Cost Modeling Techniques

Product Design & Cost Optimization

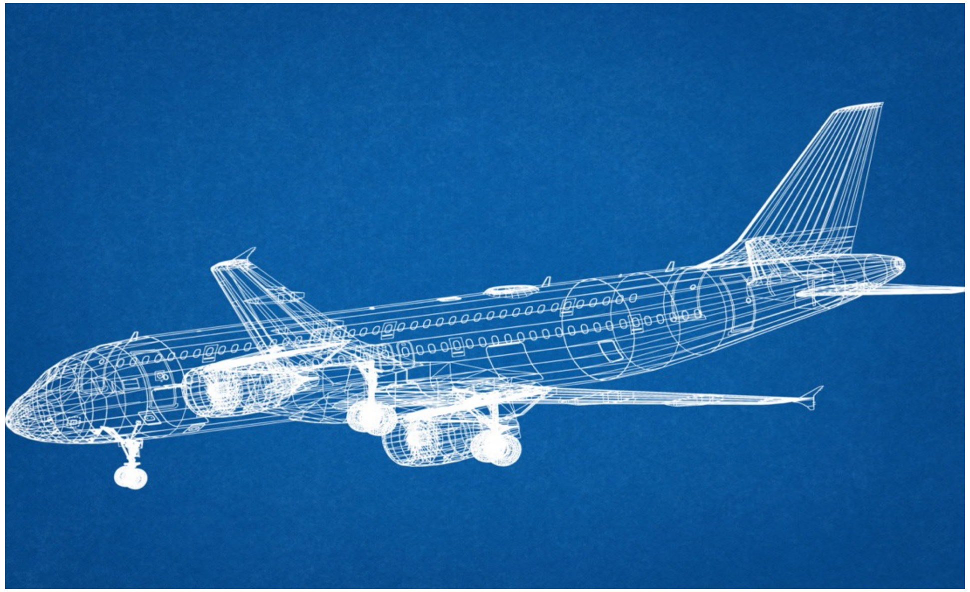
As designers, developers and engineers,
we create the next generation of products.

While the product's design and performance reflect customer requirements…

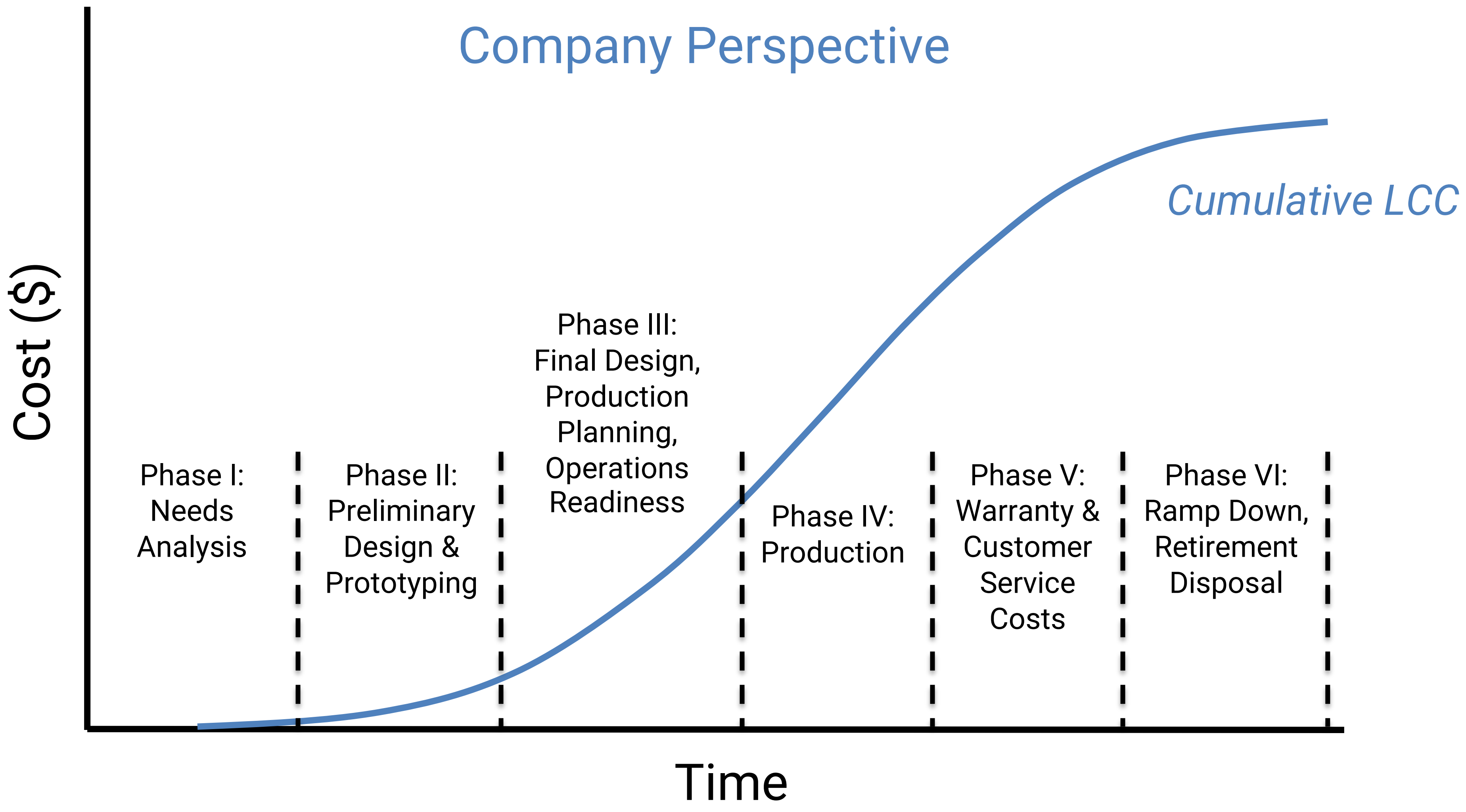
…our companies need to make them at an acceptable cost.

If price is set by the market, then profit is highly dependent upon product cost.

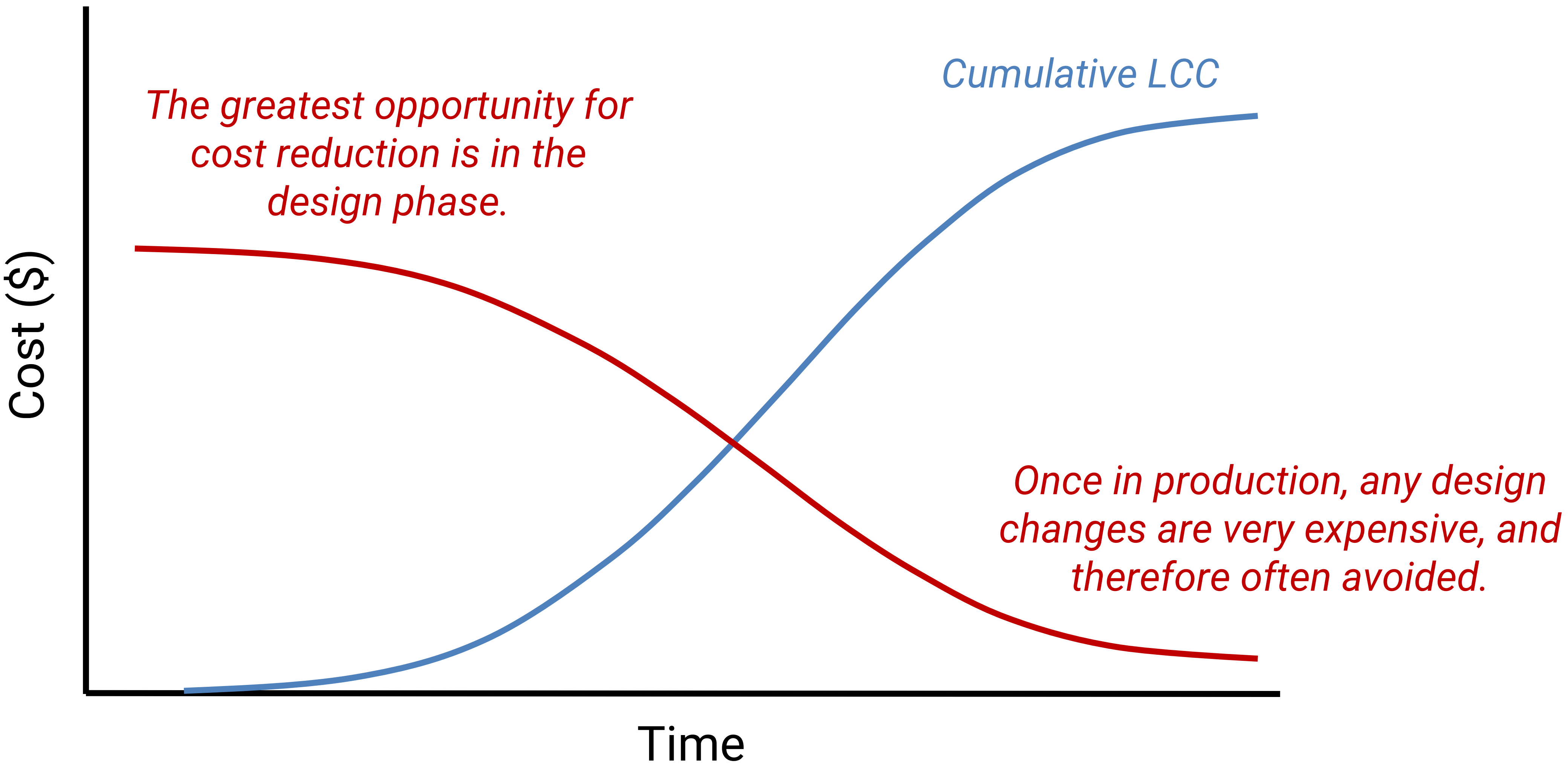
Therefore, we need to take cost into account in how we design, engineer and build these products.



Life Cycle Costs (LCC)



Life Cycle Costs (LCC)



Cost-Driven Design Optimization

A large focus of engineering is designing a component or product that has the functionality the customer wants, at the lowest cost to produce.

In many cases, product cost is driven largely by one parameter (material, production process, labor, etc.)

$\Rightarrow$ Primary Cost Driver

Cost optimization generally looks at minimizing the Primary Cost Driver

Design Objectives:

What costs should we worry about?

Investment Costs:

- design & prototyping costs
- capital to acquire plant and equipment (Capital Expenditures, "CAPEX")

Operating & Maintenance Expenditures ("O&M" or "OPEX"):

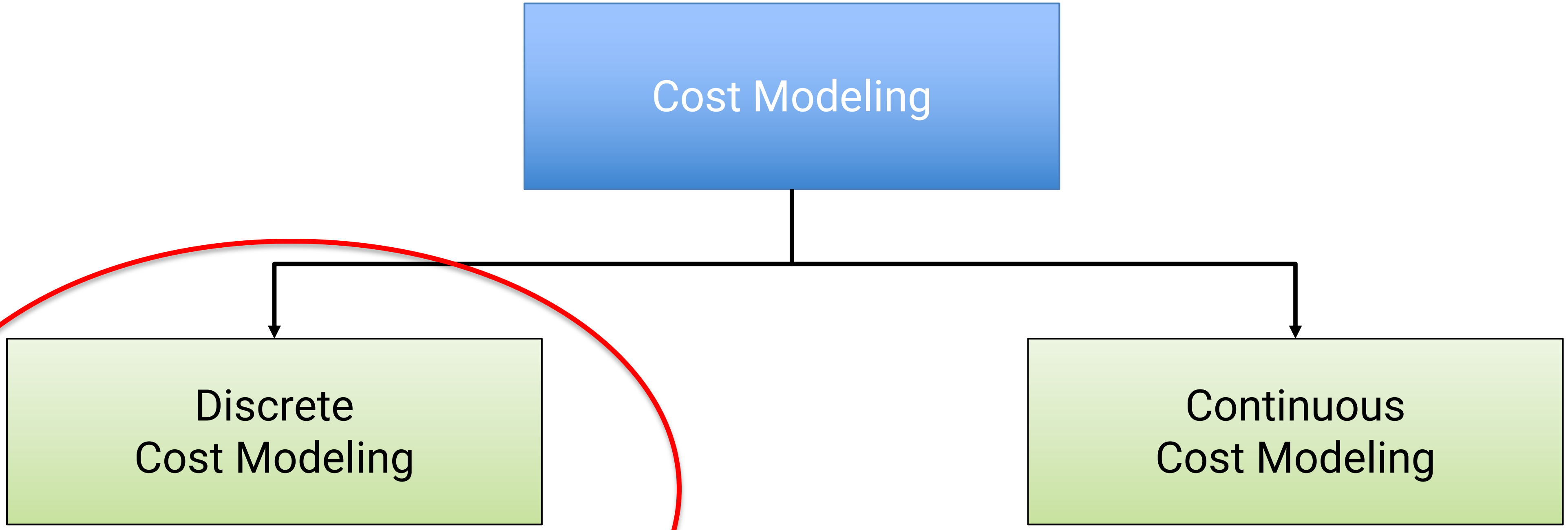
- Costs to keep everything running

Disposal Costs:

- non-recurring ("one-time-only" or "OTO") costs of shutting down operation

Cost-Driven Design Optimization

Cost Modeling to optimize costs often consists of two types:

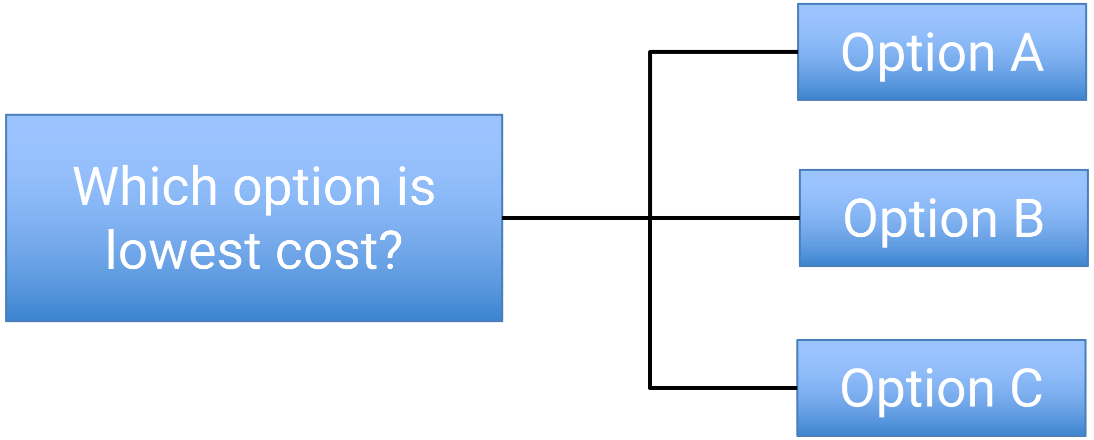


The minimum cost is selected from several different (discrete) options.

Cost is a continuous function of a design parameter or cost driver.

Discrete Cost Models

The minimum cost is selected from several different (discrete) options.



Each alternative is evaluated for cost.

The lowest cost alternative is selected (assuming it meets all other performance criteria).

Of course, ”minimum cost” needs to be defined:

- Lowest Initial Cost?
- Lowest Operating Costs?
- Lowest Total Cost (Initial Cost + Operating Costs)?
- Lowest Lifecycle Costs (Initial + Operating + Disposal Costs)?

A Useful Example…

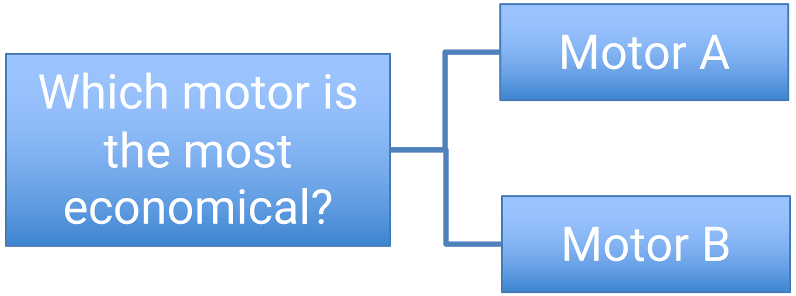
Example: Acme Chemical is evaluating two different electric motors to drive a mixer and needs to perform an economic study to determine what to purchase.

The motor will produce 75 hp and will be operated eight hours per day, 365 days for one year after which time the motor will have no value.

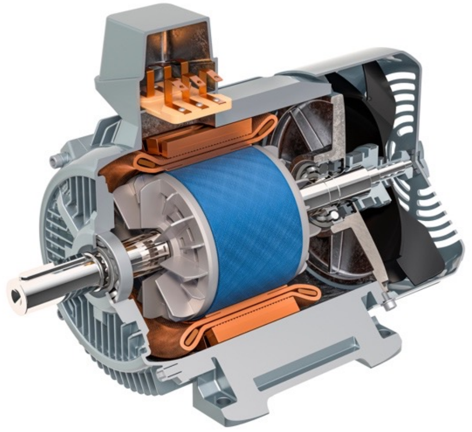
Assume Acme's electric power costs $0.15 per kWh. (Note: 1 hp = 0.746 kW)

- *The motor with the lowest Total Cost (Initial + Operating Costs) will be selected.*

	Motor A	Motor B
Purchase price	$3,500	$5,000
Annual maintenance cost	$250	$500
Motor Efficiency, η	70%	90%
Electricity Costs	?	?



The Solution…



Total Annual Cost = Initial Cost + Operating Cost

Total Annual Cost = CAPEX + OPEX

Total Annual Cost = Purchase Price + [Cost of Electricity + Maintenance Cost]

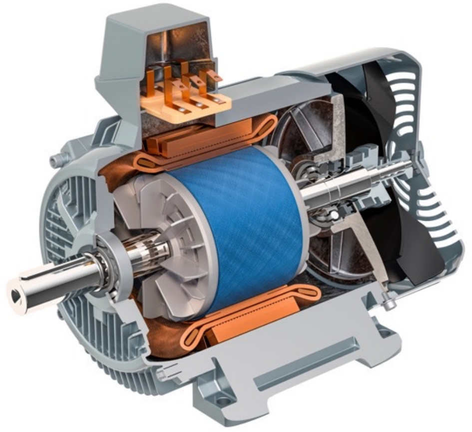
Constant

f (Power, Efficiency, Electricity Rate, Time)

Constant

$$\text{Cost of Electricity} = [\text{Power} / \eta_{efficiency}] * (\$/\text{kWh}) * t_{oper}$$

The Solution…



Motor A

Cost of Electricity to operate the motor:

$$\left(\frac{75\ \text{hp}}{0.70}\right)\left(\frac{0.746\ \text{kW}}{\text{hp}}\right)\left(\frac{\$0.15}{\text{kWh}}\right)\left(\frac{8\ \text{hr}}{\text{day}}\right)\left(\frac{365\ \text{days}}{\text{year}}\right) = \$35{,}009\ \text{per year}$$

Total Annual Cost Motor A = \$3,500 + \$35,009 + \$250 = \$38,759

Motor B

Cost of Electricity to operate the motor:

$$\left(\frac{75\ \text{hp}}{0.90}\right)\left(\frac{0.746\ \text{kW}}{\text{hp}}\right)\left(\frac{\$0.15}{\text{kWh}}\right)\left(\frac{8\ \text{hr}}{\text{day}}\right)\left(\frac{365\ \text{days}}{\text{year}}\right) = \$27{,}229\ \text{per year}$$

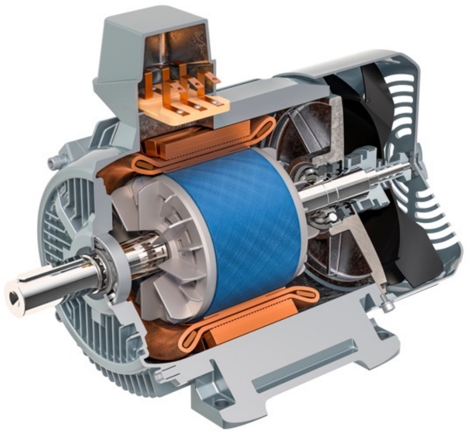
Total Annual Cost Motor B = \$5,000 + \$27,229 + \$500 = \$32,729

The Solution…

Which motor is the most economical?

$38,759 Motor A ✗

$32,729 Motor B ✓



The greater efficiency of Motor B outweighs its higher initial price and higher maintenance costs.

What is the impact of efficiency on carbon footprint?

Would you make the same decision if the Electricity Rate = $0.05/kWh?

The Value of Greater Energy Efficiency

Energy efficiency is an increasingly important method to minimize costs…

Other benefits:

✓ Less electricity consumed = less electricity required in the first place

✓ Less electricity generated = fewer emissions:

- criteria air pollutants (NOx, SOx, CO, PM)
- greenhouse gases (CO_2)

✓ Less electricity required creates the opportunity for on-site power generation through solar, wind, biogas, and others…

Main Takeaways…

- The cost of a product is often defined early in the design process.

- Cost reduction opportunities are also often defined early in the design process, well before a lot of capital has been spent on production equipment.

- In Discrete Cost Models:
  - One considers several (discrete) alternatives
  - A Cost Model is established applicable to all the alternatives
  - Cost is determined for each alternative
  - The alternative with the lowest cost is selected.

- The lowest cost can be defined as lowest total cost, initial cost, operating cost or even lifecycle cost!

Next Time...

A Real Engineering Problem!

Credits & References

Slide 1: Business illustration showing the concept of cost estimation models vy OpturaDesign, Adobe Stock (192867247.jpeg).

Slide 2: Airplane – blueprint by Marko, Adobe Stock (333938085.jpeg). Concept car rides on the road, solar panels are in the background by unlimit3d, Adobe Stock (425083450.jpeg).

Slide 10-12: Section of industrial electric motor by natatravel, Adobe Stock (375468173.jpeg).

Slide 15: Passive solar house concept by mipan, Adobe Stock (305245605.jpeg).