ESTIMATING USE PHASE ENERGY AND EMISSIONS

A Tutorial from the U.S. Department of Energy (DOE)

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Estimating Use Phase Energy and Emissions

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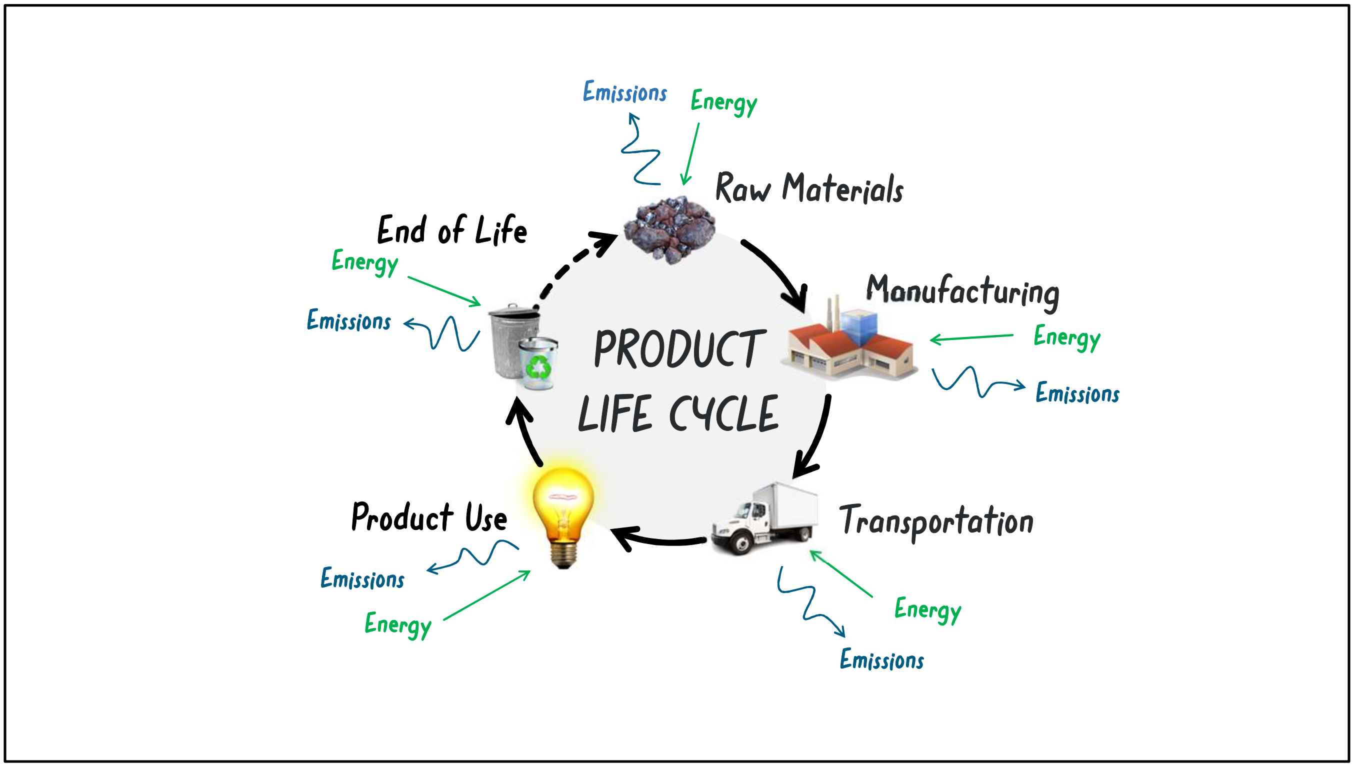
Welcome to DOE’s video tutorial series on cost and environmental impact analysis. I’m Heather.

In this module, we will:

- Describe techniques for estimating the energy and emissions associated with the use phase of a manufactured product;
- Discuss analytical boundaries for a use phase assessment; and
- Discuss methods for scaling use phase impacts for an individual product to overall impacts for the United States.

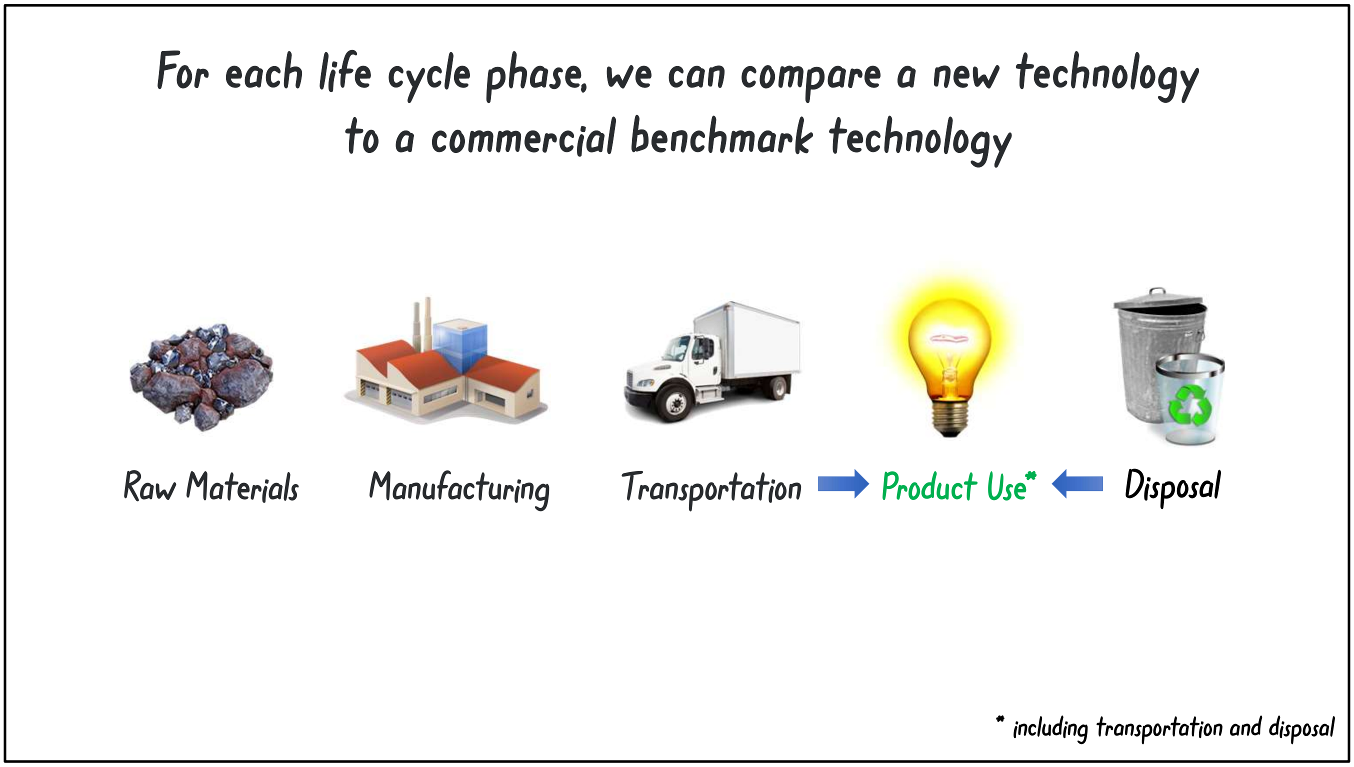


Every manufactured product has a life cycle, beginning with the extraction of raw materials from Earth's resources, continuing through product manufacturing, transportation, and use of the product, and ending with final disposal or recycling at the end of its useful life.

Energy and emissions impacts can be incurred throughout the product life cycle.

For each life cycle phase, we can compare a new technology to a commercial benchmark technology

For each life cycle phase, we can compare a new technology to a commercial benchmark technology to identify and quantify changes that would result from adoption of the new technology and replacement of the existing technology.



In this video, we'll focus on the use phase. In our modified definition of the use phase, we'll also include transportation and end-of-life.

First Step: Is the use phase a significant driver of energy or emissions impacts for the technology or product we are assessing?

As a first step, we'll want to ask ourselves whether the use phase is a significant driver of energy or emissions impacts for the technology or product we are assessing. If not, we can restrict our study boundaries to focus on the cradle to gate.

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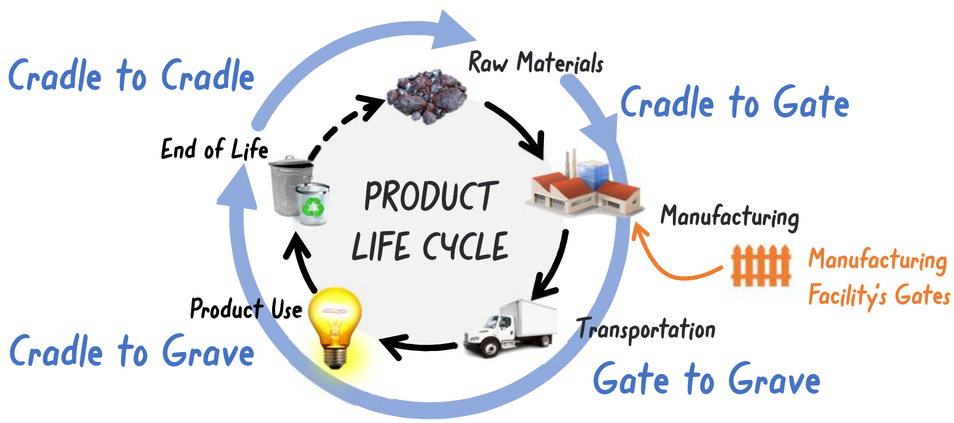
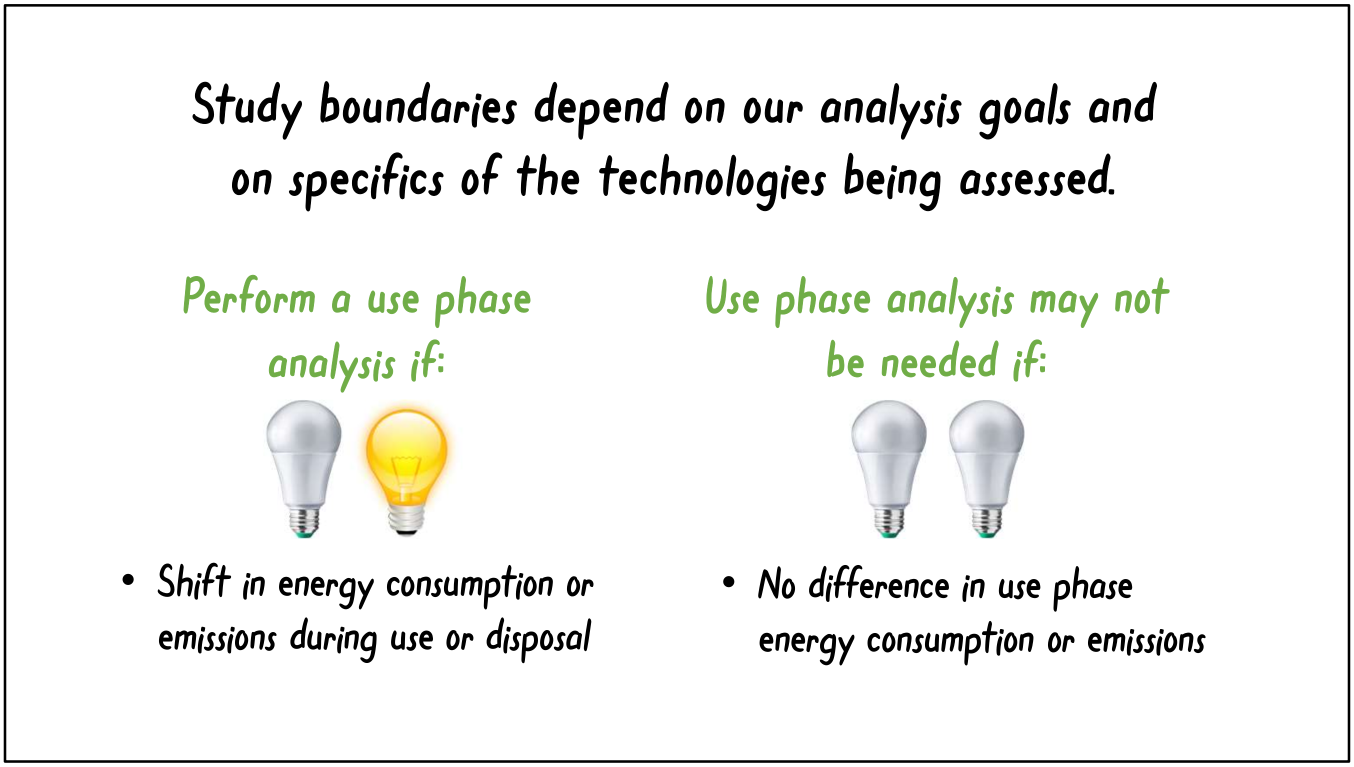


An assessment that begins with raw materials extraction and ends with a manufactured product is called a “cradle to gate” analysis because it ends with the departure of the finished product through the manufacturing facility’s gates.

An assessment that begins with a finished product and follows it through its useful life and disposal is called a “gate to grave” analysis.

And finally, an assessment that accounts for the full range of impacts from raw materials extraction through end-of-life is called a “cradle to grave” study – or “cradle to cradle” if including impacts of materials recycling and reuse.

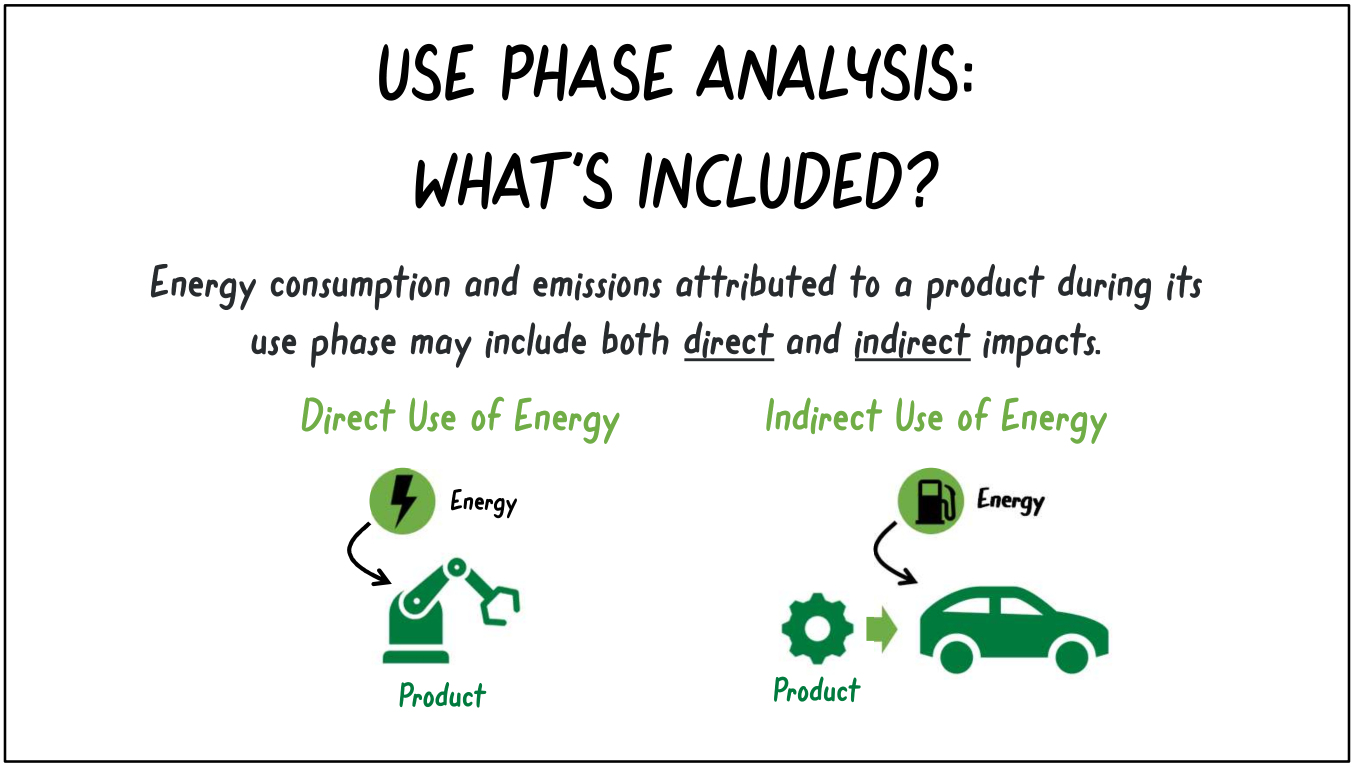


Study boundaries depend on our analysis goals and on specifics of the technologies being assessed. In a comparative assessment of two technologies, the decision about whether or not to include the use phase may depend on how similar the end products are for the new technology and for the commercial benchmark.

You should perform a use phase analysis if the new technology's product will be different enough from the replaced product that we would expect it to cause a significant shift in energy consumption or emissions during its use or disposal.

Conversely, a use phase analysis may not be needed if the new technology produces an identical end product to that of the commercial benchmark technology (and there is no difference in use phase energy consumption or emissions). In this case, a cradle-to-gate boundary may be most appropriate.

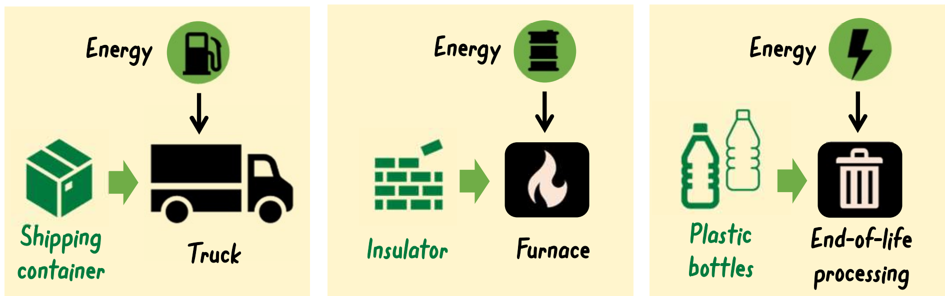
You will need to think about your technology individually to decide whether a use phase analysis is important.



If we decide that inclusion of the use phase is appropriate for our study, the next thing we should think about is what needs to be included in our use phase analysis. In this video, we'll also consider contributions from transportation and end-of-life as part of the modified use phase.

Energy consumption and emissions attributed to a product during its use phase may include both direct and indirect impacts. For example, a direct use of energy would involve energy consumption by the product itself. An indirect use of energy would involve a product that affects the amount of energy consumed by another product or process.

Indirect Use of Energy



Consider how the adoption of the new product might change how energy and emissions flow for different sectors, products, and processes.

For example,

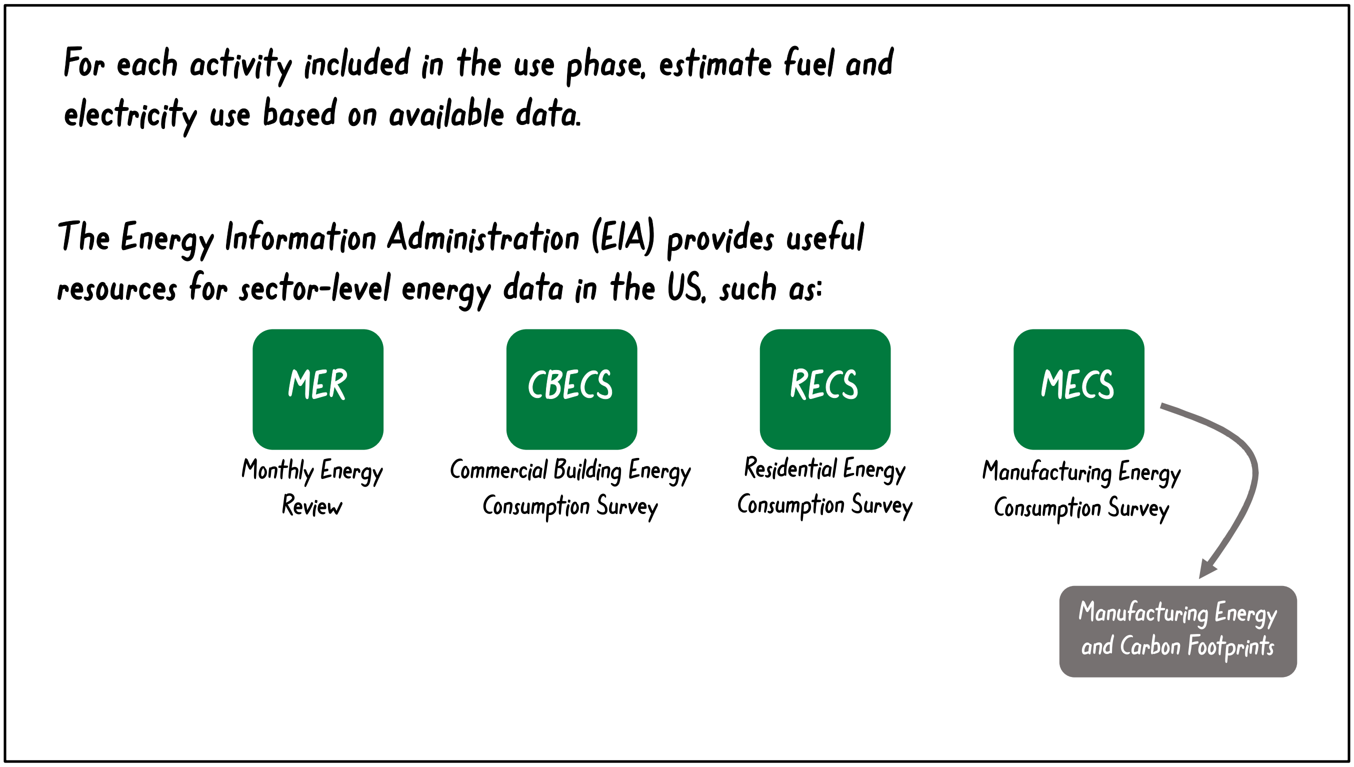
- A lighter-weight shipping container could reduce the amount of fuel used by a truck;
- A better insulator can reduce heat losses from a furnace; and
- The use of less plastic in a bottle might reduce energy involved with incineration, recycling, or other end-of-life processing.

When thinking about the product use phase, consider how the adoption of the new product might change energy and emissions flows for different sectors, products, and processes.

Consider activities in which an impact from the new technology, positive or negative, is likely

Note that lifetime impacts of a product can accumulate over many years, from the product's initial use through its ultimate retirement from service at the end of its useful life.

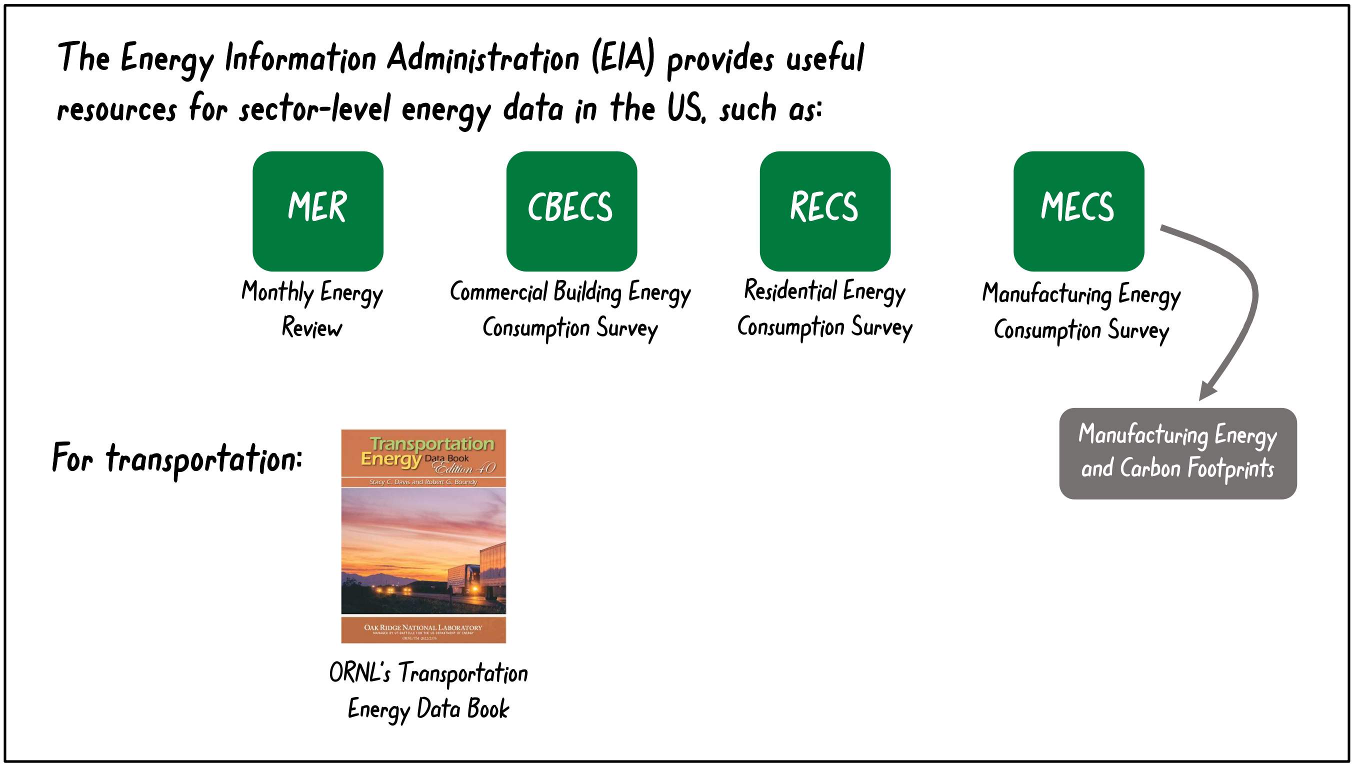
To simplify analysis, you don't need to consider every possible energy-consuming activity related to the product – just those in which an impact from the new technology, positive or negative, is likely.



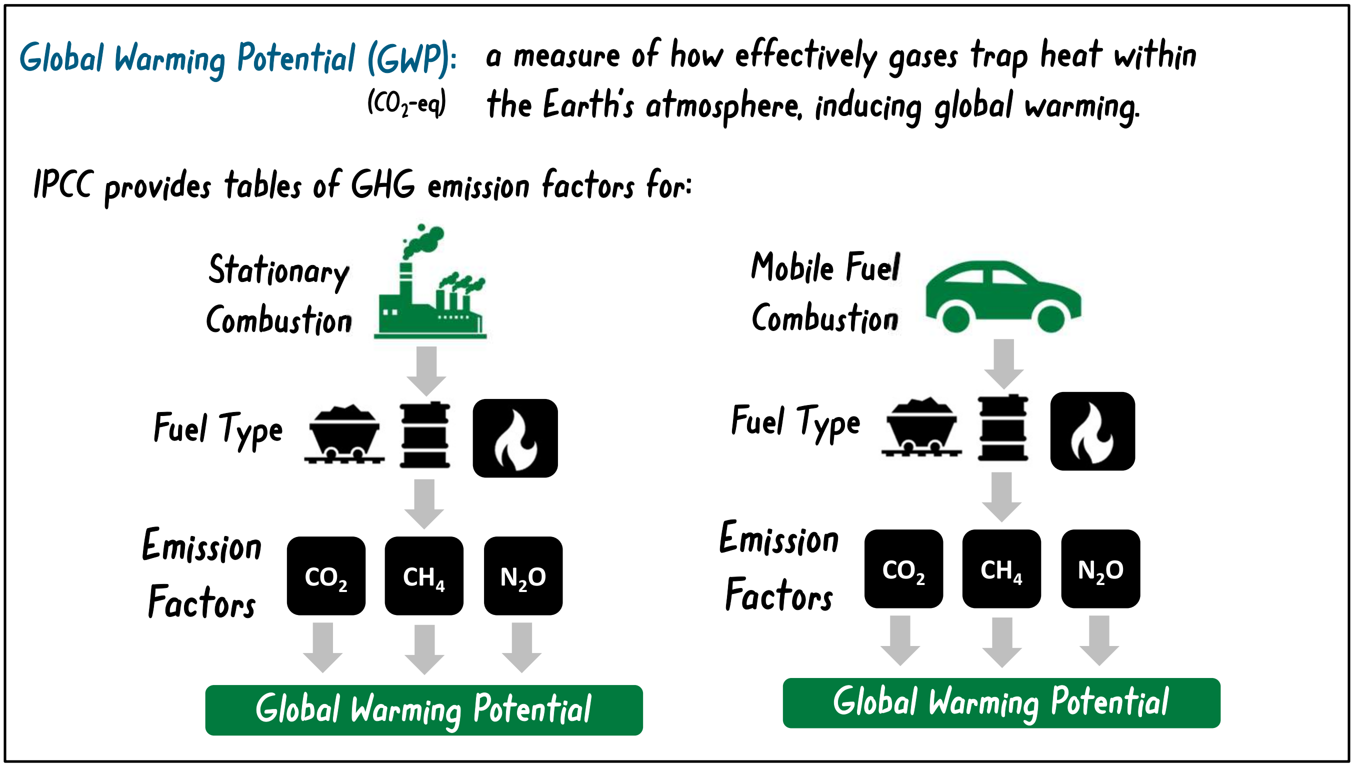
For each activity included in the use phase, estimate fuel and electricity use based on available data. If product-specific or facility-level data are available, these should be used. If not, data should be estimated based on industry averages using literature sources.

The Energy Information Administration (or EIA) provides useful resources for sector-level energy data in the United States, such as:

- the Monthly Energy Review (MER), which provides detailed information on energy use across the United States, including breakdowns by sector and energy type; and,
- CBECS, RECS, and MECS data. These surveys provide information on the amounts of energy consumed for various end-uses and purposes.
- The Manufacturing Energy and Carbon Footprints, based on MECS data, provide helpful visualizations of manufacturing energy consumption and end-uses in individual sectors.

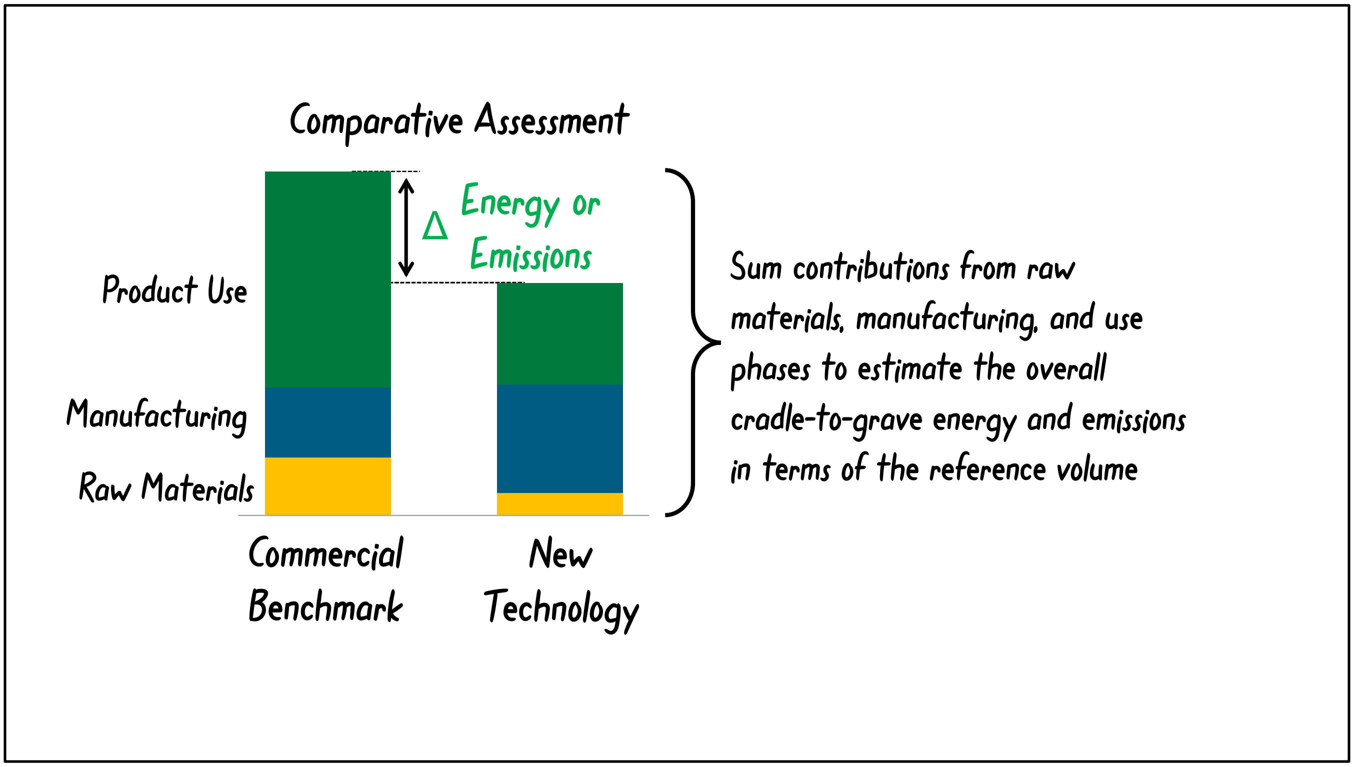


For transportation, Oak Ridge National Laboratory's [Transportation Energy Data Book] provides another useful resource.



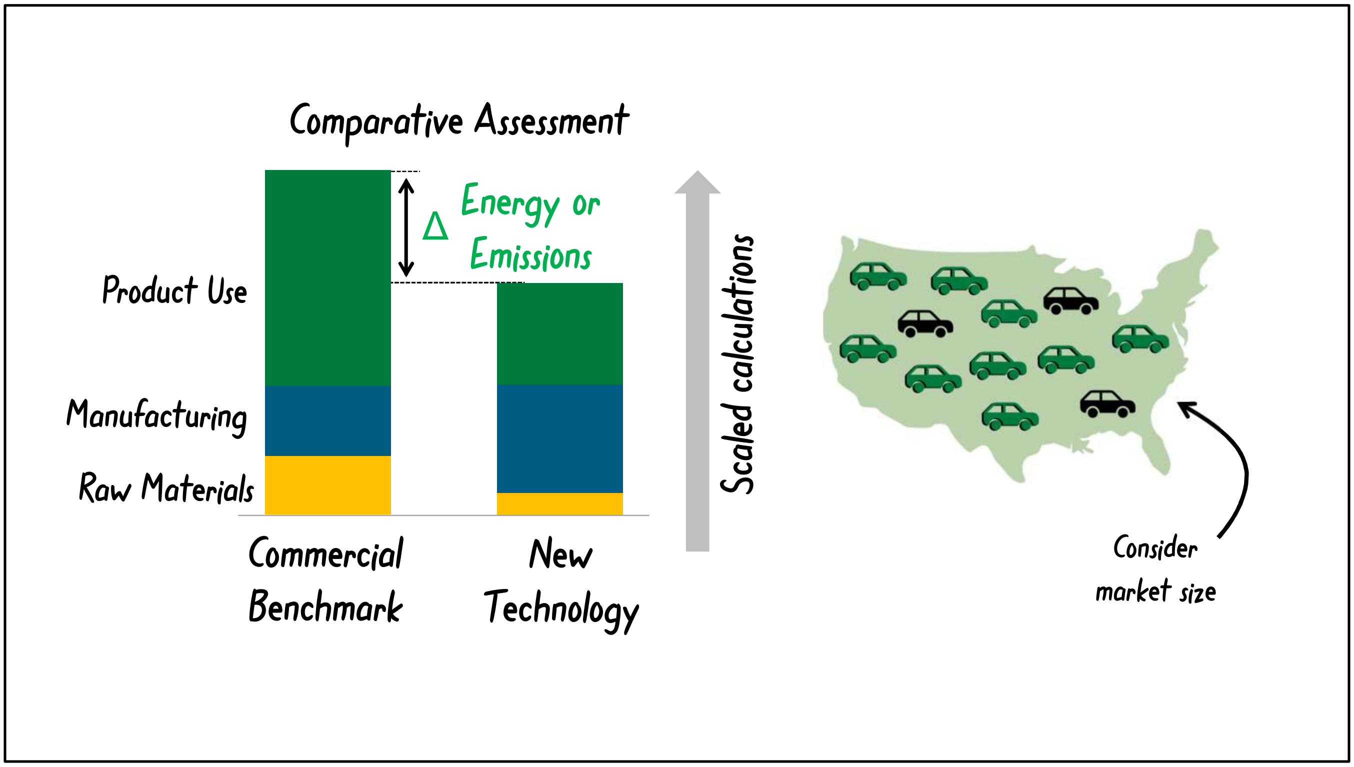
Greenhouse gas emissions can be quantified on the basis of their Global Warming Potential, or GWP. GWP, measured in units of CO2-equivalent, provides a measure of how effectively gases trap heat within the Earth's atmosphere, inducing global warming.

The United Nations' Intergovernmental Panel on Climate Change, or IPCC, provides tables of greenhouse gas emission factors for stationary & mobile fuel combustion, broken down by fuel type. These emissions factors can be used to determine the emissions associated with fuel combustion for energy. Then, we can apply the GWP value for each gas (which are also reported by IPCC) to convert the emissions of each gas to its CO2-equivalent value.



In earlier tutorial modules, we discussed methods for estimating energy and emissions contributions for the first two phases of the product life cycle – raw materials and manufacturing. All of those calculations were made on the basis of the reference volume, which was, in turn, based on the functional unit we selected for the analysis. Now, we can add the use phase contribution.

We can sum the contributions from raw materials, manufacturing, and use phases to estimate the overall cradle-to-grave energy and emissions in terms of the reference volume.



We can also scale these results to estimate potential impacts for the entire United States by assuming widespread adoption of the new technology. To do this, we will need to consider the market size – that's the total population of products in the United States that could potentially be replaced by the new technology.

Once we understand the size of the U.S. market, we can scale our life cycle calculations to assess the total changes to energy consumption or emissions that could result from product replacement. These types of calculations may just be rough estimates—but they can help us to understand the range of impacts we might expect from this new technology if successfully commercialized.

In this video, we discussed methods for estimating the energy and emissions associated with the use phase of a manufactured product, including considerations for determining appropriate analytical boundaries for a life-cycle-based assessment.

For more tools and techniques, please check out our other short tutorial videos on cost and environmental impact analysis! Thanks for watching.