Chapter Seven

Supply-Side Options

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Existing TVA plants will continue to be the backbone of TVA's power supply system for the Energy Vision 2020 planning period. However, TVA's load forecasting indicates that its customers' future needs for electricity will exceed its current generating capacity.

With four nuclear units in various stages of construction, a near-term decision was needed on whether to continue these projects. Several options were developed that involved completion, conversion, or cancellation of these nuclear projects.

TVA also created an extensive list of other generating options to meet new peaking, intermediate, base-load, and storage power supply needs through the year 2020. These included traditional technologies (e.g., coal plants, combustion turbines), as well as potential renewable and advanced technology facilities.

In addition, TVA identified options that would give TVA greater flexibility. These include the purchase of competitively priced power from other suppliers (e.g., independent power producers, cogenerators), options on future power delivery, and business partnering arrangements.

TVA characterized all of the supply-side options under consideration, describing their performance, cost, and relevant environmental emissions.

This Chapter Includes:

- Defining Supply-Side Options
- Identifying Supply-Side Options
- Characterization of Supply-Side Options

Supply-Side Options

TVA's load forecasting indicates that its customers' future electricity needs will exceed its current generating capacity. Two broad resource alternatives—energy conservation or energy generation from additional sources—are available to TVA to meet this increased demand. The best solution will probably include elements from both alternatives.

This chapter defines and identifies the broad range of supply-side options that TVA considered in Energy Vision 2020 and explains how these options are characterized according to their performance, cost, and environmental factors.

Existing plants will continue to be the backbone of TVA's power supply in the future; however, a broader definition of supply-side options captures the diverse range of possibilities open to power suppliers—like TVA—today.

Defining Supply-Side Options

Historically, electric utilities have generated, transmitted, and distributed power. Resources that generate or transmit electricity are referred to as supply-side options.

Like most utilities, TVA has satisfied most of its customers' growing electricity demand by either adding new plants to its system or increasing the amount of electricity produced at existing facilities. New generating plants are not the only way to satisfy increased customer demand, but they remain an important option for the future.

Existing plants will continue to be the backbone of TVA's power supply in the future; however, a broader definition of supply-side options captures the diverse range of possibilities open to power suppliers—like TVA—today. A more workable definition of "supply-side option" is "the actions a power supplier can take to increase the amount and reliability of power available for its customers." With this broader definition, options now include power purchased from other producers, power produced by joint ventures, and transmission system improvements. More options add opportunities for TVA to increase the value of power provided to its customers.

MEETING NEEDS FOR POWER

Demand for electricity changes constantly, which increases the need for different generating technologies. The four types of power generators are:

- **Peaking units** can respond quickly to changes in power demand, but normally operate only when demand for power is very high and not for extended periods. A gas-fired combustion turbine is an example of a peaking unit.

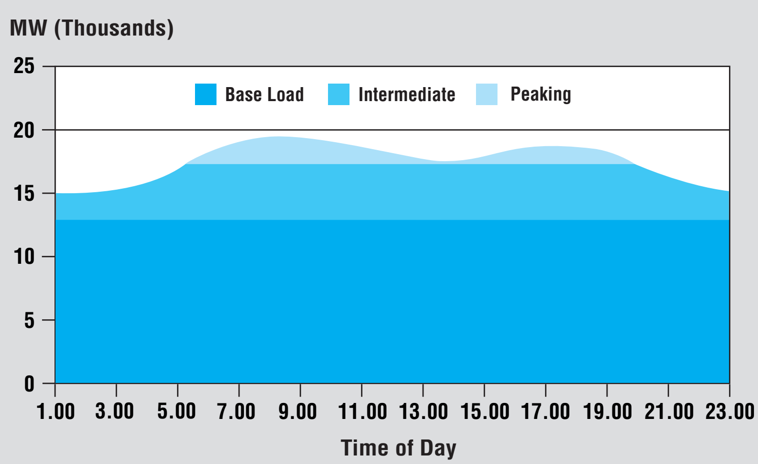
- **Intermediate units** operate to meet the next highest level of power demand. They have some of the same characteristics of peaking units; they must start and stop often and generate a wide range of power outputs. A gas-fired, combined cycle plant is an example of an intermediate unit.
- **Base-load units** meet a largely constant level of power demand and tend to be cycled on and off far less frequently than peaking or intermediate units. A nuclear power plant is an example of a base-load unit.
- **Storage units** usually serve the same power supply function as peaking units, but use low-cost off-peak electricity to store energy for generation later at peak times. An example of a storage unit is a hydro pumped-storage plant that pumps water to a reservoir during periods of low demand and releases it to generate electricity during periods of need. Consequently, a storage unit is both a power supply source and an electricity user.

Figure 7-1 illustrates the use of peaking, intermediate, and base-load generators. Although these categories are useful, the distinction between them is fuzzy. For example, a peaking unit may be called on to run continuously for some time period like a base-load unit, although it is less economical to do so. Similarly, many base-load units are capable of operating at different power levels, giving them some of the characteristics of an intermediate or peaking unit. Energy Vision 2020 considers strategies that take advantage of this range of operations.

The differences among the types of power generation can be characterized by their capital and operating costs. Peaking units generally have low capital costs and high operating costs. Base-load units usually have high capital costs and low operating costs. Costs for intermediate units tend to fall in the middle.

Figure 7-2 illustrates the costs for typical supply-side options as a function of capacity factor. As the figure shows, all options become less expensive the more they are operated. At low capacity factors, peaking units have lower costs than base-load units due to the peaking units' low capital costs. At higher capacity factors, base-load units have lower costs due to their lower operating costs.

FIGURE 7-1. **Representative Winter Day Load Profile**



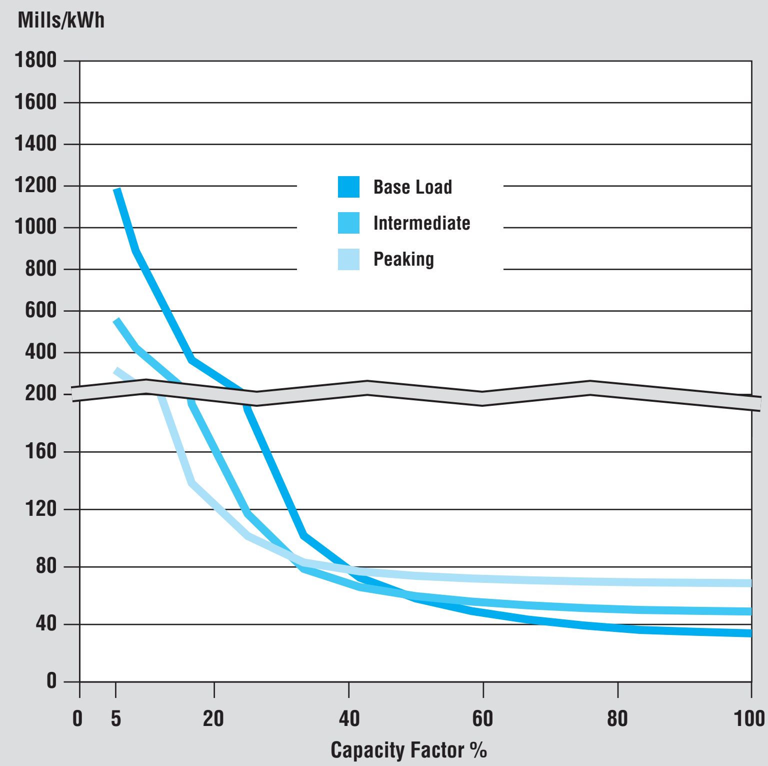
Different types of power generators are needed to meet variations in TVA's load demand.

CENTRALIZED AND DECENTRALIZED GENERATION

Most older generating plants are located in large power supply centers, or central stations, providing between several hundred and several thousand megawatts of capacity. Many available generating technologies are best suited for this type of application.

Other technologies offer the chance to locate the generation facility closer to the end user, a concept referred to as "distributed generation." Both central station and distributed generation technologies are included in the group of supply-side options considered in Energy Vision 2020. For Energy Vision 2020, however, TVA has included additional distributed generation technologies with low power levels (less than 20 megawatts) in the customer service options discussed in Chapter 8. These technologies tend to be closely tailored to customer needs, even though they satisfy the definition of a supply-side option.

FIGURE 7-2. **Cost of Producing Electricity as a Function of Capacity Factor**



While all options become less expensive when operated more, the "least cost" option changes. This characteristic, driven by the relationship between fixed and variable costs, defines whether an option is viewed as peaking, intermediate, or base load. (Capacity factor is the ratio of the actual energy output for a power plant over a certain period of time—typically one year—to the maximum achievable output over the same period of time.)

Identifying Supply-Side Options

TRADITIONAL SUPPLY-SIDE OPTIONS

Some supply-side options are traditional power supply technologies, such as the pulverized coal and natural gas-fired combustion turbine options. Other options involve projects that are unique to TVA. These include completing or converting the Bellefonte Nuclear Plant and increasing the capacity of the Raccoon Mountain pumped-storage facility. Still other options reflect ongoing research and development into new technologies including solar power, wind power, fuel cells, and some of the more advanced combustion technologies.

In developing its supply-side options, TVA faced the challenge of investigating a broad spectrum of options while keeping the total to a manageable number for Energy Vision 2020.

With four nuclear units in various stages of construction, the nuclear completion, conversion, and cancellation options were all included since near-term decisions regarding these projects are needed. (More information on these options can be found in Volume 2, Technical Document 8, Resource Integration.)

Traditional options were included because a number of these technologies are still viable—other utilities are still constructing plants using these technologies today.

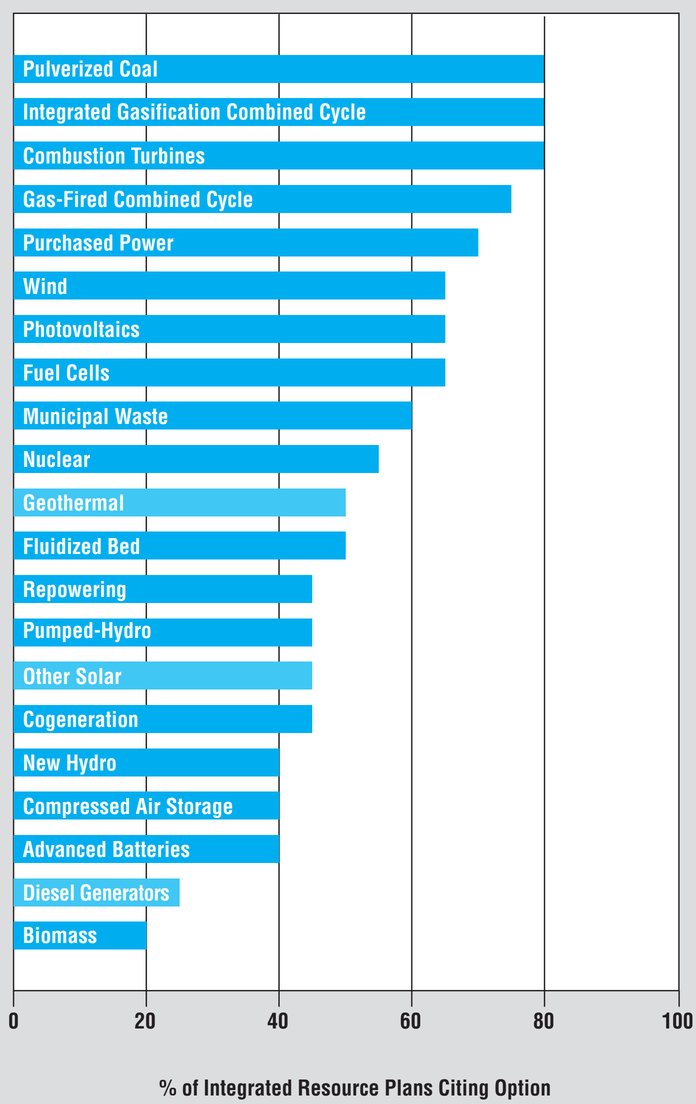
Even within the category of more traditional options, many variations are possible. Plant reliability (availability) can be increased, but usually at additional cost.

Similarly, environmental impacts can be limited to predetermined levels by using different fuels or by adding or altering environmental control equipment. The supply-side options included in Energy Vision 2020 generally include only representative projects for each technology.

TVA reviewed 20 other utility integrated resource plans to verify that its list of options was comprehensive. The treatment of supply-side options differed considerably in the plans examined, ranging from detailed option descriptions in some cases to a listing of only the most promising options in others. No clear, standard set of options emerged from this review. Nevertheless, a comparison of TVA's option list with other lists confirmed that TVA's list is comprehensive.

As shown in *Figure 7-3*, with the exception of geothermal options, large solar collectors and diesel generators, the TVA list is comparable to those in other utilities' integrated resource plans. With regard to the exceptions, TVA has not identified sufficient geothermal resources in the region to support geothermal energy options; large solar collectors are not economical compared with other solar options (i.e., photovoltaics); and diesel generators have been analyzed with customer service options.

FIGURE 7-3. **Comparison with Options Cited in 20 Other Integrated Resource Plans**



The TVA supply-side options list is comparable to those in other integrated resource plans with the exception of geothermal options, large solar collectors, and diesel generators.

RENEWABLES

Several renewable resource options are included as supply-side options. These include several biomass technologies, wind turbines, photovoltaics, landfill and coalbed methane recovery, and technologies that burn garbage as a fuel. Many of these technologies have characteristics that are beneficial compared to some of the other supply-side technologies. These characteristics include small modular size, the possibility of dispersed locations, and low environmental emission rates.

POWER FROM OTHER SUPPLIERS

The purchase of power from cogenerators and independent power producers has become a common practice in the utility industry. Contracts for outside power usually are procured through a bidding process after a utility has defined its needs (in terms of capacity type, amount of energy, and dates when power is needed). Proposals from a TVA bidding process (explained below) and certain unsolicited proposals were reviewed in Energy Vision 2020. Over the years, TVA has received a number of unsolicited proposals for power supply. TVA used these proposals as the basis for defining representative cogeneration and independent power producer projects for the supply-side options list.

OPTION PURCHASE AGREEMENTS

In July 1994, TVA issued a request for proposals for option purchase agreements. Option purchase agreements provide a means for TVA to secure reliable, competitively priced power. These agreements offer flexibility and could enhance TVA's ability to conduct business effectively in a competitive environment.

TVA asked potential suppliers to propose flexible contracts to supply peaking, intermediate, and base-load power. TVA indicated that it was interested in securing up to 2,000 megawatts of peaking capacity for the period from 1997 to 2006 and up to 2,000 megawatts of base-load capacity for the period from 2000 to 2006.

TVA solicited two kinds of option purchase agreements: a call option and a put option. With a call option, TVA pays the seller a price (premium) that gives TVA the right, but not the obligation, to purchase power from the seller at a given price at some specified time in the future.

A put option is the reverse. The seller of the power pays TVA a premium for the right, but not the obligation, to sell power to TVA at a given price at some specified time in the future. In this case, if the owner of the put option chooses to sell the power, TVA is obligated to buy it. Therefore, the put option increases the uncertainty that TVA must consider in planning future supply capacity, but TVA receives an upfront payment as compensation.

In its request for proposals, TVA explained that it would accept proposals from other electric systems, marketers and brokers, demand-side management projects, and developers. Any company could bid, thus opening the process to a variety of services.

In addition to proposals for call and put options, TVA also accepted proposals for forward contracts. A forward contract is not an option purchase agreement. It is simply a firm contract for TVA to buy power from a seller at a specified price at a future date.

TVA received 138 proposals from the request for proposals. These represent 9,800 megawatts of peaking capacity and 12,200 megawatts of base-load capacity.

Proposals received by TVA have been evaluated on the basis of their price, flexibility, and transmission capabilities, as well as their financial, technological, environmental, and economic development attributes. From the results of these evaluations, the proposals were ranked, and TVA developed a "short list" of the best candidates. TVA will negotiate the price, amount of capacity, and premiums with these candidates.

A full description of the option selection process can be found in the document "Request for Proposal for Option Purchase Agreements," dated July 8, 1994, and a supplement, dated September 22, 1994.

FIGURE 7-4. **Typical Project Implementation Schedule**

Project Phase	Typical Duration
Site Selection, Environmental Studies, & Permitting	2 years
Contracting, Engineering, & Procurement	2 years
Construction & Startup	3 years
Total	7 years

The typical implementation schedule for an option involves three phases.

FLEXIBLE SUPPLY-SIDE OPTIONS

While Energy Vision 2020 outlines the amount and time frame of TVA's need for power, each supply-side option has its own lead time (time required for its implementation). Typically, the implementation of an option involves three phases. During the first phase, the preferred site for the option is identified (and possibly secured), environmental studies are performed, and environmental permits are obtained. During the second phase, engineering analysis and design are completed, and contracts for construction are placed. During the final phase, the plant is constructed and begins operation. While some overlap is reasonable, these phases generally are viewed as sequential activities. *Figure 7-4* provides a typical project implementation schedule, which is applicable to a number of options.

Overall project schedules can be shortened by selecting sites and performing environmental studies prior to making the decision to commit to the project. Although the usefulness of such studies can be limited, they usually remain valid for at least 5-10 years. In Energy Vision 2020, TVA considered the desirability of identifying sites and performing environmental studies for some options in order to shorten their lead times. This provided additional flexibility for some of the options.

POWER FROM OTHER UTILITIES

TVA also can buy power from other utilities. For the next few years, some utilities in the region are expected to have excess generating capacity. This excess capacity is expected to be depleted by the early 2000s. After that, power purchases from other utilities will still be possible, but prices will likely reflect the cost of adding new capacity.

TECHNOLOGIES NOT CURRENTLY COMMERCIALLY AVAILABLE

Identifying new technologies presented a challenge. Ongoing research and development are continuing to produce new technologies as well as significant improvements in existing applications. No one can predict the full range of options that will become available over the next 25 years.

Research and development efforts are underway for many potentially attractive new technologies, ranging from ideas on the drawing board to prototype technologies that have been tested but are not yet commercially available. It was neither feasible nor necessary to include every conceivable new technology in Energy Vision 2020. To be considered an option in Energy Vision 2020, a new technology had to be sufficiently well developed that its date of commercial availability, cost, and performance could be credibly estimated.

TVA identified these options through public comments, its own research and development, and utility industry research provided by the Electric Power Research Institute.

Forecasting cost and performance characteristics for a new technology includes many uncertainties. Nevertheless, some important trends in technology development have been observed. Estimates of cost and performance can be overly optimistic until prototypes have been tested and their detailed designs completed. Cost and reliability estimates improve as more units are built, although unforeseen problems may occur at any time.

Some promising new technologies are now being used outside the TVA region where climate and other conditions are favorable. This is true for wind turbines and solar photovoltaic cells. Since industry research and development are continuing to improve both the cost and performance of these options, they are included as supply-side options in Energy Vision 2020.

The costs for each supply-side option in Energy Vision 2020 include two ranges of uncertainty: one for the developmental status of the technology and another reflecting the accuracy of the cost estimate. Appropriately, both ranges are wide for technologies in early stages of development, allowing for either innovative breakthroughs or future problems. Both ranges narrow as development proceeds toward a standard commercial product, and costs become less uncertain.

NON-TRADITIONAL BUSINESSES AND BUSINESS ARRANGEMENTS

Conventional power plants owned and operated by utilities are not necessarily the ideal solution for obtaining additional capacity in the TVA region. By the same token, conventional power purchase agreements may also not be ideal. The changing competitive environment in the utility industry provides several new alternatives to consider.

Conventional power supply options typically use one of two approaches. A utility or independent power producer primarily generates power as a business and may make some minor side products. Alternately, a cogenerator may use a manufacturing process that generates small quantities of power as a byproduct. As technology advances, opportunities for more closely aligning manufacturing or chemical processes with power production appear increasingly attractive. TVA is exploring such arrangements, which are referred to as coproduction. At this time, the best opportunities for such an arrangement are associated with coal gasification technologies.

Finally, conventional utility projects have relied on utility ownership and financing. Although financing by a single entity remains feasible, partnership arrangements may also be beneficial. TVA is considering two partnership options for the Bellefonte Nuclear Plant—either complete it as a nuclear plant or convert it to a coal gasification plant. For the nuclear completion partnership option, TVA would invest no capital beyond that which it has already invested. For the coal gasification partnership option, additional capital may be required for equipment.

Other partnership opportunities may also be beneficial, particularly as a means of minimizing TVA's debt.

The rapid changes occurring in the utility industry will continue to challenge planners to look beyond conventional options for supplying power in a cost-effective, environmentally responsible way. In some cases, these opportunities may take the form of different business arrangements for implementing technologies that are already included in the supply-side option list (for example, a Bellefonte partnership). In others, new technologies or combinations of existing technologies may arise.

BELLEFONTE CONVERSION

One of the options being considered in Energy Vision 2020 is the conversion of the Bellefonte Nuclear Plant to an integrated gasification combined cycle plant that generates power and makes chemical products. Doing this as a partnership arrangement is also being considered.

The concept for the integrated gasification combined cycle with coproduction and partners is the same as for a conventional integrated gasification combined cycle, with the addition of chemical coproduction capability. Some of the syngas is diverted from the combustion turbines for use as a feedstock in a chemical process plant. The studies to date have indicated that methanol and some of its derivatives represent the most feasible coproduction alternatives. Under one scenario, the ultimate facility is assumed to consist of four 3,000 ton-per-day gasifiers providing syngas to fuel two combustion turbines plus the coproduction plant. The facility will be able to generate approximately 484 megawatts with the capability to produce 6,600 tons per day of methanol and associated products. It is also assumed that the gasification and coproduction plants are owned and operated by partners. TVA would own and operate the power block only. The chemical coproducts were assumed to be shipped to the Gulf Coast area by barge for sale to markets in that region.

The construction schedule for this concept is based upon a multi-phase installation. The integrated gasification combined cycle option described above is based on the successful demonstratoin of the use of integrated gasification combined cycle technology. An effort is under way to demonstrate at Bellefonte the feasibilty of integrated gasification combined cycle technology through the use of Department of Energy Clean Coal Technology funding. The demonstration facility will consist of one 3,000 ton-per-day gasifier and a combustion turbine combined cycle repowering of one of the Bellefonte nuclear units with a capacity of 400 megawatts. (The Department of Energy has tentatively approved resiting the Combustion Engineering Clean Coal II Springfield project to Bellefonte.) Approvals for construction of the demonstration plant are expected to be obtained by October 1997. Operation of the demonstration plant will occur in the latter part of 2000. Subsequent gasifiers could go into operation after a two-year demonstration period, as determined by economic considerations. Construction of the chemical coproduction facilities could proceed in parallel with the construction of these future gasifiers, as economically justified.

The concept is sufficiently flexible to allow several alternatives for the development of Bellefonte. TVA will be conducting an 18 to 24 month study to evaluate the various long-term conversion options. Meanwhile, the Department of Energy demonstration project will proceed on a schedule agreed to by both TVA and the Department of Energy. To meet this schedule, planning for the demonstration unit is under way.

Subsequent expansion could follow several different scenarios. The steam turbines at Bellefonte are sufficiently large to allow connection of several combustion turbine combined cycle units. For example, initial installations could consist of phased combined cycle units fueled by fuel oil or natural gas (if available) starting as peaking combustion turbines, then converted later to combined cycle operation. These units could then be updated to syngas operation by the construction of additional gasifiers as economics dictate.

TRANSMISSION OPTIONS

Consistent with a broader definition of supply-side options, TVA also considered the following two transmission system improvement options:

- A series of transmission system capital improvements would reduce transmission losses on the TVA system. Since TVA continually evaluates projects that reduce losses, those projects are not explicitly evaluated as a part of each strategy in Energy Vision 2020.
- The location of future generation in the western part of the power system can reduce losses and improve transfer capacity on transmission interfaces with other utilities. The loss reduction would be equivalent to about 45 megawatts per 1,000 megawatts of capacity and would mean a savings of $30 to $50 million.

ENVIRONMENTAL CONTROL OPTIONS

Compliance with the 1990 Clean Air Act Amendments' Phase II requirements for sulfur dioxide reduction is another consideration in Energy Vision 2020. Compliance is a dynamic activity that requires ongoing consideration of changes in fuel markets, sulfur dioxide allowance markets, cost of pollution control equipment, opportunities for power purchases, etc. Thus, defining a detailed strategy in Energy Vision 2020 is not feasible. However, TVA established a general approach to Phase II compliance from which appropriate strategies will emerge.

The capital and operating costs of sulfur dioxide emissions reduction options vary widely. Emissions control options include scrubbers and the use of low sulfur coal. Energy supply options include switching to an alternative fuel such as natural gas, converting a facility to a technology with lower emissions (i.e., repowering), or replacing coal-fired units with low emission generation capacity. Demand-side management or conservation options can also reduce sulfur dioxide emissions by reducing usage of existing facilities or avoiding the need for new capacity. Purchasing allowances from other regulated sources that exceed their emissions reduction requirements is also an option.

The costs of implementing any of these options depend on timing. For example, emissions reductions taken earlier than required or exceeding minimum requirements may be less expensive at one TVA source and delay the need for equivalent reductions at another source in the TVA system. The relative costs of

FIGURE 7-5. **Alternative Phase II Acid Rain Control Options**

Reference Case	Minimum Capital Borrowing	Repowering – Minimum Carbon Dioxide (CO_2) Impact
Wet flue gas desulfurization (scrub) at Paradise Unit 3 in 2002 and add coal reburn in 2000	Switch Paradise Unit 3 to 100% powder river basin coal in 2006	No scrubbers at Paradise Unit 3
Wet flue gas desulfurization at Allen Units 1-3 in 2004 and add coal reburn in 2000	Switch Allen Units 1-3 to 100% natural gas in 2000; no coal or gas reburn	Repower Allen and Johnsonville Units 1-10 with gas-fired combined cycle in 2004
Switch to eastern low sulfur coal at selected plants	Switch to medium and low sulfur coal at selected plants	Switch to low sulfur coal at selected plants
Build up allowance bank in Phase I; buy and sell allowances in Phase II	Sell excess allowances in Phase I; buy and sell allowances in Phase II	Build up allowance bank in Phase I; buy and sell allowances in Phase II

Energy Vision 2020 considers 3 alternatives to comply with the Clean Air Act: (1) a Reference Case, (2) Minimum Capital Borrowing, and (3) Repowering—Minimum Carbon Dioxide (CO_2) Impact.

achieving emissions reductions from TVA sources will depend on future environmental regulations, future costs of alternative fuels, and the development of new emissions control technologies.

Typical Phase II environmental control options can be formulated to address TVA's Energy Vision 2020 criteria. For example, a control option to minimize impacts on rates would include sulfur dioxide scrubbers, while a control option to minimize debt would minimize capital expenses and use extensive fuel switching. Other examples include control options that not only reduce sulfur dioxide emissions, but also minimize carbon dioxide emissions and maximize the use of new technologies for emissions controls and repowering.

The precise operational details of a control option must be worked out in response to future events (e.g., new regulations, generation demands). Prior to deploying specific pollution control projects, further environmental reviews would be conducted. *Figure 7-5* shows Phase II acid rain control options that are being considered in Energy Vision 2020.

In Energy Vision 2020, additional carbon dioxide mitigation was represented through options for cofiring biomass fuel at TVA's existing coal-fired plants. For the first option, it was assumed that the overall amount of biomass fuel would be 0.3 percent and in the second option, 1.3 percent.

Many of the options considered in Energy Vision 2020, such as repowering and demand-side management, could also help TVA comply with the Clean Air Act.

Characterization of Supply-Side Options

All of the supply-side options that TVA identified for consideration in Energy Vision 2020 were characterized using data describing their performance (e.g., capacity, heat rate), cost (e.g., capital cost, operation and maintenance

FIGURE 7-6A. **Conventional Supply-Side Options—Performance Characteristics**

Option Name	Status	Duty Cycle	Net Full Load Capacity (MW)	Net Full Load Heat Rate (Btu/kWh)	Fuel	Total Schedule (Yr)	Coproducts
Supercritical Pulverized Coal Plant (4x300 MW)	Mature Commercial	Base Load	1,200	9,522	High Sulfur Coal	8	None
Simple Cycle Combustion Turbine (1x150 MW)	Mature Commercial	Peaking	150	10,500	Natural Gas	5	None
Natural Gas-Fired Combined Cycle (1x470 MW)	Mature Commercial	Intermediate	470	7,000	Natural Gas	5	None
Compressed Air Energy Storage with Humidification (3x337 MW)	Initial Commercial	Peaking	1,011	5,874	Natural Gas	7	None
Integrated Gasification Combined Cycle (IGCC) (3x245 MW)	Initial Commercial	Base Load	740	7,230	High Sulfur Coal	8	Sulfur
Integrated Gasification Cascaded Humidified Advanced Turbine (G Series CT) (2x420 MW)	Large Scale Demo	Base Load	840	8,200	High Sulfur Coal	8	None
Landfill Methane (1x2 MW)	Pilot Scale	Intermediate	2	6,450	Landfill Gas (Methane)	3	Waste Heat, Steam
Hydro Generation: Modernization at Existing Projects	Mature Commercial	Peaking	3,864	NA	NA	11	None
Bellefonte (BLN) Repowering – IGCC with Coproduction with Partners (2x242 MW)	Initial Commercial	Base Load	484	7,200	Syngas	8	Multiproducts
Generic Natural Gas Combined Cycle Independent Power Producer (1x150 MW)	Mature Commercial	Intermediate	150	7,500	Natural Gas	5	None
Wind - 39 Meter Variable Speed Advanced Wind Turbine (444x0.45 MW)	Pilot Scale	Intermediate	200	NA	Wind	6	None
Power Purchase - Peaking	Mature Commercial	Peaking	300	12,000	NA	0	None

Figures 7-6A-E. Supply-Side Options – Conventional, Flexible, and Option Purchase Agreements. These figures show performance (7-6A), cost (7-6B), and environmental characteristics (7-6C) for some of the supply-side options. The flexible options (7-6D) are different than the conventional options in their schedules and costs (all other characteristics remain the same). By doing some work upfront, such as site identification and permitting, before a final decision is made to put an option in place, the total schedule can be significantly reduced. The accelerated schedule, the upfront cost to complete this preliminary work, and the remaining cost to complete the option are shown for the flexible options.

cost, fuel cost), and environmental emissions (e.g., air, water, solids).

Selected conventional supply-side options, characterized by performance, cost, and environmental emissions, are shown in *Figures 7-6A*, *7-6B*, and *7-6C*. Flexible TVA-built options are shown in *Figure 7-6D*, and option purchase agreements are shown in *Figure 7-6E*. These supply-side options are shown because they are included in the final set of strategies evaluated in Energy Vision 2020.

A complete list of the supply-side options identified for consideration in Energy Vision 2020 and their characteristics can be found in Volume 2,

FIGURE 7-6B. Conventional Supply-Side Options—Cost Characteristics

Option Name	Base Capital ($/kW)	Fuel Cost ($/MMBtu)	Base Fixed Operating &Maintenance ($/kW-Yr)	Base Variable Operating &Maintenance (Mills/kWh)	Base Fixed Additions &Improvements ($/kW-Yr)
Supercritical Pulverized Coal Plant (4x300 MW)	$1,345	$1.00	$20.0	1.3	$13.6
Simple Cycle Combustion Turbine (1x150 MW)	$360	$2.48	$2.0	2.6	$0.0
Natural Gas-Fired Combined Cycle (1x470 MW)	$655	$2.48	$4.7	1.25	$4.5
Compressed Air Energy Storage with Humidification (3x337 MW)	$315	$2.48	$2.2	2.5	$0.0
Integrated Gasification Combined Cycle (IGCC) (3x245 MW)	$1,524	$1.00	$20.8	1.2	$12.0
Integrated Gasification Cascaded Humidified Advanced Turbine (G Series CT) (2x420 MW)	$1,126	$2.48	$18.6	0.9	$13.2
Landfill Methane (1x2 MW)	$1,034	$1.29	$9.8	1.7	$40.0
Hydro Generation: Modernization at Existing Projects	$52	NA	$6.9	0.0	$10.8
Bellefonte (BLN) Repowering - IGCC with Coproduction with Partners (2x242 MW)	$465	$3.59	$4.7	1.3	$4.5
Generic Natural Gas Combined Cycle Independent Power Producer (1x150 MW)	$0	$2.48	$86.7	17.16	$0.0
Wind - 39 Meter Variable Speed Advanced Wind Turbine (444x0.45 MW)	$958	NA	$15.0	0.0	$0.0
Power Purchase - Peaking	$0	NA	$33.6	31.8	$0.0

Fuel cost data are in 1995 dollars. Other cost data are in 1994 dollars.

FIGURE 7-6C. Conventional Supply-Side Options—Environmental and Other Characteristics

Option Name	Sulfur Dioxide (lb/MMBtu)	Nitrogen Oxides (lb/MMBtu)	Carbon Dioxide (lb/MMBtu)	Thermal Discharge (MMBtu/MWh)	Solid Waste (lb/MMBtu)	Economic Development (Annual Average Employment)
Supercritical Pulverized Coal Plant (4x300 MW)	0.3	0.1	210	0	24.0	918
Simple Cycle Combustion Turbine (1x150 MW)	0	0.08	115	0	0	20
Natural Gas-Fired Combined Cycle (1x470 MW)	0	0.08	115	0	0	128
Compressed Air Energy Storage with Humidification (3x337 MW)	0	0.03	115	0	0	130
Integrated Gasification Combined Cycle (IGCC) (3x245 MW)	0.05	0.035	205	0	9.5	610
Integrated Gasification Cascaded Humidified Advanced Turbine (G Series CT) (2x420 MW)	0.05	0.01	205	0	9.5	569
Landfill Methane (1x2 MW)	0	0.16	-798	0	0	1
Hydro Generation: Modernization at Existing Projects	0	0	0	0	0	619
Bellefonte (BLN) Repowering - IGCC with Coproduction with Partners (2x242 MW)	0.03	0.08	131	0	9.5	108
Generic Natural Gas Combined Cycle Independent Power Producer (1x150 MW)	0	0.08	115	0	0	15
Wind - 39 Meter Variable Speed Advanced Wind Turbine (444x0.45 MW)	0	0	0	0	0	108
Power Purchase – Peaking	0	0.1	115	0	0	0

FIGURE 7-6D. **Flexible TVA Supply-Side Options**

Option Name	Original Schedule (Yr)	Accelerated Schedule (Yr)	Cost to Obtain Accelerated Schedule ($/kW)	Cost Remaining ($/kW)
Simple Cycle Combustion Turbine (1x150 MW)	5	1.5	$22	$338
Natural Gas-Fired Combined Cycle (1x470 MW)	5	2	$14	$641
Integrated Gasification Combined Cycle (IGCC) (3x245 MW)	8	3.5	$18	$1,506
Integrated Gasification Cascaded Humidified Advanced Turbine (G Series CT) (2x420 MW)	8	3.5	$15	$1,111
Landfill Methane (1x2 MW)	3	1.5	$205	$829
Bellefonte Repowering – IGCC with Coproduction with Partners (2x242 MW)	8	3.5	$20	$445

The schedule for the landfill methane option is constrained by the commercialization of the fuel cell technology upon which it is based. Thus, an accelerated schedule would not reduce the timing of the initial availability of the option.

FIGURE 7-6E. **Option Purchase Agreements**

Option Type	Schedule (Yr)	Availability	Option Price ($/MW-Yr)	First Year Charges ($/MWh)
Base Load - Call	3	85 – 100%	100 – 65,000	$24 – 52
Peaking - Call	2	95 – 100%	150 – 1,346	$40 – 250

Technical Document 6, Supply-Side Options. A brief description of each option, identifying the primary source of data for characteristics of the option, is also found in Volume 2, Technical Document 6, Supply-Side Options.

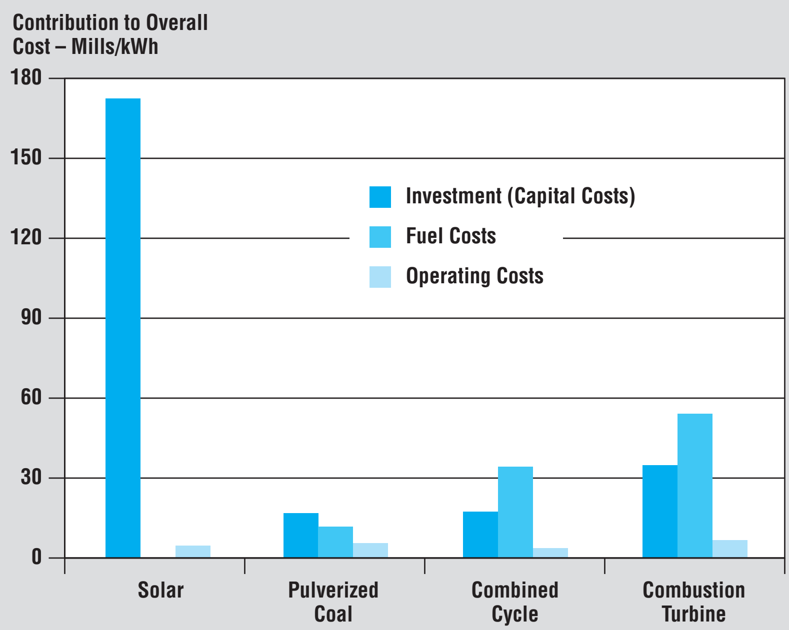
In developing Energy Vision 2020, TVA considered whether to use a single source or multiple sources of data to characterize the options. A single source provides better data consistency across options; however, multiple sources provide the advantage of a broader range of data and more recent data. TVA elected to use multiple sources, recognizing that this approach could introduce some differences in how costs are allocated in different categories and how critical factors such as contingencies are treated. In many cases, Electric Power Research Institute's Technical Assessment Guide was used as a source. This guide provides the most comprehensive assessment of supply-side options available. In other cases, option descriptions reflect information from proposals or other specific studies available only to TVA.

COST, PERFORMANCE, AND ENVIRONMENTAL CHARACTERISTICS

A review of *Figure 7-6* reveals the broad range of performance attributes, cost factors, and environmental emissions associated with the supply-side options. Comparing options across this full range is a daunting task, but some general guidelines can help.

Figure 7-7 shows the sensitivity of overall cost to various cost factors for four typical supply-side options. As shown in *Figure 7-7*, the magnitude of different cost factors varies considerably among different options; however, for most options either capital costs or fuel costs (or both) dominate.

FIGURE 7-7. **Cost Factor Sensitivities**



The relative magnitude of the contributing cost factors varies considerably among different options based on expected operating capacity factors.

While the cost of power is an important consideration for the selection of supply-side options in Energy Vision 2020, other factors are also significant. Environmental emissions differ dramatically depending on fuel type and technology. Each option also requires different capital investments, which will affect TVA's overall debt. TVA considers these effects within the framework of Energy Vision 2020. In general, the broad range of supply-side options support strategies that perform well from the perspectives of cost, environmental factors, rates, and debt.

SITING CONSIDERATIONS

Supply-side option costs and benefits are site-specific. Since Energy Vision 2020 is programmatic in nature, site-specific decisions will be made later. Therefore, for many supply-side options, TVA evaluated generic locations. Where specific conditions are necessary to conduct the review, such as for estimating transmission costs and effects, TVA considered a location at milepost 160 on the Tennessee River, which is in the western part of the TVA system.

Some options can only be implemented at a single location (for example, the completion of Bellefonte Nuclear Plant or its conversion to use of another fuel). For these options, the actual location was considered in estimating the effects on the transmission system and determining likely fuel costs.