensing activities for a new 300 MW PC unit to be in-service in the early 1990's. In mid-1982 work on that project was stopped, and the in-service date identified as 1993. Following the 1983 Energy Plan Study the in-service date was deferred to 1995. With a new PC unit having a 10 or more year project

schedule and a target in-service date of 1995, the 1985 Construction Budget review became a decision point on when to begin working again on the unit.

The plan used by PEPCO's Generating Engineering and Construction Group which leads to construction budget recommendations is based on the evaluation of all practical generating unit alternatives. The group then selects, recommends, and secures approval of the alternative that best meets the Company's objective. PEPCO's new generating unit objective, as noted earlier, is to provide the new capacity, when required, at the lowest mix of cost, schedule and technical risk. Additional objectives are to avoid excess generating capacity, insure acceptable performance, defer capital expenditures, provide schedule/planning flexibility and have a low environmental impact.

Energy planning forecasts for the 1985 Construction Budget continued to identify the need for capacity additions beginning in 1995 at approximately 100 MW per year. Based on the 1983 Energy Plan Study and 1983/84 Phased GCC Evaluation, the 1985 review focused on two options:

- A 300 MW PC unit
- A 360 MW phased GCC power plant

As in past evaluations, other conventional and advanced options were discussed. Of the advanced options, in late 1984 only GCC was considered by PEPCO to be developed enough to support decisions leading to a 1995 unit in-service. The successful start-up of the Cool Water demonstration project in mid-1984, and its early results which continually exceeded all expectations, led PEPCO to decide that a GCC system very probably can be developed for service on PEPCO's system in the 1990's.

For the 1985 Construction Budget Review, earlier economic analyses were updated and re-run. The results again favored the phased GCC alternative. This analysis also included a sensitivity case using an estimate with additional GCC capital cost contingency, to reflect the added GCC uncertainty compared to a PC unit.

The following three alternatives were presented for 1985 Construction Budget Review:

- proceed with a 300 MW PC unit
- proceed with a 360 MW GCC unit
- proceed with both the PC and GCC units

Factors leading to the Construction Budget recommendation included:

- Uncertainty in new capacity requirements
- Status of the Cool Water demonstration
- Combustion turbines are the initial GCC phases
- Combined cycles are current technology
- The GCC recommendation will further defer a PC unit
- A PC unit project schedule of less than 10 years has significant cost and schedule risk
- GCC has about a $100 million present worth benefit over PC in January 1983 dollars

Considering all factors, in late 1984, as part of the 1985 Construction Budget review, it was recommended and PEPCO decided that a phased GCC power plant was the preferred alternative for the Company's next generating plant addition. The Table 5 GCC-PC advantage comparison summarizes the PEPCO evaluation. The table is divided into two sections, the first based on the Company's major new generating capacity objectives, and the second other considerations important in any new capacity decision.

Table 5
1985 Construction Budget
GCC - PC Comparison
Advantage Summary

	PC	GCC
Objectives:		
Schedule Flexibility		X
Deferred Capital Requirements		X
Overall Economics		X
Small Capacity Increments		X
Deferred Major Commitments		X
Schedule Risk		X
Performance Risk	X	
Other Considerations:		
Experience with Technology	X	
Early In-Service		X
Fuel Flexibility		X
Operating Costs		X
Efficiency		X
Availability		X
Environmental Impact		X
Proven Components	X	
Flue Gas Scrubbers		X
Cost Risk	X	

The following advantages were identified as the basis for changing to a GCC power plant from the PC unit:

- Greater planning flexibility
- Smaller incremental capacity additions
- Deferred cash flow
- Potential lower overall cost
- Potential lower environmental impact

The 1985 Construction Budget approved expenditures to begin project planning, and concept and feasibility studies for a phased GCC power plant. The in-service date for the first capacity increment, or phase, is currently scheduled for Spring 1995. With the uncertainty in future load growth, the project plan to be developed must be flexible to meet changing capacity addition requirements.

The GCC concept approved in the 1985 Construction Budget, and included in PEPCO's 10-year Construction Budget forecast, has taken the deferred PC unit's planning designation, Station H. The new Station H capital cost estimate in the 10-year forecast includes the added GCC contingency noted previously.

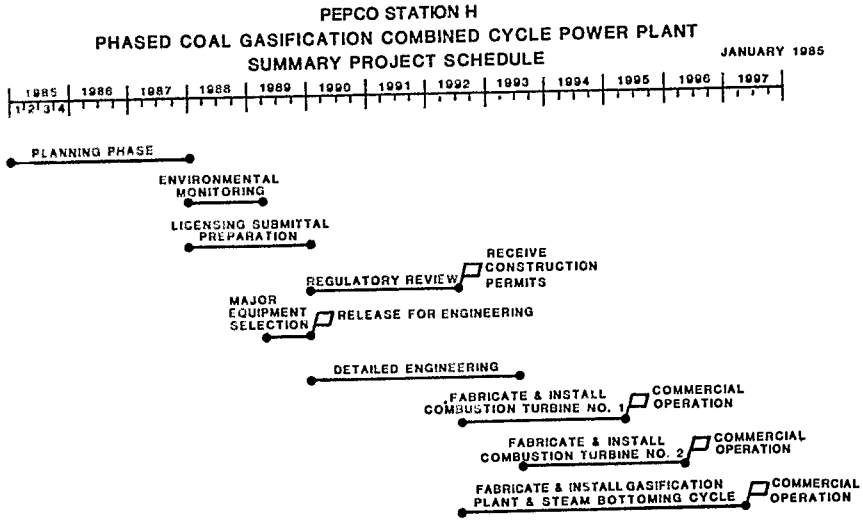
With the 1985 Construction Budget approved, the next activity was to develop a project plan.

PEPCO Flexible Expansion Strategy

In developing a detailed project implementation plan for Station H, to be known as the PEPCO Flexible Expansion Strategy (FLEXS), it was decided that the first step should be a brief kickoff plan. This kickoff plan has been issued and is being used to initiate work on the project.

FLEXS enumerates the general goals, objectives, assumptions and criteria for the project. It also provides some background on how the GCC decision was reached. It describes the current base case GCC power plant and alternatives which will be used in the initial technical and economic comparisons. The base GCC power plant is similiar to the plant in the 1983 Energy Plan Study and 1983/84 Phased GCC Evaluation. FLEXS also includes the overall Station H project schedule (Figure 2).

FIGURE 2



The schedule starts with a multi-year planning phase. This planning phase is intended to make maximum use of the early project years, as they are not specifically required to put the first phase of the plant (a combustion turbine) in-service. Early project planning will provide greater flexibility, more thoroughly evaluated decisions, and a smoother transition into the later phases. By the end of the planning phase,the following project tasks should be completed:

- Feasibility Studies
- Site Selection Studies
- Fuel Selection Studies
- Licensing Planning
- Environmental Monitoring Planning
- Conceptual Design
- Architect/Engineer Selection
- Business Planning

Some of the 1985 planning phase activities are:

- Preparing and implementing a detailed project plan
- Planning and implementing an in-house information program
- Completing preliminary site selection study activities, such as:
  - Preparing the site selection study plan
  - Identifying potential sites
  - Identifying potential fuels
  - Preparing the site selection study concept design
- Assessing further the feasibility, benefits and risks of the GCC concept, including:
  - Preparing a preliminary licensing evaluation
  - Establishing support and information transfer agreements
  - Following industry progress (particularly the Cool Water and advanced combustion turbine development programs)
  - Performing economic and technical analyses of alternatives
  - Participating in PEPCO's 1985 Energy Plan Study
  - Participating in UCGA activities
- Defining support contractor needs and procurement strategies
- Continuing work to improve the power plant licensing process
- Evaluating alternative business options

Regarding planning flexibility, a number of issues are being addressed, including:

- Placing the combustion turbines in-service early (using either current or advanced technologies)
- Deferring or advancing the in-service date of the gasification plant
- Adding summer peaking capacity by including heat recovery steam generator supplementary firing

To better focus the available resources, the 1985 engineering alternatives have been limited to:

- Current (nominal 70 MW) and the advanced General Electric combustion turbines, with other vendors evaluated for possible future consideration
- Texaco and Shell gasification systems, with other vendors evaluated for possible future consideration
- Radiant and convection, radiant only and quench gasifier cooling
- The addition of heat recovery steam generator supplementary firing

To implement FLEXS, a project team has been formed. The team is headed by a Project Engineer, with other engineers identified as the focal points for each of the major project areas. In addition, two review committees are being formed to provide direction and review the work of the project team. First, a Management Review Committee will provide a forum for senior management review and direction to the Project Engineer. Second, an Engineering Review Committee made up of managers and supervisors from the engineering areas involved, will provide technical review of the work as it develops under the direction of an Engineering Coordinator who reports to the Project Engineer. The Engineering Review Committee will also provide early project involvement for those on the Committee, even before staffing from their areas may be required.

CONCLUSION

In conclusion, PEPCO has a program to provide additional generating capacity, when required, at the lowest mix of cost, schedule and technical risk. Key elements in the program's decision making process are bi-annual energy planning and formal construction budget reviews. This process led in late 1984 to a decision that a GCC power plant very probably can be developed for service on PEPCO's system in the 1990's, in place of conventional fossil fuel technology, as our next generating plant addition. Our current plan is based on a phased GCC power plant, with 1995 identified as the in-service date for the first phase (a combustion turbine). The decision was based on many factors, including GCC's greater planning flexibility, smaller incremental capacity additions, deferred cash flow, and potentially lower overall cost and environmental impact. The project, Station H, has been approved, a kickoff plan (FLEXS) issued, initial project team members identified, and preliminary project planning and feasibility studies started.

REFERENCES

1983 Energy Plan Study. Washington, D. C., Potomac Electric Power Company, February 1984.