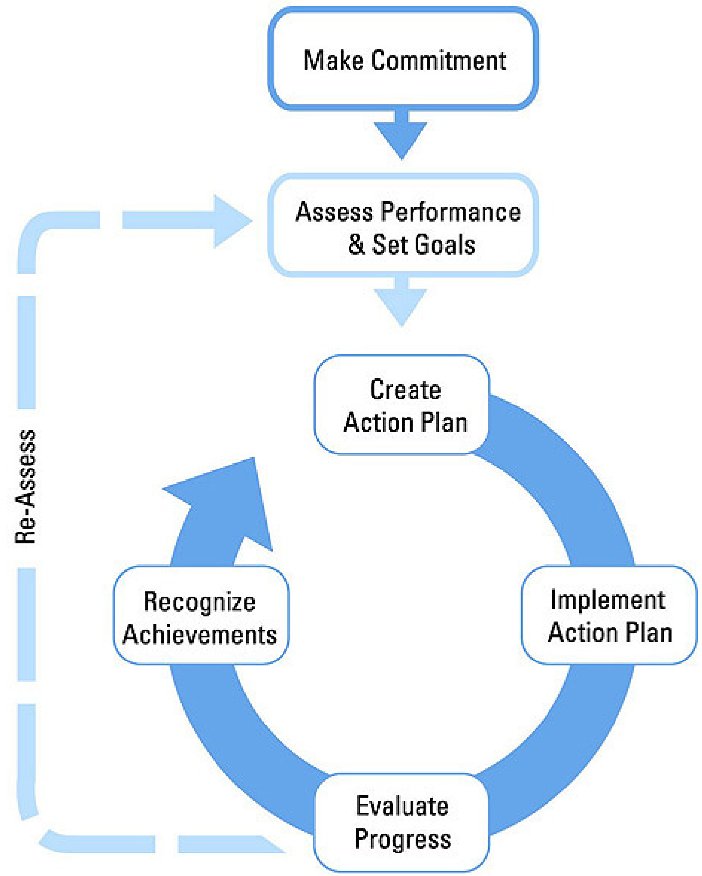
# Motor Energy Efficiency

**ENERGY STAR Web Conference**
**February 16, 2005**

Call-in Number: 1-800-914-3396
Access Code - 9307720

# About The Web Conferences

- **Monthly**
- **Topics are structured on a strategic approach to energy management**
- **Help you continually improvement energy performance**
- **Opportunity to share ideas with others**
- **Slides are a starting point for discussion**
- **Open & interactive**



# Web Conference Tips

- Mute phone when listening!  Improves sound quality for everyone.

- If slides are not advancing, hit reload button or close presentation window and press the launch button again.

# Web Conference Tips

- Chat Feature


- Presentation slides will be sent by email to all participants following the web conference.

- Hold & Music – If your phone system has music-on-hold, please don't put the web conference on hold!

# Today's Web Conference

- Welcome
- Kevin Dunn – Baldor Electric Company
- Steve Coppinger – CPC
- George Weed & Jim Breeze - Kodak
- Questions & Discussion
- Announcements

# Selection of Electric Motors for Increased Reliability and Energy Efficiency

**Kevin Dunn**

**Baldor Electric Company**

**Fort Smith, AR**

MOTORS • DRIVES • GENERATORS

ENERGY STAR PARTNER

**February 16, 2005**

# Introduction

- What is a NEMA Premium™ efficient motor?
- End user concerns
  - Importance of managing motor inventory
  - Plan what to do on failure
- Life cycle costs
- Use best motor for application
- Motor management software

# Premium Efficiency Milestones

- **Early 1980's**
  - **Energy crisis sparks interest in higher efficiency motors**
- **September 1990**
  - **NEMA MG1 first "Energy Efficient" levels defined**
  - **Later became efficiency levels for Energy Policy act of 1992 (EPAct)**
- **1994**
  - **IEEE 841-1994 at NEMA Energy Efficient and EPAct efficiency levels**

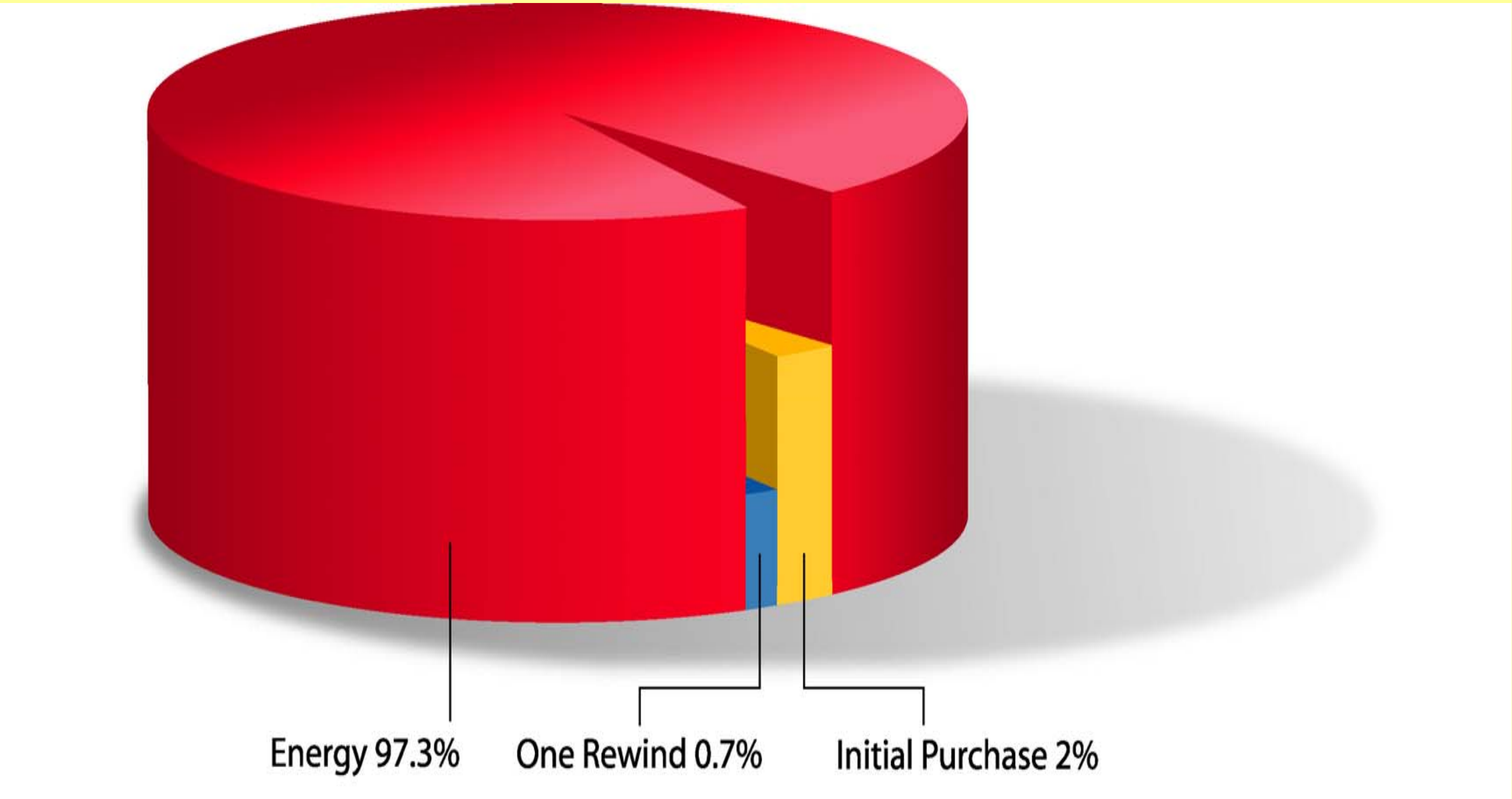
# Premium Efficiency Milestones

- **1996**
  - **Consortium for Energy Efficiency (CEE) establishes premium efficiency guidelines for 1 thru 200 HP motors**
- **October 1997**
  - **EPAct production in effect**
  - **1 thru 200 HP TEFC & ODP standard motors**

# Premium Efficiency Milestones

- **2001**
  - **IEEE 841-2001 raises efficiency levels to EPAct plus 1 NEMA efficiency level**
- **August 2001**
  - **NEMA Premium™ efficient levels established in MG1-1998 rev 2**
  - **NEMA Premium included in current edition NEMA MG 1-2003**

# Consider Life Cycle Costs

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# Energy Costs Can Be Managed

- **Survey your plant and upgrade to NEMA Premium™ efficient motors**
- **Add adjustable speed drives on fans and pumps to control flow**
- **Work with electric utilities on rates**
- **Join Energy Star and get assistance**

# Energy Standards

- **NEMA Premium™ efficient motors have higher efficiency and are available to 500 HP**

| HP | DOE average efficiency | NEMA Premium™ minimum efficiency |
|---|---|---|
| 250 | 93.4 | 96.2 |
| 300 | 93.3 | 96.2 |
| 350 | 93.3 | 96.2 |
| 400 | 93.3 | 96.2 |

4 pole TEFC designs

# Life Cycle Cost Energy Savings

| 250 HP 4 pole operating costs | DOE average efficiency | High efficiency motor | NEMA Premium™ efficiency |
|---|---|---|---|
| Efficiency | 93.4 | 95.0 | 95.8 |
| Electrical cost / year | $131,189 | $128,979 | $127,902 |
| Annual savings | | $2210 | $3287<br>X 25 years |

Continuous operation at $0.75/kWh

**$82,175 total savings**

# Adjustable Speed Motors

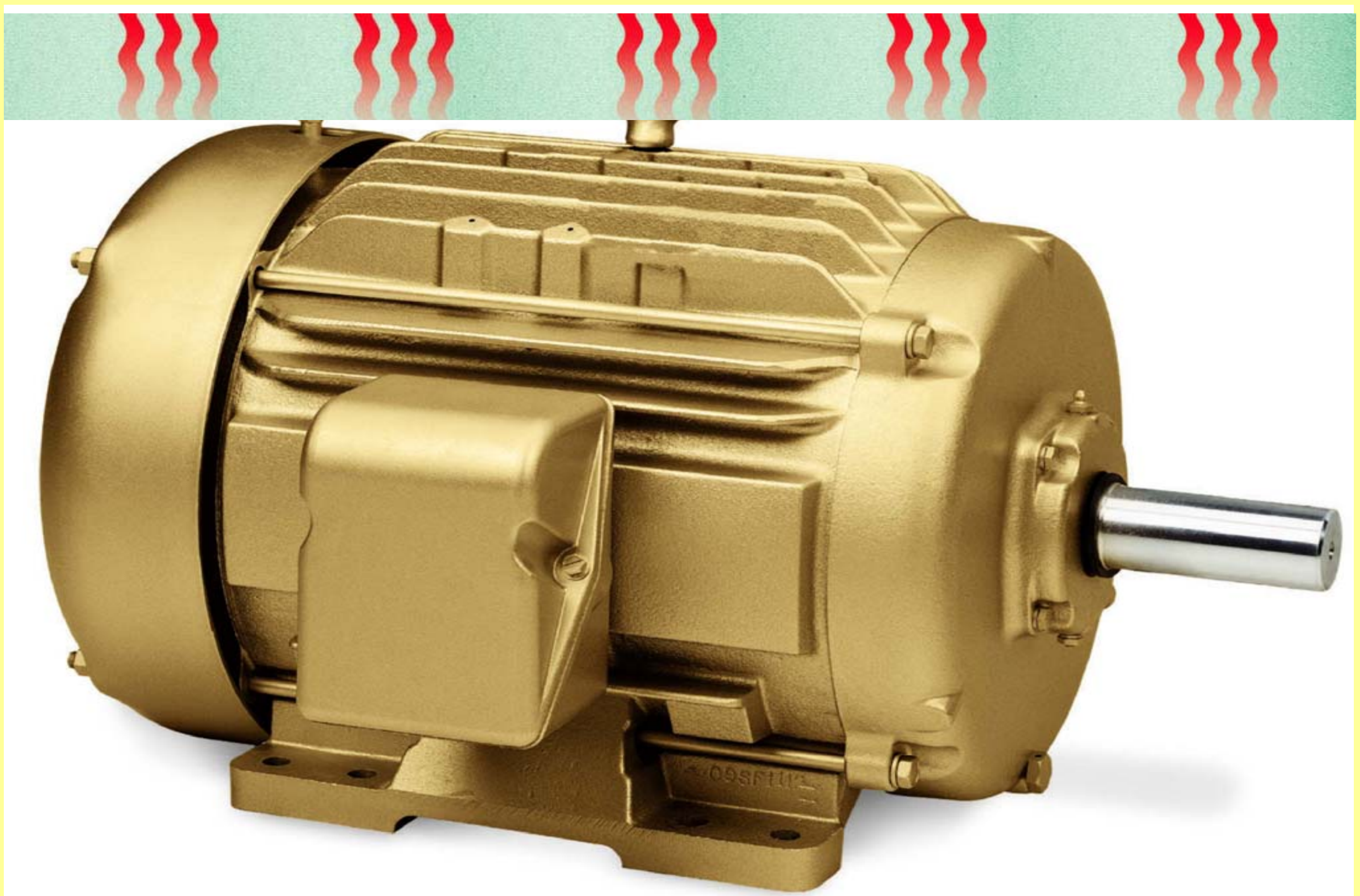
- **Indicate motor will be used with ASD at time of order**
  - **Some manufacturers may need to upgrade insulation components or recommend a different line of motors**
  - **Decide if control bypass may be used**
  - **Consider shaft grounding brush**
  - **460 volt system has advantages over medium voltage (motor + drive less expensive)**

# Motor Efficiency

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

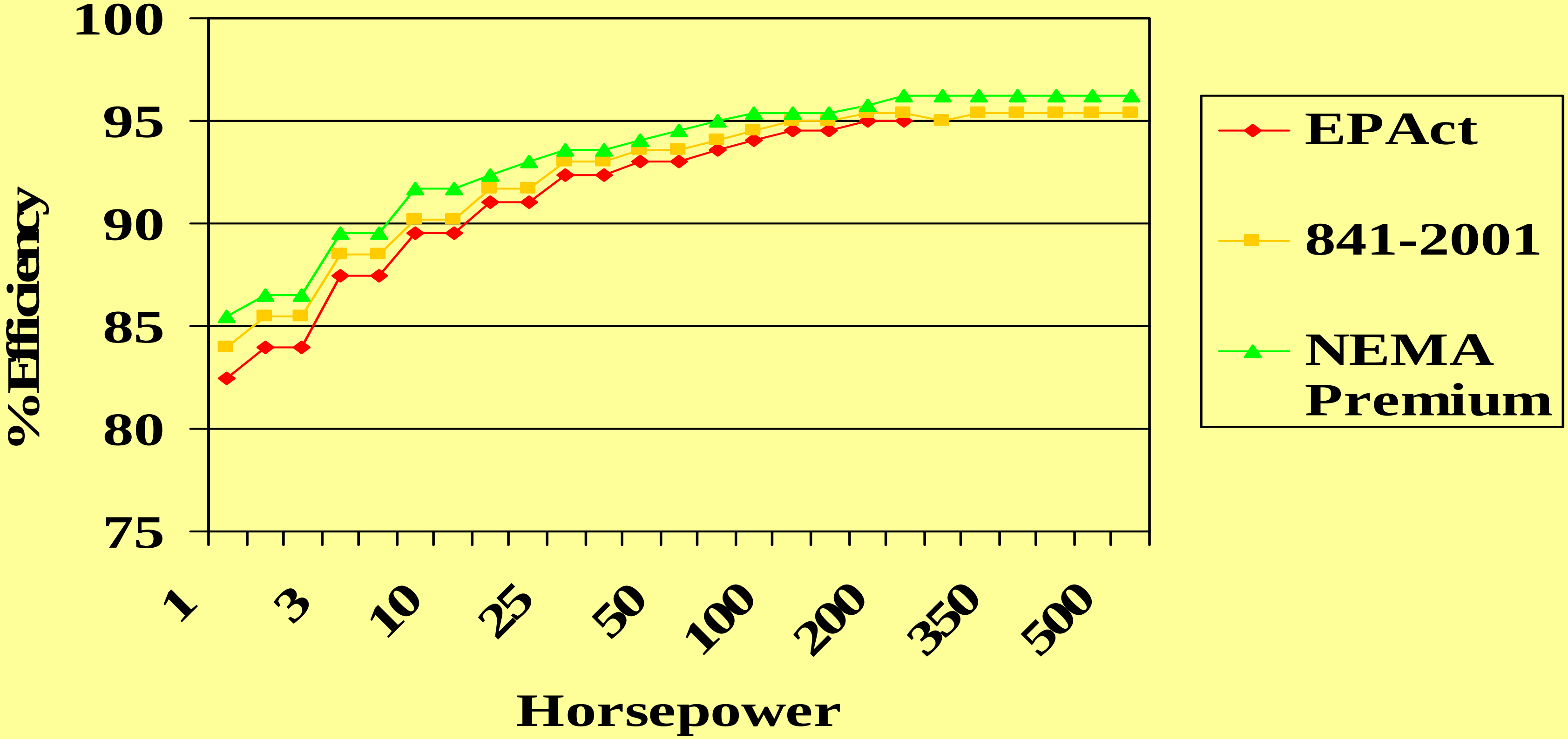
Total Losses 7.6%

Input Power 100%



Output Power 92.4%

# Comparison of Efficiency Standards

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# Comparison of Efficiency Measurement Standards

- **IEEE 112 and CSA C390-98 measure all losses**
  - **Most accurate**
- **IEC 60034-2 assigns values for stray load losses**
  - **Higher than IEEE 112 on “Standard Efficient” motors, lower on “Premium Efficient™” motors due to assigned losses**
- **JEC-37 (Japan) ignores stray load losses**
  - **least accurate**

# Efficiency Gains Through Better Lamination Steel

- Steel laminations are coated to insulate from adjacent laminations
  - Reduces circulating current (iron losses)
- Thickness of laminations
  - More laminations of thinner material reduces losses (more lams per inch)
  - Better steel allows use of thicker laminations (less lams per inch)
  - “Balancing act” between lam thickness and coating to reduce losses; reduce production time and tooling wear

# Efficiency Gains Through Better Lamination Steel

- **Coating may be damaged during improperly performed rewind**
  - **Increased iron losses**
  - **Lower efficiency**
  - **Hotter operation**
- **Utilize EASA guidelines for rewind *ANSI/EASA AR100-1998 Recommended Practice for the Repair of Rotating Electrical Apparatus***
  - **Limit to 400º C during burnout**
  - **Some new steels are good to 480º C**

# Additional Benefits of Premium Efficient Motors

- Lower losses result in cooler motors
  - Every 10º C cooler doubles insulation life
  - Allows for use with PWM power supply
  - Increased bearing life
- Manufactured to closer tolerances
  - Better balance / bearing life

# Additional Benefits of Premium Efficient Motors

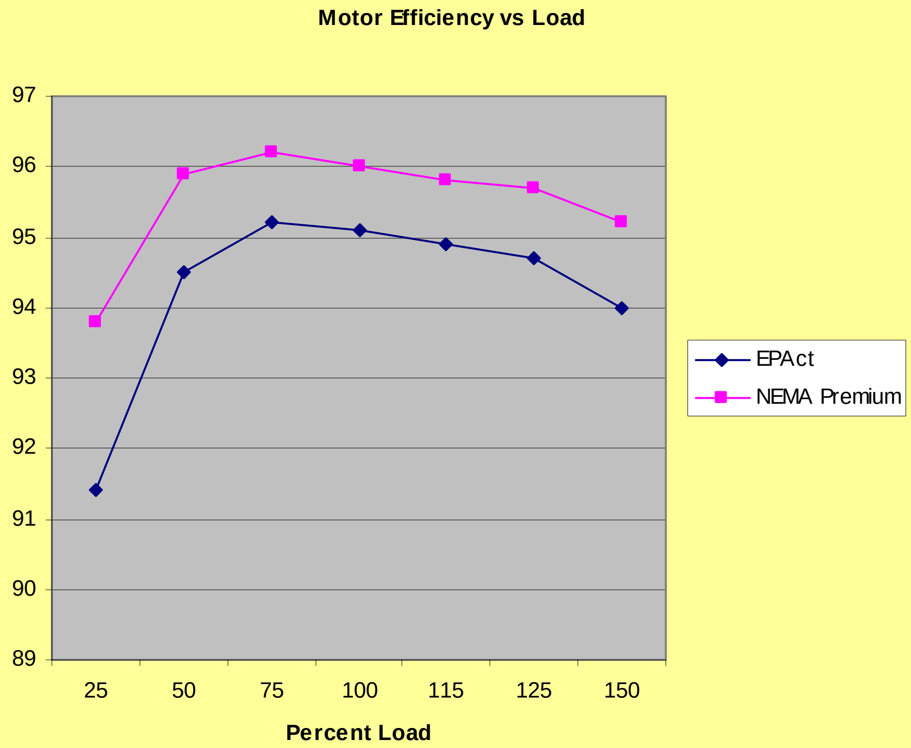
- Severe Duty motors including IEEE 841 require cast iron frames, endplates, fan covers and conduit boxes
  - Finned housings for heat dissipation
  - Structural rigidity and balance
  - Better foot flatness and easier to align
  - Increased vibration damping
  - Full round laminations for increased heat dissipation

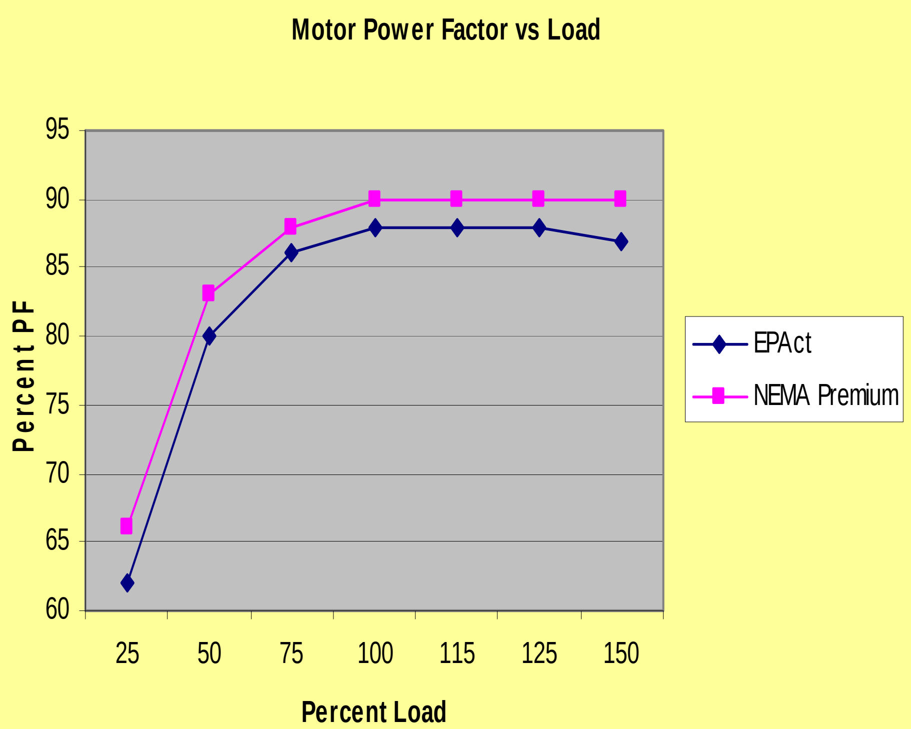
# Additional Efficiency Gaining Considerations

- Specify motors but with NEMA Premium™ efficiency levels
  - Open Drip Proof – TEFC
  - Severe Duty
  - Washdown Duty
  - Pump Motors
  - Explosion proof motors

# "Right-size" the Motor

- Choose the correct rating for the application
  - Oversized motors have lower efficiency and power factor
  - Highest efficiency 75 - 100% of rated load
  - Service factor is for short-term operation



# Additional Efficiency Gaining Considerations

- Most motors are supplied with polyurea-based grease
  - Many users specify lithium greases
  - Newer synthetic greases provide lower losses, cooler operation and longer life
  - Motors used in food areas may need to have FDA approved greases

# Additional Efficiency Gaining Considerations

- New bearing developments for longer life
  - Non-contact and low friction seal on sealed bearings
  - A single ceramic ball in the bearing may reduce lubrication intervals and be “self-healing”
  - Hybrid bearings with ceramic balls

# Manage Motor Inventory

- **Survey plant and inventory motors**
- **Decide what to do for each motor before it fails and tag motor**
  - **Motor Decisions Matter 1-2-3 Motor Management Program**
  - **motorsmatter.org**
  - **Local electric utility**
  - **EASA shop for service**

# Why Software Helps

- Decision makers can understand savings if they are related to an investment with a favorable payback
- Manual calculators difficult – one motor at a time
- Automatically matches old motor to current premium efficient design and enters data for comparison
- Software defines unknown motor efficiency from US DOE survey averages

# Conclusions

- **Use life cycle cost – not initial cost**
- **Survey motors**
  - **Software makes this easy**
  - **Mark what to do on failure**
- **“Right size” motors**
- **Add drives where appropriate**
- **Partner with electric utility provider**
- **Join ENERGY STAR for assistance**

# Thank you

**Any questions?**

National Manufacturing Week

**February 25, 2004**

# CPC Motor Management

Steve Coppinger
Chief Electrical Engineer
California Portland Cement Company
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Presented at the Energy Star Webcast
February 16, 2005

# CPC Motor Management

OVERVIEW

- Introduction
- Company Background
- Why a Motor Management Program?
- CPC's Motor Management Program
- Conclusions

# CPC Motor Management

CPC COMPANY BACKGROUND

- Founded in 1891
- Producer of Cement, Concrete and Aggregates
- 3 Cement Plants (AZ & CA), ready mix plants (CA)
- Terminals in CA & NV
- Market area – Southwest US including California, Arizona and Nevada
- Created formal Energy Management Program in 2003

# CPC Motor Management

Why Have a Motor Management Program?

- Reduce energy costs
  - Electrical Energy Costs = 21% of total production costs & 37% of variable costs
  - Avg. Power Bill = over $ 3 Million/month
  - Annual power usage = 525,000 mWh = over 75,000 homes
  - One 100 hp motor costs > $40,000/year
- Reduce power peak demand
- California Power Costs = ~ 9 cents/kWh
- Reduce Emissions
- Previous policy did not encourage energy efficiency
- Minimize downtime

# CPC Motor Management

CPC Motor Management Policy

Improve energy efficiency through the installation and proper maintenance of premium efficiency motors, the correct application of motors in the process and the training of personnel in proper motor management

# CPC Motor Management

CPC Motor Management Program

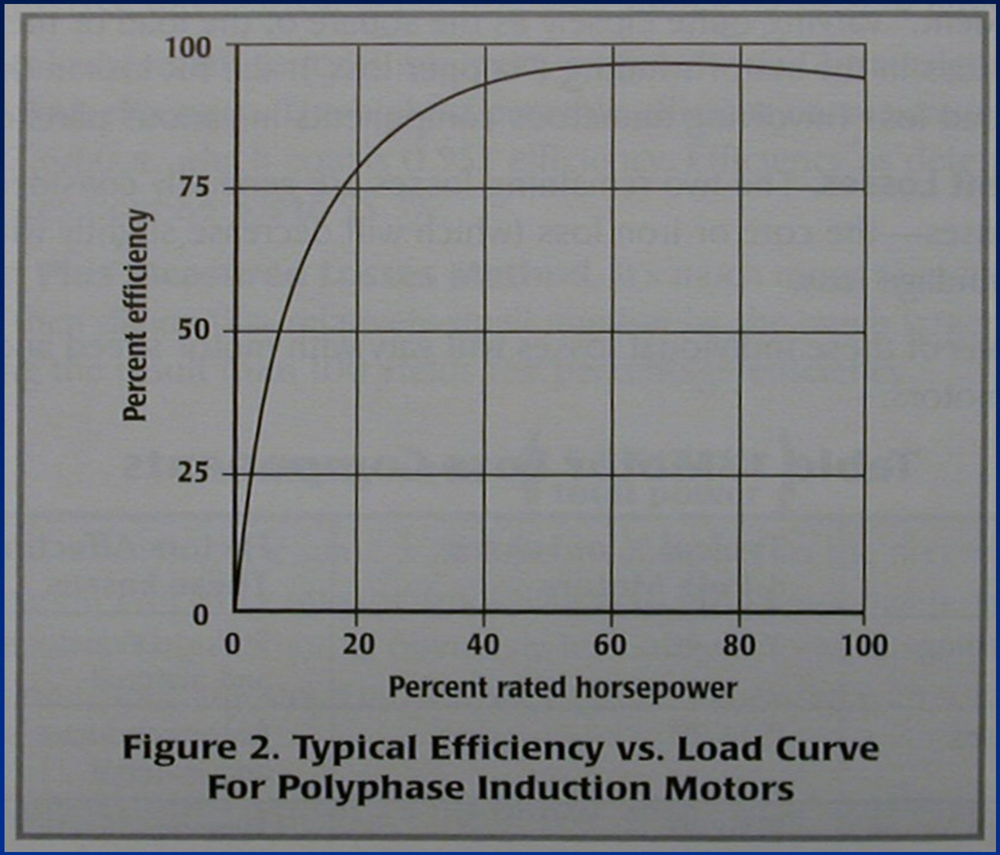
- Engineering and Specifications
- Purchasing and Inventory Policies
- Maintenance and Repair Policies
- DOE MotorMaster Program
- Awareness and Training

# CPC Motor Management

Engineering and Specifications

- Develop Premium Efficiency Spec
  - NEMA MG1 2003 Efficiency
  - IEEE 841 Severe Duty
- Use spec for failed motor replacement & new construction
- Properly size motor for application
  - 75% = Max Efficiency
  - Efficiency for Operating loads < 40% is drastically reduced
- Use VFDs where applicable
- Establish power factor goals
- Use EASA motor re-wind spec

# CPC Motor Management




Typical Motor Efficiency Curve – EASA Publication
“Understanding Energy Efficient Motors”

# CPC Motor Management

Purchasing and Inventory Policies

- Establish Corporate Policy
- Provide specifications for new purchase
- Select 2 or 3 acceptable motor vendors
- Inventory motors & spares with nameplate info
- Update stock cards/computer inventory with preferred replacement motors i.e. premium efficiency
- Establish motor distributor agreement
- Proactively replace stock motors with Premium Efficiency
- Explore government or utility motor programs
  - Motor Resource Center – 100 motor study
  - Utility Rebates
  - DOE Grants

# CPC Motor Management

Example - Motor Replacement w/ Premium Efficiency

**<u>Existing Motor</u>** – 100 hp, 1800 rpm TEFC
75% Load, 8000 hours/yr.
Std. Efficiency = 91.7%
Operating data = $43,930/yr., 488,113 kWh/yr.

**<u>New Motor</u>** – Same as existing except:
Premium Efficiency = 95.5% (3.8% improvement)
Purchase Price = $ 5253

Energy Savings = 19,619 kWh/yr., $1766/yr.
Simple Payback = 3.05 Years

# CPC Motor Management

Maintenance and Repair Policies

- <= 100 hp – Buy new
- > 100 hp – Evaluate costs of re-wind
  - If re-wind = >50% cost of new – buy new
  - Use MotorMaster ROI
- Purchase price of motor is ~2% of lifecycle cost
- Establish good relationship with motor shop
- Ensure availability of common premium eff. motors
- Use EASA spec when re-winding motors
  - Up to 2% efficiency loss per re-wind
- Perform PM & RCM on motors e.g. vibration analysis, infrared…

# CPC Motor Management

Motor Fan – Premium Efficiency (Left), Standard Efficiency (Right)

# CPC Motor Management

DOE MotorMaster Program

- Database for over 25,000 motors & 18 manufacturers
- Estimates costs of motor operation
- Estimates ROI on motor replacement and/or re-wind
- Manages motor inventories
- Free

# CPC Motor Management

Training and Awareness

- Train personnel on specifications
- Clearly define motor preferences
- Communicate motor repair/purchase & inventory policies
- Educate personnel on efficiency benefits
  - Motor Vendor presentations
  - DOE Training
  - Energy Star Webcasts

# CPC Motor Management

CONCLUSIONS

- Program offers great savings potential
- Awareness is critical
- Must work within constraints of plants
  - e.g. time constraints when motor fails
- Requires changing age-old practices
- Must justify additional first costs for premium efficiency
- Will have higher inventory costs
- Some motor distributors not savvy with motor requirements
- Perception that premium efficiency motors run hotter

# CPC Motor Management

THE END

THANKS FOR YOUR ATTENTION!

# Motor Optimization Program At the Eastman Kodak Company

EPA ENERGY STAR Webcast

February 16, 2005

George Weed & James Breeze

# Key Points

- Motors Contribute 60+ % of Electricity Usage in Industry
- Oversizing Motors is a common practice
- Oversizing Motors is wasteful & expensive
- Implementing a Motor Standardization Program Saves Energy, $CO_2$, & Cost
- Selecting Premium Efficient Motors PAYS
- Right Sizing Motors PAYS
- Right Sizing Equipment PAYS

# Motor Applications at Kodak

- HVAC
- Process Pumps
- Process Fans
- Conveying
- Grinding
- Extruding
- 80,000 Motors in inventory

# Key Motor Program Elements

- Central Inventory Control
  - Reduce redundancy
  - Reduce number of suppliers
  - Reduce spare parts
  - Reduce number of specialty motors
- Replace versus Repair Policy
  - Replace any failed motor smaller than 20hp
  - Analyze motors over 20 hp with Motor Master before making a repair.
  - Replace motors with 1-2 year payback
- Purchasing Policy
  - Standardization---Purchase only NEMA Premium Efficiency Motors
  - Standardize on only one manufacturer
  - Non-standard purchases are flagged for special approval

# Criteria for Replacement of Motors

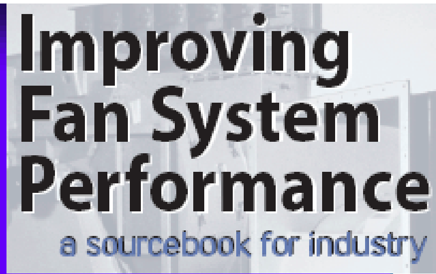
1. Motors must comply with NEMA PREMIUM ENERGY EFFICIENT (XEX) standards.
2. Motors must adhere to the STANDARDIZATION policy relating to energy conservation and the desire to reduce green house gases at Eastman Kodak Company.
3. Motors that DO NOT meet the ENERGY EFFICIENCY guidelines WILL NOT be repaired, but WILL be replaced. (Exceptions are production critical or "special" motors designed for a process.)
4. This criteria for replacement of motors is constantly being reviewed and updated.

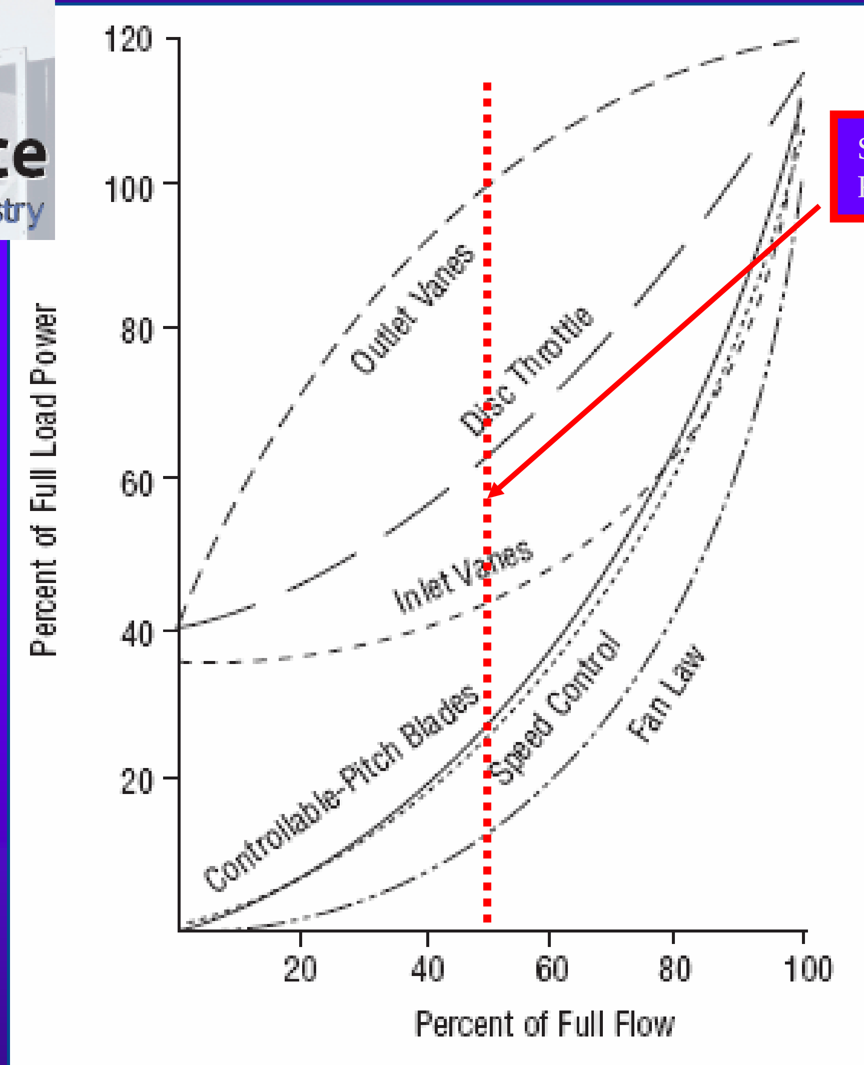
# Efficiency Counts

- NEMA premium efficiency motors pay for themselves in 1-2 years compared to rewinding standard motor
- 78,000 HP was replaced over 8years
- At typical tariff rates, the energy savings from our Motor Replacement Program is equivalent to $1.5 Million.
- Motor replacements have also reduced CO2 emissions by 38,000,000 lbs over 8 years

# Right Sizing Motors & Equipment Also Saves Energy

- Replacing oversized motors where practical
- Trimming pump impellers
- Re-sheaving fans
- Installing VFDs where applicable
- These activities have saved in excess of $1.5 million in the last three years alone.




Scenario With a 50% Reduction in Flow Rate

**Figure 2-20. Relative Power Consumption Among Flow Control Options**

Chart from "*Improving Fan System Performance*" a sourcebook for industry,

U.S. Department of Energy

Energy Efficiency and Renewable Energy

# Fan Laws

$$\left\{\frac{RPM_1}{RPM_2}\right\}^3 = \left\{\frac{BHP_1}{BHP_2}\right\}$$

**Example:**

$RPM_1 = 1800$

$BHP_1 = 100$

$RPM_2 = 900$

$BHP_2 = BHP_1 \text{ x } (RPM_2 / RPM_1)^3$

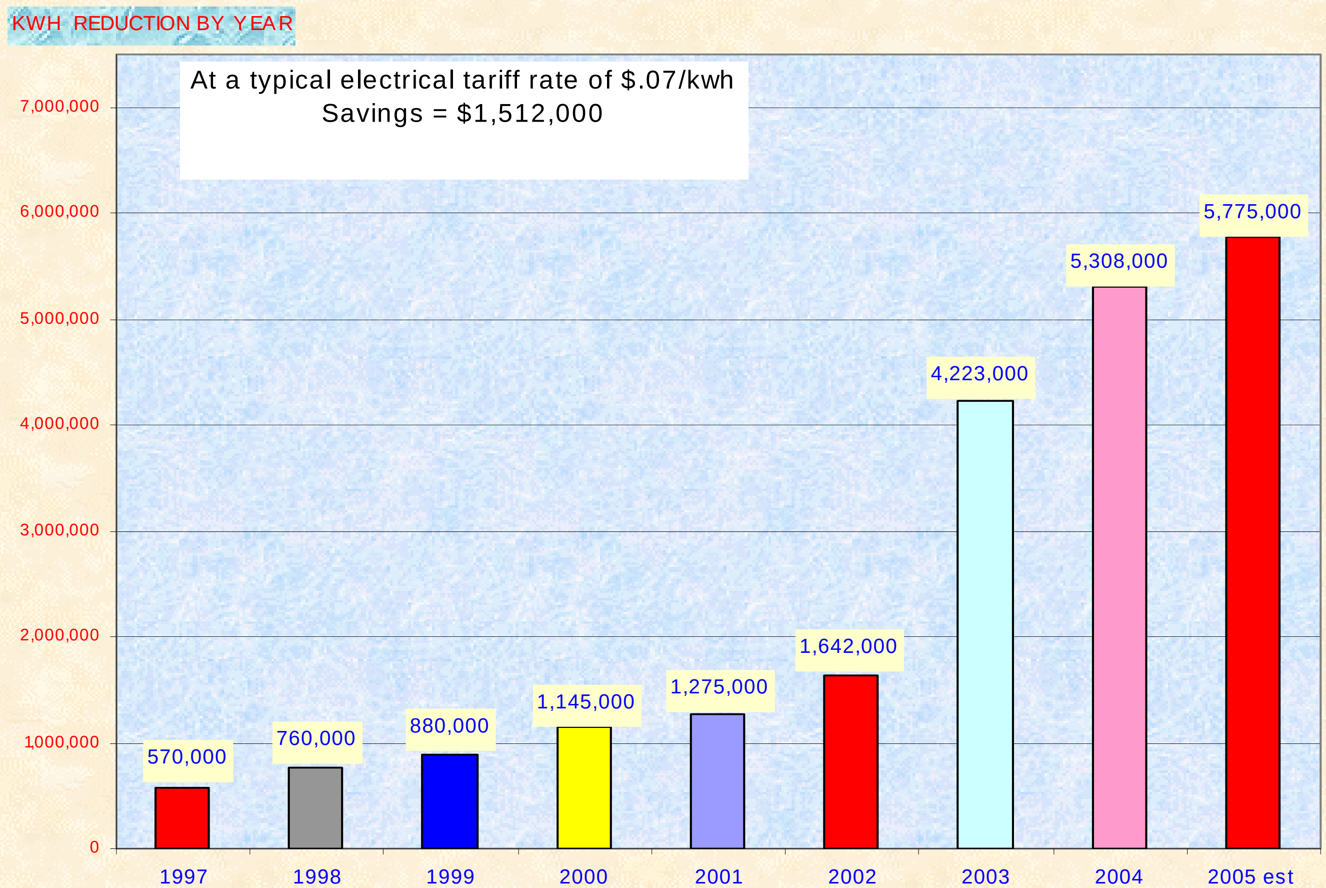
$= 100 \text{ x } (900/1800)^3 = 12.5 \text{ bhp}$

In this example:

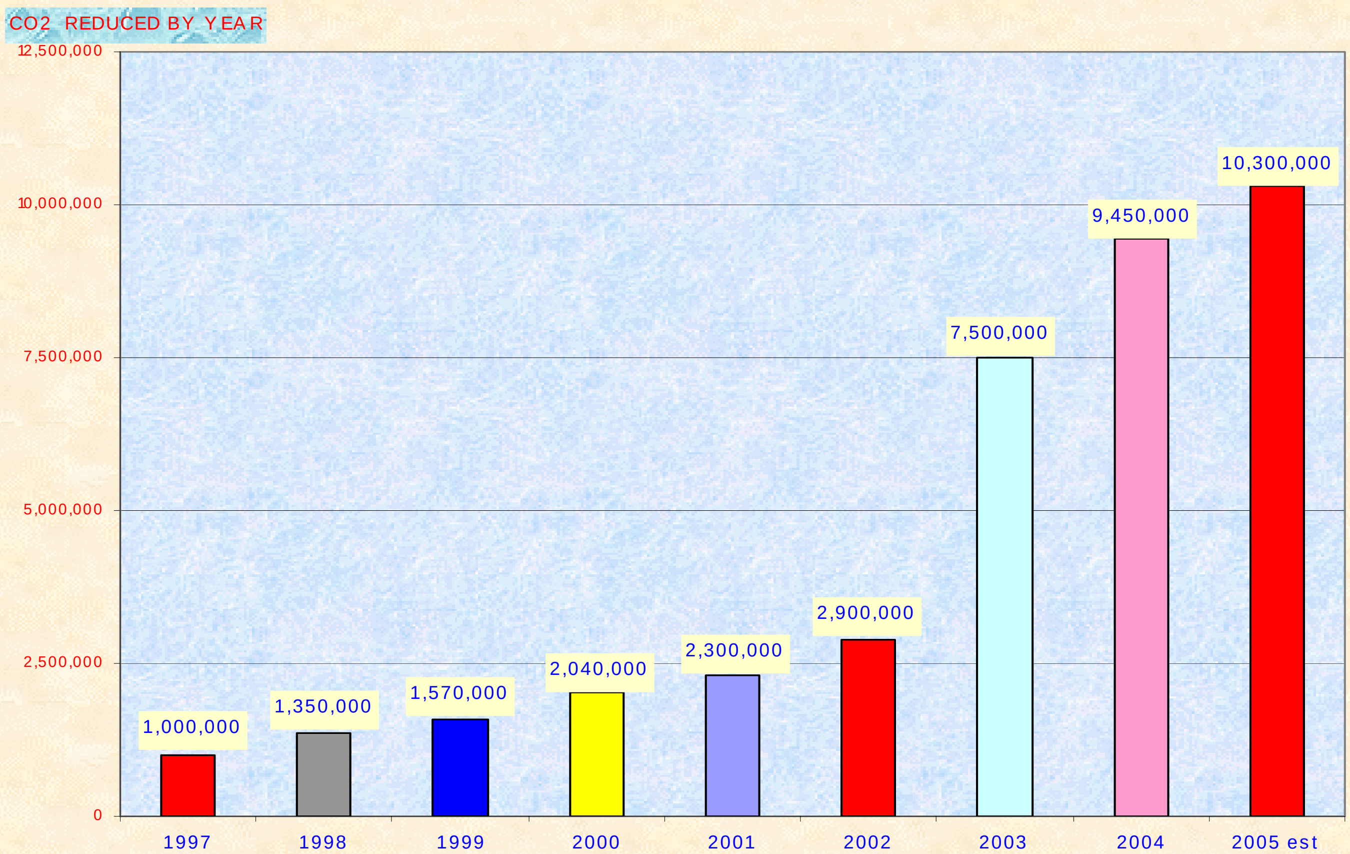
If the flow rate were cut in half by reducing the speed from 1800 RPM to 900 RPM, the fan would only need 12.5 HP compared to 100 HP at 100% load.

KWH REDUCTIONS 1997-2005

Total = 21,600,000 KWH



## CO2 REDUCTIONS 1997-2005
Total = 38,400,000 lbs




REDUCTION IN CO2 REPRESENTS ACTUAL EMISSIONS REDUCED FROM MOTORS SCRAPPED AS NON ENERGY EFFICIENT AND REPLACED WITH NEW AS WELL AS NEW PROCESSES & PROCEDURES THAT FOCUS ON NEMA PREMIUM EFFICIENT MOTORS.

Questions ?

# Contacts & References

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- george.weed@kodak.com

  (585) 477-3518

- Improving Fan System Performance

  http://www.oit.doe.gov/cfm/fullarticle.cfm/id=749

# Questions & Comments

# Upcoming Web Conferences

March 16 – Benchmarking for Strategic Energy Management

April 20 – Meet The ENERGY STAR Partners of the Year

Annual Awards Ceremony

- March 15, 2005 in Washington, DC
- Register now

www.energystar.gov/networking

Thank you for participating!