Table F1. Conversion Efficiencies of Noncombustible Renewable Energy Sources
(Percent)

Source	Notional Efficiency[1]
Geothermal	16
Conventional Hydroelectric	90
Solar Photovoltaic	12
Solar Thermal Power	21
Wind	26

[1] Efficiencies may vary significantly for each technology based on site-specific technology and environmental factors. Factors shown represent engineering estimates for typical equipment under specific operational conditions.

Sources: **Geothermal:** Estimated by EIA on the basis of an informal survey of relevant plants. **Conventional Hydroelectric:** Based on published estimates for the efficiency of large-scale hydroelectric plants. See http://www.usbr.gov/power/edu/pamphlet.pdf. **Solar Photovoltaic:** Based on the average rated efficiency for a sample of commercially available modules. Rated efficiency is the conversion efficiency under standard test conditions, which represents a fixed, controlled operating point for the equipment; efficiency can vary with temperature and the strength of incident sunlight. Rated efficiencies are based on the direct current (DC) output of the module; since grid-tied applications require alternating current (AC) output, efficiencies are adjusted to account for a 20 percent reduction in output when converting from DC to AC. **Solar Thermal Power:** Estimated by dividing the rated maximum power available from the generator by the power available under standard solar conditions (1,000 W/m2) from the aperture area of solar collectors. **Wind:** Based on the average efficiency at rated wind speed for a sample of commercially available wind turbines. The rated wind speed is the minimum wind speed at which a turbine achieves its nameplate rated output under standard atmospheric conditions. Efficiency is calculated by dividing the nameplate rated power by the power available from the wind stream intercepted by the rotor disc at the rated wind speed.

Conclusion

After review of the three options, EIA has elected to follow a hybrid of the first two approaches for the AER 2010. The primary energy value of noncombustible renewables consumed for electricity generation will be measured using the fossil-fuel equivalent factor. However, this value will be reported as the sum of captured energy and an "Adjustment for Fossil Fuel Equivalence," which is the difference between the fossil-fuel equivalent value and the value obtained using the 3,412 Btu/kWh factor. This adjustment value represents the energy loss that would have been incurred if the electricity had been generated by fossil fuels. For solar and geothermal energy used directly, EIA will continue to use the factors currently employed.

This method will not cause a change to total primary energy consumption of hydro, solar, or wind energy, but it will allow users to easily distinguish actual economic energy consumption from the imputed displacement value, which is retained both to provide backward compatibility for data users accustomed to this measure and to allow for easier analysis of certain energy efficiency and production trends. The separate reporting of captured energy will also facilitate comparisons with international data sets.

For geothermal energy consumed to generate electricity, EIA will recalculate current and historical values using the fossil-fuel equivalent factor. This recalculation will change the following values presented in the AER 2010: the primary consumption of total energy (Tables 1.1 and 1.3); the consumption of geothermal for electricity generation (Tables 8.4a and b); and the consumption of renewable energy (Tables 10.1 and 10.2c).

New Representation of Delivered Total Energy and Energy Losses

The examination of heat rates for noncombustible fuels led EIA to also consider alternative methods of accounting for final energy consumption and energy losses. Final energy consumption differs from primary energy consumption in that it represents the amount (in terms of Btu) of energy actually consumed, in its final form, by an end user. For example, primary energy consumption of coal includes all the heat content in the coal consumed, while final energy consumption will include only the heat content of any coal consumed in its original form and the heat content of any products transformed from coal, such as electricity generated from coal.

EIA analyzed energy transformation in the United States. In all transformation processes, some useful energy is lost in achieving the conversion from one energy form to another. The most significant losses, by far, occur when electricity is generated from primary energy resources. Figure F1 illustrates an alternate method of accounting for energy consumption, based on the concept of delivered total energy.

In the AER 2010, as in previous AERs, the electric power sector is viewed as an energy-consuming sector. For each of the end-use sectors – residential, commercial, industrial, and transportation – total energy consumption is made up of the primary energy source consumed plus electricity retail sales and electrical system energy losses. Electrical system energy losses include transformation losses, the adjustment for fossil fuel equivalence (as discussed above), power plant use of electricity, transmission and distribution losses, and unaccounted for electricity. They are allocated to the end-use demand sectors in proportion to each sector's share of total electricity sales.