

# Total Energy Cost per Kilowatt-Hour by Source of Power

There are too many analyses comparing generation sources of electricity. Each source claims to have the definitive answer on cost of power. Each analysis starts with many assumptions. Some assumptions are specified, and others are buried in the mathematical models used by the author. In many cases, the data sources used for each type of electricity generation type are from different years or may be based on just the first year or so of operation. Some analysis burry the cost or benefits of government taxes/fees or incentives that can include national, state, or regional items. For this analysis straight-line amortization of capital costs is used to provide equality and to avoid the complexity of various types of depreciation as well as factors such as tax deferrals and depletion allowances that benefit carbon-based energy.

To achieve an equitable analysis of the cost of generating electricity, all data should be equalized based on the production of 1 kilowatt-hour averaged over an extended period of time. To simplify calculations and minimize complexity, each type of energy source was analyzed over a period of 100 years and averaged. Nothing lasts for a full 100 years without some combination of operations & maintenance (O&M) and partial or total replacements. For further simplification, a total replacement is included at the end of the useful life of each generation type. In general, total replacement at the end of the prescribed useful life is also cost efficient to prevent ongoing repairs and maintenance from dominating costs.

A summary of the average cost of electricity generation over many years per kilowatt-hour by type is summarized in the table below.

## Comparison of Electric Power Generation Costs by Type

Based on average Kilowatt-Hour cost over extended periods  
(Values are for central electric power generation sources and exclude interest expense, taxes, and government incentives)

Energy Source	Amortization	Operations & Maintenance	Fuel	Total Cost per KwHr
Natural Gas	0.004500	0.019400	0.03842	0.062
Coal	0.013000	0.045400	0.02500	0.083
Wind	0.033000	0.057900	0	0.091
Solar PV	0.073800	0.078800	0	<b>0.153</b>
Nuclear	0.016900	0.022500	0.00490	0.044
Geothermal	0.011900	0.049200	0	0.061
Hydroelectric	0.007200	0.010300	0	<b>0.018</b>

### NOTES REGARDING THIS ANALYSIS:

- Detailed analysis, equations used, and starting data are noted in a paper on this website titled "Detailed Analysis of Energy Cost by Source".
- A listing of data sources used along with links to websites are noted in a paper on this website titled "Sources for Energy Data".
- A third paper lists the numerous sources of data used with web links to each source.
- Even government agencies have different internal departments that publish different data. When there were multiple sources with conflicting data, the most recent data source was used since nearly all generation types have shown improvements for efficiency that would be included in any new system installed in coming years.
- When two or more respected sources provide widely different values, several other sources were analyzed, and some form of consensus data was developed.
- Power generation systems that consume fuel uses the most recent fuel prices available for each fuel and attempt to adjust fuel prices based on the futures market. Many commercial power systems hedge fuel prices with futures contracts from the CME Group. <https://www.cmegroup.com>
- Useful life and "average up-time" (hours per year at output equivalent to nameplate power) have major impacts on overall energy costs.
- Location of each system is critical. Values used for this analysis are based on averages provided by the US Dept. of Energy. Due to the economics of commercial enterprises that provide energy, the majority of locations for each type of system tend to be in areas where performance is expected to be good. Geothermal generation achieves low cost in regions where very-high temperatures are close to the surface, such as near geysers. Geothermal generation incurs very-high cost in other areas due to high costs for drilling deep to high-temperature rock. Solar photovoltaic output for identical systems can vary more than 2 to 1 depending on average cloud cover and solar angle. <https://www.nrel.gov/>
- **As expected, hydroelectric generation achieves the lowest total cost of electricity by far and produces no health issues during its operation.** The relatively high cost of each large hydroelectric dam has a limited impact of average cost of energy.
  - The high cost of construction is ameliorated by the very-long useful life a dam such as Hoover Dam, and a negligible decline in output over time with suitable maintenance.
  - Unfortunately, there are few opportunities to increase hydroelectric production given the environmental impacts from building a new dam that floods a vast area for a reservoir.