All real-world processes are imperfect (Section 3.2) and waste some energy (Table 2.2), and the overall energy utilization efficiency can be quite low. Figure 2.1 illustrates one of the most common energy lifecycles—transformation of the chemical energy of a mineral fuel to visible light using an incandescent electric bulb. There are different ideas on where to draw the boundaries for lifecycle analysis (Allenby, 1999). One approach includes activities well upstream and downstream of the primary energy generation source. In the light bulb example, the analysis would account for the energy and environmental impacts of manufacturing and ultimately disposing of the (spent) light bulb, of building the electric power station, of mining and delivering the coal, and of disposing of the ash and other wastes from the generation plant. A lifecycle view resonates with our core proposition that energy provides useful products or services, but typically does so with environmental penalties that may or may not be known contemporaneously.

![Diagram](image)

\[
\text{Overall Efficiency for Converting Chemical Energy To Light Energy} = E_1 \times E_2 \times E_3 = 0.35 \times 0.90 \times 0.05 = 0.016
\]

Figure 2.1. Multiple steps and associated efficiencies in converting the chemical energy of a fuel to energy as visible light for illumination.

To identify the substantive tradeoffs among sustainable energy options, we need an understanding of current and prospective consequences for the earth and its inhabitants of each option under consideration. However, the larger the boundaries of the lifecycle, the more difficult it becomes to define precise information requirements and to obtain putatively responsive data. Thus, flexibility should guide the selection of spatial and temporal boundaries for lifecycle analyses aimed at informing sustainability decision-making.

Rational compartmentalization of energy systems into manageable size lifecycles allows for informative "cradle-to-grave" analyses without the need to wait on further advances in information technology or additional data. Thus, for the light bulb of Figure