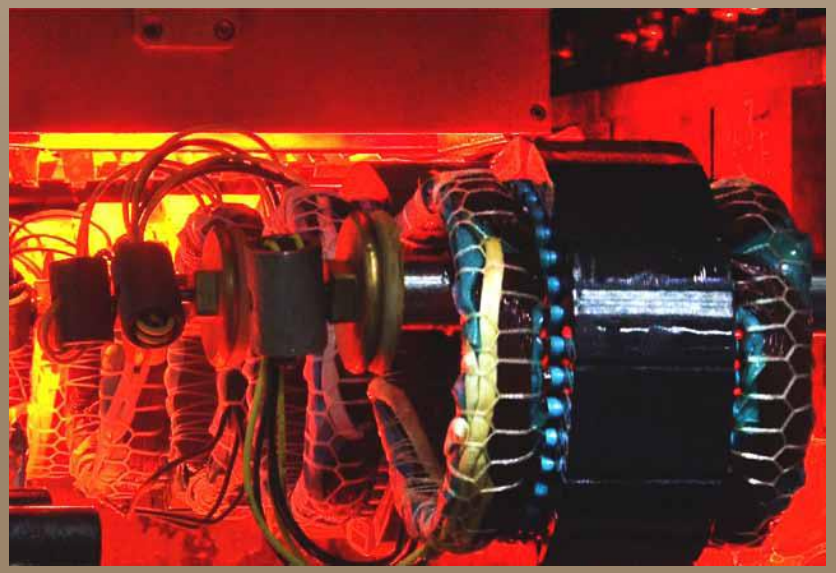
Copper Development Association Inc.
Copper Alliance

Motor Management Best Practices

AEE North Ohio Chapter
Thursday December 12, 2013
Mavis Winkle's
Independence, Ohio



Richard E, deFay
Project Manager, Sustainable Energy
Copper Development Association Inc.

Overview

- *Who is CDA/ Objectives of Presentation*
- *Energy Efficiency Standards*
- *Motor Management Principals*
- *Brief Discussion - New Motor Technologies*
- *Motor Efficiency Testing CRM vs. PM*

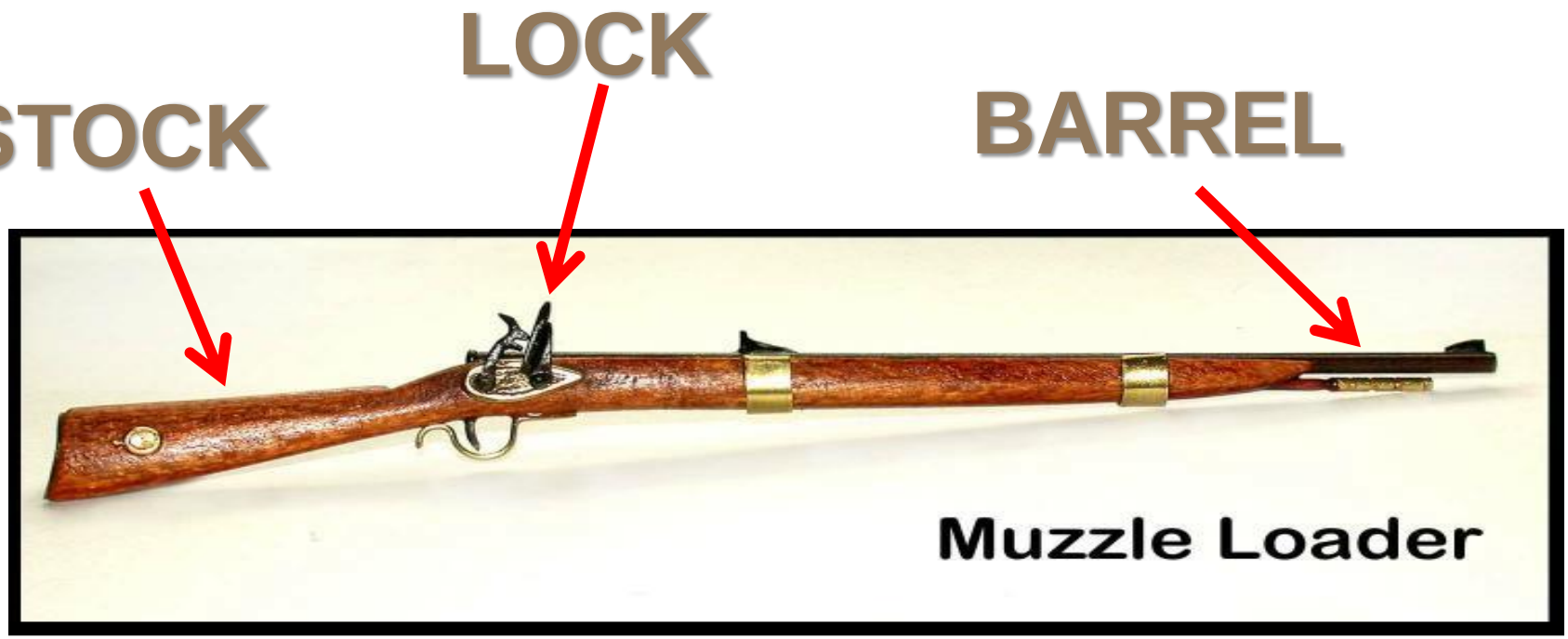
Objective

- To persuade you of the importance of motor management, suggest some tools available to assist in decision making. Additionally to discuss and review recent tests comparing the efficiency of the CRM with the PM motor.

End Result

- You have an awareness of the big picture
- You understand the need to improve efficiency for your own survival
- You are aware of the tools at your disposal

Lock, Stock & Barrel



Get the Lead Out

- Not meant the way we use the term today
- During Colonial times, it was a sign of competence when a militiaman could load and fire his musket at least 4 times in a minute…or in other words, “Get the lead out”. If not, he was relegated to a practice squad.

Copper Development Association, Inc.

CDA, is the market development, engineering and information services arm of the copper industry, chartered to enhance and expand markets for copper and its alloys in North America.

We have different & diverse specialties.

Cu

My Role

To speak at:

- Conferences
- Trade Shows
- Workshops
- Seminars
- Conventions

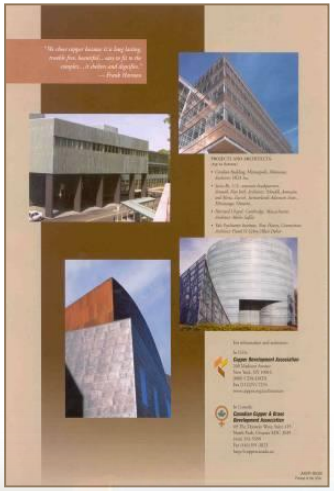
About:

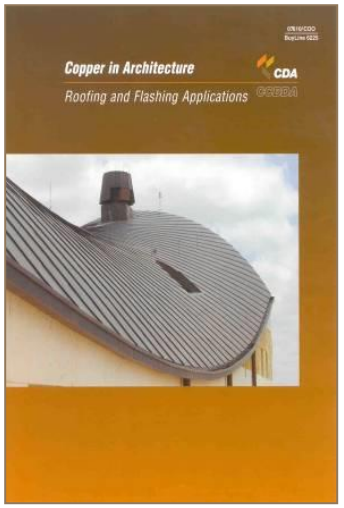
- Energy Efficiency
- Energy Efficient Motors
- MotorMaster+ Software
- Transformers
- Public Health

And their relationship to copper

Building & Construction - Architecture

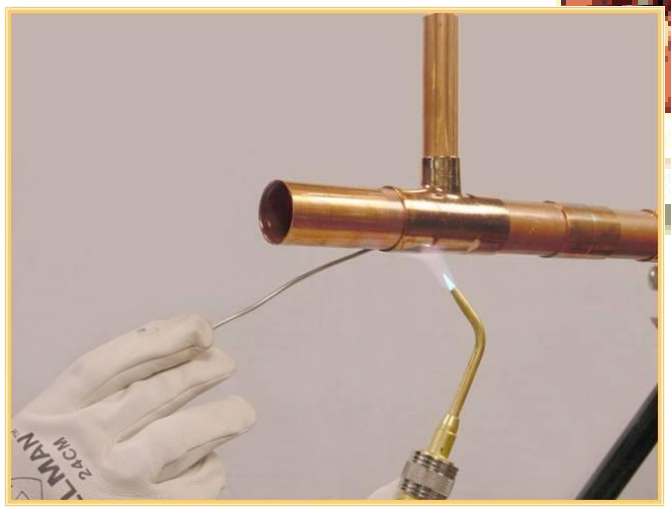
- Seminars
- Design Assistance
- Installer Training
- Research
- Testing & Evaluation





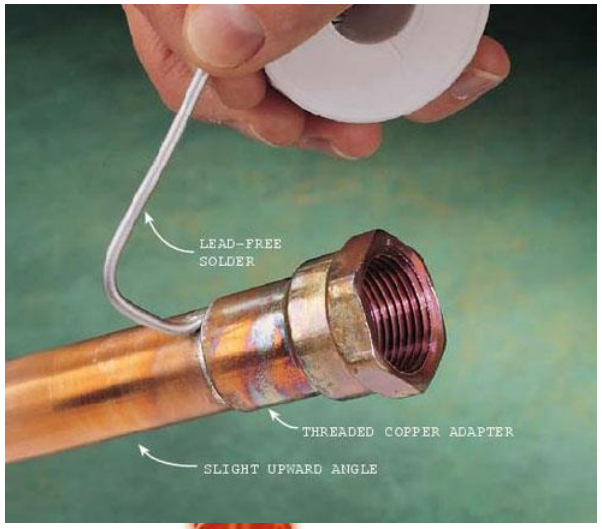
Building & Construction – Pipe & Tube

- Providing training and technical assistance
- Training the trainers to train



Building & Construction – Pipe & Tube

- Teaching proper soldering and brazing techniques to benefit us all.



Building & Construction – Electrical

Building & Construction - Electrical

- Headed by:

  David Brender, P.E. National Program Manager

- Recipient of the 2009 *International Power Quality Leadership Award* for his contributions to the field of power quality. The award was presented at the annual Power Quality & Reliability Conference held in Las Vegas.

Building & Construction – Electrical

- Active on NEC code committees
- Recognized expertise with Power Quality issues
- Electrical energy efficiency
- Providing resources & training

Health & Environment

- Capably headed by Joseph Gorsuch, Manager, Health and Environmental Sciences
- A longtime contributor to the imaging industry with Eastman Kodak and a committed environmental scientist,
- Recipient of the 2009 International Imaging Industry Association Achievement Award

Health & Environment

- Coordinates research on copper's health & environmental impact
- Monitors states for water quality standards
- Offers expert witness testimony in environmental court cases

Sustainable Energy Efficiency

- Motors
- Transformers
- Energy Efficiency
- Sustainable/renewable energy

Sustainable Energy Efficiency

- Motor Management Training/MotorMaster+
- Influence legislation to improve efficiency standards
- Work with DOE on numerous projects
- ACEEE Ally Partner

U.S. Department of Energy
Energy Efficiency and Renewable Energy
Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

Industrial Technologies Program

Sustainable Energy Efficiency

- Coordinate with International Colleagues
- Work closely with other groups

The Association of Energy Engineers

LIANCE TO
VE ENERGY
ing an Energy-Efficient World

ACE3

IEEE

NYSERDA

NEMA

Cu

Background

- NYSERDA Motor Program Audits
  - Conducted 63 motor audits of small to medium Industrial facilities
  - 7,995 motors were inventoried (85% not NEMA Premium)
  - 4,128 motors (51%) meet end-user payback requirements for replacing with NEMA Premium at failure
  - 950 motors (11%) meet end-user requirements for immediate replacement with NEMA Premium
  - Identified potential savings of 7.9 GWh and 1.0 MWh

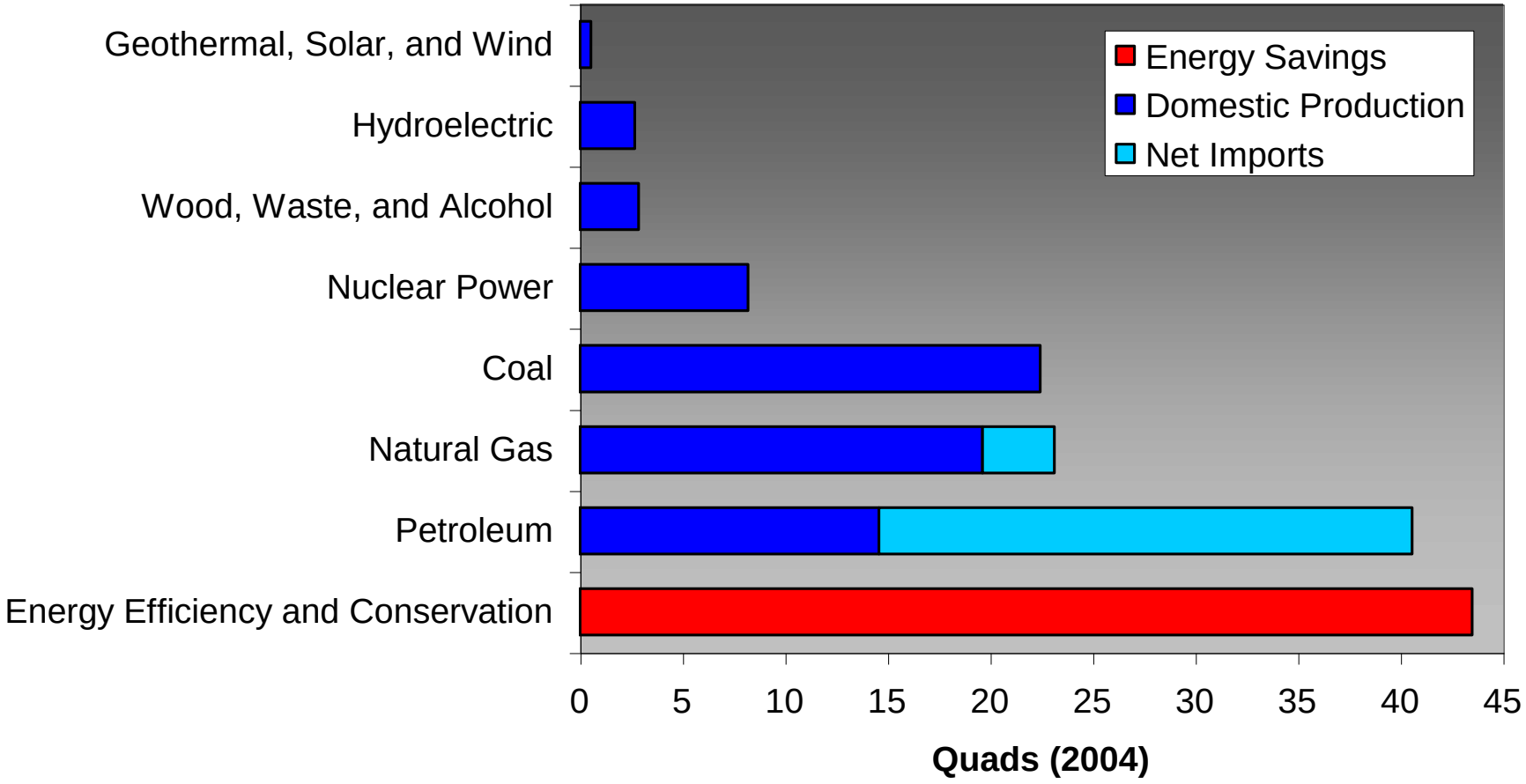
(Courtesy APT)

Why Motor Management?

- Efficiency is our greatest resource to conserve energy
- It is the least expensive means at our disposal
- Motors consume a significant portion of industrial electric energy consumption
- The payback or ROI can be quick and considerable

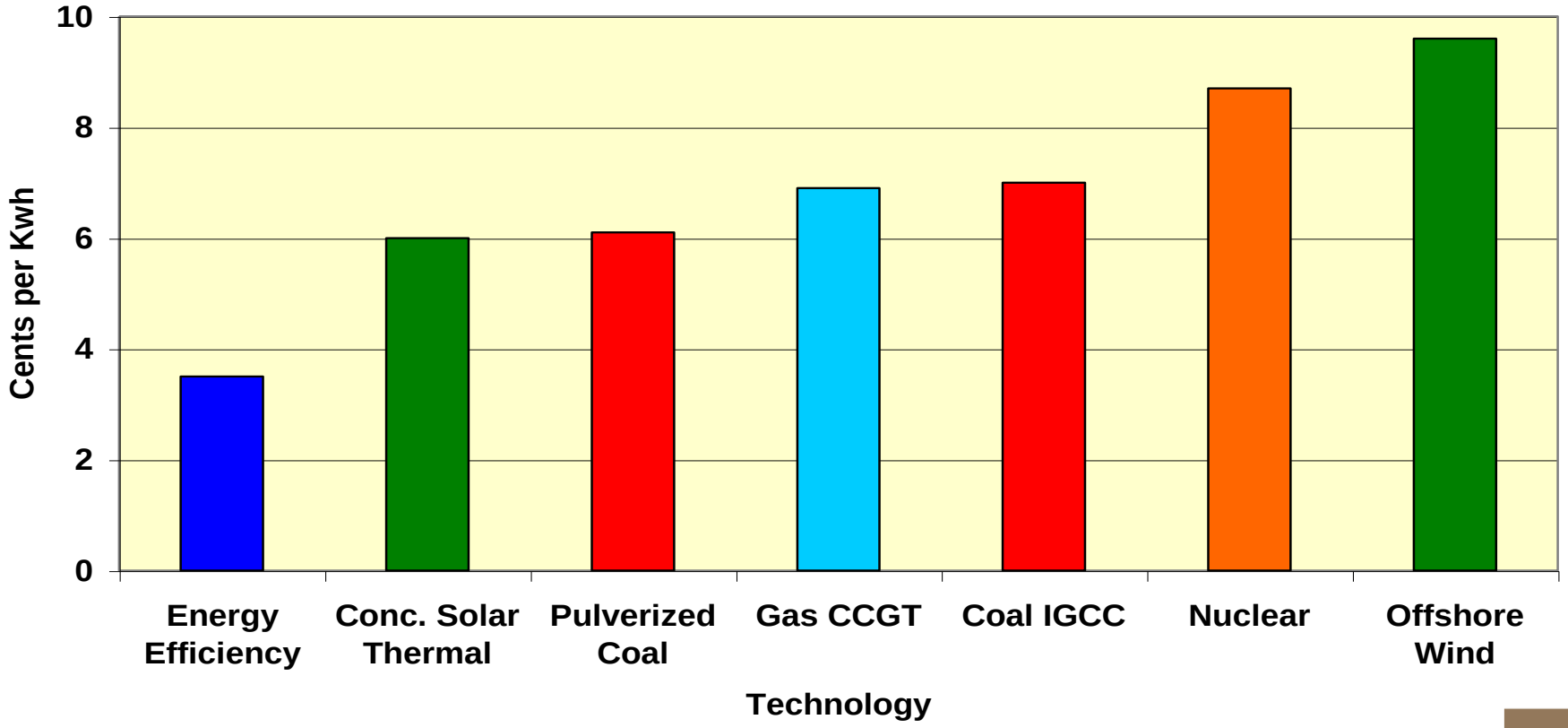
Efficiency: America's 1st Energy Resource

Source: Neal Elliott, PhD. ACEE



Cost of Electricity Resources

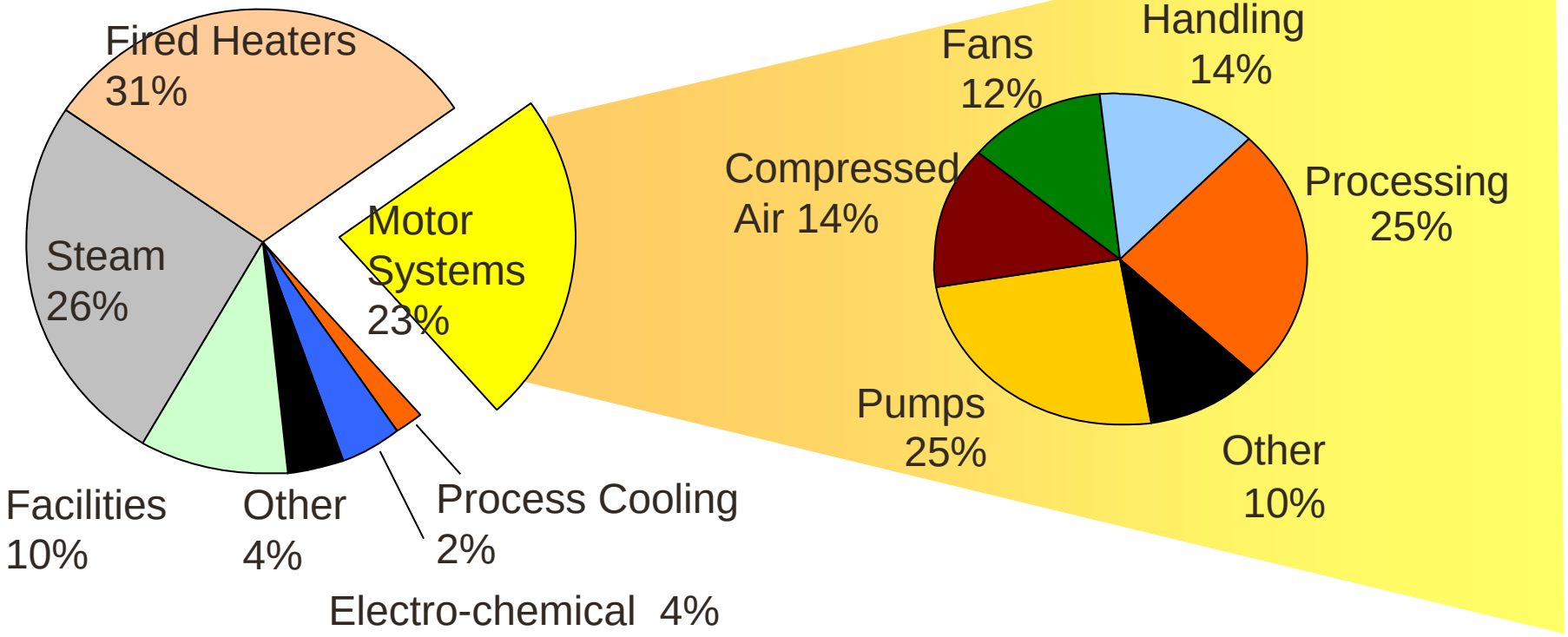
Source: Neal Elliott, PhD., ACEEE 2006, EPRI 2006



Motor Background

- US - 1.4 Million 3-phase, 1-200 HP motors sold annually
  - HVAC, compressed air, process systems, pumps, fans, conveyor systems, etc
  - These motors consume 679 BILLION kWh's per year
  - HVAC motors can account for 30-50% of commercial energy use
  - Up to 65% of industrial energy use
  - Up to 23% of all electricity consumed in the US

Industrial Electrical Energy Use

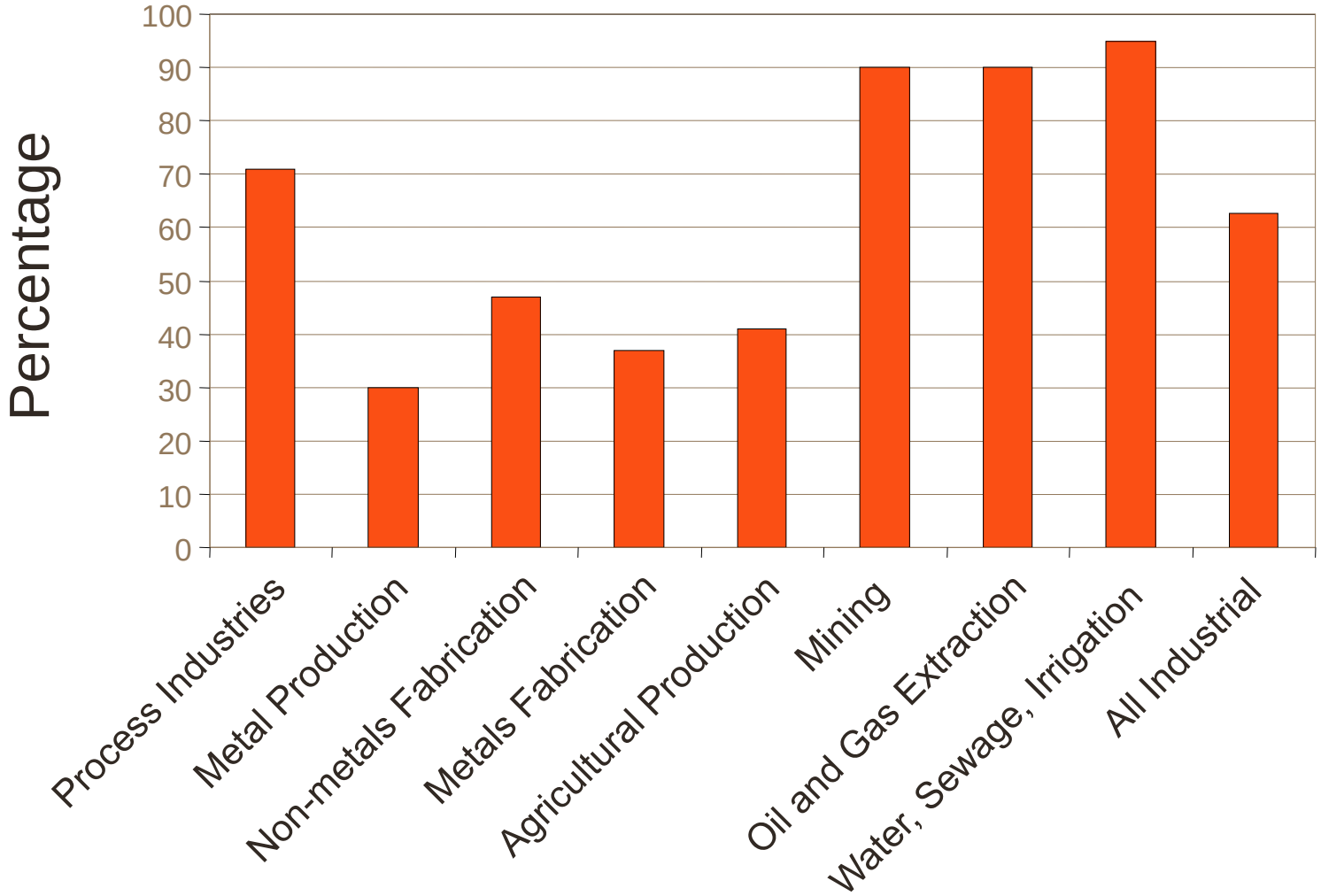


Source DOE

Includes electricity generation/distribution/transmission losses

Percent of Electric Energy Driving Motors

Source: Gilbert McCoy WSU

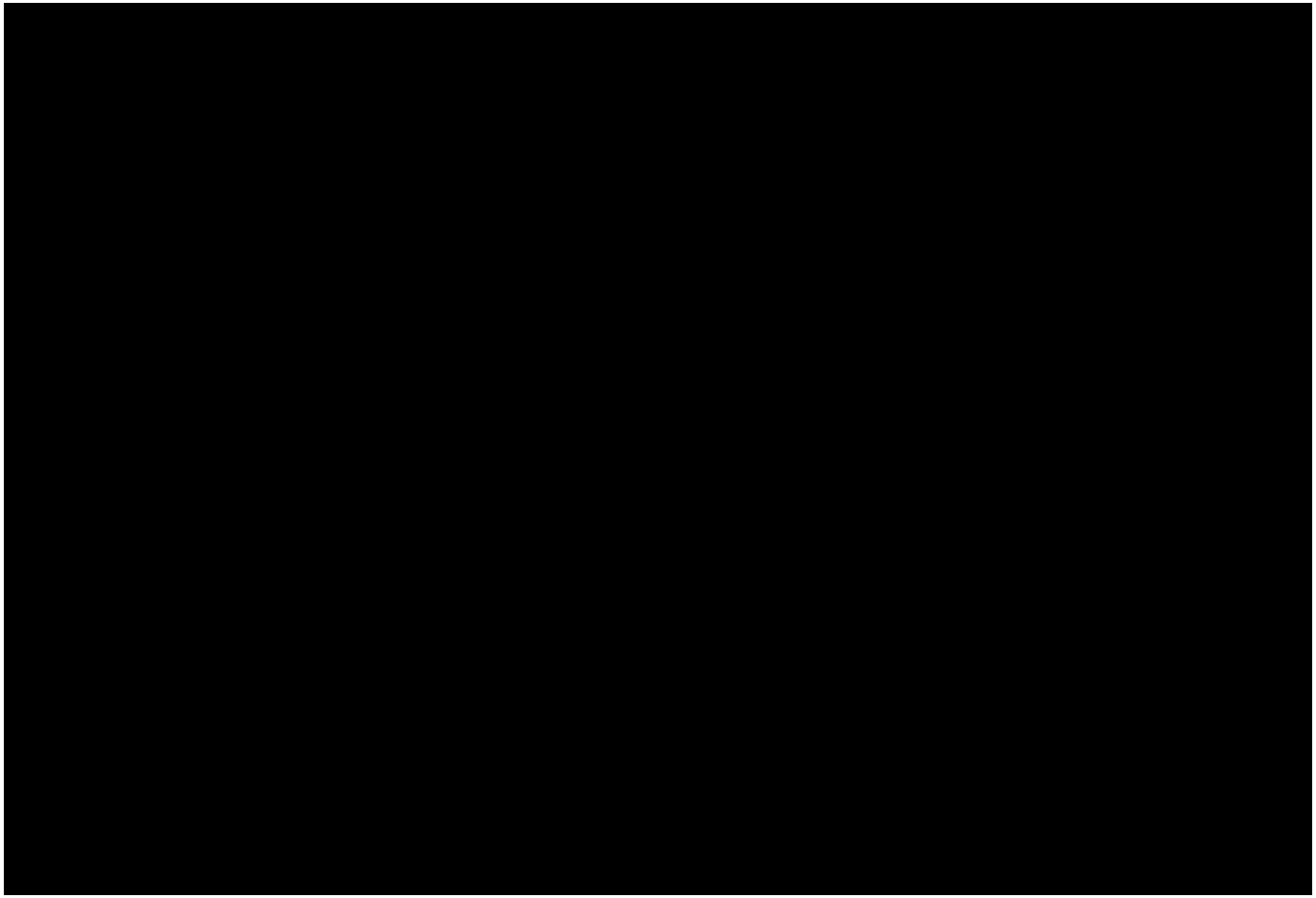


Cu

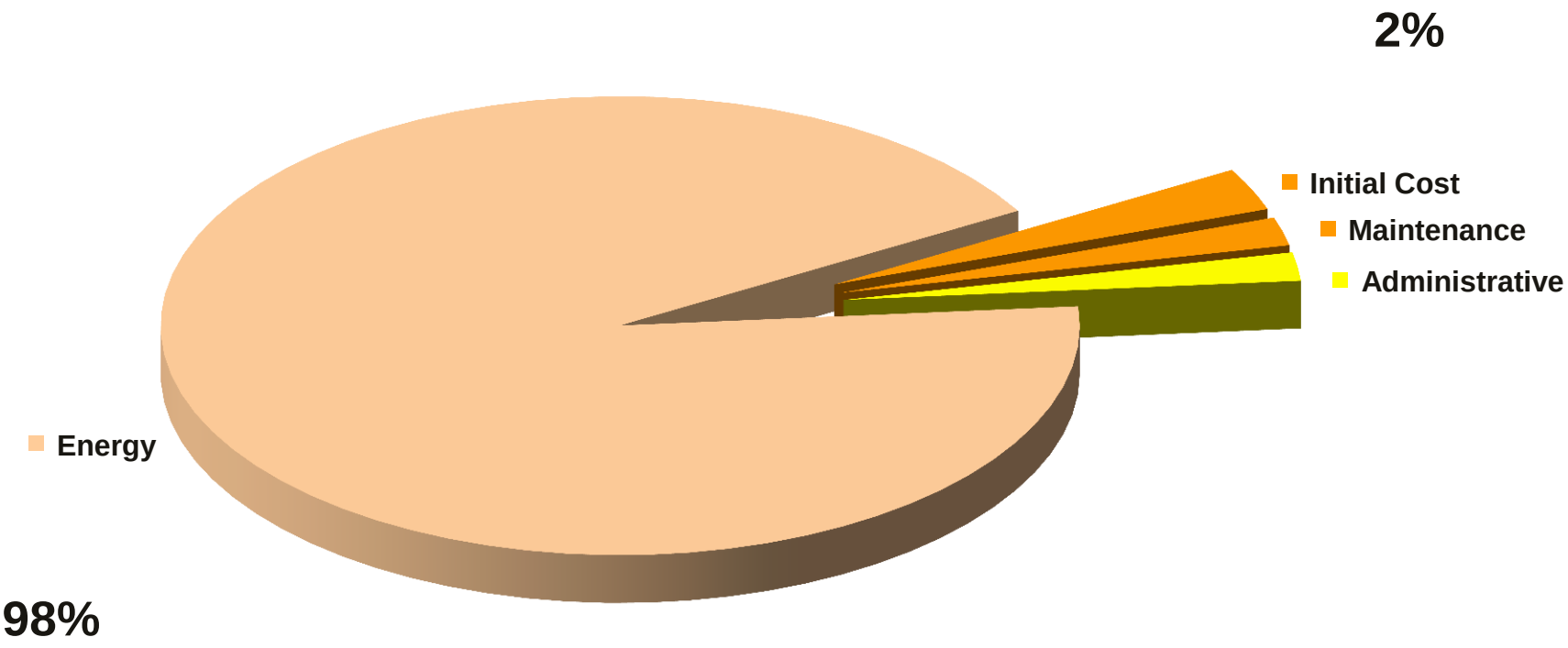
Why should motors matter?

- To an industrial facility, school, hospital or commercial building
  - To buy them (capital cost)
  - To operate them (operating cost)
  - At failure (downtime, loss of productivity)

Down Time



Did you know



Thus……

- If the purchase price of a motor represents 2% of the cost of ownership
- And the operating cost represents 98%
- The question that needs to be addressed…

Which is more important to control?

If you had to guess…

- How much does it cost to run a 40 HP EPAct efficient motor

- Assume 8760 hours/year at $0.10 kWh

Answer

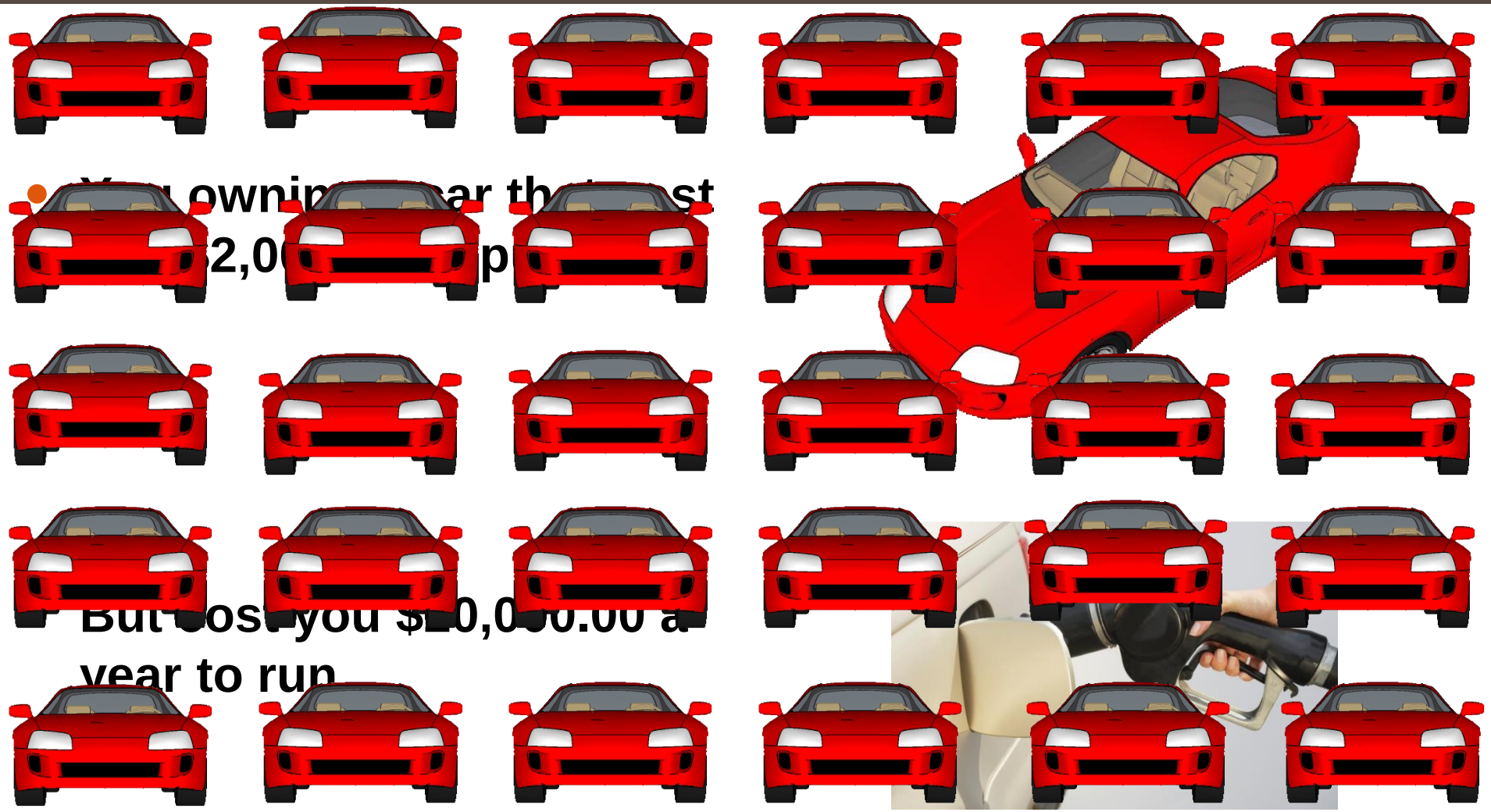
- Just shy of $20,000.00

Thus:

- If a motor cost less than $2,000.00 to purchase

- And you pay 10 times its cost to run it each year

It Would Be Like



- Y[illegible] ownin[illegible]ear th[illegible]st $2,0[illegible]p
- But cost you $1[illegible]0,000.00 a year to run

What if you had a fleet of 30 of them?

It’s not about first cost

- If a 100 HP TEFC EPACT motor costs ~ $6,300.00
  - It costs ~$38,985 to operate per year!

    (or 623% of first cost)

    @ $.054/kWh & $4.87/kW, 8150 hrs/yr, 100% load

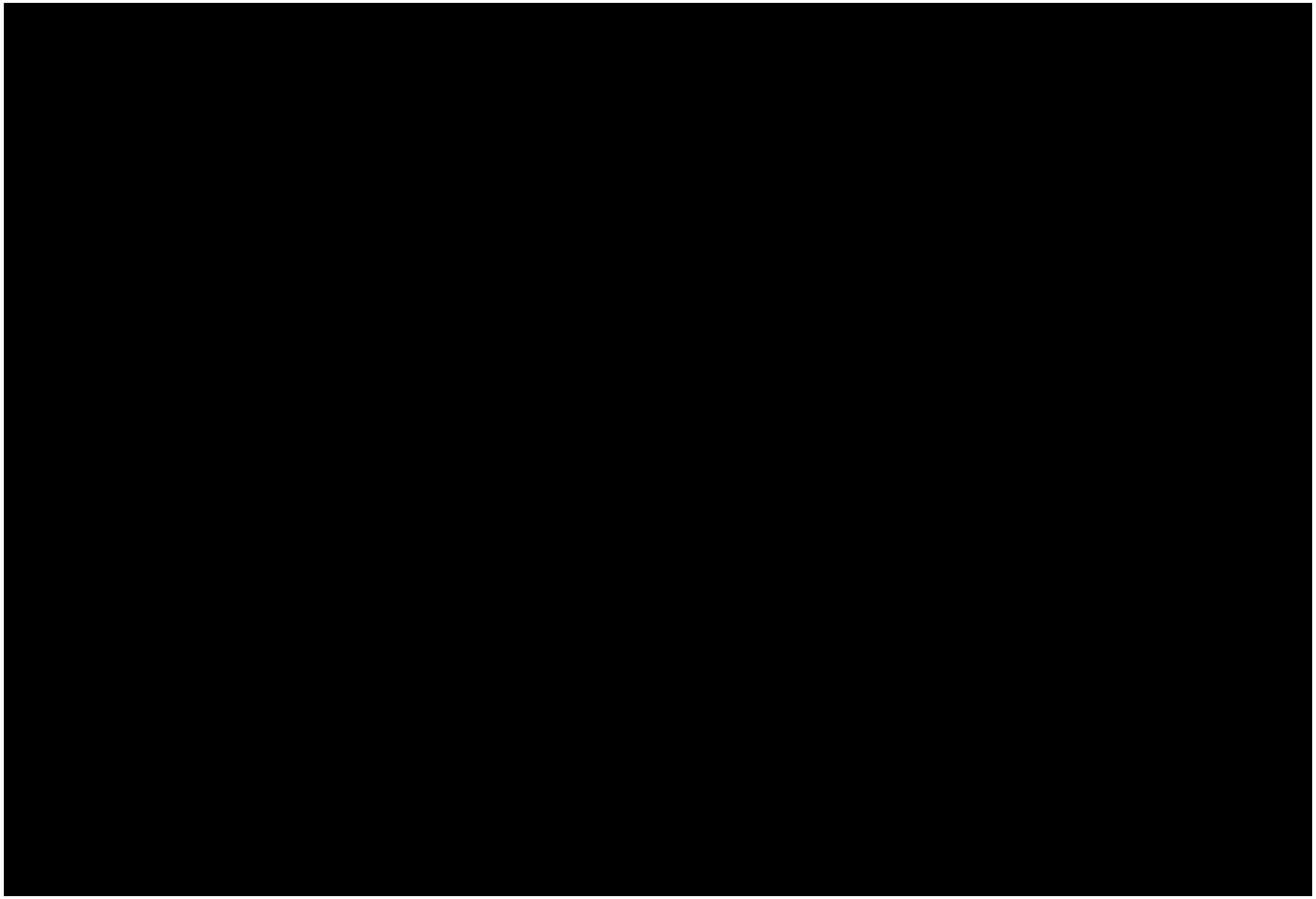
Now consider a car: First cost ~ $25,000

At $3.00/gal, annual fuel costs are about $2,500 or 10% of the purchase price of the vehicle driving 20,000 miles/year @ 24 mpg

Equivalent rate of use

- If a car used energy at the same ratio of first cost to annual operating cost as a motor:
  - ---It would have to be driven about 216,375 miles every two months or
  - ---Gasoline would have to be priced at $311.58/gal

Life Cycle Cost Analysis



If you remember one thing remember this:

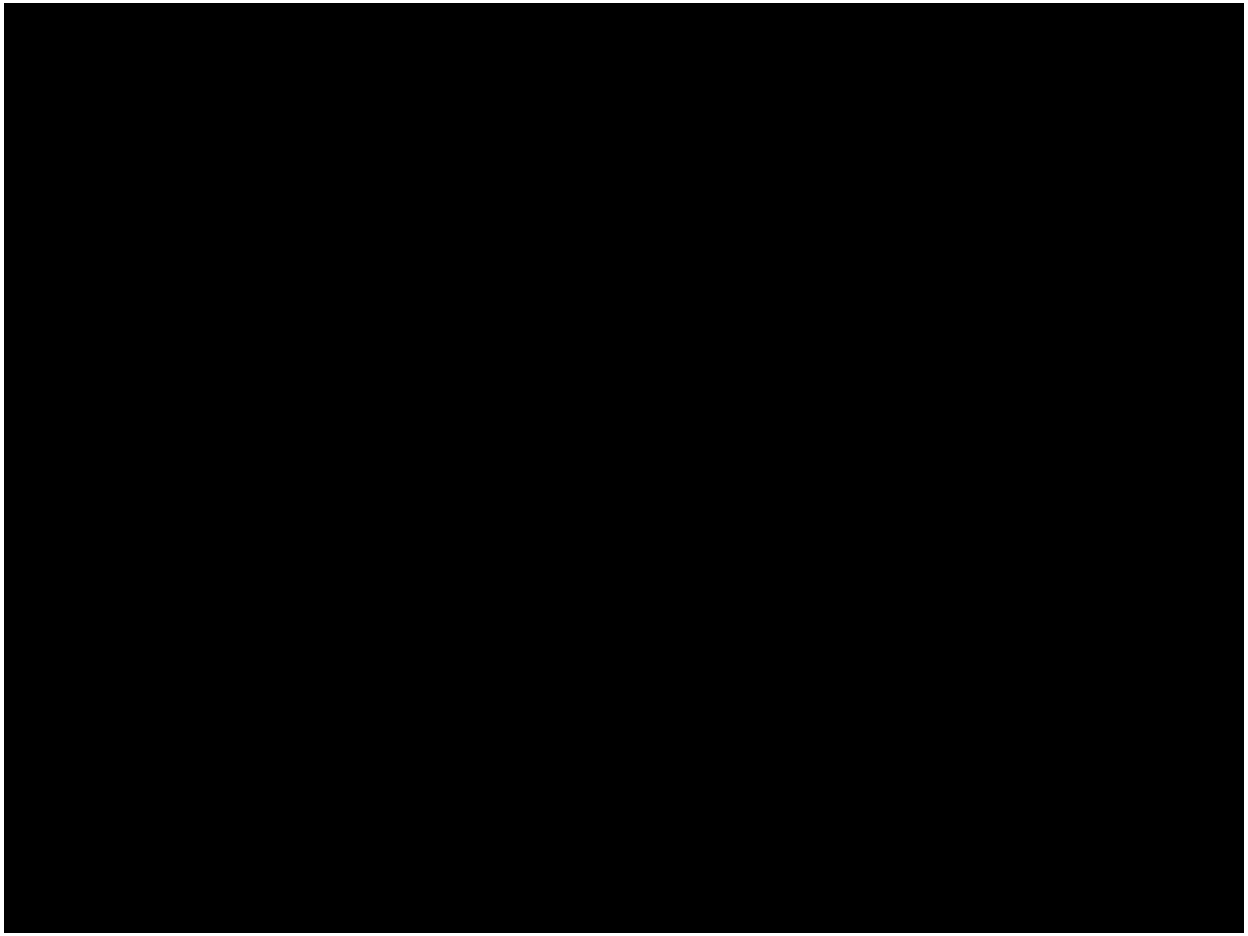
- It is not about first cost
- It’s about life cycle cost

Waiting cost you

Developing a Motor Management Plan

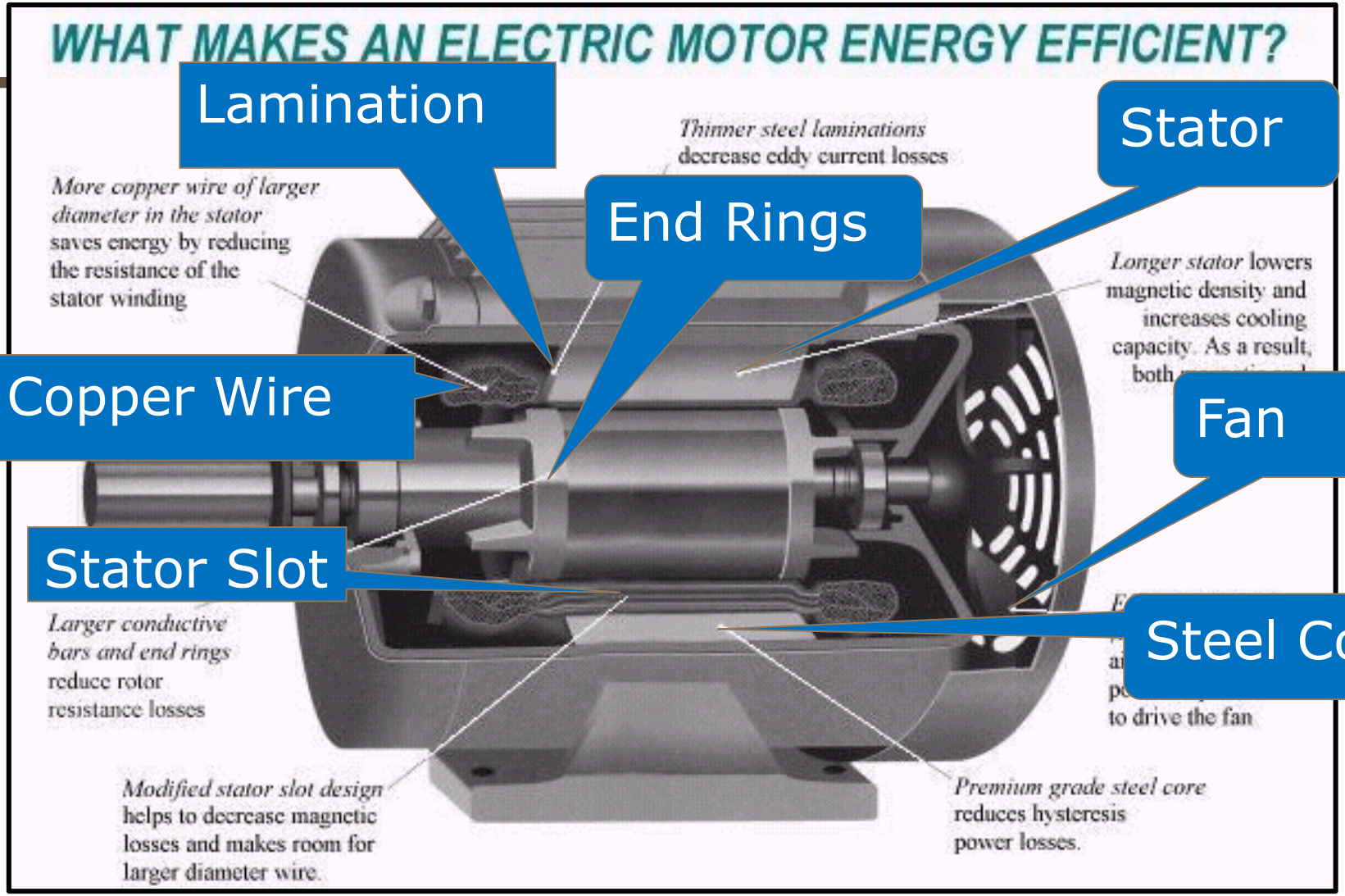
- Starts with an assessment of your motors – creating a survey
- Repair/replace guidelines
- Create a motor failure policy
- Purchasing Specifications
- Repair specifications
- Predictive/preventive maintenance

Motor Management Best Practices

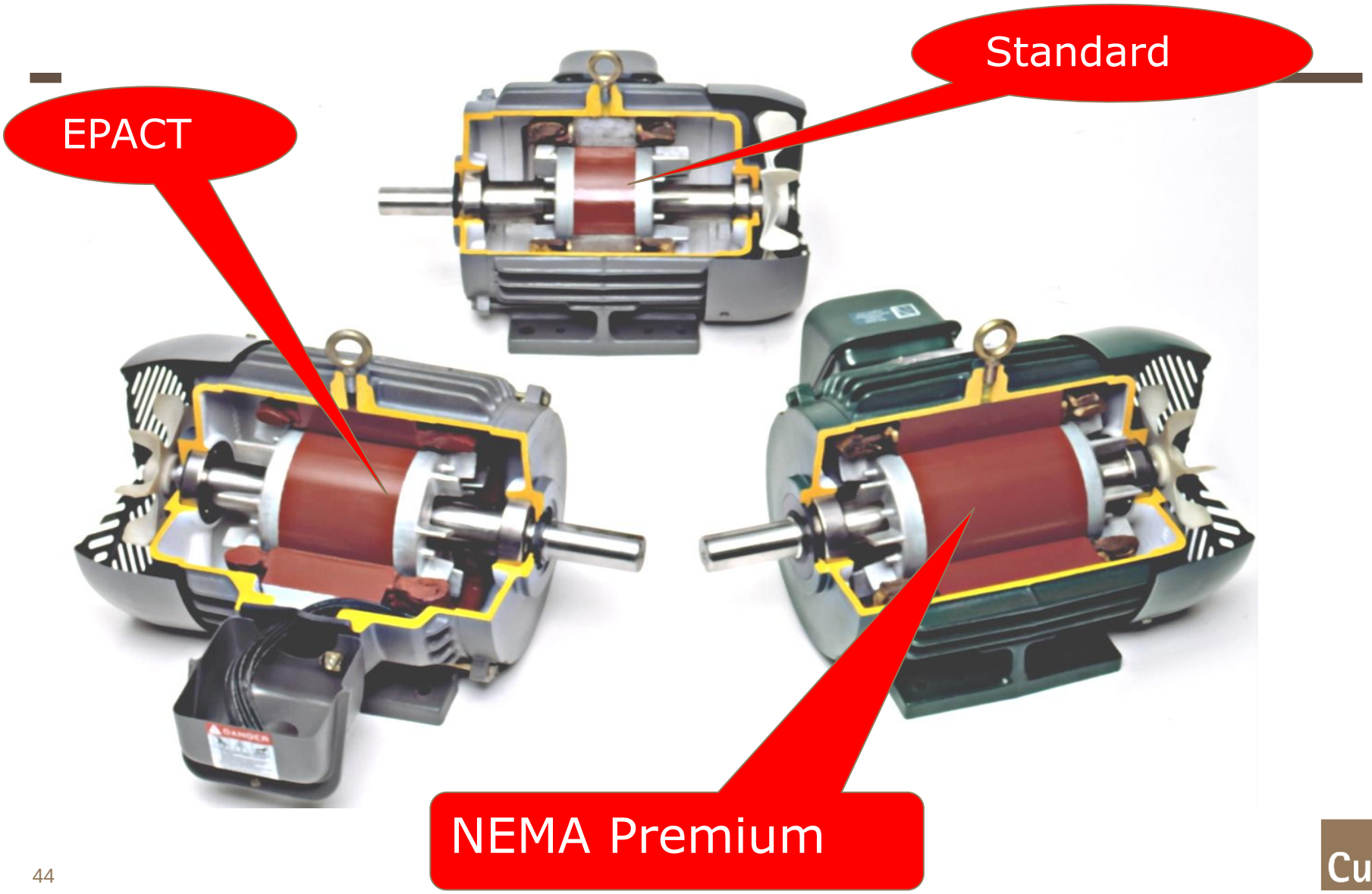


What makes an energy efficient motor?

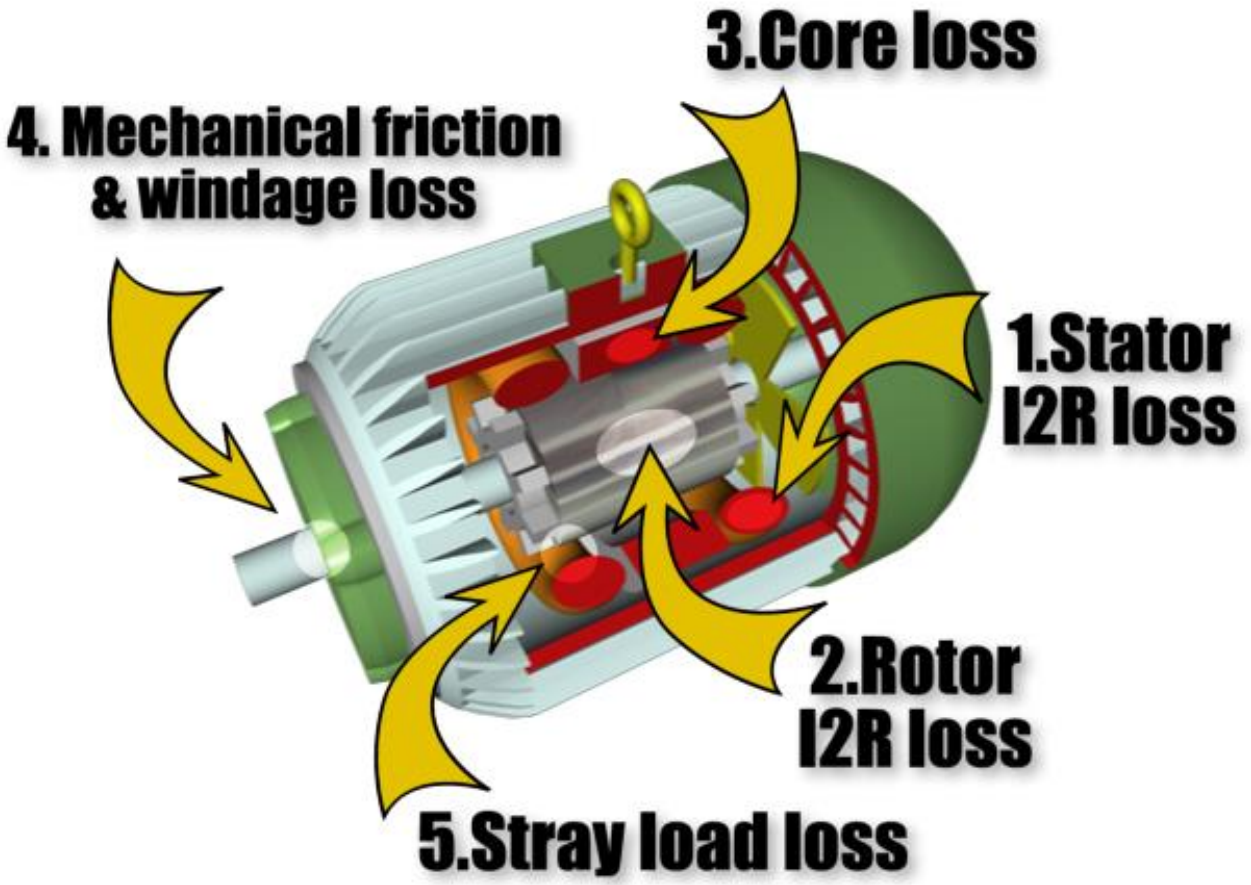
Key ingredients



How they are made

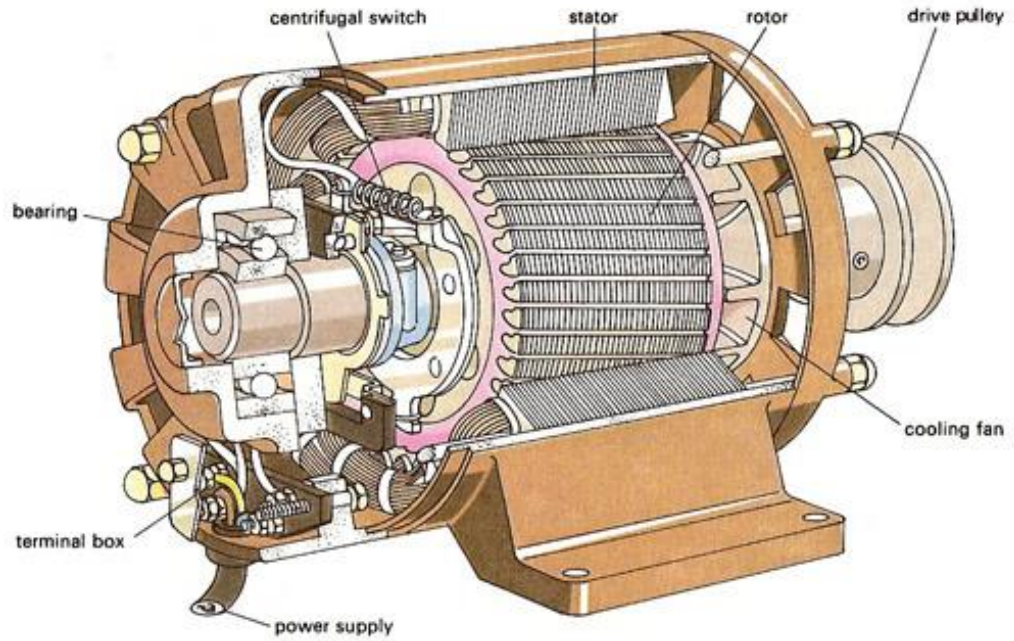


Motor Heat Losses



Motor Efficiency Standards

- Standard Efficient
- EPAct 92
- NEMA Premium
- Above NEMA Premium



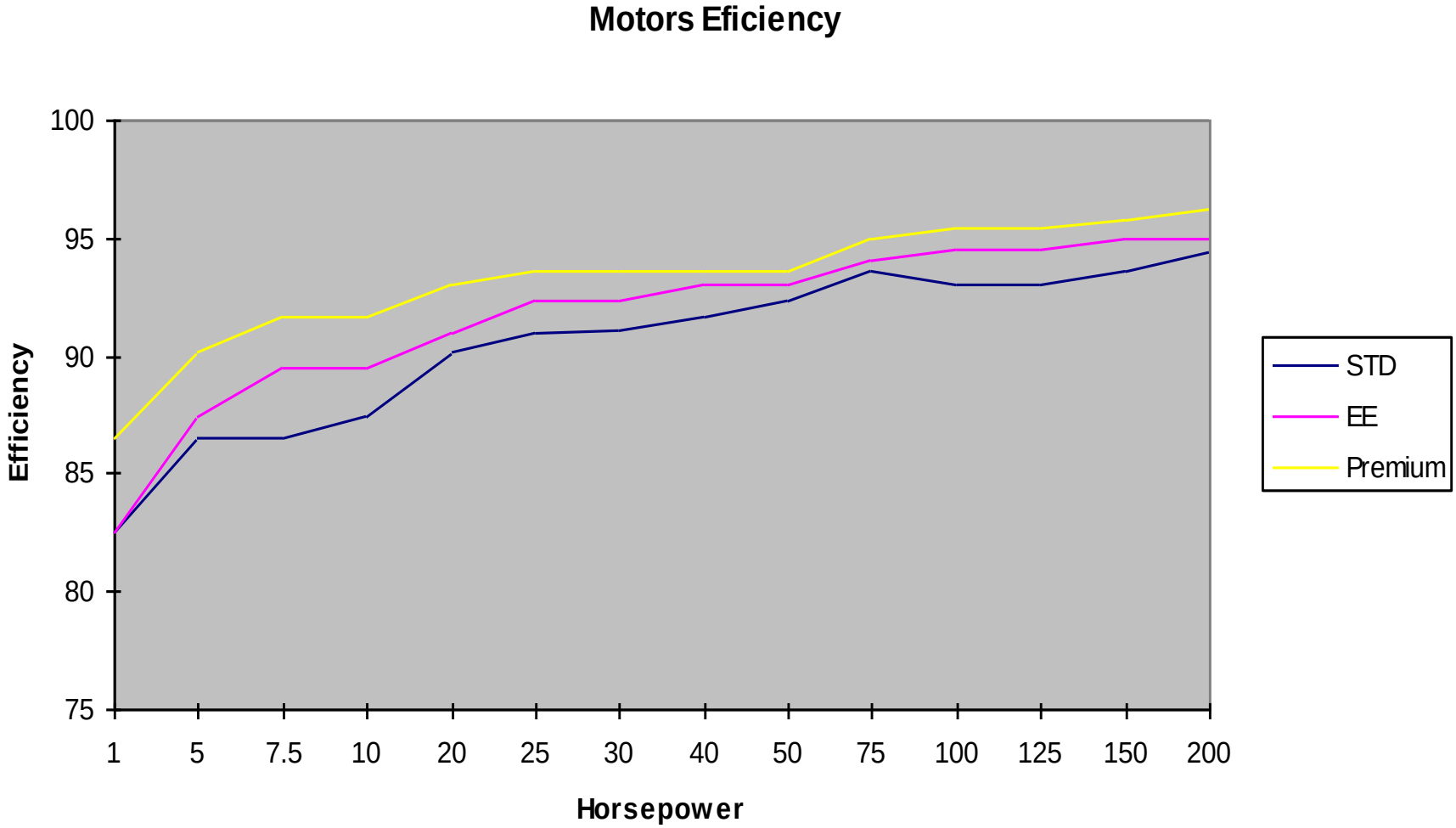
Background: EPAct motors

- Energy Policy Act of 1992
- General purpose
- 1-200 HP
- 3 phase (220/460/575 volt)
- NEMA design “A” & “B”
- ODP & TEFC
- 1200, 1800, 3600 RPM

NEMA Premium

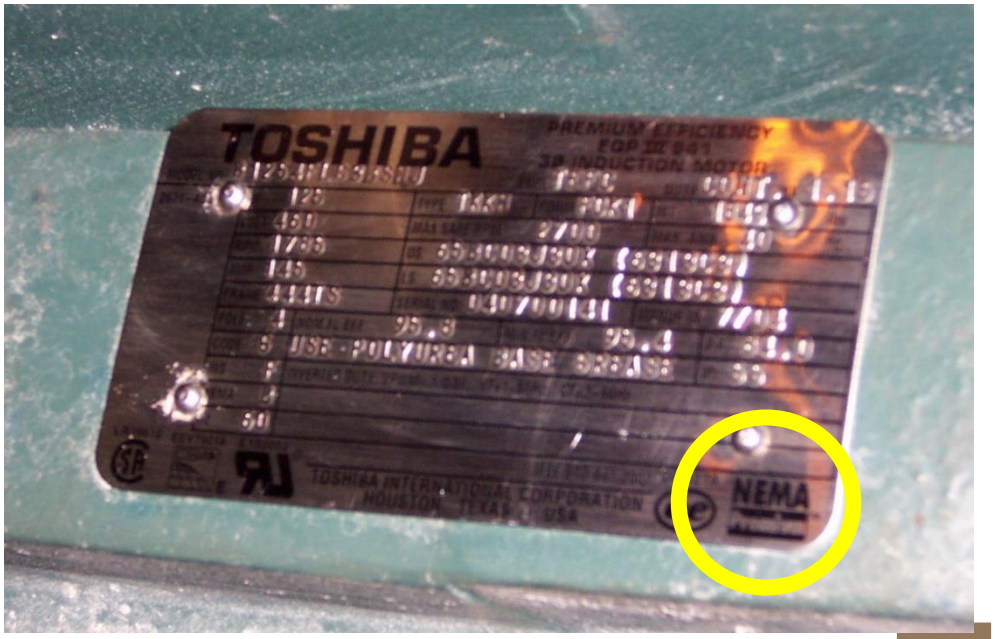
- Standard for premium efficient motors adopted by manufacturers
- .5 to 4% more efficient than EPAct
- Run cooler
- Extended warranties
- Claims of reduced downtime and increased reliability
- Simple payback
- **Less expensive to operate**

Three levels of efficiency



How do we find efficient motors

- NEMA premium label where it appears



Are you aware…

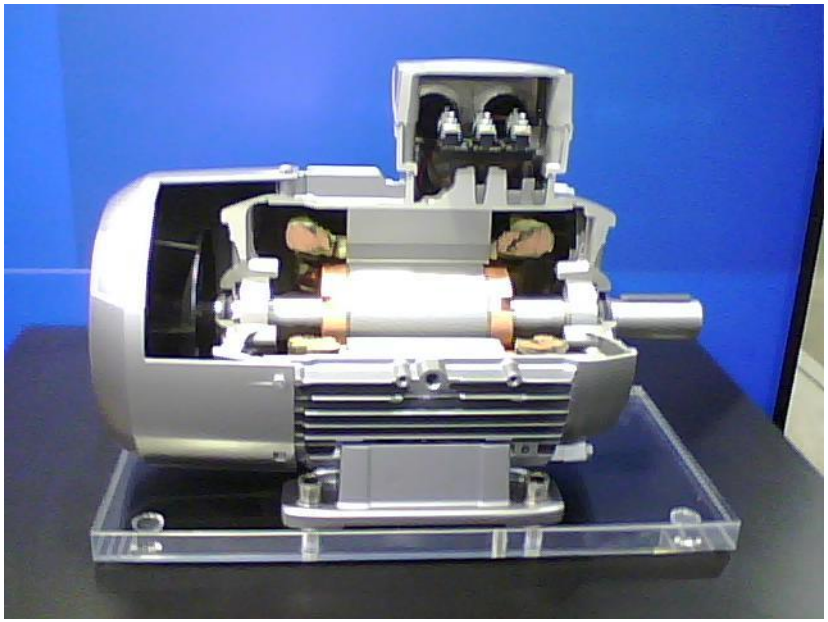
- The NEMA label used to be voluntary

How do we find efficient motors

- NEMA premium label where it appears
- MotorMaster+ software

How do we find efficient motors

- NEMA premium label where it appears
- MotorMaster+ software
- Manufacturer's literature
- Many available motors exceed NEMA premium efficiencies

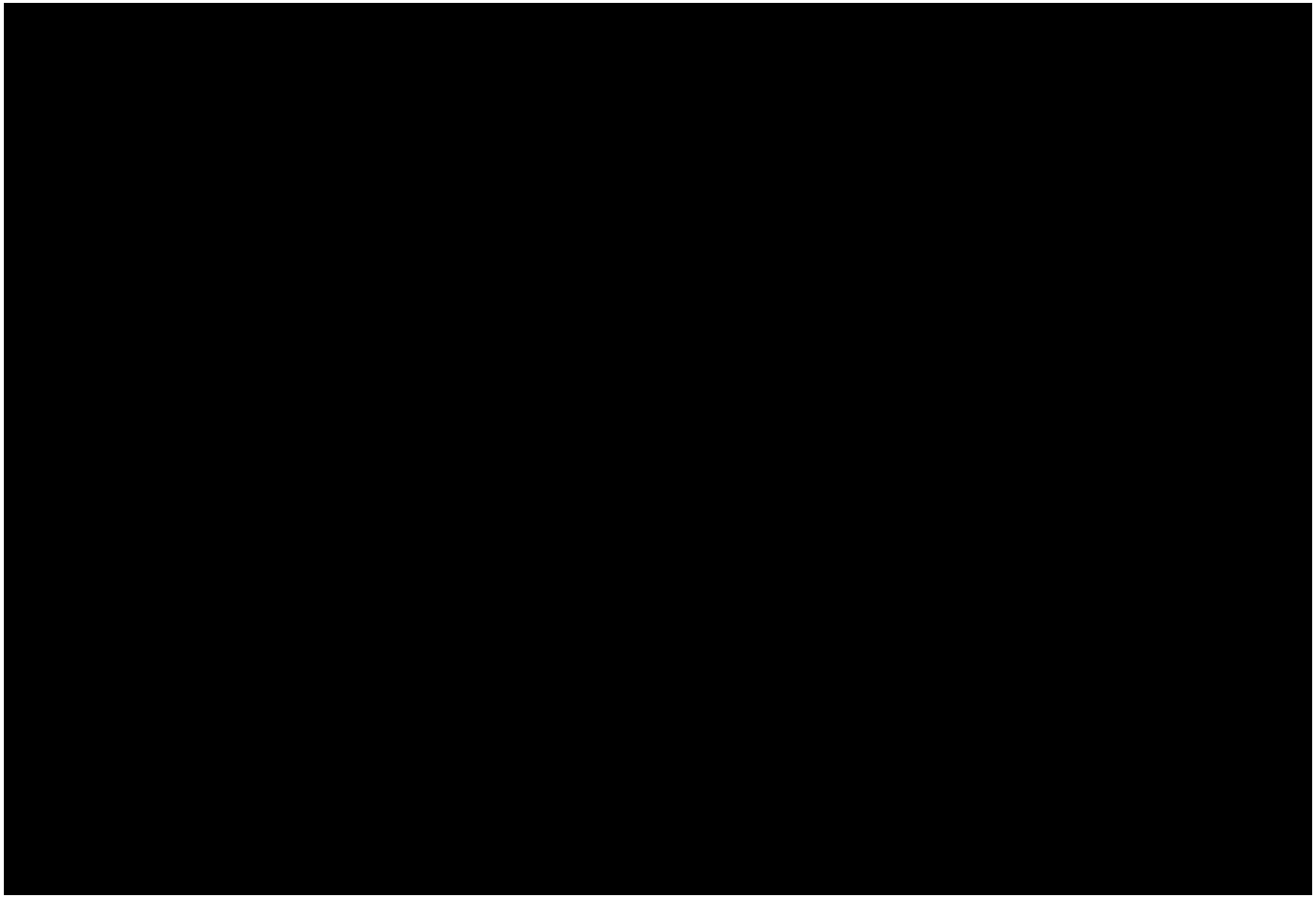


Caveat:

Premium efficient motor differences are:

- Operationally:
  - Different speed
  - Starting torque
  - Starting current characteristics
- Physically:
  - May or may not be same weight
  - Physically the same size
- Construction:
  - Higher slot fill in copper winding
  - Use thinner laminations of steel (alloy also modified)
  - Reduced air gap
  - Redesigned cooling fan
  - Improved bearings
- All engineering parameters must be taken into account when considering motor replacement

Caveat



New Technologies

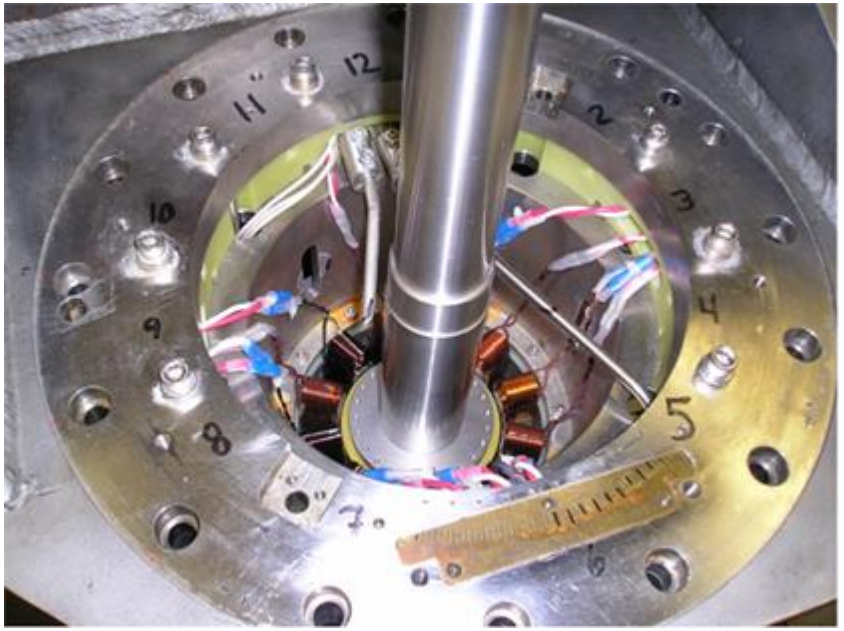
- More is better
- Switched Reluctance Motors
- Permanent Magnet Motors
- Copper Rotor Motor

Induction Motors

- More is better
  - More copper in windings
  - Higher grade steel core
  - Improved bearings/insulation
  - Improved fan design

Switched Reluctance Motors

- The basic design elements



Courtesy Gil McCoy, WSU

Main Advantages

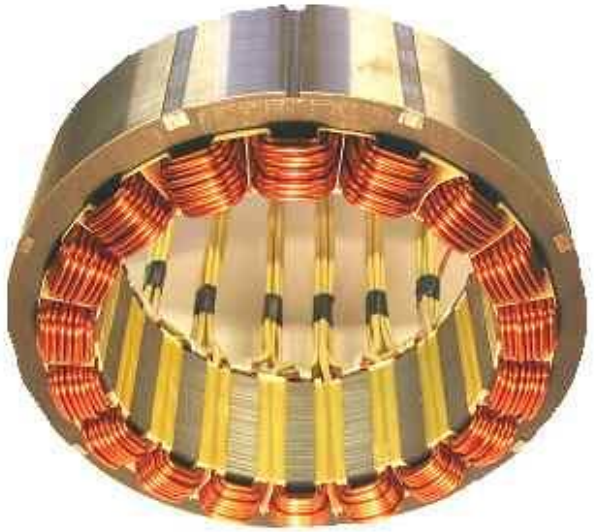
- Advantages
  - High efficiency
  - High torque and speed
  - High reliability and long lifetime
  - Simple and robust construction
  - Low cost
  - Simple controller(1 power switch per phase
  - High power density
  - Available in different sizes and shapes

Disadvantages

- Ripple torque,
- High vibration level
- High acoustical noise
- Converter always necessary

SR Applications

- Washing machines
- Vacuum pumps
- Centrifugal machines
  - Compressors
  - Pumps
- Vacuum cleaners
- HVAC
- VSD systems
- Automation
- Traction
- Machine tools



Permanent Magnet Motors

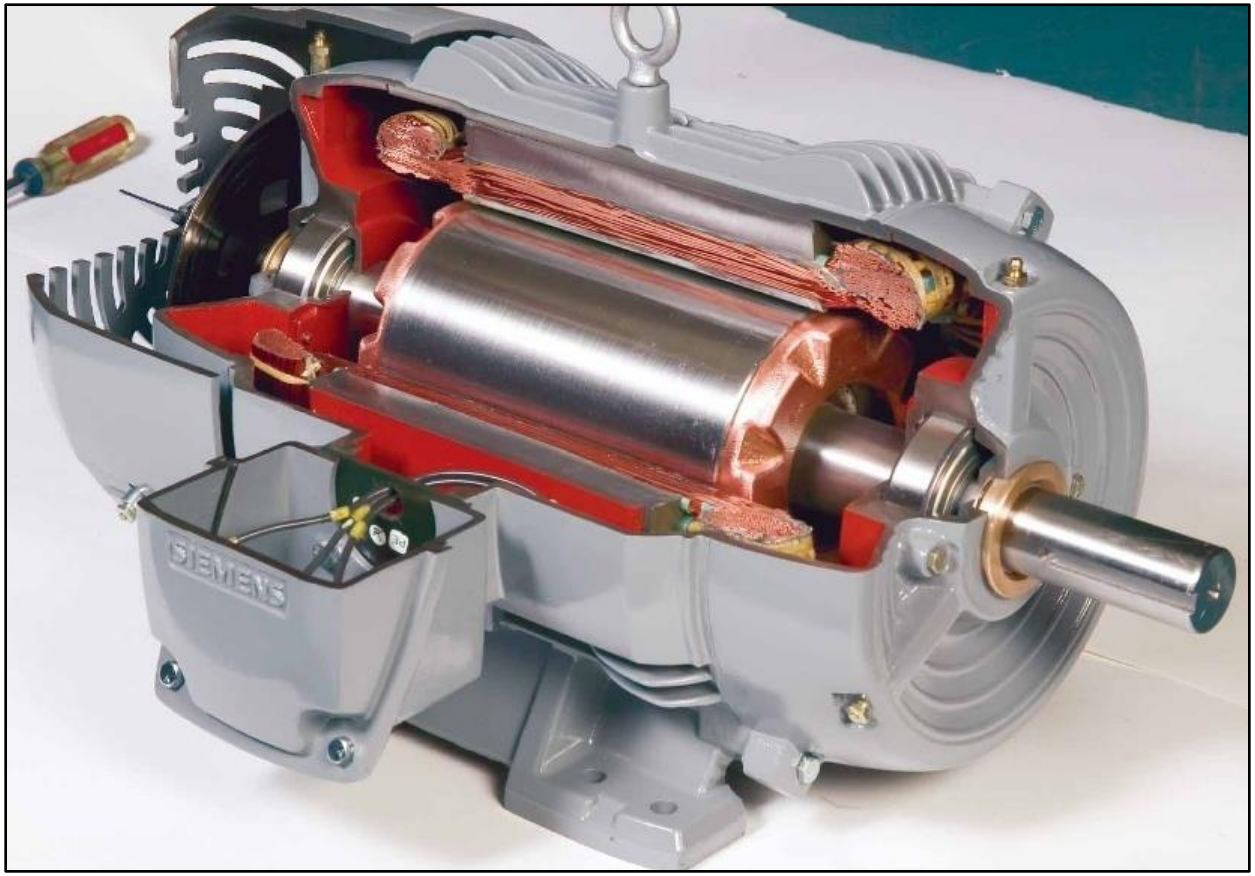
- A brief overview of the technology of the PM Motor

Courtesy Gil McCoy, WSU

Permanent Magnet Motor Advantages

- Main Advantages
  - Excellent torque-speed curve
  - Excellent dynamic response
  - High efficiency and reliability
  - Low maintenance
  - Longer lifetime
  - Low acoustical noise
  - High speed capability
  - High torque/volume ratio or high power density
- Main Disadvantages
  - High cost
  - Need for a VSD except for Low speed PM.
  - Rare Earth Material availability

The Cast Copper Rotor Motor



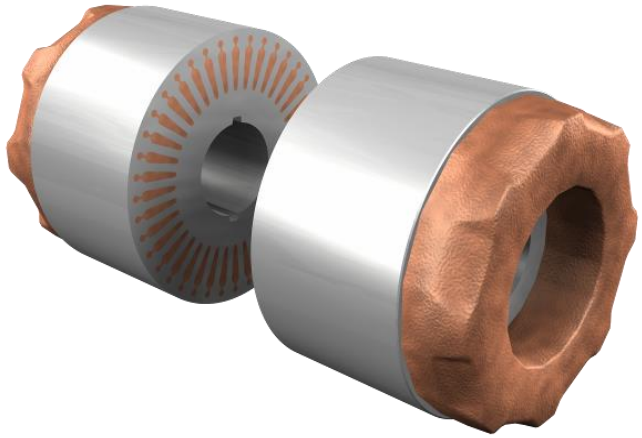
Design objective

- Electric Motor Efficiency Improvement

- Development of mold (die) materials and processing for cost effective mass production of a copper rotor motor

Die-mold considerations

- Previously, die cast copper rotors had not been economical to make because:
  - The melting point of CU (1083C) made die casting more difficult than using AL (660C) because of the much higher temperature requirements



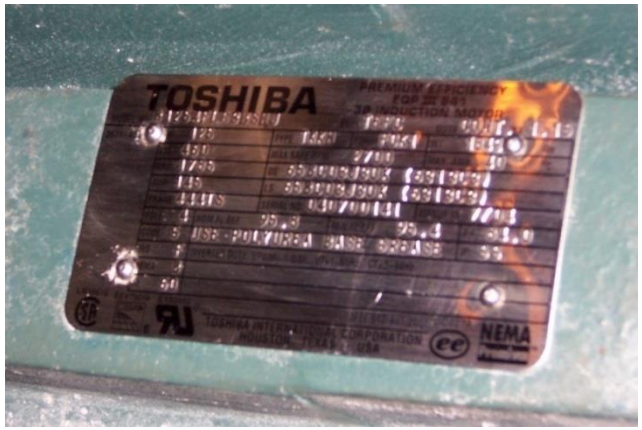
Die material testing

- Many problems occurred with traditional mold materials:
  - High temperature requirement to melt copper
  - Substantial latent heat
  - Thermal shock
  - Thermal fatigue (heat checking)
  - High operating temperature meant loss of die strength
  - In previous attempts, molds lasted only a few shots

Cu

Conductivity of CU – 60% higher than AL

- Using a copper rotor instead of aluminum, of the same motor design, an additional 10-15% reduction of motor losses (input/output method)could be achieved
- This loss reduction translates to between a 1% to 5% increase in motor nameplate efficiency
- Resulting in:
  - Reduced energy consumption
  - Reduced environmental impact
  - Reduced motor weight



Cu

Implications for improvement

- In motor efficiency:
  - Would create a “Super” or “Ultra” premium efficient motor product
  - With above NEMA premium efficiencies
  - By replacing the AL rotor with CU

Cross-section of cast-copper rotor

Advantages/Disadvantages

- Advantages
  - Less porosity than AL rotor
  - Reduced I2 R losses/runs cooler
  - Efficiency increase above NEMA Premium
  - Longer warranties
  - Longer potential life
- Disadvantages
  - Fluctuating copper and steel prices
  - Requires different die mold materials
  - Manufacturing machine retooling
  - Tooling machinery may not be available

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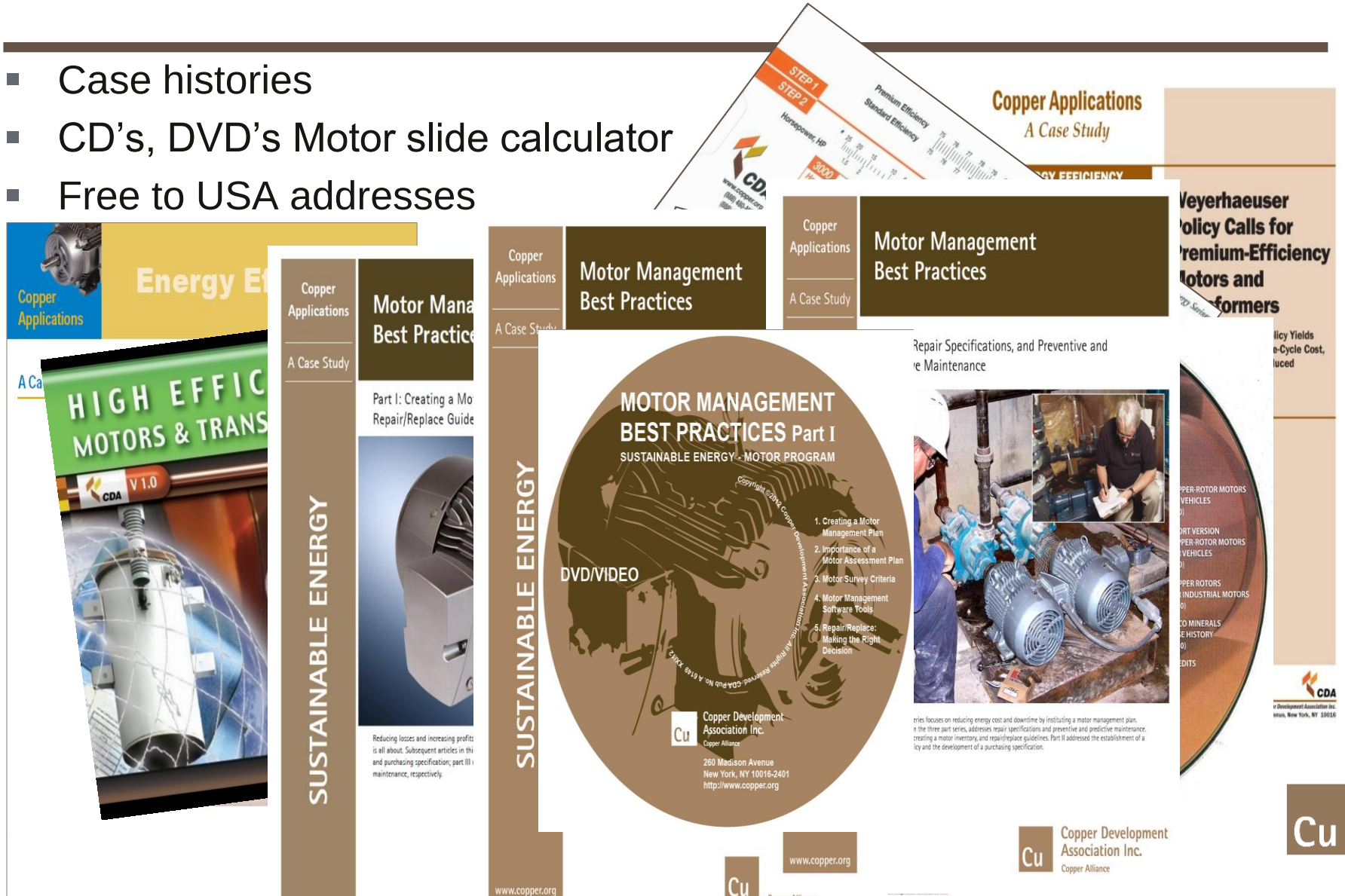
Trade Shows, Seminars, Workshops

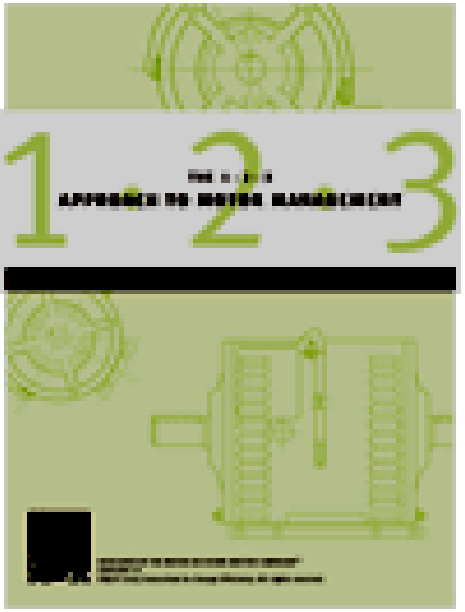
- Case histories
- CD's, DVD's Motor slide calculator
- Free to USA addresses



MotorMaster+ Software

- Developed by WSU
- Financed by the DOE
- Database of 22,000 motors
- Enable you to compare:
  - New
  - Rewind
  - Retrofit

Other Resources



Motor Decisions Matter SM

NEMA

U.S. Department of Energy
Energy Efficiency and Renewable Energy
Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

Industrial Technologies Program

Cu

Thank You

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