



Wind Energy Costs

Recent developments in wind energy technology have reduced costs to competitive levels.

Cost has been a major obstacle that traditionally has challenged renewable energy technologies such as wind energy. In the 1980s, conventional energy producers could discount wind energy on the basis of economics -- it was simply too expensive. Recent developments, however, have reduced the cost of wind energy to competitive levels and led to increased use of the technology.

Costs of a wind energy project can be calculated using three measures. The first measure -- installed capital cost -- accounts for installation of a complete wind system that is ready to generate and deliver electricity. The second measure -- specific capital cost -- includes installed capital costs and the costs needed to operate the system to produce a kilowatt-hour over a one-year time period. The final measure incorporates the first two costs, and adds cost estimates for operation and maintenance over the lifetime of the facility and capital costs. This third measure describes the total cost of energy.

Turbines used at a wind plant vary in physical dimension and installation patterns. The estimations used here describe the cost of wind energy systems with values appropriate to the most economical application, namely large-scale, grid-connected windfarms. A typical wind farm of this size has a generating capacity of 50 megawatts (MW).

Installed capital cost to prepare a wind system for operation includes all planning, equipment purchase, construction and installation costs.

Installed capital cost

The first measure, installed capital cost, includes all planning, equipment purchase, construction and installation costs required to prepare a wind-system for operation. Delivery and installation at the site are included in this cost, along with electrical maintenance and any supporting infrastructure. This includes costs of establishing the electrical power collection system that gathers electricity from each of the wind turbines and routes it to a substation. The electrical system costs may include the capital costs of the substation. If it does not, a lease or usage charge will be levied by the utility for use of the facility.

Buildings in support of operations and maintenance (OHM), inventory of spare parts, and maintenance and diagnostic equipment are included in the calculation of installed capital costs. Depending on the ownership and location of the wind farm, there also may be costs of negotiating land use agreements, power purchase contracts and transmission access agreements.

Specific capital cost

The specific capital cost combines the installed cost with the site's wind characteristics and the potential to efficiently capture wind power. *Wind speed distribution* is a measure of hours per year that the wind lies within certain speed intervals. The *wind turbine power curve* measures the turbine's output as a function of wind speed. Together, these measures determine an estimate of annual energy production.

The specific capital cost, therefore, measures the installed costs and the annual energy production in order to calculate the cost of generating one kilowatt-hour per year. Specific capital cost does not include O&M costs over the life of the facility.

Life-cycle cost of energy

The third measure of wind energy cost is the life-cycle cost of energy (CoE). It incorporates all elements of cost, including, installed capital cost, cost of capital, O&M costs over the life of the installation, and the cost of major overhauls and subsystem replacements.

The installed capital cost over the 20 to 30-year physical lifetime of the wind plant determines the cost of capital.

The cost of capital is determined by spreading the installed capital cost over the 20- to 30-year physical lifetime of the wind plant. This measure is calculated using a typical long-term, fixed charge rate (FCR). The FCR is the percentage of the installed capital cost allocated to each year of operation and includes the cost of debt service.

The majority of O&M costs are incurred for maintenance, including unscheduled but statistically predictable routine maintenance of turbines, preventive maintenance, and major overhauls and subsystem replacement of turbines. Unscheduled maintenance visits account for approximately 75 percent of the total maintenance costs, while preventive visits and major overhauls account for 20 percent and 5 percent, respectively.

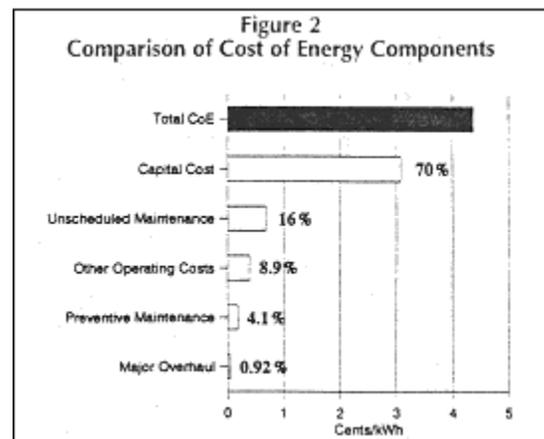
The OHM measure includes costs for maintenance staff, replacement parts and additional maintenance items. Other routine, annually-recurring operating costs include property and other taxes, land use payments, insurance, transmission access and wheeling fees, management fees and administrative costs. Operating costs typically are small in comparison to maintenance costs.

Because certain costs are incurred over several years and not routinely during each year, accounting practices require an annual accrual of funds. The accrual involves a net present value calculation to apportion infrequent overhaul and equipment replacement costs to an annualized basis consistent with other cost elements.

Total cost of energy

In summary, the total cost of energy drawn from turbines and windfarms is calculated in these components of capital cost, OHM costs and the levelized costs of overhaul and major subsystem replacement. Figure 1 compares cost components estimated for a 50 MW wind system.

These are the basic factors that influence the cost of a windfarm. The magnitude of these estimated values provide insight into the overall economics of wind power systems. Actual costs will vary depending on the size of the installation, the difficulty of construction, the sophistication of the equipment and supporting infrastructure, and the cost of capital.



This brief was summarized by Jeff Dale, National Conference of State Legislatures, from a *Wind Energy Series Report* by OEM Development Corporation.

The Wind Energy Issue Briefs are a product of the National Wind Coordinating Committee (NWCC). The NWCC is a collaborative endeavor that includes representatives from electric utilities and support organizations, state legislatures, state utility commissions, consumer advocacy offices, wind equipment suppliers and developers, green power marketers, environmental organizations, and state and federal agencies.

