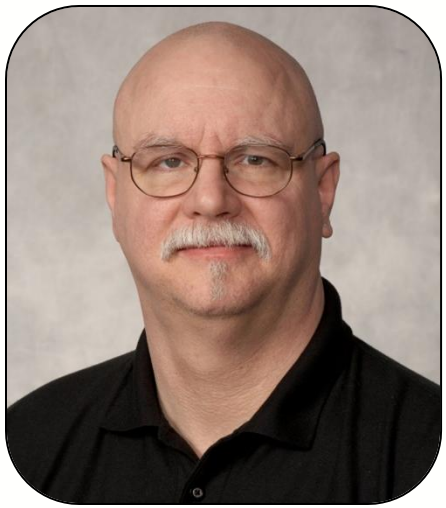
Understanding Life-Cycle Costs is Key to Optimizing Motor Efficiencies



- *Doug Cooley has years of experience in the motor and gearing industry. He started as warehouse team member/driver at a bearing company in Cedar Rapids in 1984. While there, he worked his way to inside sales. He then took an inside sales opportunity at a motor repair/sales facility in 1989. In 1993, Doug became a manufacturer's representative for a motor and gearing line. In 1994, he went back to outside sales in the motor repair/sales industry and now is a Power Transmission Specialist with Van Meter. He has six children, three of his own and three adopted grandchildren. He has been married to his wife for 28 years.*

VAN METER'S thinkGREEN SUMMIT 2011

Applying motors to reduce electrical energy demand following the new Energy Independence & Securities Act

NEMA Premium™

Presenter:

Doug Cooley

Power Transmission Product Specialist

Van Meter Inc.

Power Usage of a Motor at a Glance

- The world of electric motors is changing at an unprecedented rate
- Electric motor systems account for 23% of all electricity consumed in the U.S. and 70% of all electrical energy in the manufacturing sector
- For this reason, Efficiency has become a very important factor in business today, not only to save money, but resources

Motor Facts

- Industrial motors can have a 20-30 year in service life if maintained
- According to EASA sources the average Integral Horse Power (IHP) motor is repaired 3 or more times during its service life
- The average IHP motor uses 4 to 6 times its original investment cost in electrical usage each year

- EASA = ELECTRICAL APPARATUS STANDARDS ASSOCIATION

Electrical Energy vs. Mechanical Energy

- In the United States, electrical energy input is measured in watts, while output is given in horsepower
- In country's other than the USA, output power for motors manufactured in other countries may be stated in watts or kilowatts
- For Electrical usage, One horsepower is equivalent to 746 watts of output power

What Does Efficiency Mean To A Motor?

- Electric motors are simply a device that converts electrical energy into mechanical energy
- Efficiency is a measure of how much total energy a motor uses in relation to the rated power delivered to the shaft

What Does All This Mean?

- Since energy costs continue to rise, and resources continue to diminish, we need to
  - Think of ways to be GREEN
  - Live a GREENER lifestyle
  - Develop ways to be the GREENEST we can be for our planets sake

How Do We attempt to Go Green With Electric Motors?

- Provide tighter regulations and specifications for motor manufacturers to produce to
- Assist current motor manufacturers in developing more efficient motors by providing mandatory regulations, ie EISA 2010
- Assist consumers to upgrade to Premium/EPACT motors where ever possible

What is our Government doing to assist in our THINK GREEN requirements

- Developed the Energy Independence and Security Act of 2007 (EISA)
- EISA was signed into effect as of December 19, 2007 by the Bush administration
- EISA premium efficient regulations went into effect on December 19, 2010
- On December 19, 2010, motor manufacturers will not be allowed to produce any product with a lower efficiency rating lower than EISA specifies for each given product offering
- EISA also states, that any product produced prior to December 19, 2010 and shipped to holding facilities or distribution sites may be sold until all existing inventories are depleted.

What are the New EISA Guidelines for PREMIUM EFFICIENT Motors after December 19, 2010

- Motors must meet NEMA Premium (Table 12-12)
  - 1-200hp
  - Design A & B
  - C-face, D-flange
  - Footed
  - Any voltages covered by EPACT
    - 207-253v and 414-506v 60Hz

Note: Frame size is not an exemption. If a motor is an IEC frame, follow the rules just as if it was a NEMA Frame. If a motor is above a NEMA frame (680), follow the rules just as if it was a 440 frame.

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NEMA MG1 Table 12-12
Full load Efficiencies of NEMA Premium Motors 600 Volts or less (Random Wound)

HP	ODP			TEFC		
	2 Pole	4 Pole	6 Pole	2 Pole	4 Pole	6 Pole
1	77	85.5	82.5	77	85.5	82.5
1.5	84	86.5	86.5	84	86.5	87.5
2	85.5	86.5	87.5	85.5	86.5	88.5
3	85.5	89.5	88.5	86.5	89.5	89.5
5	86.5	89.5	89.5	88.5	89.5	89.5
7.5	88.5	91	90.2	89.5	91.7	91
10	89.5	91.7	91.7	90.2	91.7	91
15	90.2	93	91.7	91	92.4	91.7
20	91	93	92.4	91	93	91.7
25	91.7	93.6	93	91.7	93.6	93
30	91.7	94.1	93.6	91.7	93.6	93
40	92.4	94.1	94.1	92.4	94.1	94.1
50	93	94.5	94.1	93	94.5	94.1
60	93.6	95	94.5	93.6	95	94.5
75	93.6	95	94.5	93.6	95.4	94.5
100	93.6	95.4	95	94.1	95.4	95
125	94.1	95.4	95	95	95.4	95
150	94.1	95.8	95.4	95	95.8	95.8
200	95	95.8	95.4	95.4	96.2	95.8
250	95	95.8	95.4	95.8	96.2	95.8
300	95.4	95.8	95.4	95.8	96.2	95.8
350	95.4	95.8	95.4	95.8	96.2	95.8
400	95.8	95.8	95.8	95.8	96.2	95.8
450	95.8	96.2	96.2	95.8	96.2	95.8
500	95.8	96.2	96.2	95.8	96.2	95.8

What Product is exempt from Premium levels, but must meet ENERGY EFFICIENT levels

- Motors must meet EPACT(Table 12-11)
  - Close Coupled Pump
  - Vertical Solid Shaft
  - Round body
  - Nonstandard Voltages, 60Hz
  - 200-500hp
  - Fire-pump motors
  - U-frame
  - 8-Pole
  - Design C

VAN METER'S thinkGREEN SUMMIT 2011

NEMA MG-1 Table 12-11
Full-Load Efficiencies of EPACT Motors
600 volt or less (Random Wound)

HP	ODP				TEFC			
	2 Pole	4 Pole	6 Pole	8 Pole	2 Pole	4 Pole	6 Pole	8 Pole
1.0	0.0	82.5	80.0	74.0	75.5	82.5	80	74
1.5	82.5	84.0	84.0	75.5	82.5	84	85.5	77
2.0	84.0	84.0	85.5	85.5	84	84	86.5	82.5
3.0	84.0	86.5	86.5	86.5	85.5	87.5	87.5	84
5.0	85.5	87.5	87.5	87.5	87.5	87.5	87.5	85.5
7.5	87.5	88.5	88.5	88.5	88.5	89.5	89.5	85.5
10.0	88.5	89.5	90.2	89.5	89.5	89.5	89.5	88.5
15.0	89.5	91.0	90.2	89.5	90.2	91	90.2	88.5
20.0	90.2	91.0	91.0	90.2	90.2	91	90.2	89.5
25.0	91.0	91.7	91.7	90.2	91	92.4	91.7	89.5
30.0	91.0	92.4	92.4	91.0	91	92.4	91.7	91
40.0	91.7	93.0	93.0	91.0	91.7	93	93	91
50.0	92.4	93.0	93.0	91.7	92.4	93	93	91.7
60.0	93.0	93.6	93.6	92.4	93	93.6	93.6	91.7
75.0	93.0	94.1	93.6	93.6	93	94.1	93.6	93
100.0	93.0	94.1	94.1	93.6	93.6	94.5	94.1	93
125.0	93.6	94.5	94.1	93.6	94.5	94.5	94.1	93.6
150.0	93.6	95.0	94.5	93.6	94.5	95	95	93.6
200.0	94.5	95.0	94.5	93.6	95	95	95	94.1
250.0	94.5	95.4	95.4	94.5	95.4	95	95	94.5
300.0	95.0	95.4	95.4	94.5	95.4	95.4	95	0
350.0	95.0	95.4	95.4	94.5	95.4	95.4	95	0
400.0	95.4	95.4	0.0	0.0	95.4	95.4	0	0
450.0	95.8	95.8	0.0	0.0	95.4	95.4	0	0
500.0	95.8	95.8	0.0	0.0	95.4	95.8	0	0

What Motors are not covered by EISA?

- Design D high slip
- Adjustable speed with optimized windings
- Customized OEM mounting
- Intermittent duty
- Integral with gearing or brake where motor cannot be used separately
- Submersible motors
- Single Phase motors
- DC motors
- Two-digit frames (48-56)
- Multi-speed motors
- Medium voltage motors
- TENV and TEAO enclosures

How to Create a More Efficient Motor

- **Premium-efficiency motors contain about 20% more copper in there windings than EPAct motors.**

- Generally speaking, the more copper there is in a motors windings, the lower will be the resistive, or I^2R, losses, which typically account for the largest portion of a motors operating losses.

How to Create a More Efficient Motor

What other items affect premium designs:

Premium-efficiency motors typically incorporate

1. Smaller fans
2. Improved bearings and lubricants
3. Are machined to tighter tolerances and are able to maintain lower noise and vibration limits
4. Upgrading the laminations to a premium grade low gas silicone impregnated steel

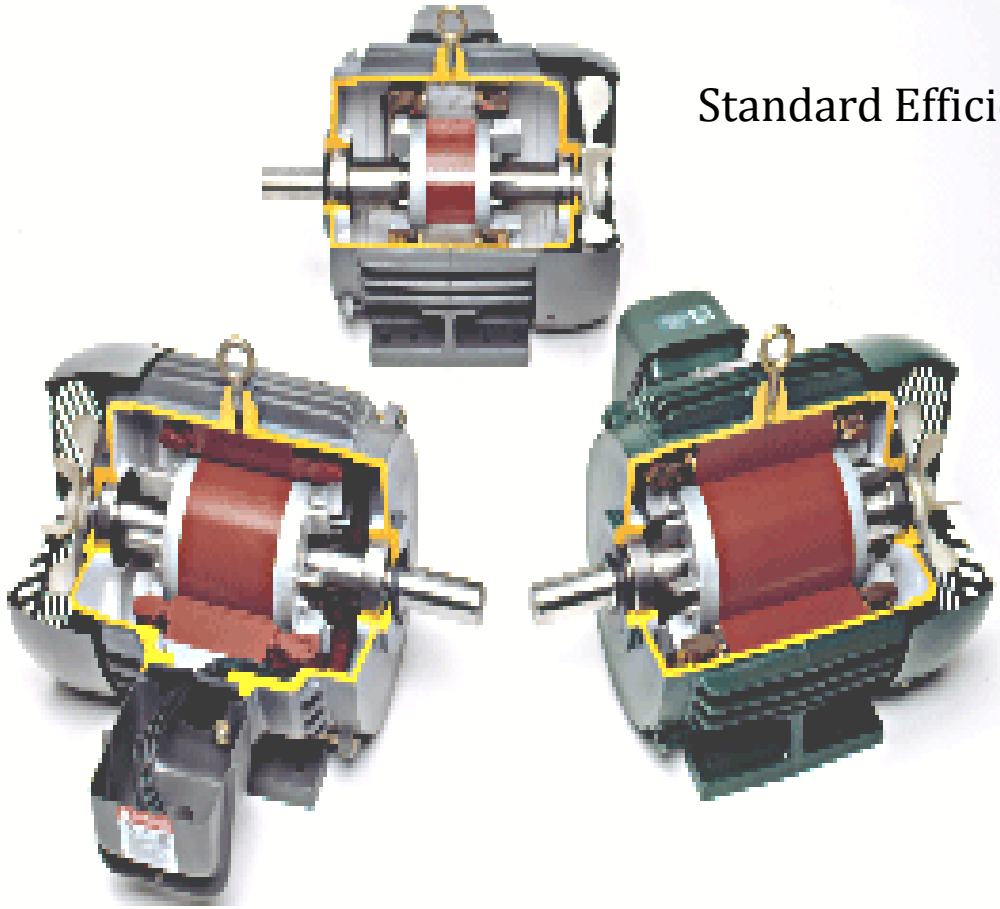
The Effects of Creating a Premium Efficient Product

- Motors will still meet all NEMA specified dimensions (shaft size, height, foot pattern, flange, etc.)
- A typical Premium efficient motor will be longer overall due to additional copper and laminations required to permit for efficiency designs
- A slightly elevated locked rotor amperage could be seen in most applications
  - typically not enough to warrant heater or drive upsizing
- Premium product is meant to run as many hours as possible without restart for maximum cost efficiency

Motors As They Become More Efficient

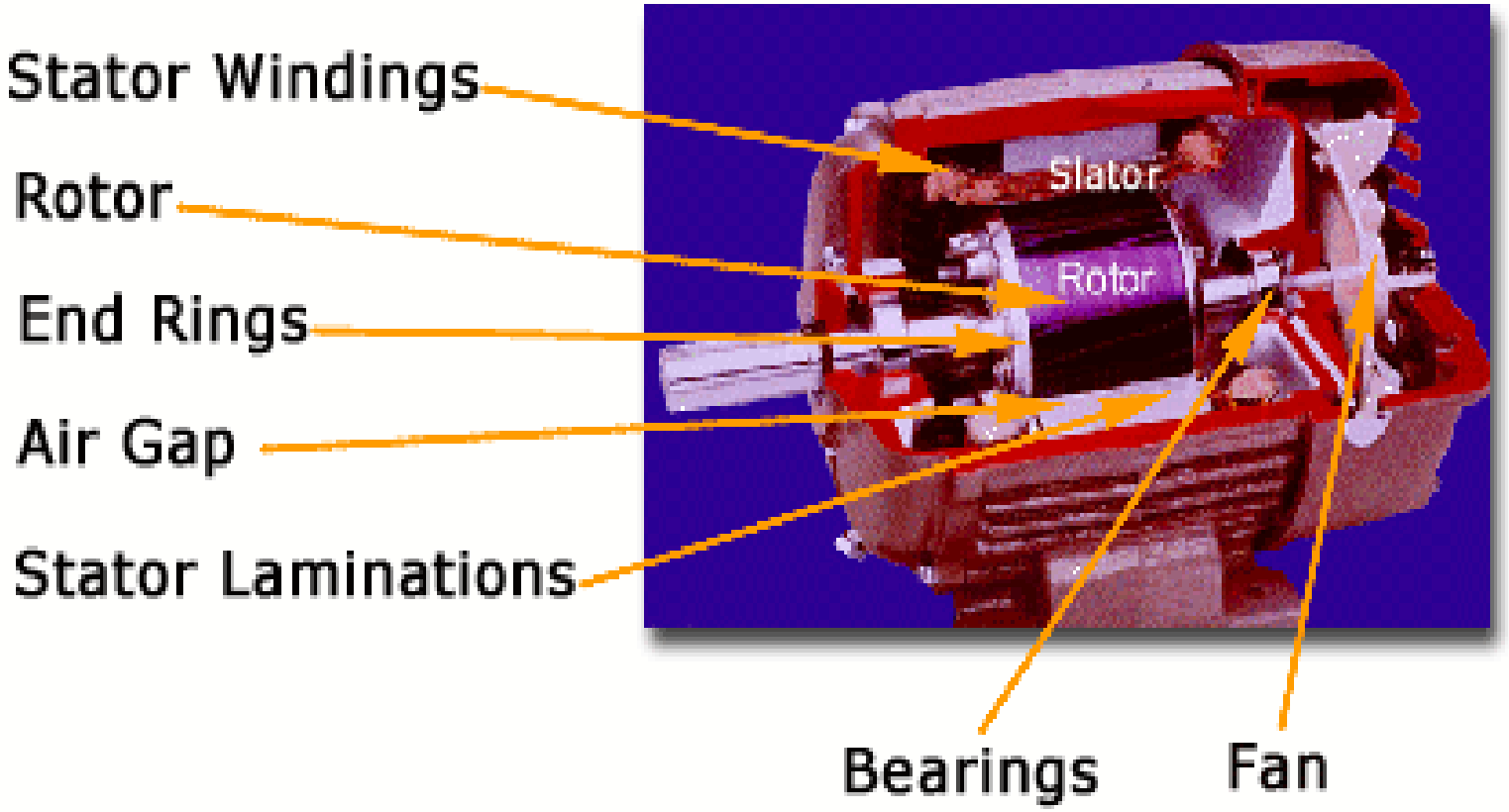
Standard Efficient Motor

EPACT Motor



Premium Motor

Typical Breakdown For A NEMA Design B Motor



WHAT DOES ALL THIS MEAN WHEN CREATING A MORE EFFICIENT MOTOR?

More copper = Lower losses = Higher efficiency = Lower operating costs

ALL THIS LEADS TO A BETTER BOTTOM LINE.

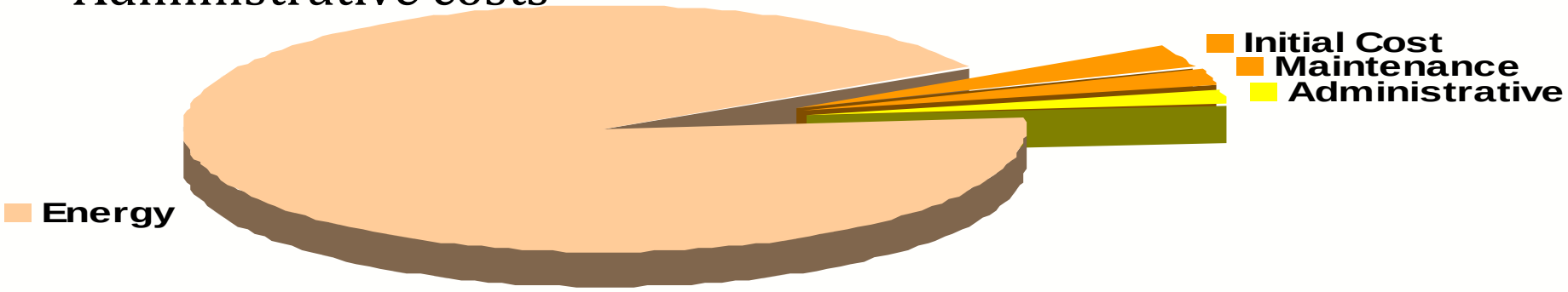
HOW DO WE DEFINE THE ACTUAL COST OF A MOTOR?

Motor costs can be broken down into four areas during the life time of a motor:

1. INITIAL COST
2. Cost per electrical KW of operation
3. Maintence costs
4. Administrative costs

Factors Effecting A Motors Overall Lifetime Cost Efficiency

- Initial cost
- Cost per KWH of operation
- Maintenance costs
- Administrative costs



Dependent upon motor size energy cost and number of operating hours

Why should we follow the EISA suggestions and upgrade?

- To take advantage of the Higher efficient motors available to
  - 1) Reduce the operating costs and less stress on utilities, supporting Green initiatives
  - 2) Motors Generally operate at a lower temperature and for every 10°C reduction in operating temperature, insulation life doubles extending motor life
  - 3) Motors are generally quieter (smaller fans)
  - 4) Motors have lower vibration with lower bearing temperatures for longer bearing life
  - 5) Earn available energy rebates from utilities if available

WHY REPLACEMENT VS. REPAIR?

- Rewinding/rebuilding a motor might improve its efficiency above the value at the time the motor was taken out of service. But because the amount and configuration of the motor steel remains fixed and no additional copper can be added, the rebuilt motor's efficiency can only attain its original value, at best, which may be lower than that of currently available models.

- Reprint from case study by Weyerhaeuser, written by John Holmquist, EE for Weyerhaeuser Engineering.

WHAT ARE OUR OPTIONS?

- **Repair/Rewind.** This option can cost up to 80% of the price of a new motor, but it doesn't improve an old motor's efficiency beyond its original rating, which is locked in by its basic design. Rewound motors usually consume just as much power, or maybe more, as they did when they were new, and thus cost at least as much to operate.
- **Replace the motor with a NEMA Premium efficiency** model. This option can produce the fastest payback and result in the highest total cost savings over the life of the motor.
- Reprint from case study by Weyerhaeuser, written by John Holmquist, EE for Weyerhaeuser Engineering.

EXAMPLE OF EFFICIENCY LEVELS THROUGH THE DIFFERENT STAGES, STD, EPACT,

HP	Standard-Efficiency Motors Average Efficiency at 100% Load	EPAct Energy-Efficient Motors Minimum Nominal Efficiency at 100% Load	NEMA Premium Motors Minimum Nominal Efficiency at 100% Load
5	83.3	87.5	89.5
10	85.7	89.5	91.7
20	88.5	91.0	93.0
25	89.3	92.4	93.6
50	91.3	93.0	94.5
100	92.3	94.5	95.4

EXAMPLE COST SAVINGS FOR A 75HP 1800RPM MOTOR

Supplier	A	B	C
Efficiency	89.5%	91.7%	95.0%
Purchase Price	$ 2,800	$ 3,000	$ 3,300
1-Year Operating Cost	$ 17,524	$ 17,103	$ 16,509
10-Year Operating Cost (Includes 5% escalation/year)	$220,413	$215,124	$207,652
Life-Cycle Cost	$223,213	$218,124	$210,952

What can we use to monitor the costs of a motor over its lifetime?

- CEE, Consortium for Energy Efficiency
  - www.cee1.org
- MDM, Motor Decisions Matter
  - www.motorsmatter.org
- MotorMaster 4.0
  - http://www1.eere.energy.gov/industry/bestpractices/software_motormaster.html

Common Questions Regarding New EISA Regulations

- Does EISA require any motors in use to be replaced?
- How about electric motors in inventory?
- Does EISA apply to rebuilt, repaired or rewound motors?
- What are the labeling requirements under EISA?

Establish a Partnership with Your Electric Utility to Reduce Energy Costs

- Electric utilities currently offer rebates to customers who buy premium efficient motors
  - For certain ratings, rebates can be as high as 15 percent of the purchase price for new and retrofit applications
  - In addition, a number of utility companies have incentive programs focused on decreasing energy use at the application level
  - Adjustable speed drives and soft starts qualify for these incentives
- The U.S. Department of Energy offers a "Save Energy Now" program to conduct plant surveys to determine ways to reduce energy consumption for certain industries
- Look to your electrical suppliers as a partner

Acknowledgements

- Material collected from the following manufacture and NEMA websites
- www.marathonelectric.com
- www.baldor.com
- www.toshiba-usa.com
- www.NEMA.com
- www.cee1.org
- www.motormatters.org
- www.copper.org
- http://www1.eere.energy.gov/industry/bestpractices/software_motormaster.html