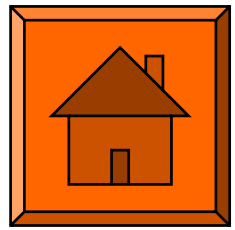
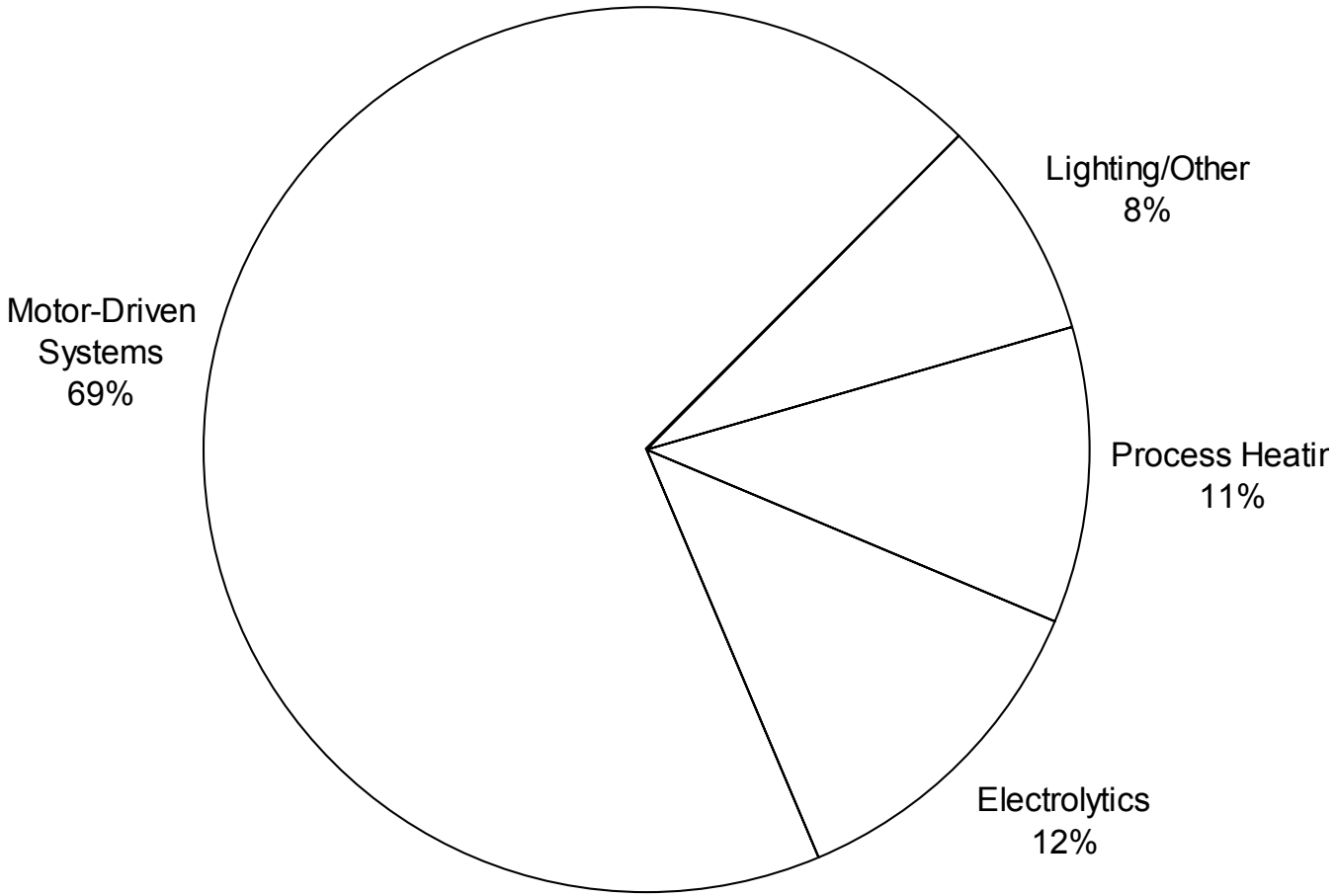
Overview of this chapter

- Why are motors important?
- What is a motor?
- The electric motor system
- Optimizing the motor component
  - efficiency and losses
  - standards
  - motor/load relationships

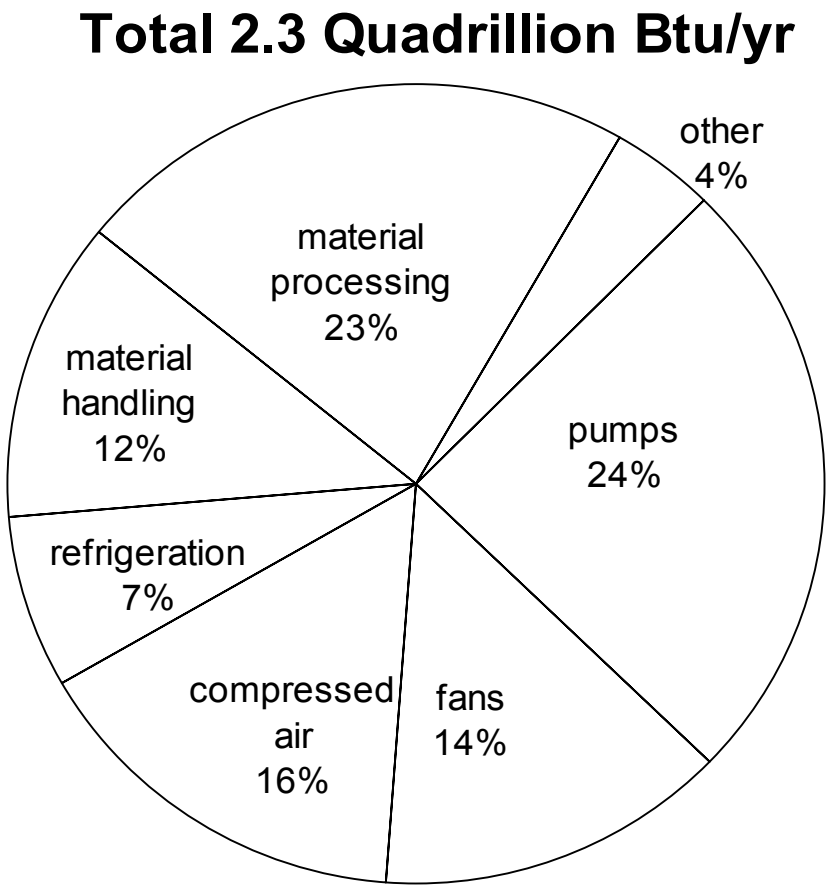


Industrial Electricity Use



Source: DOE presentation, March 1999:
Introduction to Motor Systems Management

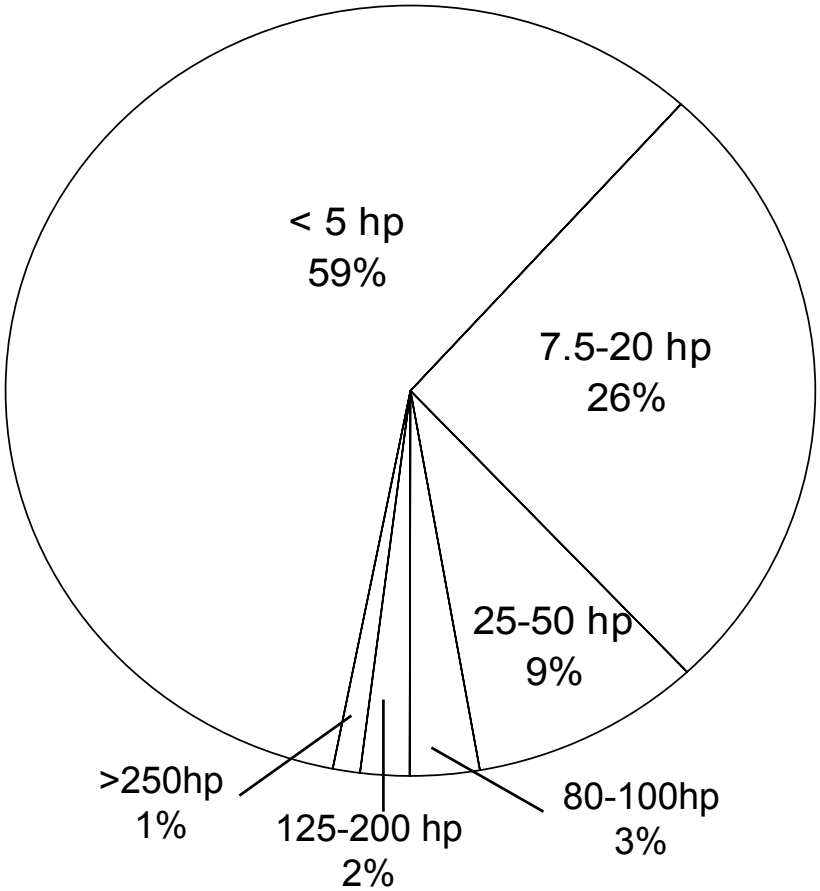
Industrial motor energy use by application



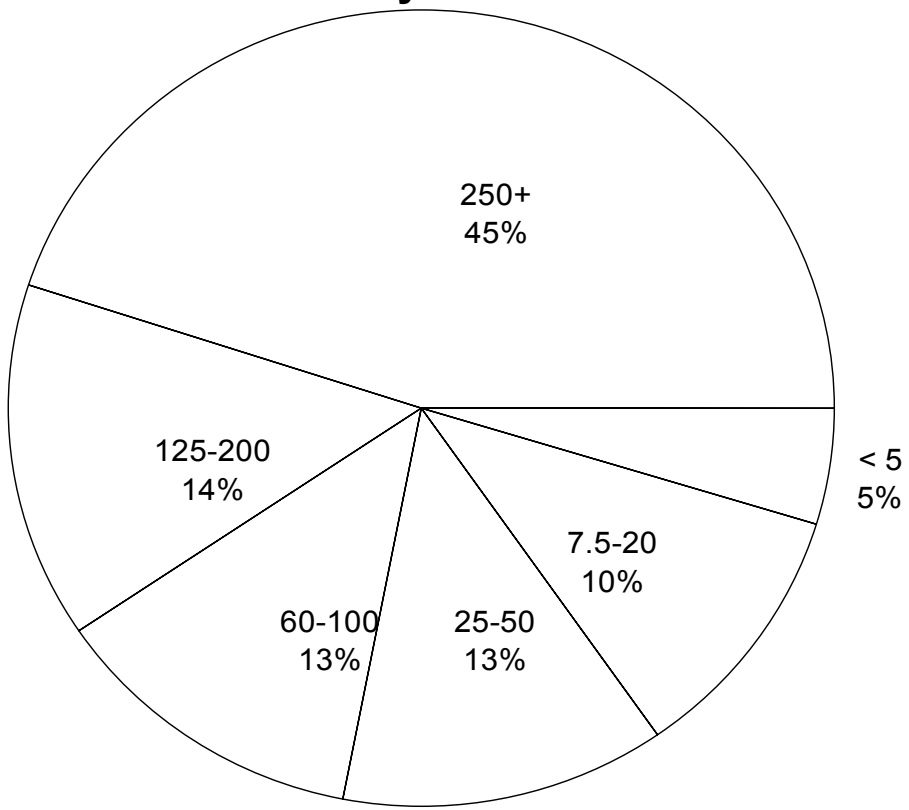
Source: United States Industrial Electric Motor Systems Market Opportunities Assessment, Office of Industrial Technologies, Office of Energy Efficiency and Renewable energy, US DOE, December 1998, Table 1-16, page 43

Motor size profile compared to energy use

Total population 12.4 million units

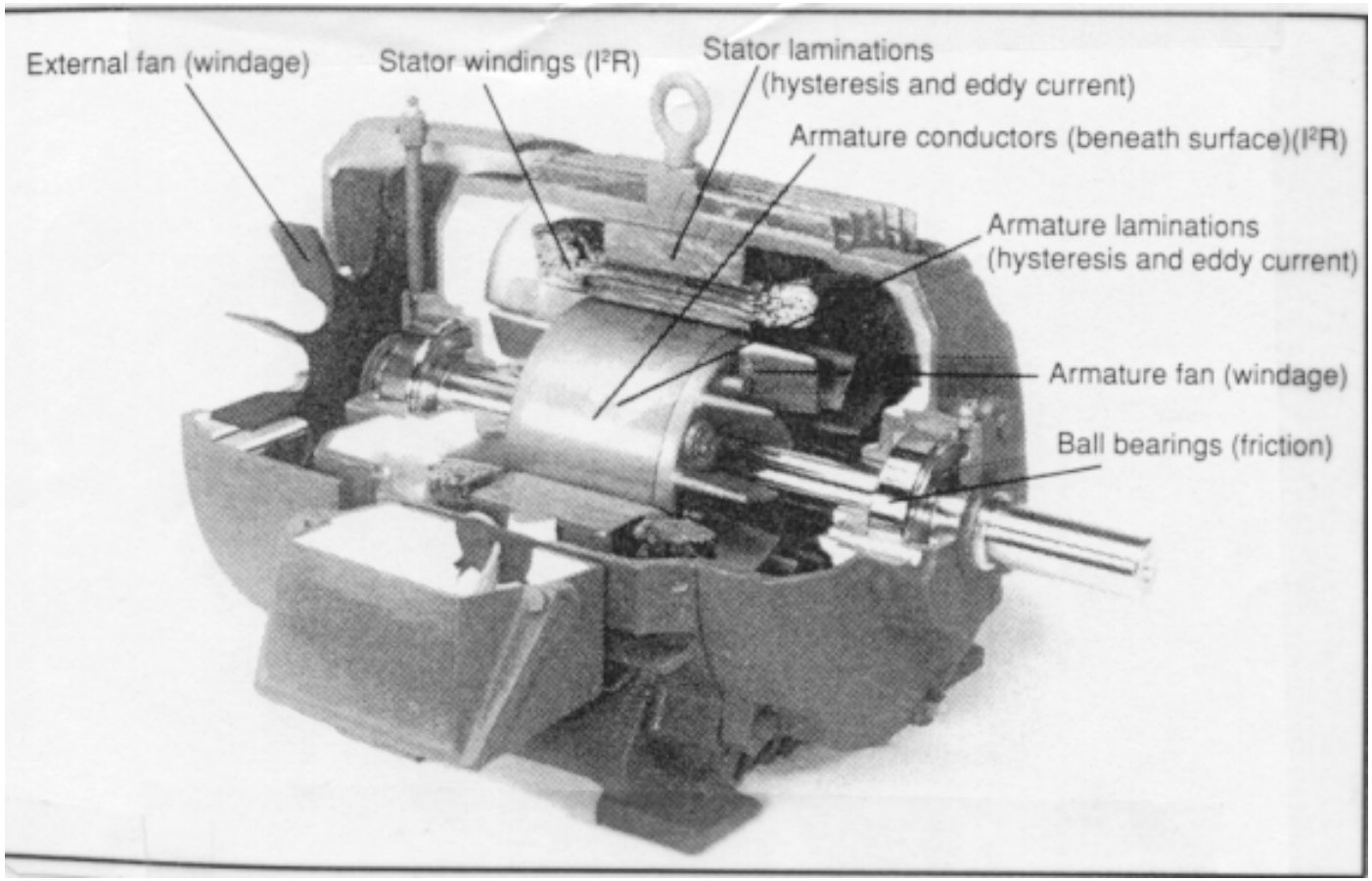


Total Energy Use: 2.3 Quadrillion Btu/yr



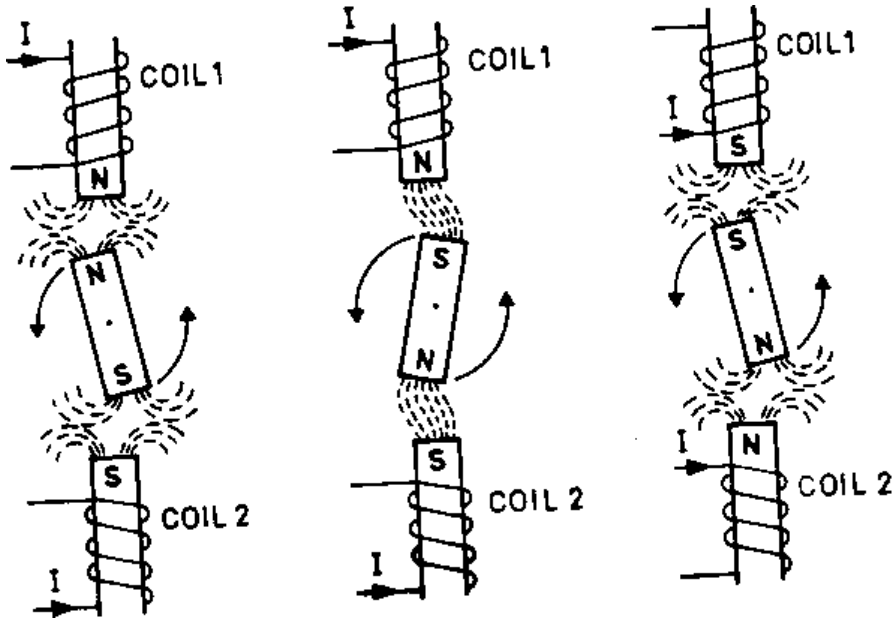
Source: OIT pg. 40

What is a motor?



Source: Energy-Efficient Motor Systems: An Handbook on Technolo-Qy, Programs, and Policy Opportunities, 1991, American Council for and Energy-Efficient Economy.

How a Motor Works



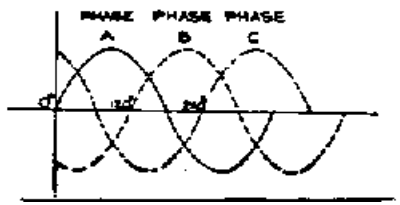
Source: The Lincoln Electric Company

Three-phase power

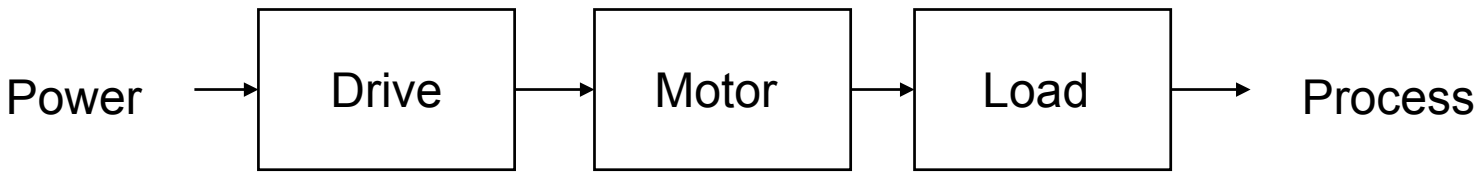
- Alternating current (AC) reverses the poles of the electromagnet
- AC reverses direction 60 times per second (60 Hz) (i.e. 3600 times per minute)
- The number of magnetic poles in a motor determines its speed

Single phase

Three phase



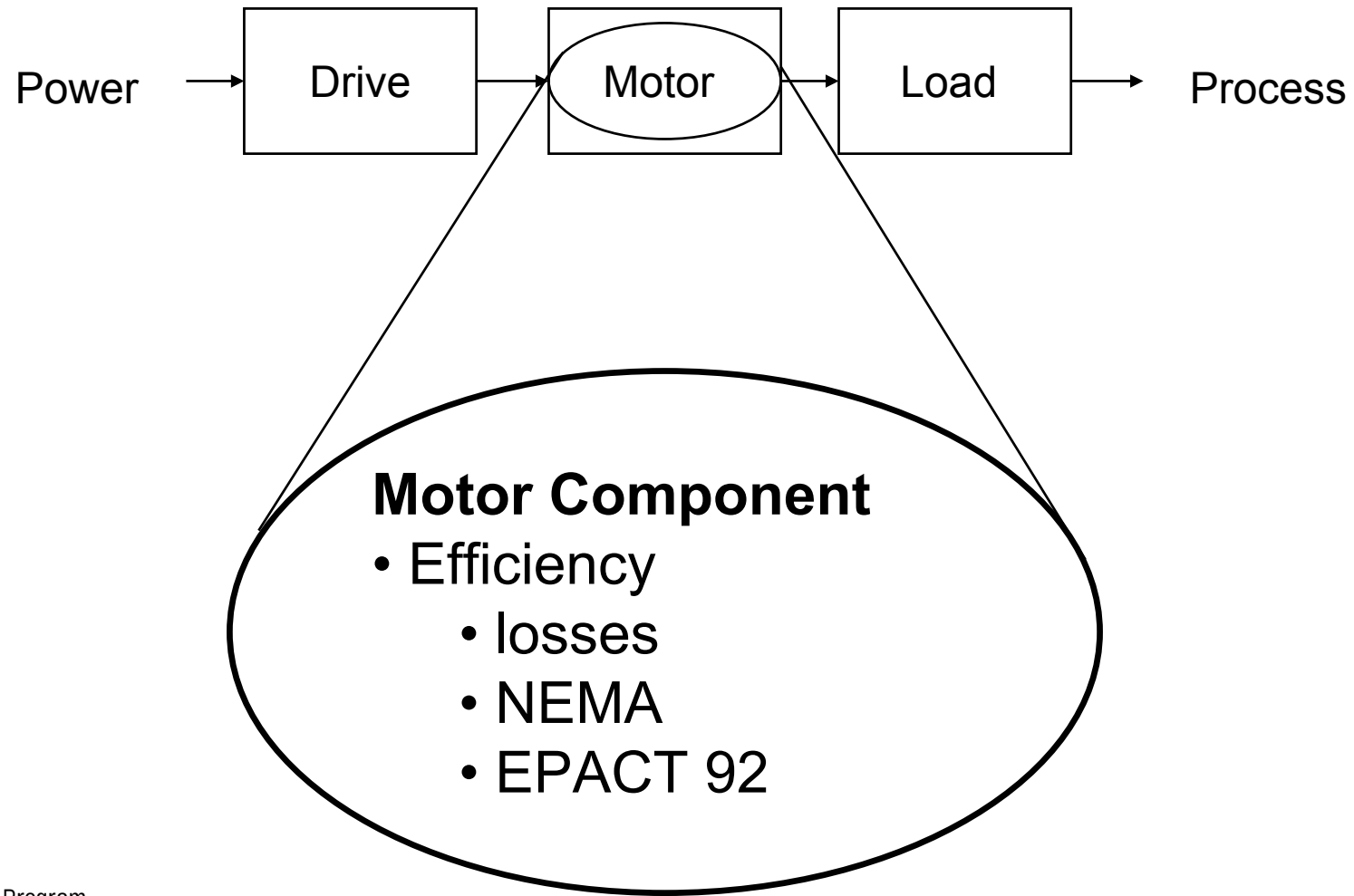
The Electric Motor System



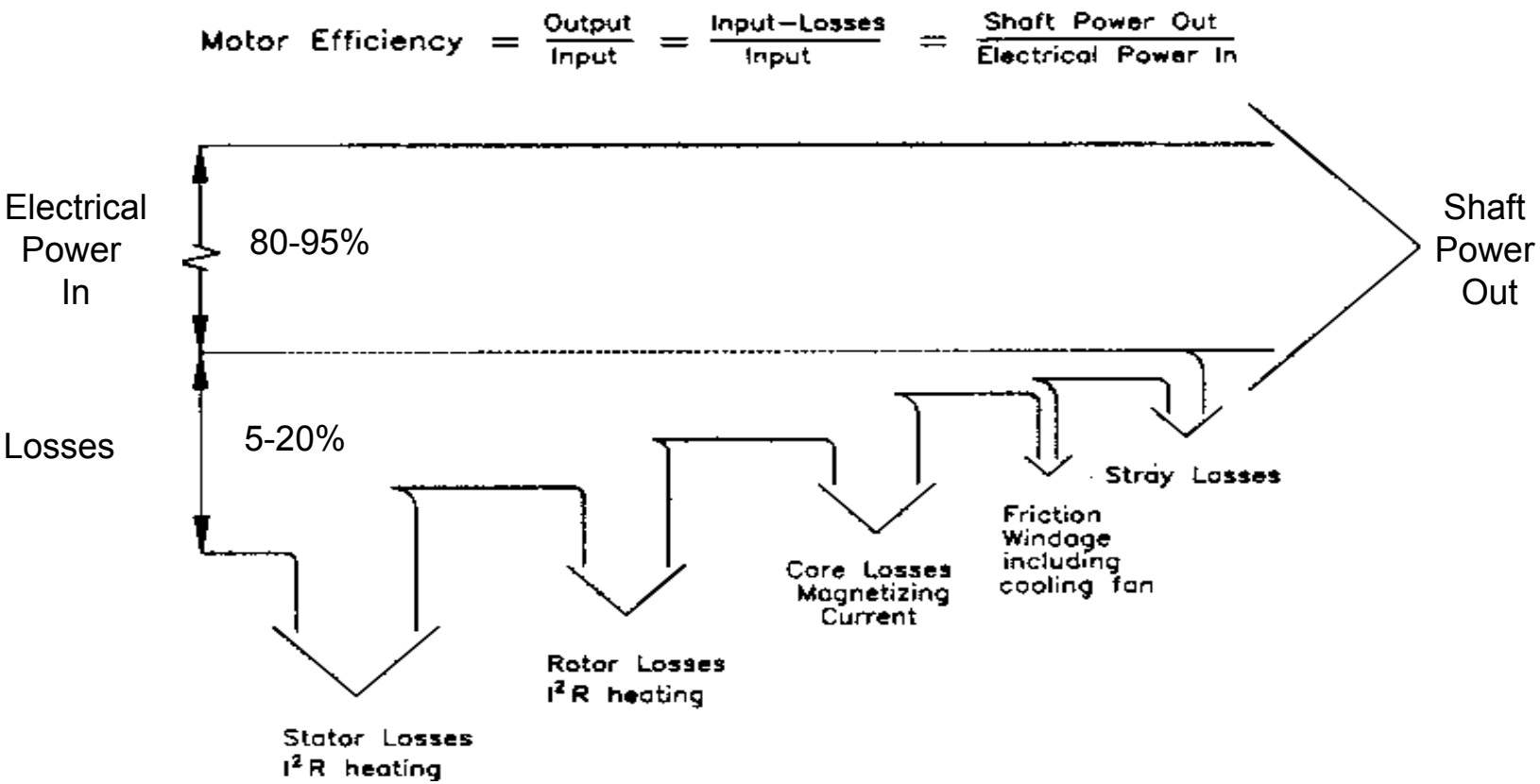
The Systems approach

- Proper integration of all components of a system
- Maximize the ratio of product output to energy input

Optimizing the motor system - MOTOR



Motor efficiency and losses



Cost of Inefficient Motors

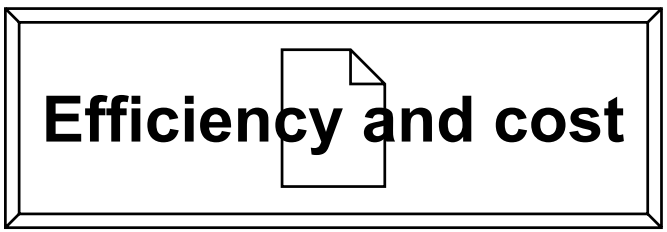
Initial cost
$5000

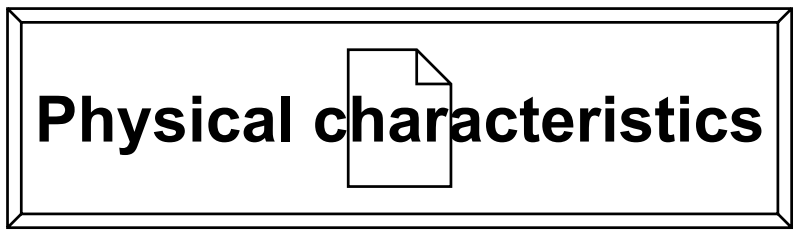
Energy cost
$525,000

100-hp motor, $0.05/kWh electricity
3 shifts, 15-year life

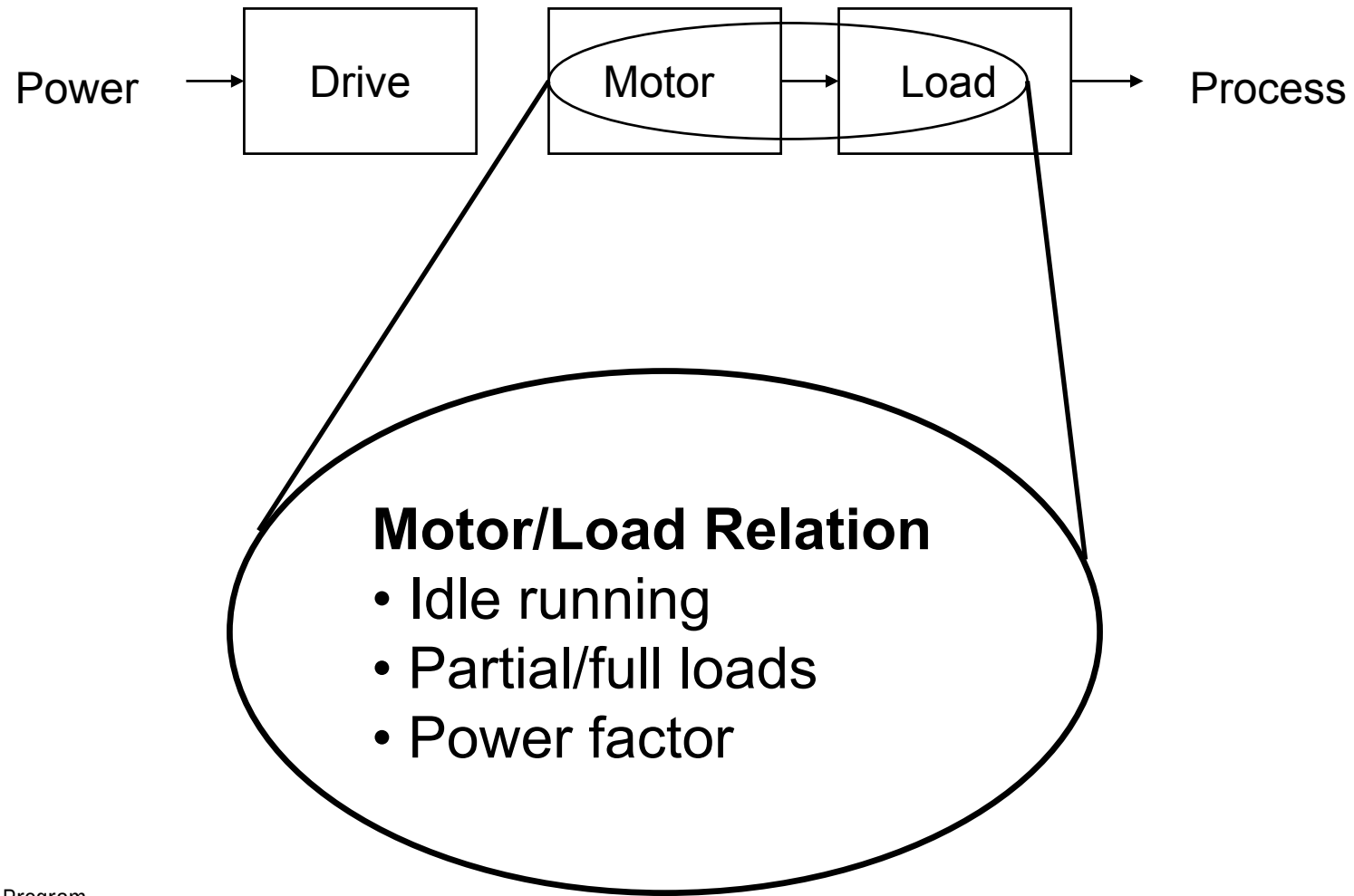
Motor efficiency "standards"

- NEMA (National Electrical Manufacturer's Association) defines energy efficient motors
- EPACT 92 (Energy Policy Act of 1992)
- High- or Premium-efficiency varies by manufacturer





Motor/load relationship



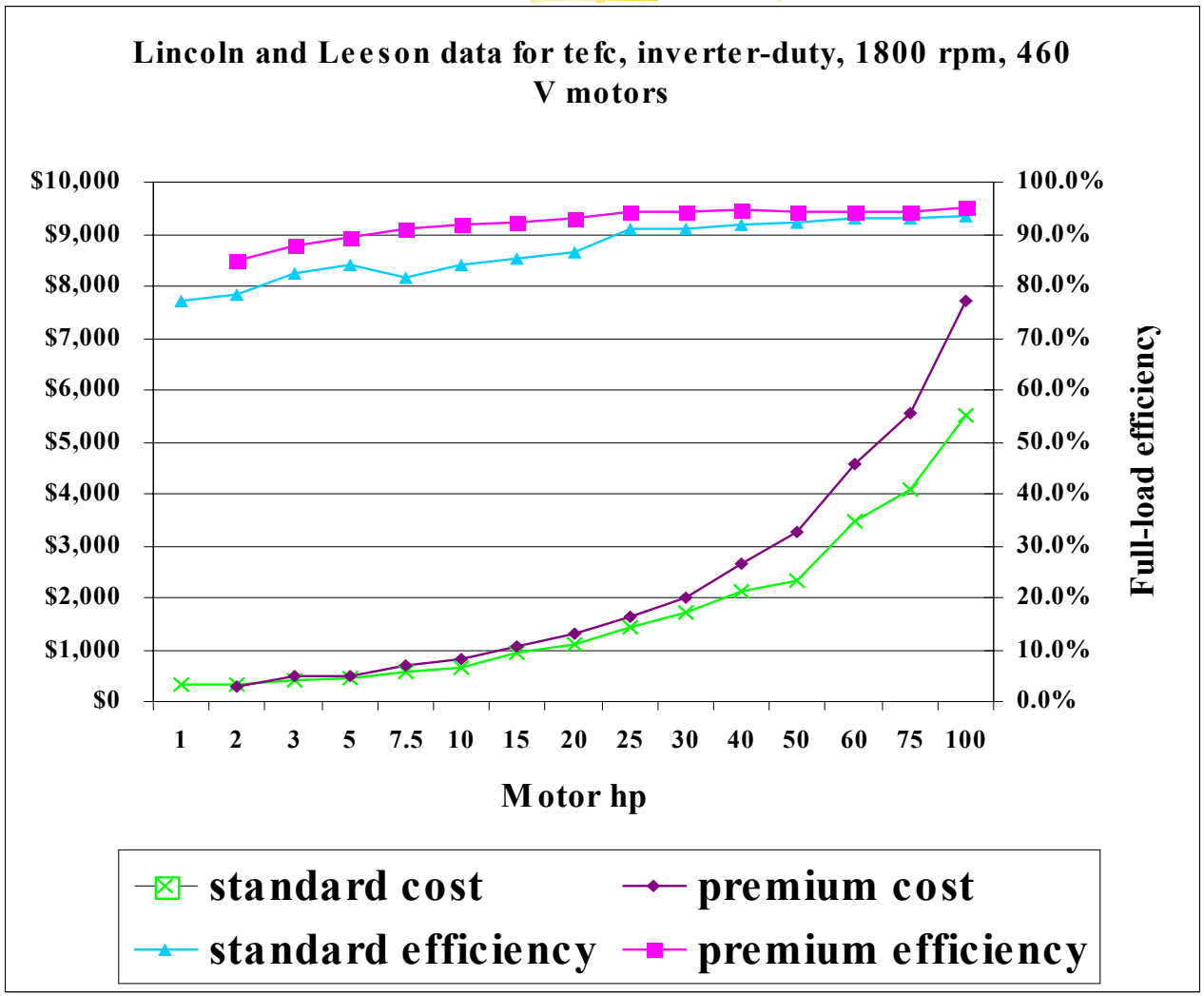
Idle Running

- No-load losses can be significant
- Low hanging fruit potential
- Idle motor shut-off should be automated/controlled

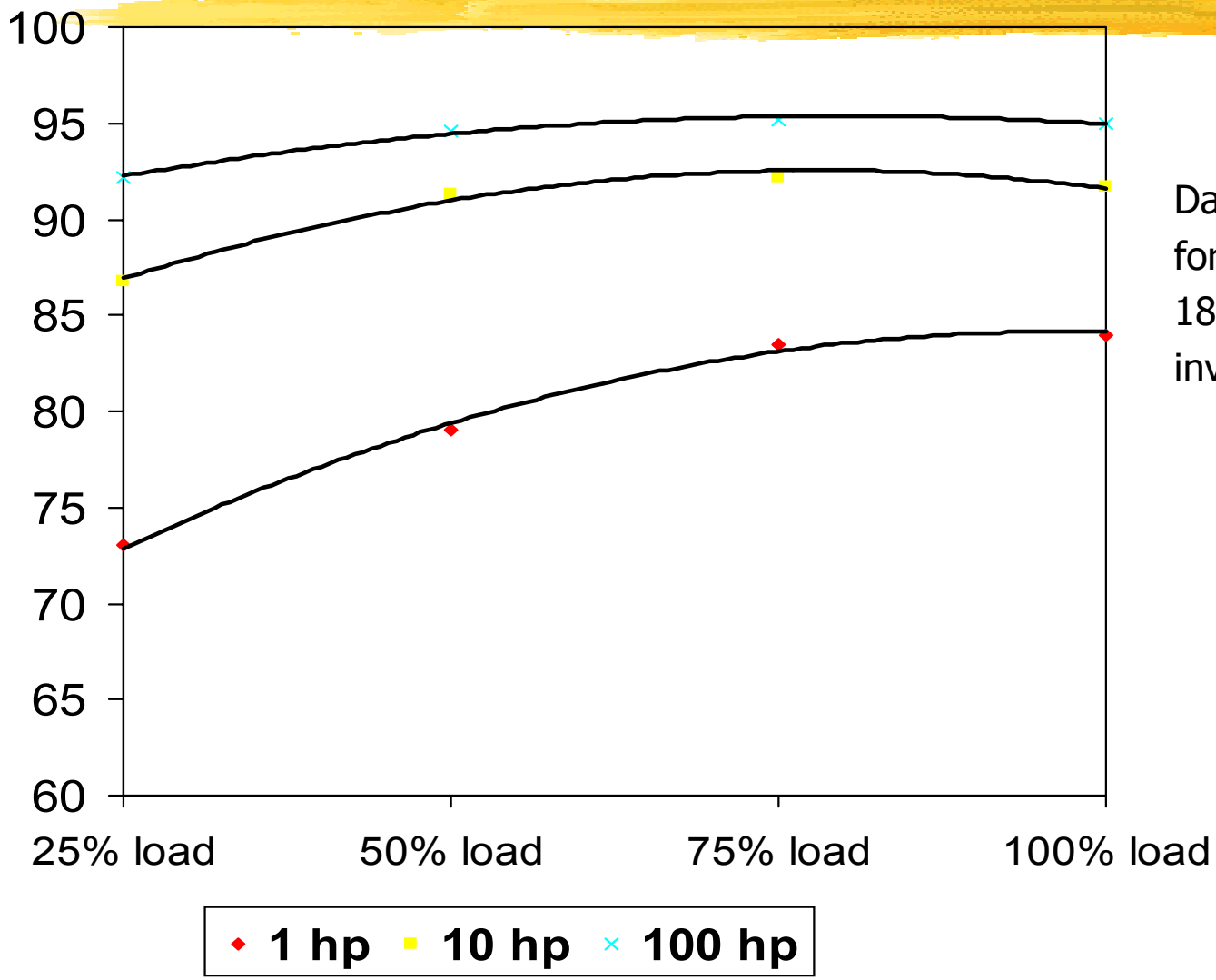
Efficiency at low load

- The efficiency of a motor is reduced when operating at partial load
- This is very common because:
  - motors must be sized for the worst case, highest load condition
  - motors are often oversized
  - load/process requirements change

Motor efficiencies and costs



Motor efficiency by size



Data from MotorMaster for Leeson "Wattsaver" 1800-rpm, 460 V, inverter-duty motors

Sample motor calculation

- Given:
  - New, 50-hp, TEFC, 1800-rpm, 4-pole motor
  - "Energy efficient motor" efficiency: 92.4%
  - EPACT efficiency: 93.0%
  - Premium efficiency: 94.5%
  - Best available: 95.0%
- Determine: payback

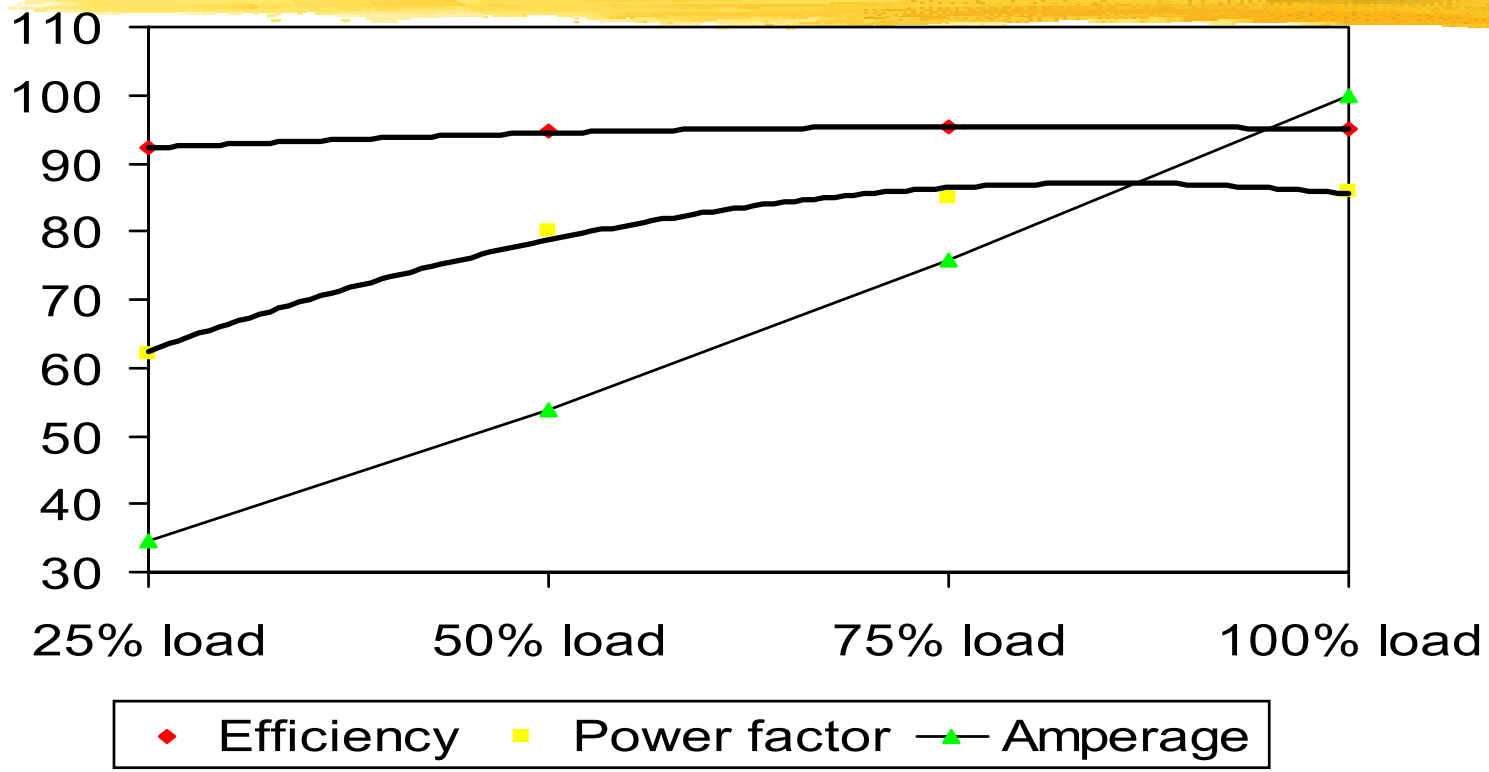
Motor calculation: exercise

- Given: 100 hp, ODP, 1800-rpm, inverter-duty motor
- Determine:
  - "energy efficient motor" efficiency
  - open motor EPACT efficiency
  - NEMA efficiency
  - best available efficiency
  - payback

Power factor

- What is power factor?
  - Ratio of real power (kW) to apparent power (kVA). Power factor is low at low load because while the real power approaches the motor losses, the reactive power (kVAR) which creates the magnetic field is constant.
  - Use capacitors to improve power factor
- Heat generation and temperature rise
- Proper sizing

Motor performance as a function of load



- Data from MotorMaster for Leeson "Wattsaver" 100-hp, 460 V, 1780-rpm inverter-duty motor
- Show percent power draw for comparison

Motor challenge program

- Sponsored by the US Department of Energy (DOE)
- Call 800-862-2086
- www.motor.doe.gov