MOTOR Efficiency

Standards and Regulations

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From Inefficient TO

Market Shift

NEMA Premium™

NEMA Standards Provide the Foundation for Motor Efficiency Policy

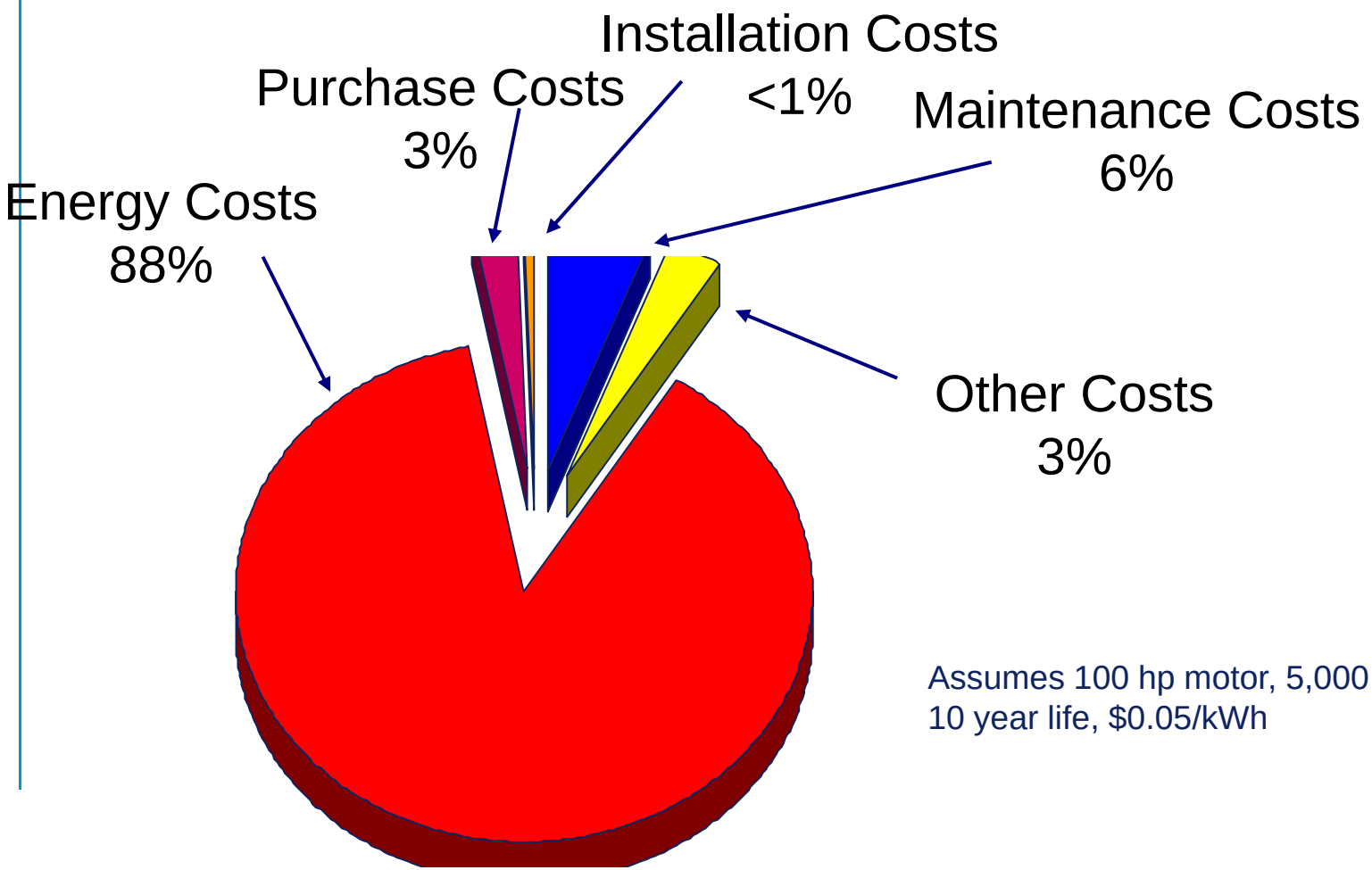
Motor Generator Section

Agenda

- Industrial Motors savings potential
- Present Standards and Regulations in North America
- NEMA Premium a new efficiency standard
- IEC and NEMA harmonization efforts
- Repair versus replacement issues
- Future changes in North American motor efficiency regulations
- Market shift

Electric Motor Life Cycle Costing

DOE 2004 Industrial Energy Savings Roadmap



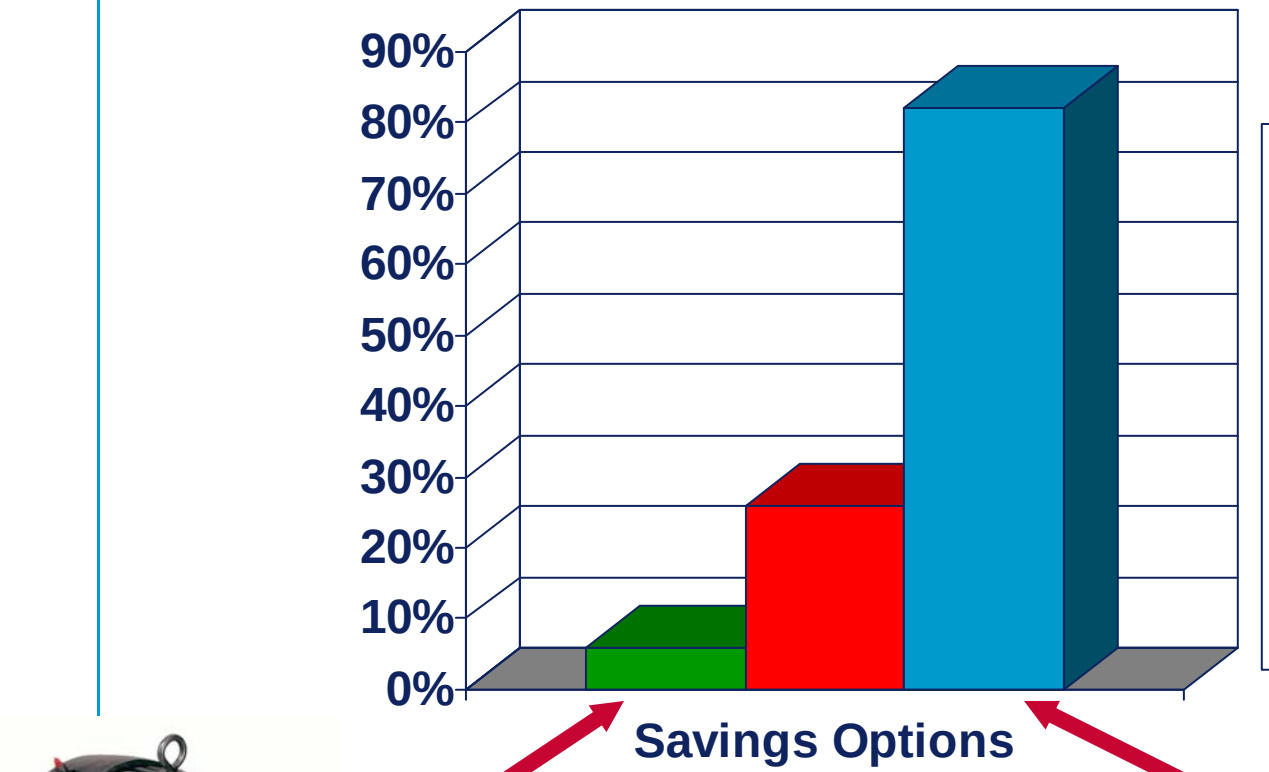
Assumes 100 hp motor, 5,000 hours/year,
10 year life, $0.05/kWh

According to a 1998 Study by the Department of Energy

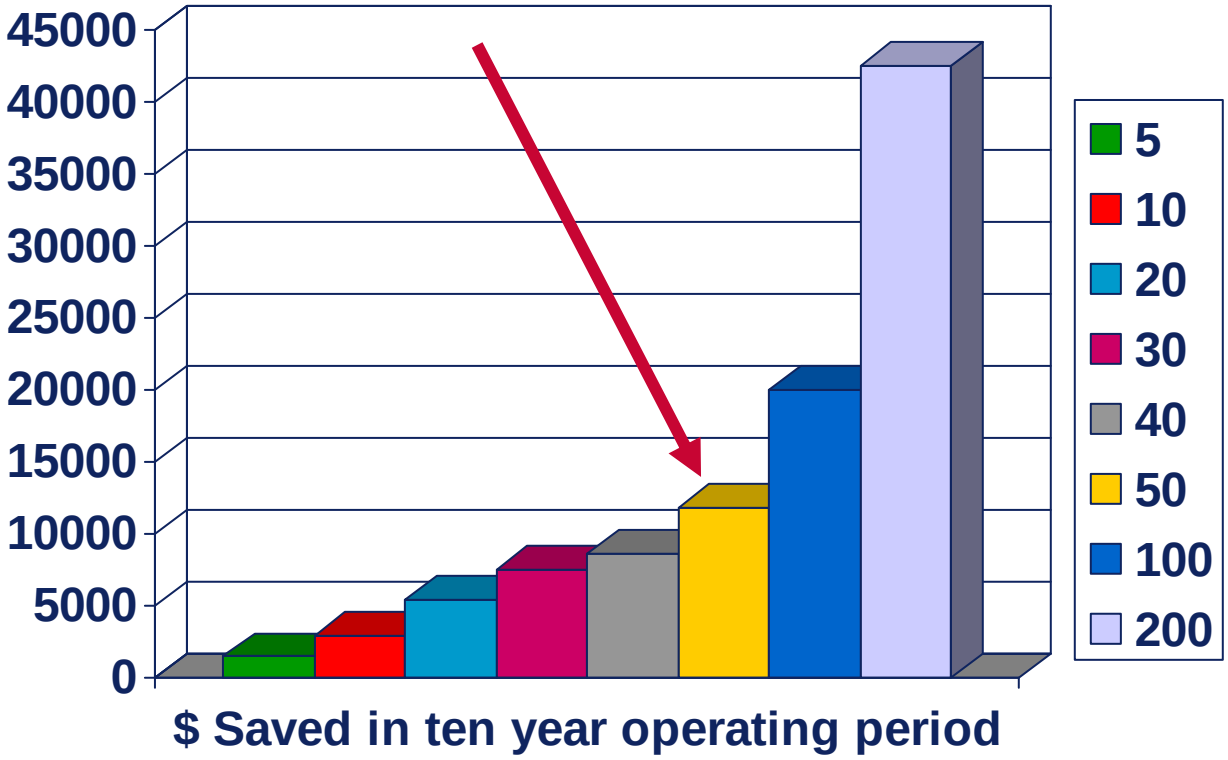
- 23% of all electricity sold in the U.S. is consumed by motor systems

- Industrial motor energy usage could be reduced up to 18% through proven technologies and practices

The energy savings opportunity



Premium Savings Over Ten Years

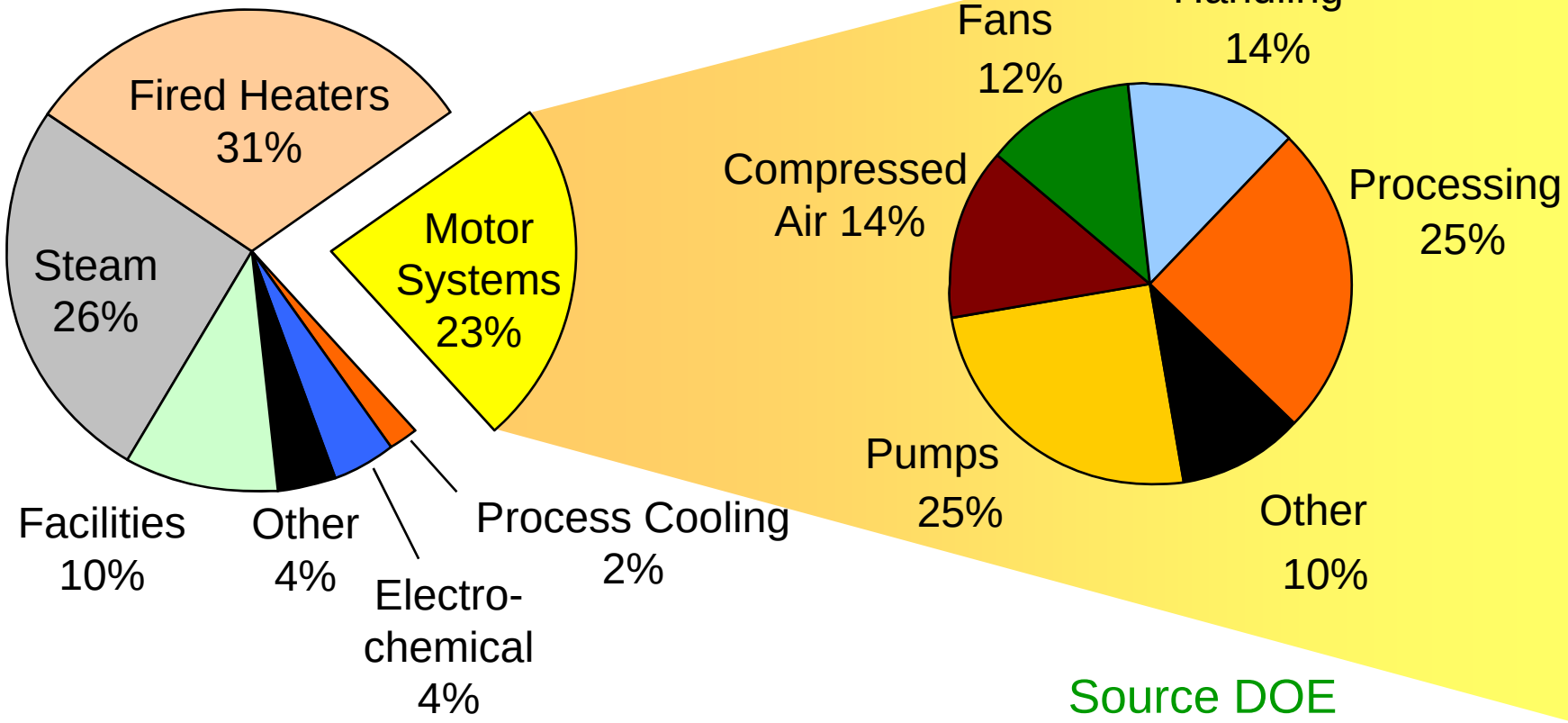


A 50hp motor can save the equivalent of a significant labor cost reduction over ten years

Regulatory Options Driving Energy Policy Act Of 1992- USA

- Continue with a voluntary approach allowing market to recognize efficient motor value and decide
- Allow states to regulate and adjust product and distribution channels accordingly
- Regulate most categories of electric motors regardless of savings potential and expense
- Select and regulate a segment of categories based on economic justification and technical feasibility

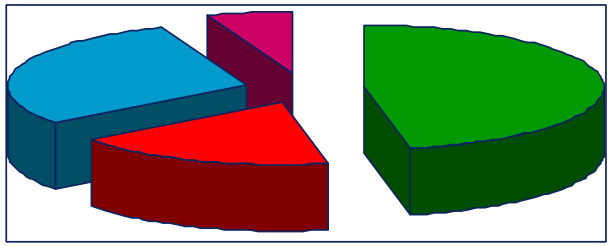
Manufacturing & Mining Energy Use



Source DOE

Includes electricity generation/distribution/transmission losses

IHP Motor Channels To Market



- OEM
- Distribution to OEM
- Distribution to User
- User Direct

Original Equipment Manufacturers and Distributor Sales channels are split evenly at approximately 48% each. Small OEMs buy 18% through distribution.

End users buy 30 % through Distribution and 4% direct from manufacturers.

34% of sales to users

Regulatory Issues Check List- Motors

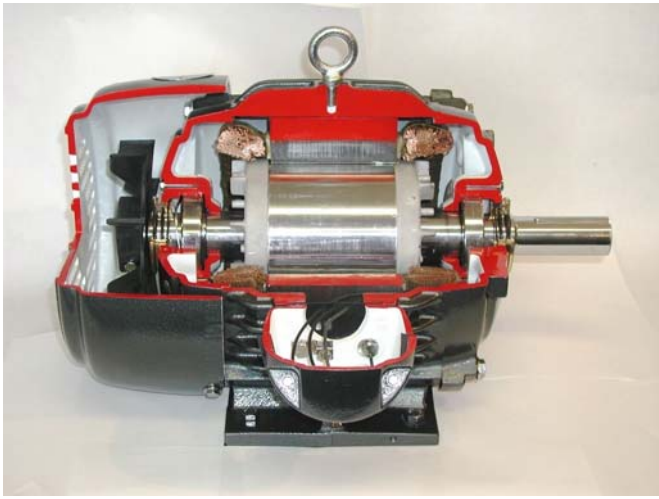
- **1] What product will be covered?**
- **2] What efficiency level will be used?**
- **3] What performance test method will be required?**
- **4] How will test labs be evaluated and accredited?**
- **5] What label requirement will be used?**
- **6] How will compliance be enforced?**
- **7] How much time will be allowed from enactment to implementation?**
- **8] How will future reviews be addressed?**

Efficiency Elements	1992	1997	2001	2005	2007	2008	2011
Covered product	Defined	Implement	Unchanged	Unchanged FEMP	Unchanged FEMP	Unchanged FEMP	?
Efficiency levels	Defined	Implement	NEMA Premium	NEMA Premium	NEMA Premium	NEMA Premium	?
Test Method	Defined	Implement	Unchanged	Unchanged	Unchanged	Unchanged	?
Lab required	Defined	Implement	Unchanged	Unchanged	Unchanged	Unchanged	?
Compliance enforce	Defined	Implement	Unchanged	Unchanged	Unchanged	Unchanged	?
Timing	Defined	Implement	Voluntary	Voluntary	Voluntary	Voluntary	?
Revisions	Defined			FEMP Added	Discussion Begins	Future Legislation	?

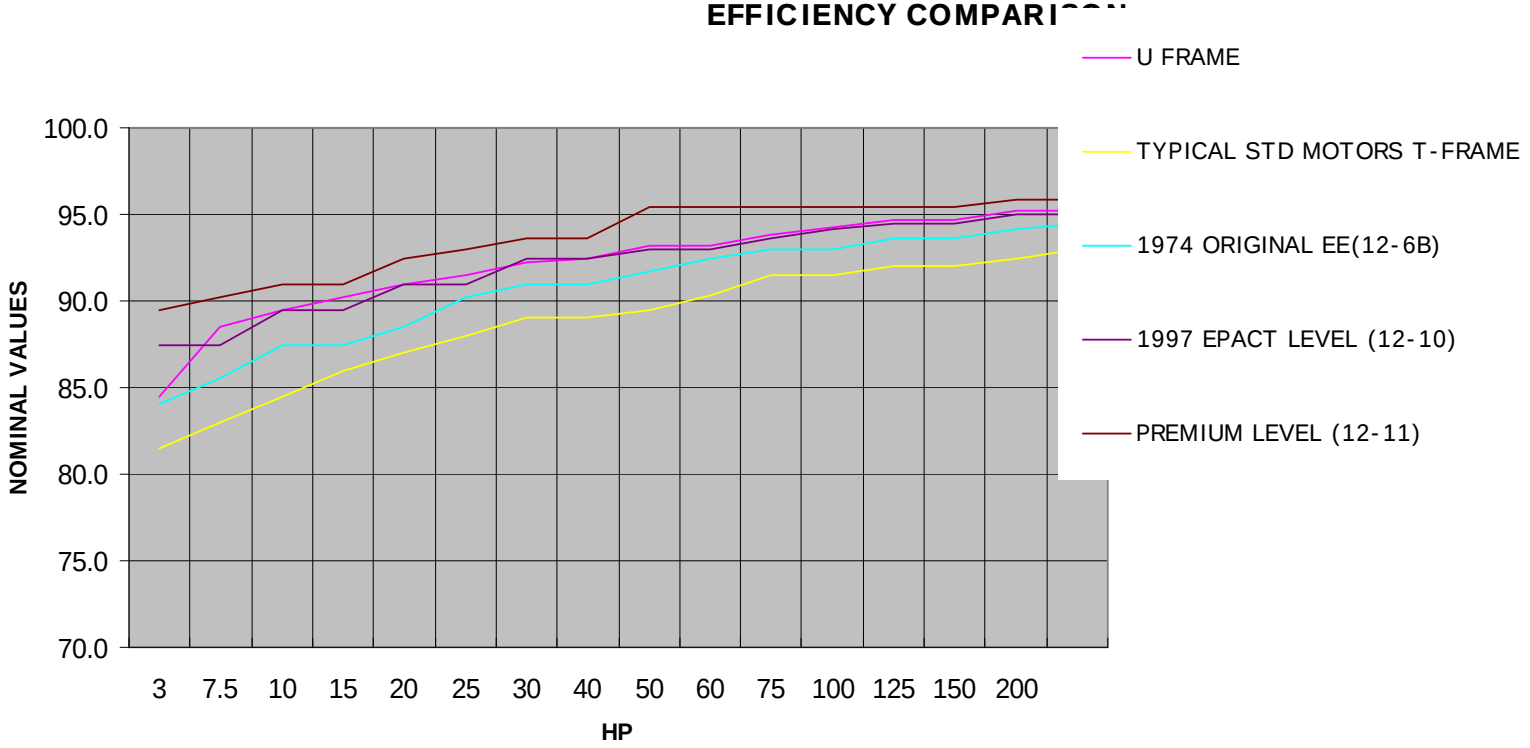
Evolution of Motor Efficiency USA

Covered Product

- Product categories as defined by MG 1
  - General purpose
  - Definite purpose
  - Special purpose
- Economically justifiable
  - Largest single segment
  - Capital spread over high volume
- Technically feasible
  - Most standard design
  - By and large no mechanical change needed



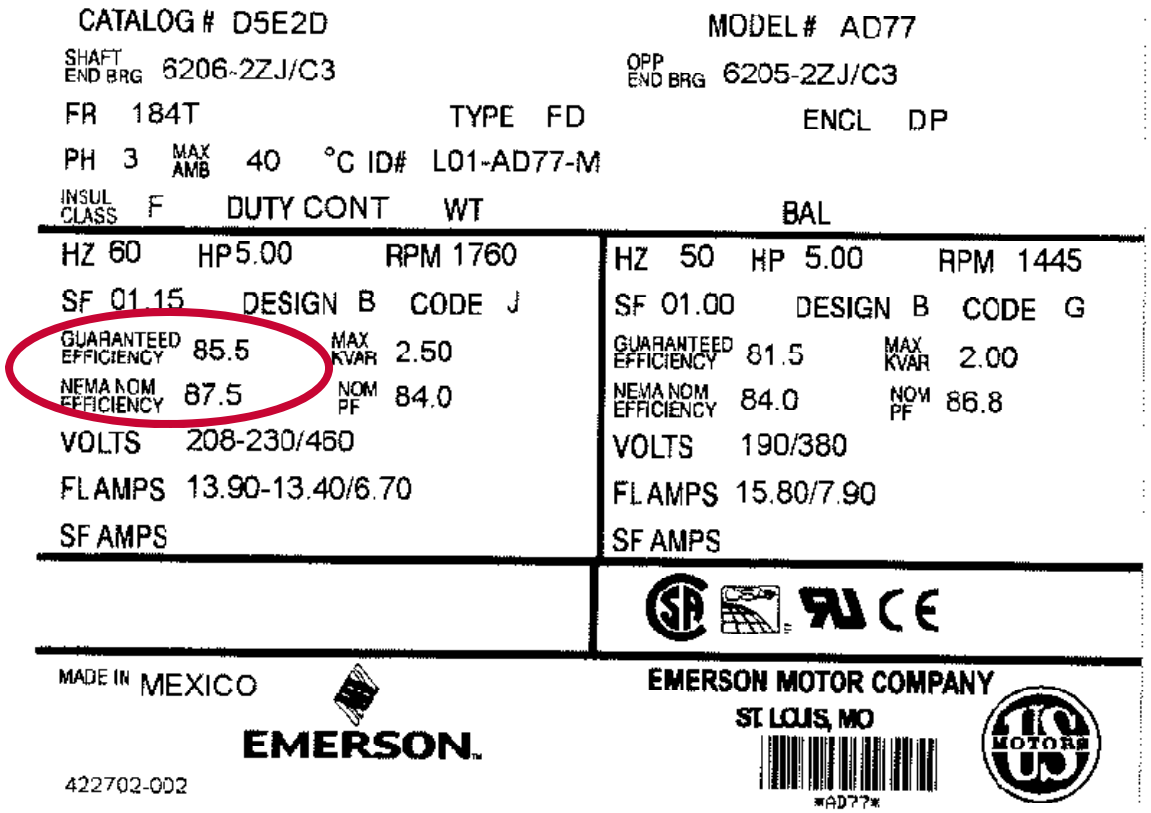
Various Efficiency Levels Exist Within MG 1



Test methods use IEEE 112 method B
IEC 60034-2-1

Labeling and Identification

- NEMA nominal efficiency definitions exist within MG1



Compliance and Enforcement

- Manufacturers accredit labs or use third party labs for testing
- Data required for 113 “basic models’
  - Submission to Department of Energy
    - Tested samples indicated
  - DOE issued “compliance number”
- Compliance test parameters determined
  - Department of Energy enforcement actions
  - Due process
    - Written notice and modification of non-compliant product
  - Remedies may include judicial restraining order

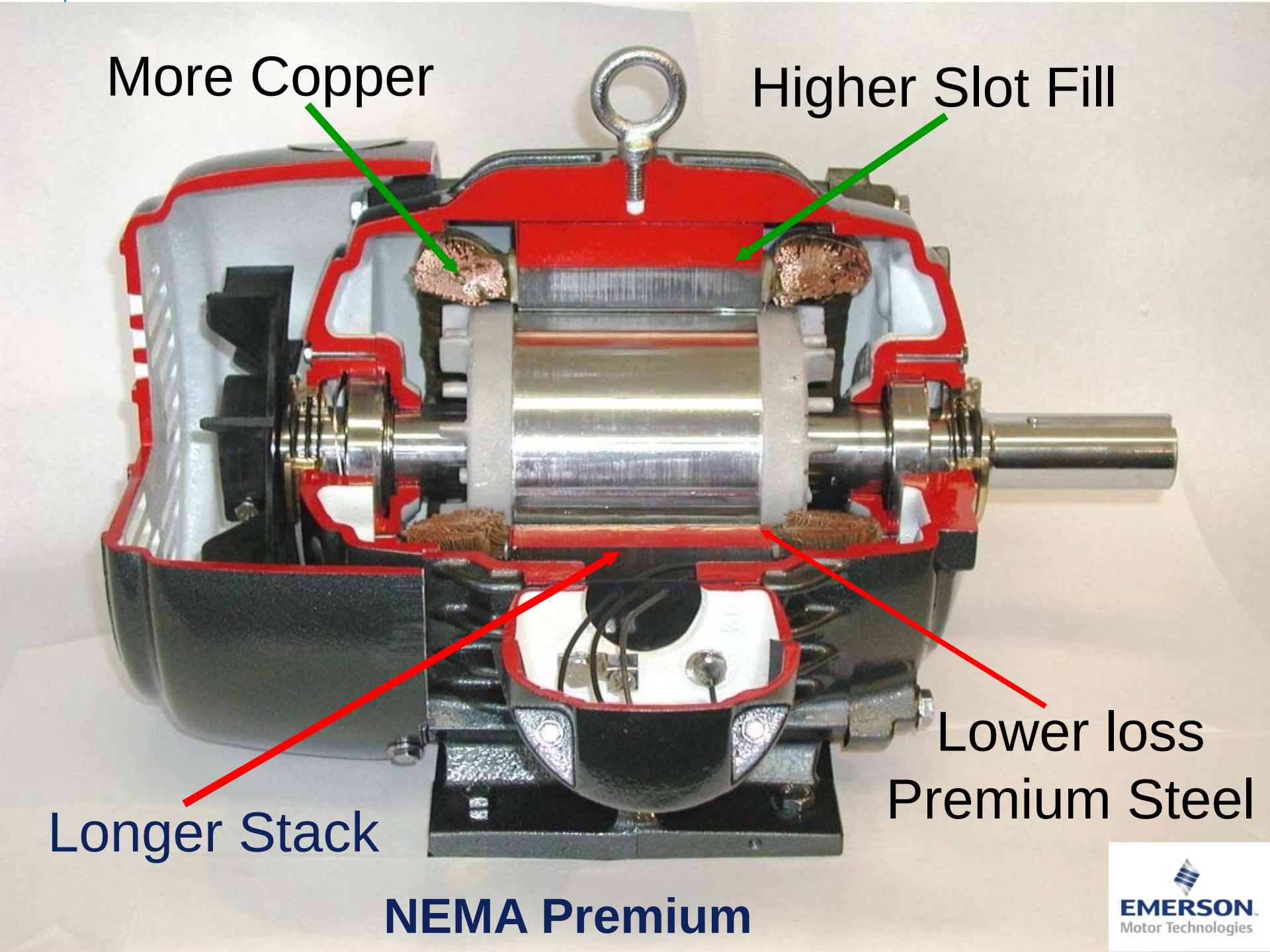
Actual DOE filing from a US motor manufacturer

HP	Number of Poles	Least Efficient Basic Model	TYPE	Nominal Full Load Efficiency	HP	Number of Poles	Least Efficient Basic Model	TYPE	Nominal Full Load Efficiency
1	4	H1E2D	Enclosed	82.5	30	2	H30E1DS	Enclosed	91.0
1	6	H1E3D	Enclosed	80.0	30	4	H30E2E	Enclosed	92.4
1-1/2	2	H32E1D	Enclosed	82.5	30	6	H30E3E	Enclosed	91.7
1-1/2	4	H32E2D	Enclosed	84.0	40	2	H40E1ES	Enclosed	91.7
1-1/2	6	H32E3D	Enclosed	85.5	40	4	H40E2E	Enclosed	93.0
2	2	H2E1D	Enclosed	84.0	40*	6	H40E3E	Enclosed	93.0
2	4	H2E2D	Enclosed	84.0	50	2	H50E1ES	Enclosed	92.4
2	6	H2E3D	Enclosed	86.5	50	4	H50E2E	Enclosed	93.0
3*	2	H3E1D	Enclosed	85.5	50	6	H50E3E	Enclosed	93.0
3	4	H3E2D	Enclosed	87.5	60	2	H60E1ES	Enclosed	93.0
3	6	H3E3D	Enclosed	87.5	60	4	H60E2E	Enclosed	93.6
5*	2	H5E1D	Enclosed	87.5	60	6	H60E3E	Enclosed	93.6
5	4	H5E2D	Enclosed	87.5	75	2	H75E1ES	Enclosed	93.0
5	6	H5E3D	Enclosed	87.5	75	4	H75E2E	Enclosed	94.1

Why NEMA Premium? IE3

- Customers demand more efficient products
- Power utilities paid rebates based on performance
- End user standards called out various levels of efficiency
- Multiple premium efficiency definitions caused market confusion and added cost to all
- The answer

NEMA Premium™



NEMA Premium

EMERSON
Motor Technologies

NEMA Premium Plan

- Establish a national motor efficiency **Identity!**
- NEMA Premium is a registered trade mark
- Expand scope of product to include a much greater number of potential units
- Create a testing and labeling scenario that is consistent with existing federal energy code
- Add NEMA premium to MG1 in two new tables as an ANCI standard
- Align utility rebates and state energy programs to use/refer to NEMA Premium

NEMA Premium Efficiency Standard

- Product scope expanded beyond existing federal regulations
  - 1-500HP low and medium [2,4,6 pole] low and medium voltage motors
  - Definite and special purpose motors

NEMA Premium™

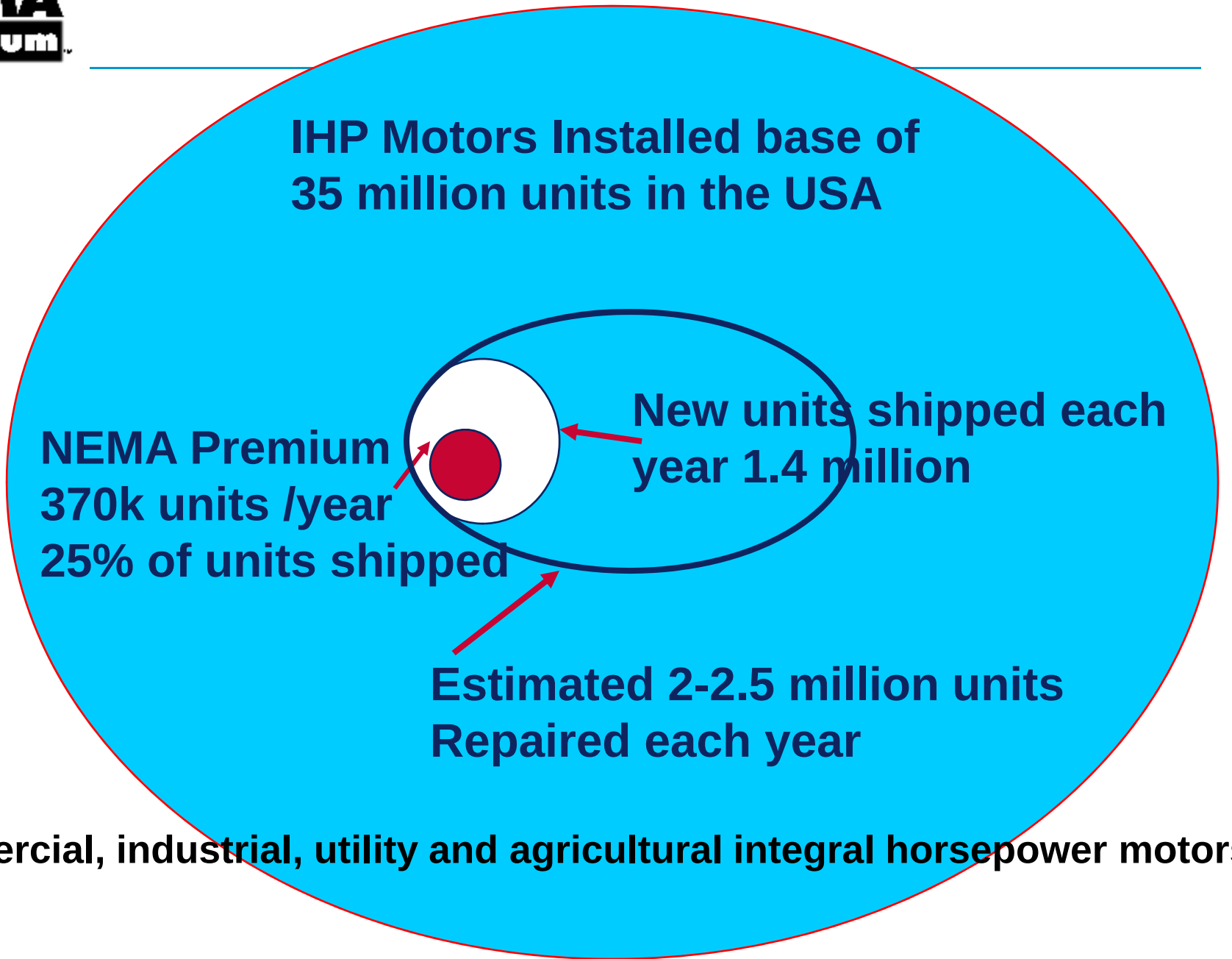
IEC and NEMA Comparison

- IE3 Premium Efficient levels 60hz yes 50 hz very close
- Test Standards
  - IEC 34-2-1
- Labeling Standards- yes
- Lab Accreditation - no
- Compliance procedures - no
- Enforcement – Each EU country
- Product definitions- not clearly defined
- Timing
  - IE2 Planned 2010

- NEMA Premium levels 60hz yes 50 hz very close
- Test Standards-
  - IEEE112B/CSA390
- Labeling Standards- yes
- Lab Accreditation -NIST
- Compliance procedures yes
- Enforcement- DOE/Manufacturers
- Product definitions- well defined
- Timing
  - Epact [IE2] 1997
  - EISA [IE3] 2010

IEC Frame Issues

- IEC motors are built in smaller diameter than similar HP/KW NEMA T frame motors
- Efficiency gains require more material and /or design changes
  - Increase motor length?
  - Increase diameter?
  - Copper bar rotor?
  - Low loss electrical steel?
- Motor users do not want a change in size
  - Dimensional replacement complications
  - New equipment redesigns fit and cost



Commercial, industrial, utility and agricultural integral horsepower motors.

Assumptions used to estimate industrial motor efficiency savings opportunity
Ten cents per kwh operating at 5000 hours per year.

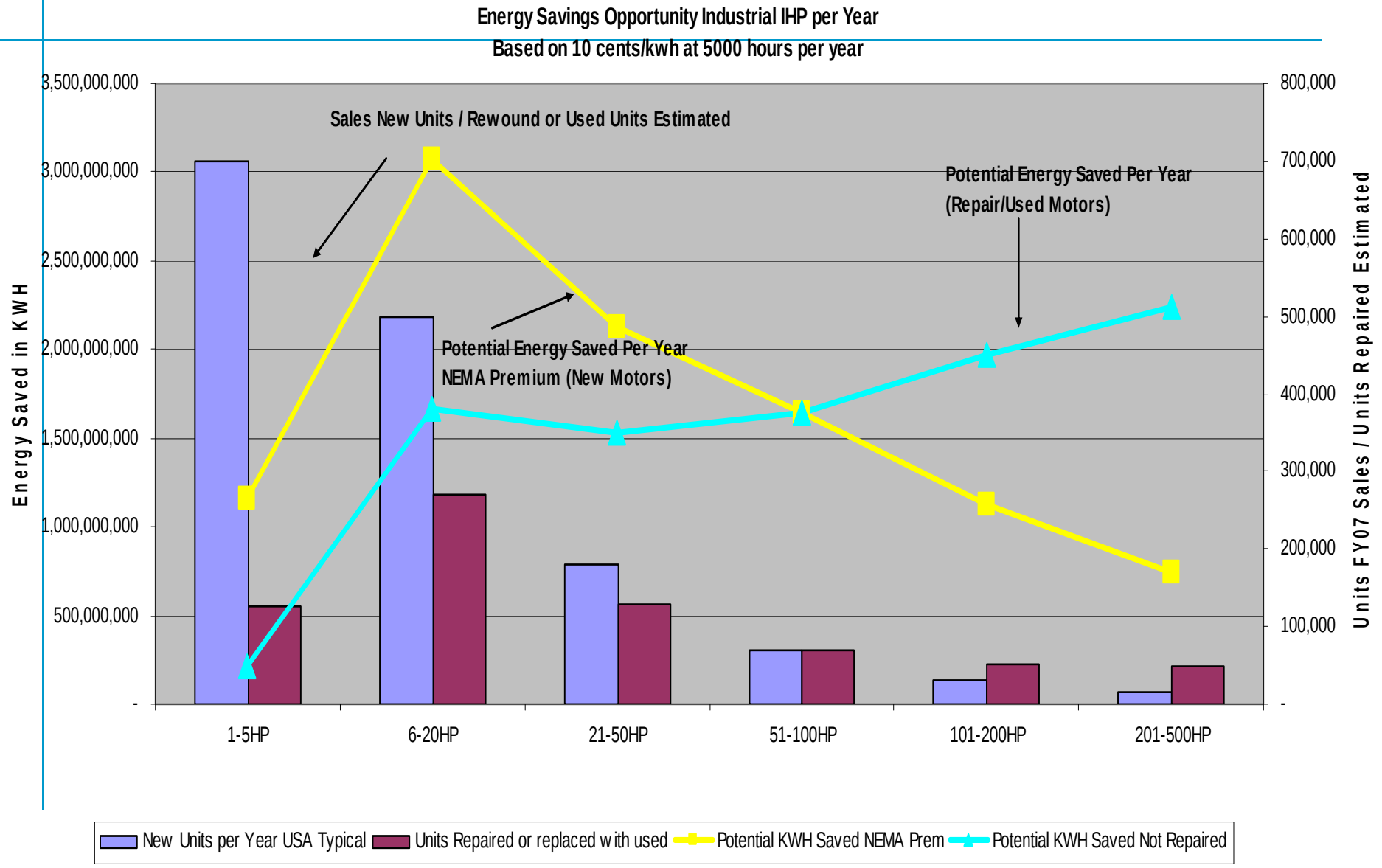
HP Range	New Units per Year USA Typical	Potential KWH Saved NEMA Prem	Repaired % of installed base	Units Repaired or replaced with used	Potential KWH Saved Not Repaired		Ave KWH Saved per unit per year average of category	Installed base USA annual sales times life	Average Motor Life
1-5HP	700,000	1,157,485,896	1%	126,000	208,347,461		1654	12,600,000	18
6-20HP	500,000	3,075,678,753	3%	270,000	1,660,866,526		6151	9,000,000	18
21-50HP	180,000	2,123,872,211	4%	129,600	1,529,187,992		11799	3,240,000	18
51-100HP	70,000	1,648,469,932	5%	70,000	1,648,469,932		23550	1,400,000	20
101-200HP	30,000	1,124,181,028	7%	52,500	1,967,316,799		37473	750,000	25
201-500HP	16,000	747,117,341	10%	48,000	2,241,352,022		46695	480,000	30
Total Industrial	1,496,000			696,100				27,470,000	

Percentage repaired estimate includes failed motors rewound or replaced by used motors from user stock or service center. Mechanical repairs including bearing replacement have not been included.
Vertical motors not included.

Size (hp) LV	Pre-EPAct[1]	EPAct[2]	NEMA Premium[4]	NEMA Prem to Pre Epact	NEMA Prem to Epact
1.0	76.7	82.5	85.5	8.8	3.0
1.5	79.1	84.0	86.5	7.4	2.5
2.0	80.8	84.0	86.5	5.7	2.5
3.0	81.4	87.5	89.5	8.1	2.0
5.0	83.3	87.5	89.5	6.2	2.0
7.5	85.5	89.5	91.7	6.2	2.2
10.0	85.7	89.5	91.7	6.0	2.2
15.0	86.6	91.0	92.4	5.8	1.4
20.0	88.5	91.0	93.0	4.5	2.0
25.0	89.3	92.4	93.6	4.3	1.2
30.0	89.6	92.4	93.6	4.0	1.2
40.0	90.2	93.0	94.1	3.9	1.1
50.0	91.3	93.0	94.5	3.2	1.5
60.0	91.8	93.6	95.0	3.3	1.4
75.0	91.7	94.1	95.4	3.7	1.3
100.0	92.3	94.5	95.4	3.2	0.9
125.0	92.2	94.5	95.4	3.2	0.9
150.0	93.0	95.0	95.8	2.8	0.8
200.0	93.5	95.0	96.2	2.7	1.2

Efficiency delta decreases as horsepower increases

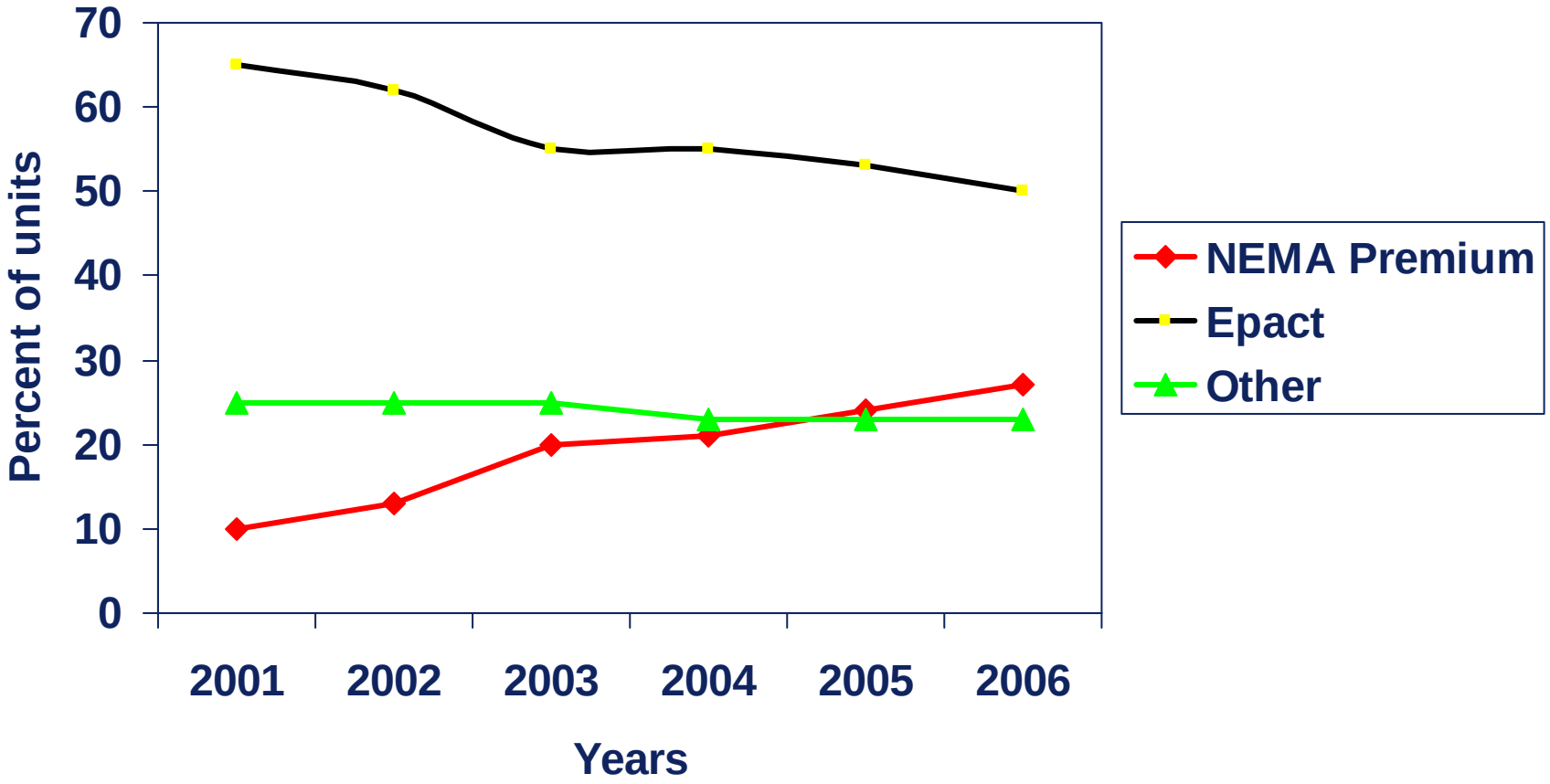
Source MDM 1,2,3


Energy Savings Opportunity Industrial IHP per Year
Based on 10 cents/kwh at 5000 hours per year
Energy Saved in KWH
Units FY07 Sales / Units Repaired Estimated
3,500,000,000
3,000,000,000
2,500,000,000
2,000,000,000
1,500,000,000
1,000,000,000
500,000,000
-
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
-
Sales New Units / Rewound or Used Units Estimated
Potential Energy Saved Per Year
(Repair/Used Motors)
Potential Energy Saved Per Year
NEMA Premium (New Motors)
1-5HP
6-20HP
21-50HP
51-100HP
101-200HP
201-500HP
New Units per Year USA Typical
Units Repaired or replaced with used
Potential KWH Saved NEMA Prem
Potential KWH Saved Not Repaired

Efficiency Elements	1992	1997	2001	2005	2007	2008	2010
Covered product	Defined	Implement	Unchanged	Unchanged FEMP	Unchanged FEMP	Unchanged FEMP	Expanded and FEMP
Efficiency levels	Defined	Implement	NEMA Premium	NEMA Premium	NEMA Premium 50	NEMA Premium	NEMA Premium
Test Method	Defined	Implement	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged
Lab required	Defined	Implement	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged
Compliance enforce	Defined	Implement	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged
Timing	Defined	Implement	Voluntary	Voluntary	Voluntary	Voluntary	Regulation
Revisions	Defined			FEMP Added	Discussion Begins	Legislation Enacted	Revisions Implement

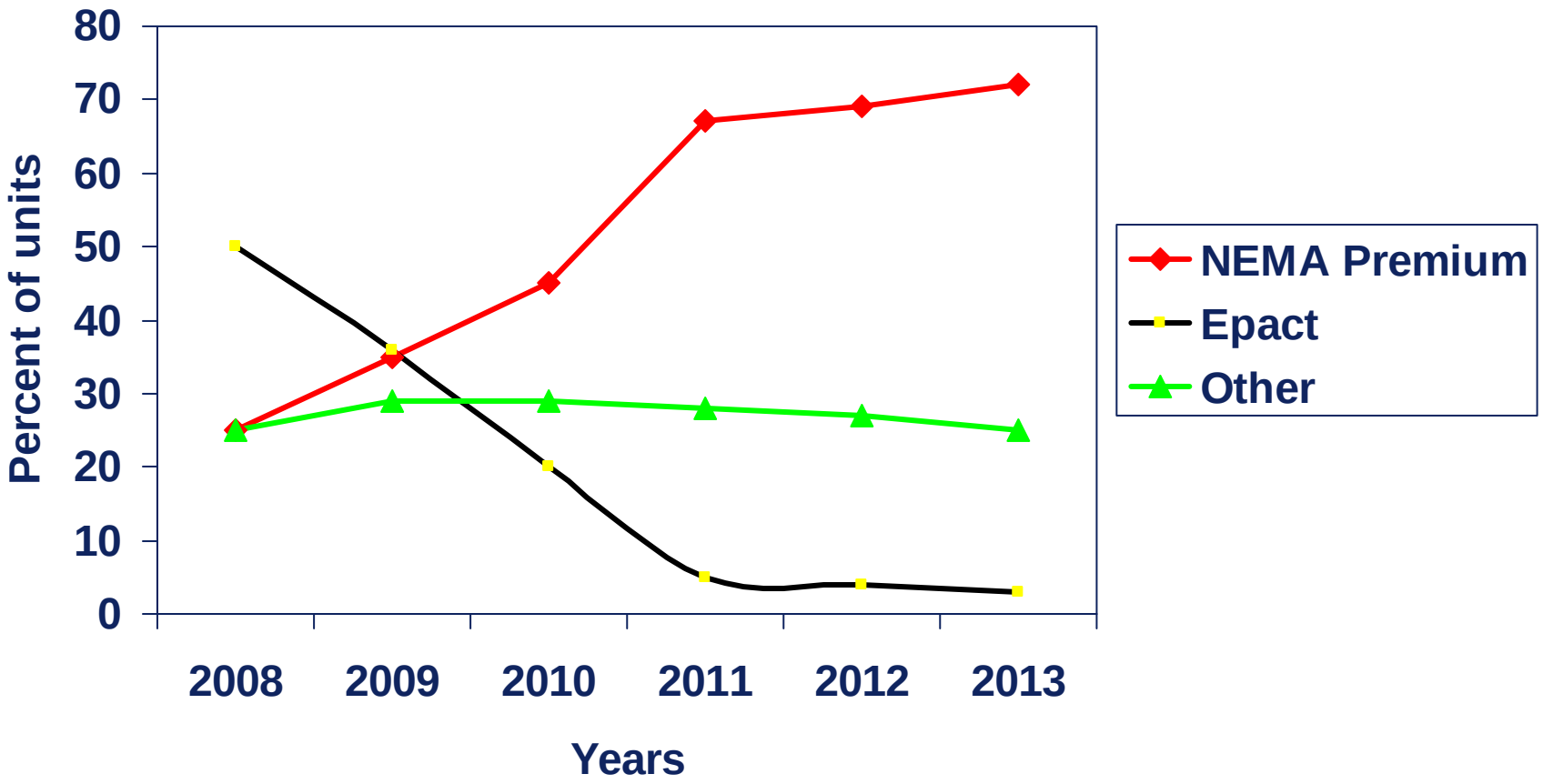
Motor Efficiency Today in North America

Historic Efficiency Trend 2001- 2006



Market penetration after six years plateaus at 20-25%

Future Efficiency Expected 2008- 2013



Regulatory revised forecast model

1 TO 200HP LVAC

Motor Efficiency Conclusion

- Epact Standards provide policy foundation in North America
  - Basic product definition determined once then evolved over time
  - Efficiency levels harmonized with IEC both 50 and 60hz
  - Test standards set and held constant now harmonized with IEC
  - Labeling agreed to early and held constant - Similar to IEC
  - Test labs requirements determined early in process and held constant not required by IEC
- NEMA Premium / IE3 will become the regulated level in 2010 in North America
- Remaining concerns
- Motor standards and eventual regulations in South America and Asia
  - Harmonized standards and regulations
  - Prevent MEPS becoming trade barriers
- Replace fixed speed motors with variable speed
  - Remove belts, pulleys, sheaves, worm gearing, throttling valves and other inefficient mechanical components
- Replace induction motors with more efficient new technologies such as SR and PM products in variable speed applications

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Market Shift

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