Energy Services
Western Area Power Administration

A comprehensive source for reliable energy solutions from Energy Experts

Sharing Objective Assessments of Emerging Technologies

Utility Energy Forum

May 17, 2013

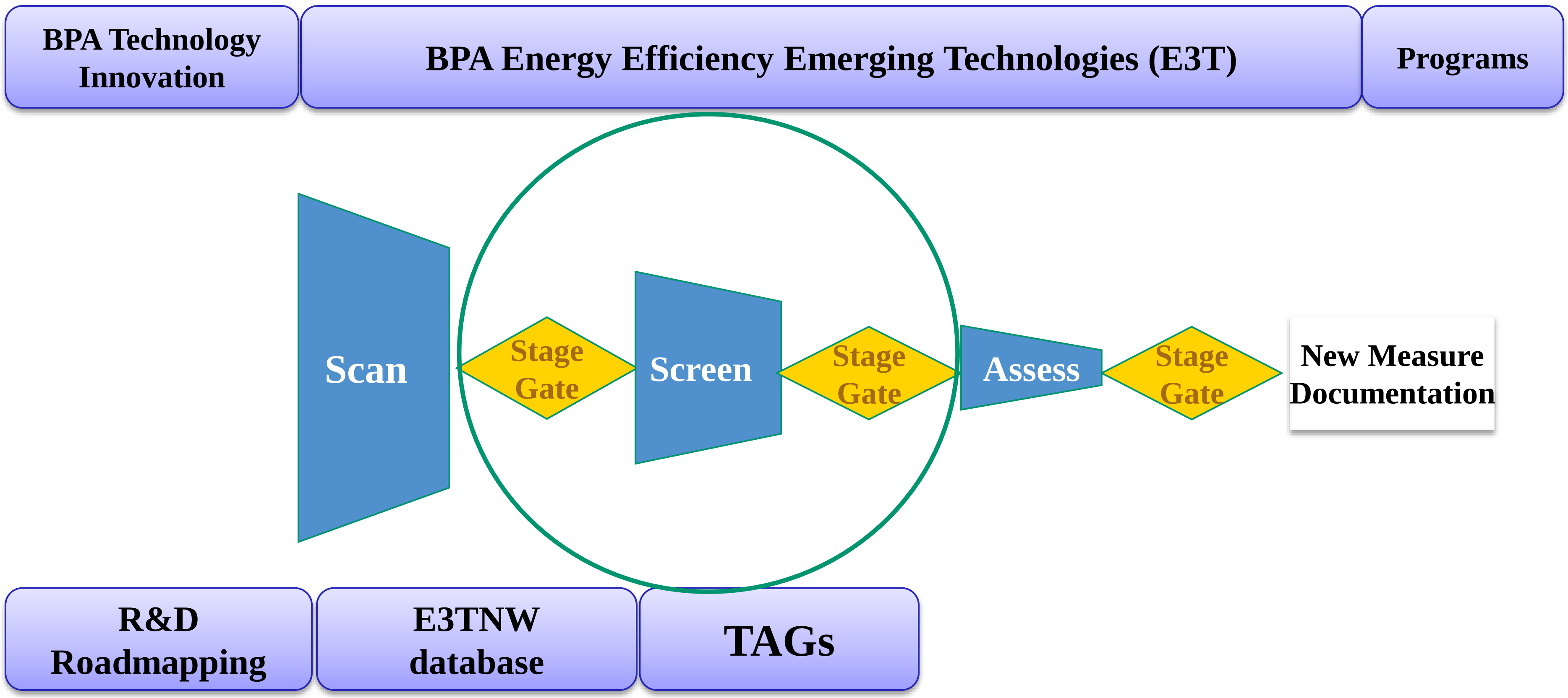
Rob Penney

Washington State University
Extension Energy Program

Overview

- Overview of E3T Technology Assessment
- Database of Emerging Technologies
- Sample New and Emerging Technologies
- More Information

The E3T Funnel



Washington State University Extension Energy Program

Technology Information

- Description
- Energy savings and dependencies
- Measure readiness level
- Installed and O&M costs
- Effective life
- Cost effectiveness
- Standard practice
- Development status
- Non-energy benefits
- End user drawbacks
- Competing technologies
- Additional information resources

Technical Advisory Groups

Lighting - 2009

HVAC - 2009 & 2010

Energy Management - 2011

LED/SSL – 2012

Smart Thermostats– 2012

Lighting Controls – 2013

TAG Partners

EPRI ELECTRIC POWER RESEARCH INSTITUTE

Northwest Power and Conservation Council

Evergreen Consulting Group, LLC

eco² electricalengineeringcompany engineering 4 tomorrow

SEA SAIK ENGINEERING ASSOCIATES, INC.

SMUD SACRAMENTO MUNICIPAL UTILITY DISTRICT The Power To Do More.

Energy Trust of Oregon

Schneider Electric

Pacific Northwest NATIONAL LABORATORY

lighting design lab

City of Ashland

EWEB

SOUTHERN CALIFORNIA EDISON An EDISON INTERNATIONAL Company

Davis Energy Group

COFFMAN ENGINEERS

Lighting Research Center

peci

BC hydro

SNOHOMISH COUNTY PUD PUBLIC UTILITY DISTRICT NO. 1

SOURCE

BERKELEY LAB

PUGET SOUND ENERGY

NORTH COAST ELECTRIC COMPANY

PAE

Lighting Wizards

Hines

WCEC WESTERN COOLING EFFICIENCY CENTER

UNIVERSITY OF OREGON

nyserda Energy. Innovation. Solutions.

ATS AUTOMATION

AHRI AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE

PLANLED

Seattle City Light

ARUP

NEMA

CLTC CALIFORNIA LIGHTING TECHNOLOGY CENTER

ecova

LIGHT DOCTOR

neep

mmb

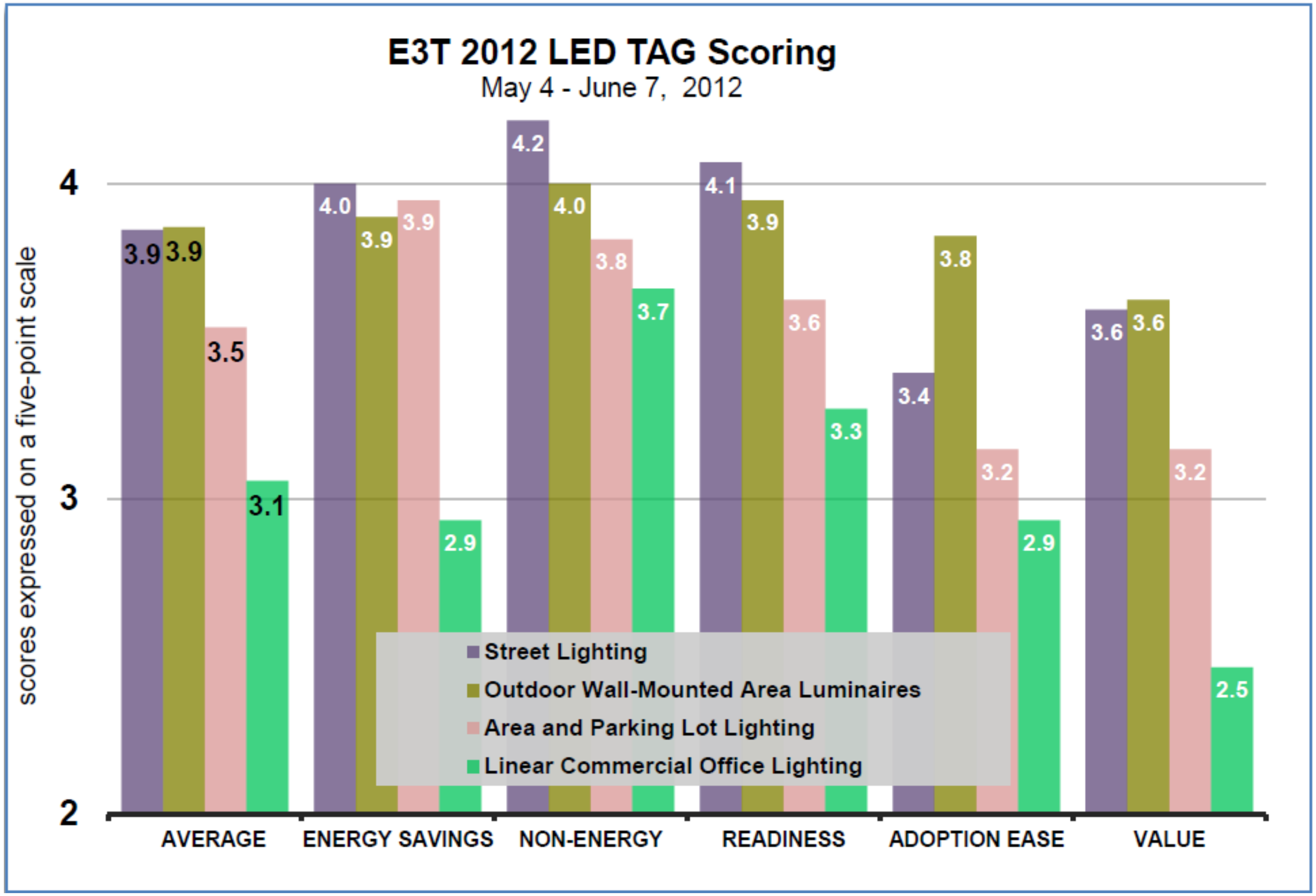
NREL NATIONAL RENEWABLE ENERGY LABORATORY

LIVINGSTON ENERGY INNOVATIONS

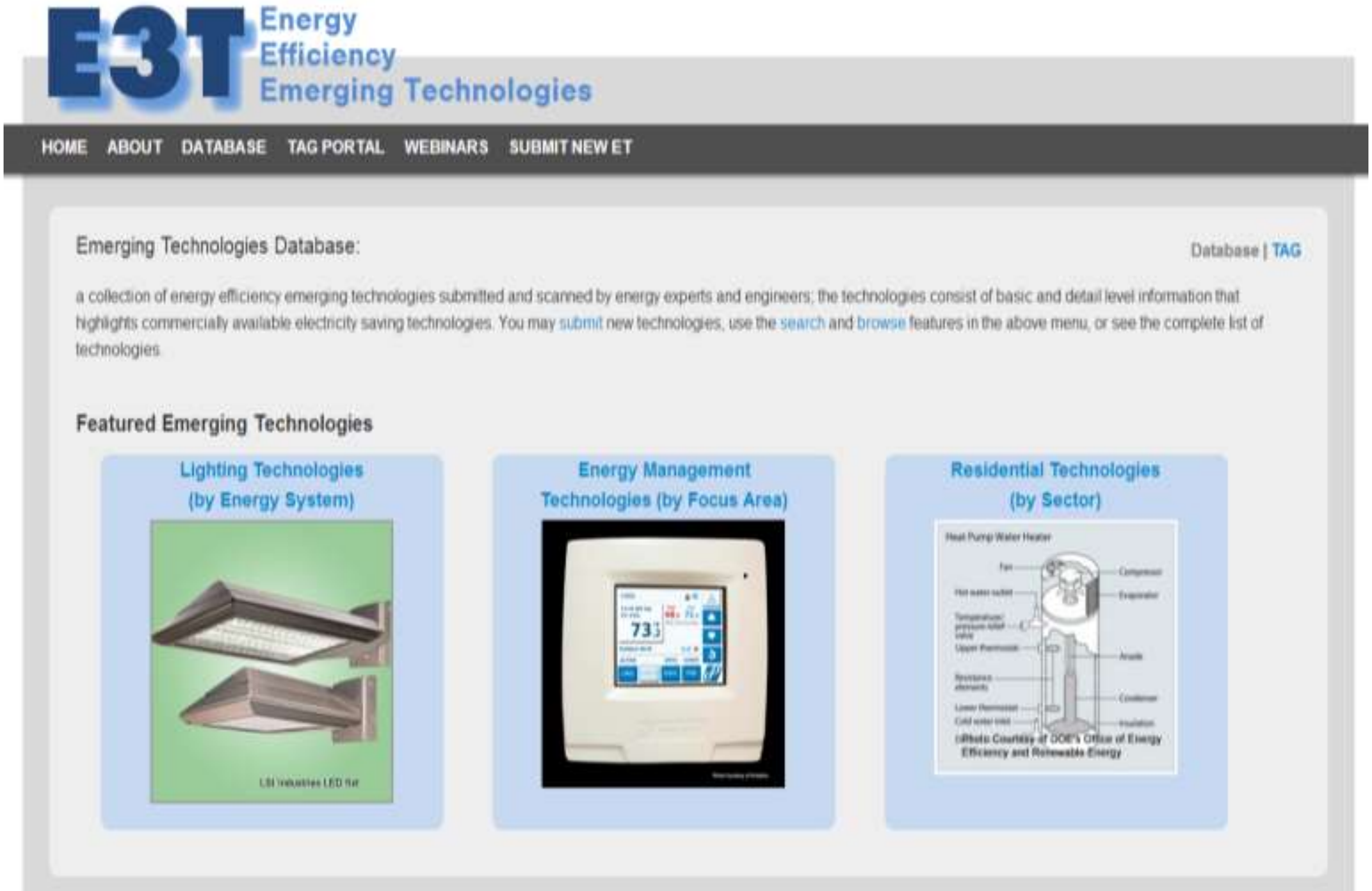
neea

PG&E

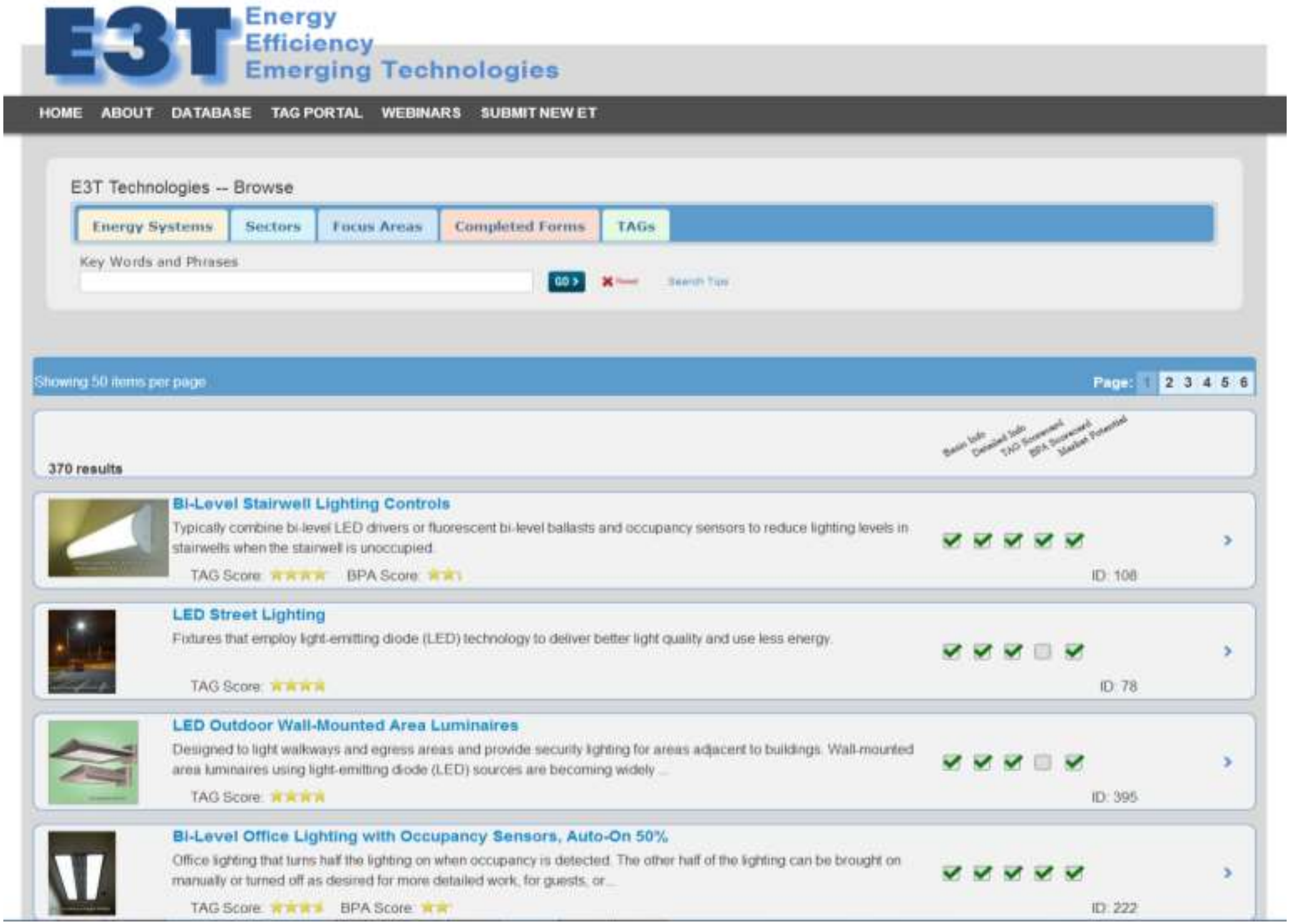
TAG Scoring


E3T 2012 LED TAG Scoring
May 4 - June 7, 2012
scores expressed on a five-point scale
4
3
2
3.9
3.9
3.5
3.1
4.0
3.9
3.9
2.9
4.2
4.0
3.8
3.7
4.1
3.9
3.6
3.3
3.4
3.8
3.2
2.9
3.6
3.6
3.2
2.5
Street Lighting
Outdoor Wall-Mounted Area Luminaires
Area and Parking Lot Lighting
Linear Commercial Office Lighting
AVERAGE
ENERGY SAVINGS
NON-ENERGY
READINESS
ADOPTION EASE
VALUE

E3TNW Database



Browsing Technologies



Technology Summary

E3T Energy Efficiency Emerging Technologies

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Summary Details Print PDF

Summary

Item ID: 432

Copper Rotor Motors

Motors up to 20 horsepower with lower resistance losses in their copper rotor conductor bars, resulting in higher efficiency.

Synopsis:

Copper rotor motors are 1 to 20 horsepower, basic alternating current induction motors with a reduced-loss copper rotor. Resistance losses in the rotor conductor bars account for about 25% of total motor losses, and copper rotors have 66% fewer losses. Reduced electrical losses translate to less heat rejected into the motor enclosure. As a result, a smaller cooling fan can be employed, which reduces friction and windage losses and improves motor full- and part-load efficiency.

Energy savings depend on the horsepower rating and synchronous speed of the motor, efficiency class of an existing operating motor, motor oversizing, loading imposed on the motor by the rotating equipment, and annual operating hours. Replacement with a Premium Efficiency copper rotor motor should occur when the operating motor fails or if an existing standard efficiency motor operates more than 2,000 hours a year. It is often cheaper to purchase a new Premium Efficiency copper rotor motor than to repair a failed motor. Savings are greatest when motors operate for extended periods of time. Copper rotor motors come in NEMA and IEC frames, so they can be drop-in replacements for conventional motors.

Copper rotor motors generally exceed the Premium minimum full-load efficiency standards by 0.6 to 2 percentage points. Copper rotor motor costs are on par with conventional Premium Efficiency motors, so payback is typically immediate. Expected life and O&M costs are also very similar. Efficiency curves are flatter, so they have added benefits when operated with adjustable speed drives and when loads are frequently light.

Energy Savings -- Manufacturer's Claim (percent): From: 0.6% Up To: 2.0%

Technology Details

Description:

Copper rotor motors are basic motors with a reduced-loss copper rotor. Resistance losses in the aluminum rotor conductor bars of conventional induction motor designs account for about 25% of total motor losses. Copper rotor motors offer improved efficiency as rotor losses are greatly decreased because copper has a volumetric electrical conductivity about 66% higher than aluminum. Reduced electrical losses translate into a reduction in heat rejected into the motor enclosure, meaning a smaller cooling fan can be employed, which reduces friction and windage losses and improves copper rotor motor full- and part-load efficiency.

Copper rotor motors are sometimes called "Beyond NEMA Premium" motors. Dynamometer testing indicates their full-load efficiency exceeds the Premium Efficiency motor standards. Siemens Energy and Automation – the only manufacturer in the U.S. currently licensed to provide copper rotor motors – has introduced a line of die cast copper rotor motors in North America for general purpose, totally enclosed, fan-cooled TEFC, and IEEE 841 (severe-duty) configurations in ratings from 1 hp to 20 hp.

Standard Practice:

Standard practice is the continued operation of old standard or energy-efficient motors or replacement through purchase, installation and operation of conventional NEMA Premium Efficiency squirrel-cage induction motors. Premium efficiency motors (copper rotor or conventional) are often 2% to 8% more efficient than old standard efficiency motor models.

Motor efficiency standards are constantly evolving, so standard practice evolves as well. In 2012, the U.S. Department of Energy adopted energy efficiency standards for fractional horsepower polyphase and single phase motors. These standards cover motors operating at 3600, 1800 and 1200 revolutions per minute (RPM), and include capacitor-start/induction run and capacitor-start/capacitor run open motors rated between 0.25 hp and 3 hp. These small motor standards are applicable in March of 2015.

The National Electrical Manufacturers Association (NEMA), whose members manufacture electric motors and several other groups, filed a petition with the U.S. Department of Energy (DOE) recommending both new and more robust energy efficiency standards for the larger types of electric motors used in commercial and industrial applications, such as pumps, conveyors and fans. It asks that the standards, if adopted by the end of 2012, be effective January 1, 2015.

Petitioners include the American Council for an Energy Efficient Economy (ACEEE), the Appliance Standards Awareness Project (ASAP), Earthjustice, Natural Resources Defense Council (NRDC), Alliance to Save Energy (ASE), Northwest Energy Efficiency Alliance, Northeast Energy Efficiency Partnerships, and Northwest Power and Conservation Council.

Technology Details

Development Status:

In 1995, the Copper Development Association undertook a project to substitute copper for aluminum in the "squirrel cage" structure of the motor rotor. The goal was to increase motor efficiency.

A short mold life was the limiting factor in achieving a cost-effective copper rotor die casting operation. Copper has a higher melting temperature than aluminum (1,083°C versus 660°C). Die life was extended through materials selection (use of nickel-based superalloys) and by preheating the die assemblies to approximately 650°C. Preheating minimizes expansion- and contraction-induced thermal fatigue that leads to premature die cracking. Additional problems that were ultimately resolved included porosity, die checking and variations in electrical conductivity.

Copper rotor motors were developed, tested, and have been shown to operate with efficiencies above the current (2012) NEMA Premium efficiency levels. They are now available in the U.S. market at ratings up to 20 hp. Siemens Industry Inc., under license with the Copper Development Association, has introduced a line of "Ultra-Efficient" die cast copper rotor motors. These motors are available in North America for general purpose **totally enclosed, fan cooled** (TEFC) and IEEE 841 (severe-duty) configurations in 1200, 1800 and 3600 RPM ratings up to 20 hp.

SEW Eurodrive uses die cast copper rotor motors in their gear motor product lines. Conventional Premium efficiency motors are often longer and sometimes have an increased diameter than their Standard Efficiency counterparts. High power density copper rotor motors fit existing gearbox designs by providing the desired efficiency improvement with no change in motor dimensions. SEW Eurodrive also produces a line of energy efficient general purpose copper rotor motors up to 50 hp.

Non-Energy Benefits:

The efficiency curve for a copper rotor motor is very flat compared with that of a conventional squirrel-cage induction motor; even a 10 hp 1800 RPM copper rotor motor maintains a high efficiency down to the 25% load point (values are 92.7% at 100% load, 93.0% at 75% load, 92.5% at 50% load, and 89.1% at just 25% load. This performance curve is very useful for adjustable speed drive applications or for machines that operate for a portion of the time partially unloaded or at light loads (like an air compressor with load/unload controls). Copper rotor motors come in standardized NEMA frame designs, so a direct retrofit of an old, standard efficiency or energy efficient motor is possible (mounting bolts line up, and shaft height and diameter are the same).

Technology Details

Energy Savings:

Rotor losses typically account for about 25% of total motor losses, and copper rotor motors offer improved efficiency. Resistance or I2R losses in the rotor conductor bars decrease because copper has a volumetric electrical conductivity about 66% higher than aluminum. Reduced electrical losses translate into a reduction in the amount of thermal energy rejected into the motor enclosure. A lower temperature means that a smaller cooling fan can be employed, resulting in reduced friction and windage losses. Stray load losses are also exceedingly low for copper rotor motors.

Tests made using the IEEE/ANSI 112-1996 efficiency testing protocol show that copper rotor motors generally exceed the Premium minimum full-load efficiency standards by 0.6 to 2 percentage points. Typical test results are shown below:

Hp Rating	3600 RPM	3600 RPM	1800 RPM	1800 RPM
	Premium Efficiency, %	Cast Copper Rotor Motor Efficiency (note 2), %	Premium Efficiency, %	Cast Copper Rotor Motor Efficiency (note 2), %
1	77.0	88.5	85.5	86.5
2	86.5	88.5	86.5	87.5
5	88.5	90.2	89.5	90.2
10	90.2	91.7	91.7	92.4
20	91.0	92.4	93.0	93.6

1. Courtesy of the Copper Development Association
2.TEFC, 2-pole (3600 RPM) and 4-pole (1800 RPM) motors. Nominal efficiency at full-load per manufacturer's catalog.

Assuming 8,760 hours per year operation for an HVAC fan (typical of a hospital application) with 100% loading, the expected energy savings due to installing and operating a copper rotor motor are 1185 kWh/year for a 3600 RPM, 10 hp motor and 540 kWh/year for an 1800 RPM motor. A 20 hp, 3600 RPM motor would yield savings of 1,088 kWh/year, while an 1800 RPM, 20 hp motor is expected to save about 900 kWh annually. While the savings are small on a per-motor basis, large facilities may operate many small HVAC motors.

Energy Use: kWh per year, per

Energy Savings Dependencies:

Energy savings are dependent upon the horsepower rating and synchronous speed of the motor, efficiency class of an existing operating motor, motor oversizing, the loading imposed on the motor by the rotating equipment, and annual operating hours. Generally, motors should operate more than 2,000 hours a year to justify an immediate change-out with a Premium Efficiency motor. Otherwise, the motor replacement should occur when the operating motor fails and requires repair. For motors that are 20 hp and below, it is often cheaper to purchase a new Premium Efficiency copper rotor motor than to repair the old motor. Savings are greatest when motors are operated for extended periods of time.

Technology Details

First Cost:

Copper rotor motor costs are competitive with conventional, aluminum squirrel-cage, NEMA Premium Efficiency motors of equal or lower efficiency. (Note: motor costs are constantly changing, due to changes in the commodity prices for copper, aluminum, and core iron.) Motor costs may vary from 20% to 60% off list price, with discount rates based on customer purchase history and suppliers' policies.

Incremental Installed Cost:

O&M Costs:

O&M costs should be comparable to those of standard aluminum cage induction motors. Maintenance consists of periodic cleaning of motor cooling fins and inlet grills, and alignment testing.

Effective Life:

There is no major difference in the life of a copper rotor versus a standard squirrel cage induction motor. Motor bearings and coupling should exhibit comparable lives to those of conventional motors. Tests have shown that the temperature rise of a copper-rotor motor is comfortably within Class B (40°C) limits. Because the windings are equipped with higher temperature-rated Class F insulation, a long winding insulation life is expected.

The U.S. Department of Energy performed a national impact analysis in support of their proposal to increase the energy efficiency standards for commercial and industrial motors ("Preliminary Technical Support Document: Energy Efficiency Program for Commercial Equipment: Energy Conservation Standards for Electric Motors," July 23, 2012). They assumed average motor operating lifetimes of 5 years for 1 to 20 hp motors used in industrial applications, with 14 to 15 years assumed given a commercial sector application. Motors in that size range used in agricultural applications were assumed to have average lifetime of 13 years. (Motor mechanical lifetimes of about 32,000 hours are assumed. Operating life is then determined by dividing the mechanical lifetime by the expected annual operating hours.)

Cost Effectiveness:

For new motor purchases, the simple payback for this technology can be immediate because the price of the copper rotor motor may well be less than the price of a NEMA Premium Efficiency squirrel cage induction motor. When replacing existing motors at their time of failure, the simple payback depends on many variables, including new motor list price discount (which can vary by customer, changing the simple payback by a factor of 2 to 6), repair costs for the failed motor, annual operating hours, motor load or load profile, utility rates for both energy and demand charges, and the availability of utility incentives.

Competing Technologies:

Competing technologies include repair and return to service of failed standard or Premium Efficiency motors. If a replacement motor is specified, the end user may select a conventional, squirrel cage, NEMA Premium Efficiency induction motor (technology #230), a permanent magnet motor (technology #431), a switched reluctance motor (technology #433), or a line-start permanent magnet motor (technology #434). The permanent magnet and switched reluctance motors are more expensive and require a controller than gives them variable speed capability, which increases savings in applications where variable flow may be provided to meet process requirements. Because these motors do not come in standard NEMA frame sizes, they are not drop-in replacements.

Efficient Elevators

- Gearless permanent magnet synchronous motors
- Advanced materials such as traction belts instead of steel ropes
- Motors with regenerative braking capability

Mirrored Light Pipe

- Translucent pipes that collect light from outside a building or from an artificial light source
- Conveys the light to locations within a building's interior where conventional daylight can't reach effectively

Low-E, High Visible Trans. Film

- Thermal efficiency equal or better than most films (U=.61)
- VT=70% on single-pane
- Consumer selling point is light—happy people with views using less electric lighting

Anti-fog Film for Cold Cases

- Film installed inside reach-in supermarket refrigerated cases
- Greatly reduces condensation and the need for anti-sweat controls, thus reducing energy use
- Also reduces compressor load

Variable Refrigerant Flow (VRF)

- Heating and cooling distribution through refrigerant piping rather than ductwork
- Transfer heat among zones
- Variable-speed fans and compressors
- Very popular in Asia and Europe

Photo Courtesy of Mitsubishi Electric Cooling and Heating Solutions

Smart LED Street Lighting

- All the energy efficiency and long life of LEDs
- Controllable light levels for time-of-day, events, emergencies, and occupancy

CO_2 Heat Pumps

- Air or water-source heat pumps that use CO_2 as a refrigerant; less GWP
- Produce hot air or water while generating chilled water or air
- Common in Japan
- Combined COPs up to 8
- Industrial model available, residential model soon

Glazing Aerogel

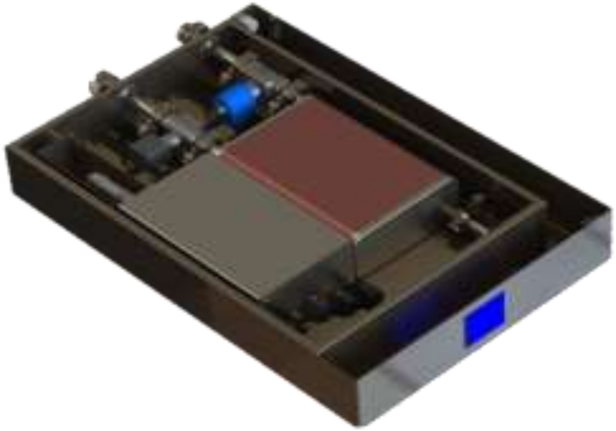
- R-value/inch up to 10+
- Translucent, allowing glare-free diffused light through
- Can be customized to allow more or less light through according to customer specifications

Smart Thermostats

- Web-enabled
- Smart-phone accessible
- Self-learning
- Occupancy sensors
- Weather forecast inputs
- Data sent to utilities and third parties
- Energy tips

Liquid-cooled Servers

- More efficient to cool a small amount of liquid than a lot of air
- Three examples:
  - Water-cooled server racks
  - Spray cooling
  - Submerged servers with dielectric oil

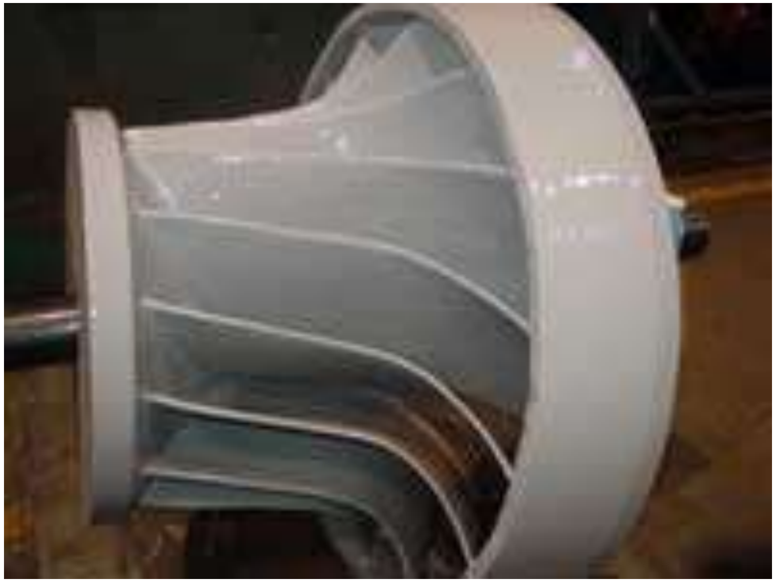


Circadian Light Color Tuning

- Adjusting the level and color temperature of lighting at different times of the day to avoid disrupting circadian rhythms, the biological cycles that can impact productivity and sleep

Pump Coatings

- Pump coatings to improve pumping efficiency by reducing friction losses
- Most cost-efficient when applied to new pumps and considering change in pumping characteristics



Permanent Magnet Motors

- Industrial motors with powerful magnets on the rotor to reduce rotor resistance losses
- Exceeds "Premium" Efficiency levels
- Provides variable speed operation when controlled by a drive

Electrodialysis for Wine Industry

- A process to stabilize wine prior to bottling
- Cuts energy use by about 80% compared with traditional cold stabilization, which involves keeping wine in bulk storage cold for long periods of time

Showcase Webinars

- LED Parking and Area Lighting
- Image Processing Occupancy Sensors
- Variable Refrigerant Flow (VRF)
- Smart Residential Thermostats
- Advanced Rooftop Unit Controls
- Demand Ventilation Control for Kitchens
- Advanced Lighting Control Systems
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More Information

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Questions?

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