Making Electric Motors More Efficient

Making Motors More Efficient

- Overview/Objectives:
  - Understand basic motor energy consumption and losses
  - Motor life cycle costs
  - Basic motor efficiency calculations
  - Motor design and materials vs. Efficiency
  - Motor energy efficiency potential

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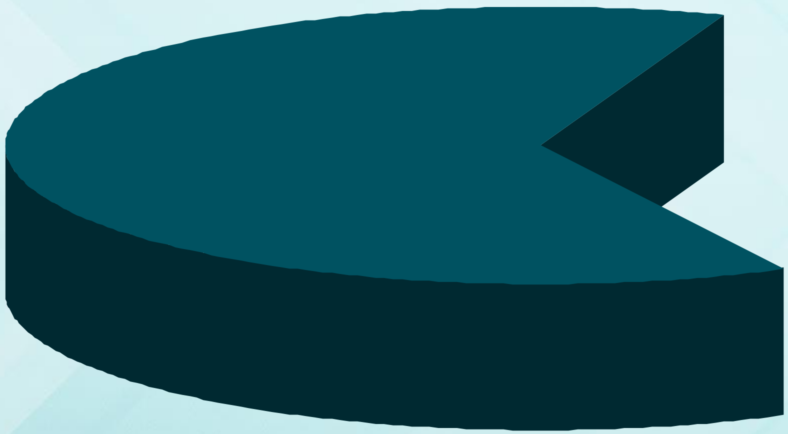
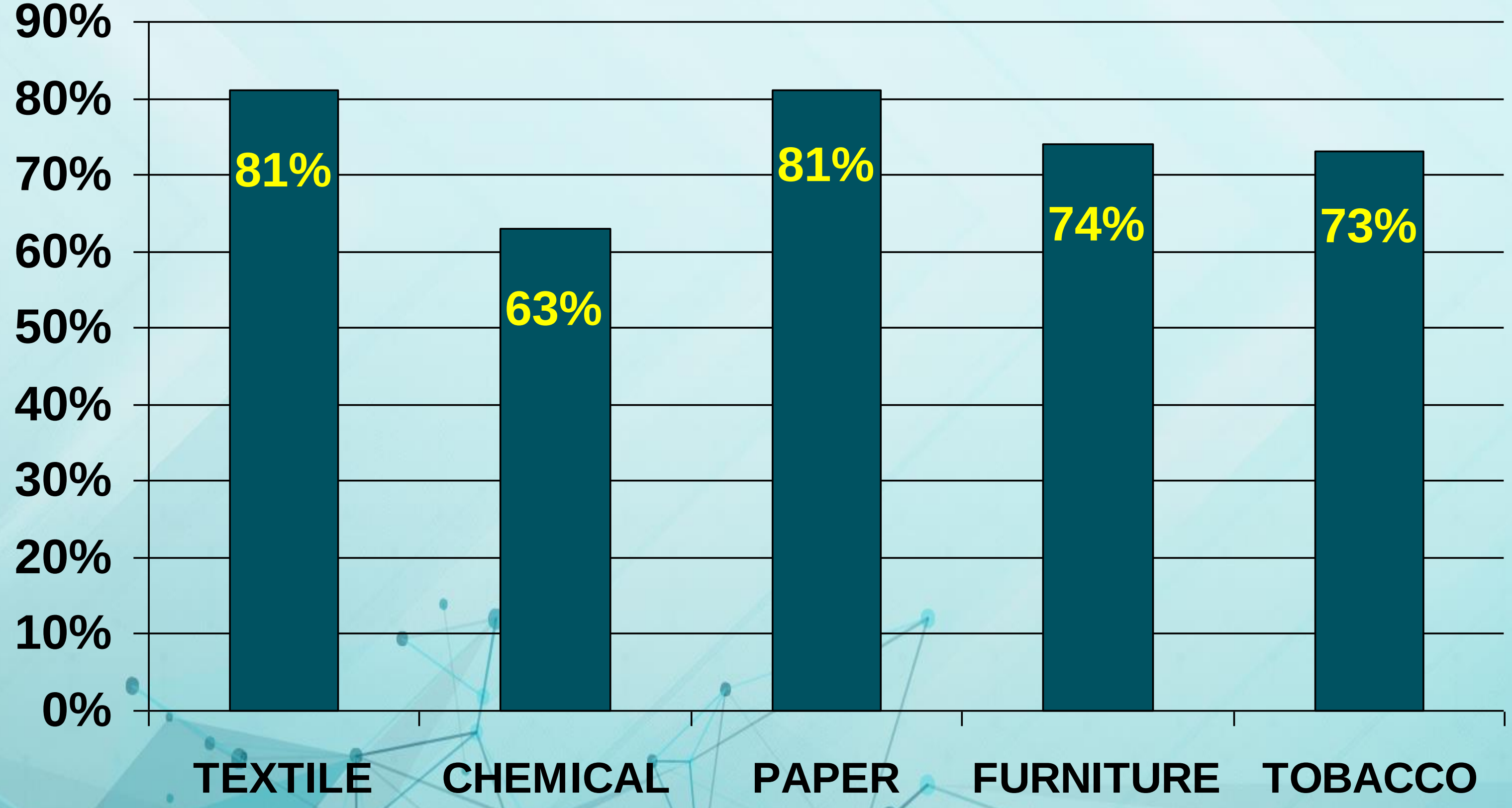
Motor Electricity Usage



- Electric motors consume 63% of electricity used by industry (1998 DOE) or about 25% of all electricity sold in the U.S.

Certain Industries Have Higher Motor Energy Consumption



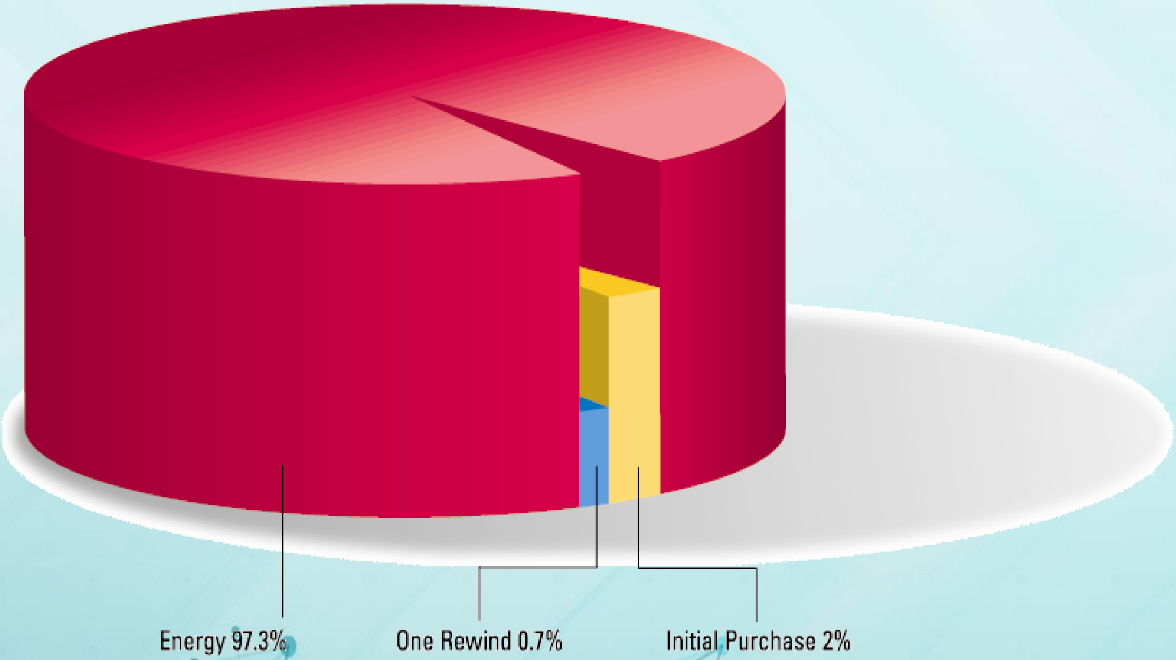
Motor Electricity Savings Potential

- Estimated potential electricity savings from Motor Systems is 18% (DOE)
- Savings from upgrading to premium efficiency motors, using adjustable speed drives, improved motor rewind practices, and equipment upgrades.

Upgrading Motors Can Cause Other Changes

- Replacing existing motors with more energy efficient motors may also affect:
  - Demand (kW)
  - Power Factor
  - Motor Starting Characteristics

Life Cycle Cost of a Motor



Motor Electricity Usage

- All of the electricity that enters a motor is either lost as heat or converted into mechanical energy (torque).
- The heat produced must be removed.

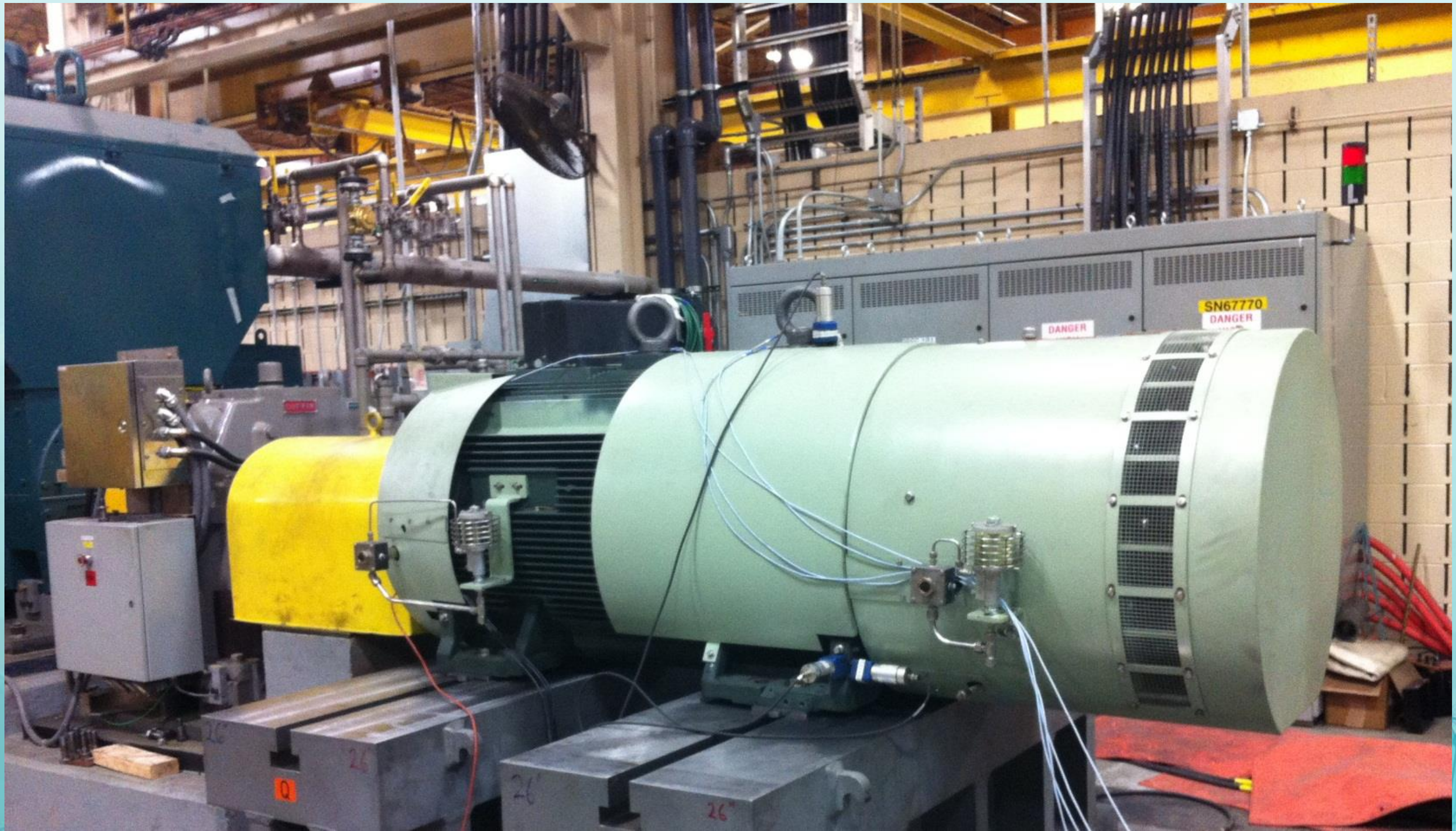
Motor Efficiency

- Motor efficiency is a measure of the effectiveness with which a motor converts electrical power to mechanical power.
- The only power actually consumed by the motor is electrical power, or watts, lost during the conversion process, which takes the form of heat dissipated by the motor frame.
- It is defined as the ratio of power output to power input or, in terms of electrical power, watts output to watts input. (1 HP = 746 WATTS)
- Motor Efficiency =

$$\frac{HP \times 746}{(HP \times 746) + \text{Watts Loss}}$$

Efficiency

- Efficiency = $\dfrac{\text{Output}}{\text{Input}} = \dfrac{\text{Output}}{\text{Output + Losses}}$



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Induction Motor Power Losses

- Primary I^2R (Stator Winding)
- Secondary I^2R (Rotor bars)
- Core Losses (Iron)
- Friction & Windage (Fan & bearings)
- Stray Load Loss

Motor Efficiency

Iron core losses | Stator resistance | Rotor resistance | Windage & friction | Stray load losses

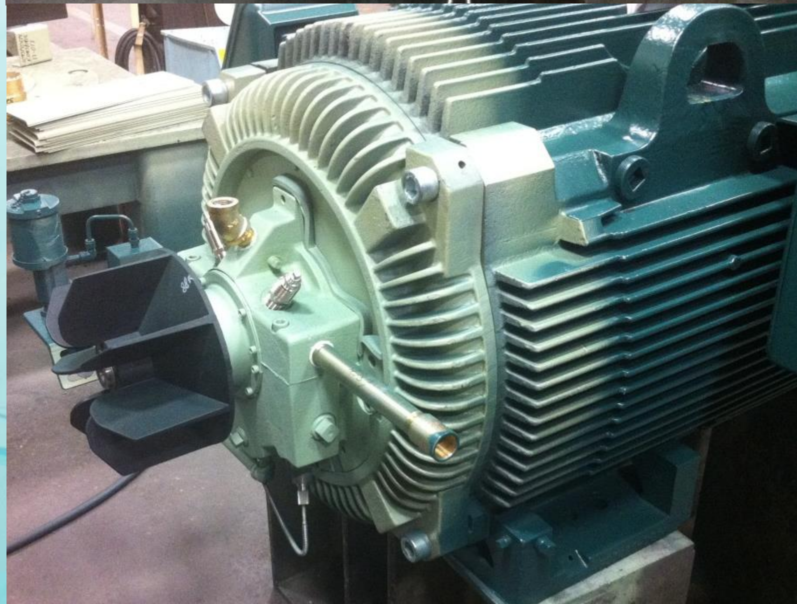
Total Losses 7.6%

Input Power 100%

Output Power 92.4%

Energy Efficient Motor Design

- Additional Active Material
  - Winding (add copper)
  - Rotor (add aluminum or copper)
  - Stator Core (add electrical steel)
- Improved Electrical Steel (lower loss per lb)
- Thinner Laminations
- Fan Design (Low Loss)

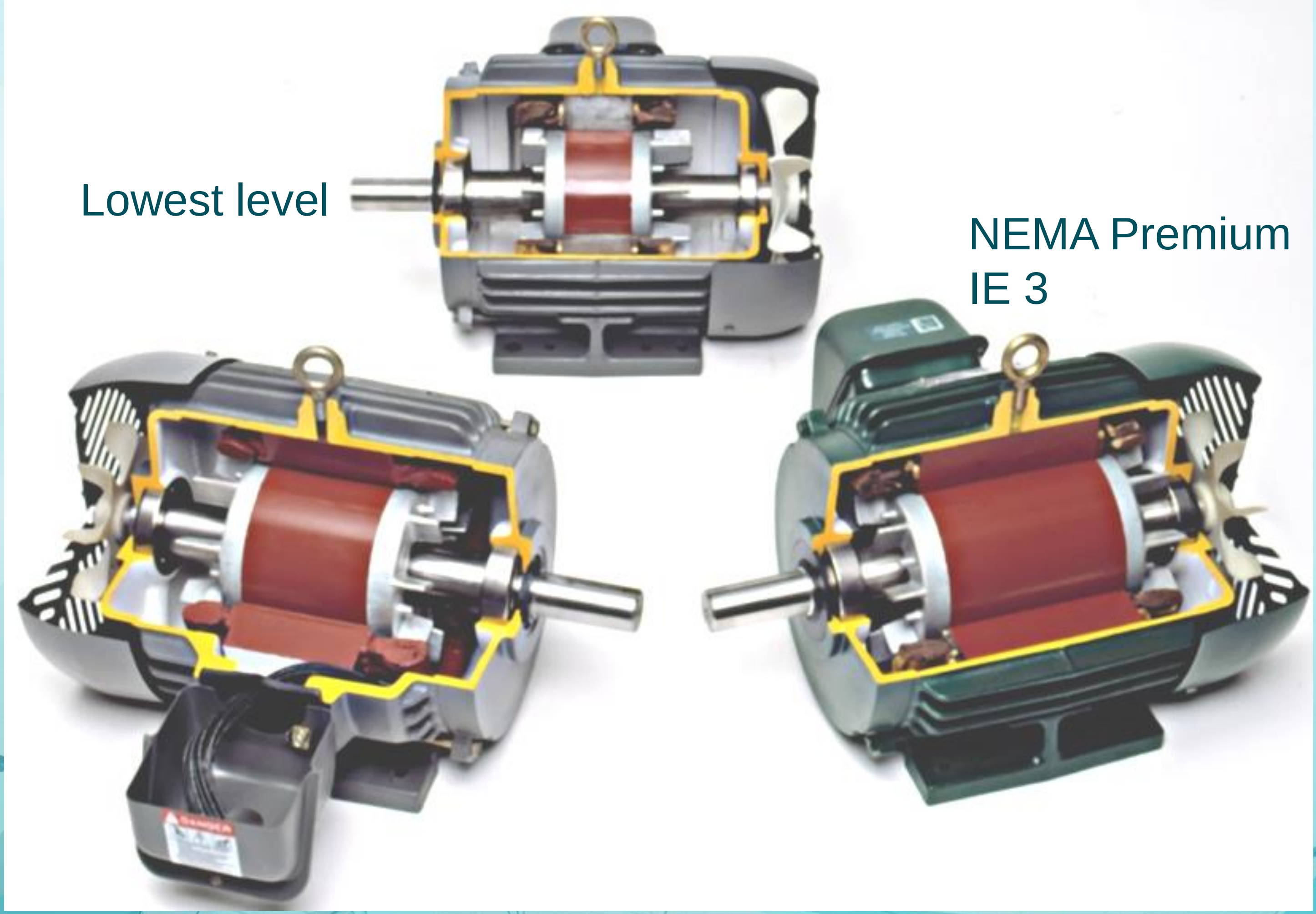


Progression of Active Material Requirements

Lowest level

NEMA Premium
IE 3

Epact 92
IE2



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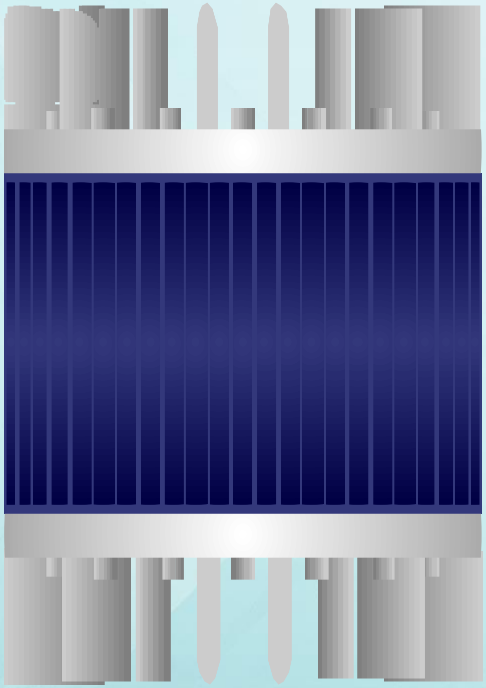
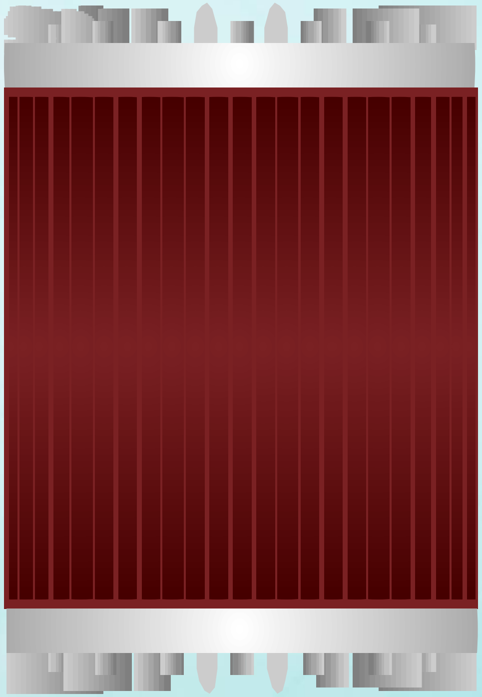
Rotor General Comparison



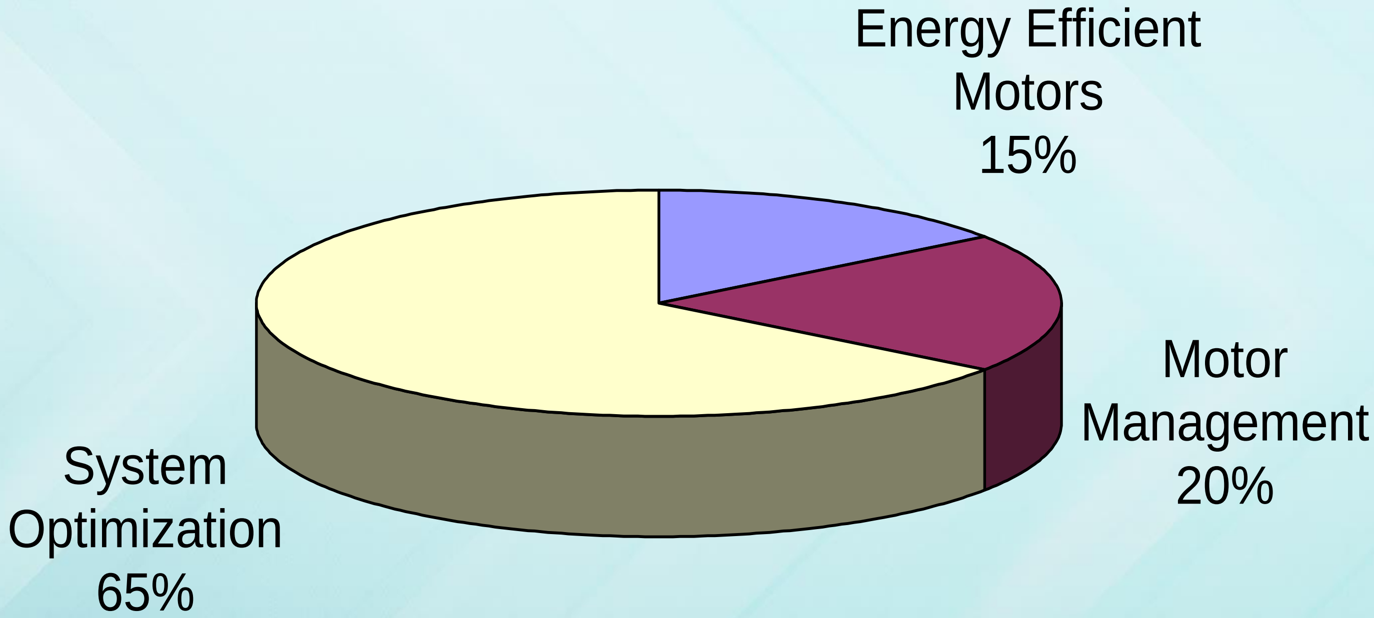


Standard

High

~15% more material

Industrial Motor System Savings Potential



Source: US Dept. of Energy; "United States Industrial Motor-Driven Systems Market Assessment: Charting a Roadmap to Energy Savings for Industry"

Quiz

- Besides changing the design and construction of the motor, what is another common way to increase system efficiency?
- Motor power losses are typically manifested as what?
- Increasing efficiency via material quantity changes is accomplished by 1) adding or 2) subtracting material?

- Adding a Variable Speed Drive (VSD)
- Heat
- 2) Adding material