Energy efficiency: From drives and motors to a complete solution
Presentation Content

Energy efficiency: From drives and motors to a complete solution

- Energy Consumption
- Component versus System Improvements
- Component Improvements
  - Motors
  - Gearing
  - MPT
  - Example
- System Improvements
  - Pumps/Fans
  - Examples
- Plant Assessments
  - Three Levels
  - Motor Management
  - Calculation Tools
- New Technologies
World industrial energy usage

- Industrial = 50% of world’s energy
- 1.4% growth annually
- 200 quadrillion BTU
- 307 quadrillion BTU
Energy Consumption
The Facts

- Higher energy price and global warming push customers to find energy saving possibilities
  - Energy consumption is set to double by 2050
- 65% of world’s industrial electricity consumed is used by motors
- Only 10% of the world’s installed motors are combined with a drive
  - Most energy intensive industries are cement, chemical, iron and steel
  - Pumps & fans are the most common applications that provide the most savings potential
- Companies are investing in billions of dollars to improve their energy efficiency and reduce their carbon footprint
- Country’s governments all over the world are providing rebates and tax incentives to companies for a “greener” way of operating
Identifying Energy Savings

- **Component Savings**
  - Easier to identify & smaller returns
    - Retrofitting drives to current fixed speed motor applications
    - Replacing drive or motor components as part of a preventive maintenance plan

- **System / Variable Speed Application**
  - Harder to qualify but most effective & largest return investment
    - Upgrading entire drive systems to latest technology or to extend functionality of existing drives and motors
    - Recycling of all removed drives and motors to latest legislation
    - Investment in new technology paid from the savings generated
Industrial Motor System Savings Potential

- System Optimization: 65%
- Energy Efficient Motors: 15%
- Motor Management: 20%

Motor Life Cycle Costs

- Energy 97.3%
- One Rewind 0.7%
- Initial Purchase 2%
## Life Cycle Cost Energy Savings

<table>
<thead>
<tr>
<th>200 HP 4 pole operating costs</th>
<th>DOE average efficiency</th>
<th>High efficiency motor</th>
<th>NEMA Premium® efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency</td>
<td>93.5</td>
<td>95.0</td>
<td>96.2</td>
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<tr>
<td>Electrical cost / year</td>
<td>$139,785</td>
<td>$137,578</td>
<td>$135,862</td>
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<tr>
<td>Annual savings</td>
<td>$2207</td>
<td>$3923</td>
<td>X 20 years</td>
</tr>
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</table>

- Continuous operation at $0.10/kWh
- $78,460 total savings
Energy Efficiency Motors

- Lowest level
  - ~IE1

- EPAct 92
  - IE2

- NEMA Premium®
  - IE3
  - NEMA Premium®
Induction Motors

- Workhorse of Industrial and Commercial Applications
- Motor efficiency regulated by US DOE
  - EPAct effective 1997
  - EISA effective 2010
  - Integral Motor Rule effective Jun 2016
  - Small Motor Rule effective Mar 2015
- These new rules will push most motors < 500 HP to NEMA Premium levels
“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

![Motor Efficiency vs Load](chart1)

![Motor Power Factor vs Load](chart2)
Improving Component Efficiency

Replacing products with comparable high efficient products

- Motors:
  - Standard Efficient
  - NEMA Premium®

2 to 3%
Beverage Company Example

Application Bottling Line Conveyors

- Belt driven worm gear system
- Maintenance issues identified:
  - Multiple parts to stock and source
  - Sourcing issues; German supplier
  - Difficult to mount / dismount
  - Plexiglass breaks, leaking seals
  - Expensive to repair and replace
- Low efficiency 48-58% for system:
  - Motor  77%
  - Belt drive  95 to 93%
  - Worm gear  65 to 75%
**Beverage Company Example**

**Existing Worm Gear**
- Average Efficiency 58%
- Performance varies with speed
  - Worm Gearbox: 60 to 80%
  - Standard Motor: 77%
  - Belt Drive: 93 to 95%
  - Total Efficiency: 48 to 58%

**New Helical Bevel Gear**
- Efficiency 95%
- Speed independent performance
  - Helical Gearbox: 96%
  - Premium Motor: 88%
  - Belt Drive: N/A
  - Total Efficiency: 85%
**Beverage Company Example**

**International Food Account Location**

- **Assumptions for calculations:**
  - Motor Nameplate Horsepower: 1.5 HP (0.6 measured load)
  - Annual Operating Hours: 7,200 each
  - Cost of Energy: $0.07 / kWh

- **Energy Calculations:**
  
  \[ Kw \ (use) = \frac{HP \times 0.746 \times \text{hours/year}}{\text{System Efficiency}} \]

<table>
<thead>
<tr>
<th>System Type</th>
<th>Energy Consumption</th>
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<tbody>
<tr>
<td>Worm Gear</td>
<td>13,891 kWh</td>
</tr>
<tr>
<td>Helical Bevel</td>
<td>9,478 kWh</td>
</tr>
</tbody>
</table>

- **Cost / year = kWh x Cost Energy**
  
  - Worm Gear: $973
  - Helical Bevel: $663

- **Facility Savings Overview:**
  - Annual savings per Helical Bevel: $310
  - Average No. units per facility: (75)
  - Total Savings: $23,250
Evaluate all components in system to maximize efficiency

<table>
<thead>
<tr>
<th>Component</th>
<th>Efficiency</th>
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<tbody>
<tr>
<td>Transformer</td>
<td>98%</td>
</tr>
<tr>
<td>Drive</td>
<td>98%</td>
</tr>
<tr>
<td>Motor</td>
<td>95%</td>
</tr>
<tr>
<td>Gearbox / Mechanical PT</td>
<td>50-85%</td>
</tr>
<tr>
<td>Driven load – Compressor, Pump, Fan</td>
<td>?</td>
</tr>
<tr>
<td>Process Control to optimize workflow</td>
<td>?</td>
</tr>
</tbody>
</table>
System Efficiency

Variable Speed Applications

Good variable speed applications
- High Annual Hours of Operation
- Moderate to High Horsepower
- Variable Load (high degree of throttling) and/or
- Process improvement (improved control)

<table>
<thead>
<tr>
<th>Application</th>
<th>Saving Potential</th>
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</thead>
<tbody>
<tr>
<td>Variable torque such as pumps and fans</td>
<td>50% +</td>
</tr>
<tr>
<td>Partial flow or intermittent duty</td>
<td>30% +</td>
</tr>
<tr>
<td>High HP applications benefiting from reduced speed</td>
<td>20% +</td>
</tr>
<tr>
<td>Elimination of inefficient mechanical components</td>
<td>15% +</td>
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</table>
Variable Speed Applications

Affinity laws and energy savings

- Variable speed control takes advantage of the affinity laws:
- Flow is proportional to speed directly
- Power is proportional to the cube of speed:
  \[
  \frac{P_1}{P_2} = \left(\frac{N_1}{N_2}\right)^3
  \]
- Example: 80% flow:
  \[(0.8)^3 = 0.512 \text{ or } 51\% \text{ HP}\]
# Affinity Laws for Centrifugal Loads

<table>
<thead>
<tr>
<th>Speed</th>
<th>Volume</th>
<th>Pressure/Head</th>
<th>Horsepower Required</th>
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<tbody>
<tr>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>90%</td>
<td>90%</td>
<td>81%</td>
<td>73%</td>
</tr>
<tr>
<td>80%</td>
<td>80%</td>
<td>64%</td>
<td>51%</td>
</tr>
<tr>
<td>70%</td>
<td>70%</td>
<td>49%</td>
<td>34%</td>
</tr>
<tr>
<td>60%</td>
<td>60%</td>
<td>36%</td>
<td>22%</td>
</tr>
<tr>
<td>50%</td>
<td>50%</td>
<td>25%</td>
<td>13%</td>
</tr>
<tr>
<td>40%</td>
<td>40%</td>
<td>16%</td>
<td>6%</td>
</tr>
<tr>
<td>30%</td>
<td>30%</td>
<td>9%</td>
<td>3%</td>
</tr>
</tbody>
</table>
Reducing Air Volume and/or Flow Rates

Methods to reduce flow rates:

- Changing Motor and/or Equipment
  - Motor base speed
  - Pump impeller diameter
  - Fan belt ratio
  - Blade pitch adjustment

- Regulate the output discharge
  - Inlet Guide Vanes
  - Pump Valves
  - Variable Frequency Drive (VFD)

- Of the methods; variable speed control is the only method to take advantage of the affinity laws and it is the most cost effective solution
Variable Speed Approach to Energy Savings

- **Review Application**
  - Identify centrifugal loads (pumps & fans)
  - Select high hour operation processes with variable flow requirements
  - Look for process control improvements
  - Look for mechanisms that control motor on/off and pressure reduction or mechanical valves
  - Select best candidates for further analysis

- **Typical Information Needed:**
  - Motor Nameplate Data (Horsepower & Voltage)
  - Pump / Fan Nameplate Data
  - Annual Operating Hours
  - Load Duty Cycle

- Measure with power meter (voltage, amps, power factor, kw)
- Document savings and calculate payback
Variable Speed Drive Example – Ball Valve

- **Check List: 50 HP Starch Pump Example**
  - Current VSD drive: NO ✔
  - Valve restricting flow: YES ✔
  - Centrifugal pump: YES ✔

- **Present Operation**
  - Ball valve estimated around 30% closed
  - 80% of rated flow is required by production

- **Solution**
  - Control flow by variable speed drive with pressure feedback or open loop speed control
  - Keep the manual flow control valve open

- **Energy Savings Analysis:**
  - Energy Saved: 142 MWh
  - Hours of operation: 8,700 / year
  - Financial Savings: $12,800 / year
  - Simple Payback: 0.52 years
Variable Speed Drive Example – Butterfly Valve

- Check List: 25 HP Potato Flume Pump Example
  - Current VSD drive NO ✓
  - Valve restricting flow YES ✓
  - Centrifugal pump YES ✓

- Present Operation
  - Butterfly valve more than 50% closed
  - 60% of rated flow is supplied; measured power with valve control = 22 HP

- Solution
  - Control flow by a VSD with pressure feedback
  - Keep the manual flow control valve open

- Energy Savings Analysis:
  - Energy Saved 107 MWh
  - Hours of operation 8,700 / year
  - Financial Savings $9,000 / year
  - Simple Payback 0.52 years
Pump Efficiency Regulations (coming soon)

- US DOE Energy Efficiency rules for Centrifugal Pumps, Fans and Compressors
  - Expect rules to become effective 2019
  - Each industry seems to be taking different approach to rule making
    - Pumps: Negotiated Regulation (NEGREG)
    - Appliance Standards and Rulemaking Federal Advisory Committee (ASRAC)
      Commercial and Industrial Pump Working Group
      - Term sheet complete
      - 2 – 200 HP pumps (circulator pumps in second round)
      - Clean water applications
      - Target 25% least eff pumps
      - Pumps labeled on how they are sold:

<table>
<thead>
<tr>
<th>Bare Pump</th>
<th>Bare Pump + Motor</th>
<th>Bare Pump + Motor + Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEI_C1</td>
<td>PEI_C1</td>
<td>PEI_L</td>
</tr>
<tr>
<td>Model number</td>
<td>Model number</td>
<td>Model number</td>
</tr>
<tr>
<td>Impeller diameter for each unit</td>
<td>Impeller diameter for each unit</td>
<td>Impeller diameter for each unit</td>
</tr>
</tbody>
</table>

- Expect more pump regulations to follow (WWT)
Industrial energy assessments/audits
Four levels

Level 0 – Benchmarking
- High level energy use analysis
- Historic utility use and costs
- Comparison to those of similar plants/processes.

Level 1 – Walk-through Audit
- Identify simple/low-cost improvements and conservation measures.
- Visual verifications, study of installed equipment and operating data
- Detailed analysis of data collected during the benchmarking phase.

Level 2 – Detailed Audit
- Enhancement to Level 1
- More comprehensive analysis
- Detailed analysis of the facility,
- On-site measurements
- Engineering analysis of selected energy retrofits

Level 3 – Investment-grade Audit
- Detailed Analysis of Capital intensive modifications
Facility Surveys Tools

- Baldor Energy Savings Tool 4.0 BE$T
  - PC software to analyze survey results, Premium motors, evaluate addition of drives and calculate payback, kWh & CO$_2$ saved
  - Also available as mobile App

- ABB FanSave and ABB PumpSave
  - PC Software to calculate the energy consumption of fan & pump applications

- ABB EnergySave Calculator
  - Mobile App that compares AC drive control to conventional flow control for pumps and fans

- Installed Base Evaluation Team – Motors Evaluation
Energy assessment (audit)
Level 1: Installed base evaluation

- Detailed inventory of the installed (operating) base of electric motors, drives and mechanical power transmission equipment
- Inventory includes nameplate efficiency of installed base
# Energy assessment (audit)

## Level 1: Installed base evaluation

<table>
<thead>
<tr>
<th>Location</th>
<th>Qty</th>
<th>Manufacturer</th>
<th>ModelNumber</th>
<th>Eff</th>
<th>Baldor</th>
<th>Eff</th>
<th>Energy Savings</th>
<th>Payback (Years)</th>
<th>Recommendations</th>
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</thead>
<tbody>
<tr>
<td>LINES 6,7_CORNELL PUMP DESORTER</td>
<td>1</td>
<td>Toshiba</td>
<td>B0104FLF2US</td>
<td>87.5</td>
<td>EM3714T</td>
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<td>$242.81</td>
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<tr>
<td>LINE 4_PASTEURISADOR</td>
<td>1</td>
<td>Reliance</td>
<td>P14H1448</td>
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<td>2ND_LINE 6 DEMATIC_SYSTEM_CONV 8</td>
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<td>Reliance</td>
<td>P16C4902</td>
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<td>EM3616T</td>
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<td>$114.94</td>
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<tr>
<td>FLOOR 2_FORMULATION_JUGO</td>
<td>1</td>
<td>Leeson</td>
<td>C182T17VK1D</td>
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<td>DEM3611T</td>
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<td>$32.12</td>
<td>1.91</td>
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<tr>
<td>LINE 8_TEGRA 2_CORNELL PUMP</td>
<td>1</td>
<td>Reliance</td>
<td>P16C370C</td>
<td>85.73</td>
<td>EM3714T</td>
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<td>$366.38</td>
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<td>SUGAR TANK_PUMP_MOTOR 1</td>
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<td>CM3554</td>
<td>85.5</td>
<td>EM3554</td>
<td>86.5</td>
<td>$32.55</td>
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<tr>
<td>LINE 6,7_OVERHEAD_CONV</td>
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<td>Baldo r</td>
<td>VM3554</td>
<td>87.6</td>
<td>EM3616T</td>
<td>88.5</td>
<td>$32.55</td>
<td>2.00</td>
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<tr>
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<td>EM3558T</td>
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<td>$38.71</td>
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<td>CIRCULATION PUMP_MOTOR 1 &amp;2</td>
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<td>Reliance</td>
<td>P16C3405G</td>
<td>81.45</td>
<td>EM3611T</td>
<td>89.5</td>
<td>$173.49</td>
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<td>WATER PUMP_PARA MESA DE ENFIAMIENT</td>
<td>1</td>
<td>Baldo r</td>
<td>M2334T</td>
<td>88.52</td>
<td>EM3611T</td>
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<td>$369.98</td>
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<tr>
<td>WATER PUMP_FORMULATION_JUGO</td>
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<td>Baldo r</td>
<td>M3615T</td>
<td>87.5</td>
<td>EM3616T</td>
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<td>P16C3405G</td>
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<td>EM3611T</td>
<td>89.5</td>
<td>$369.98</td>
<td>2.37</td>
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<tr>
<td>LINE 2 &amp;3_BOMBA WAUKESHA MODELO 210</td>
<td>1</td>
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<td>M3312T</td>
<td>89.5</td>
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<td>LINE 8_OVERHEAD_CONV TO COKING AREA</td>
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<td>E08B</td>
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<td>COOKER 5_MAIN MOTOR</td>
<td>1</td>
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<td>P28P311</td>
<td>89.5</td>
<td>EM4103T</td>
<td>93.6</td>
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<td>HYDROMATIC TOWER_COOL WATER PUMPS</td>
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<td>Baldo r</td>
<td>JMM370T9</td>
<td>84</td>
<td>JMM370T9</td>
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<td>$374.68</td>
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<tr>
<td>LINE 5,6_HEAT EXCHANGER</td>
<td>1</td>
<td>Baldo r</td>
<td>JMM370T9</td>
<td>84</td>
<td>JMM370T9</td>
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<td>$374.68</td>
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<td>LINE 6,7_HEAT EXCHANGER_PUMP</td>
<td>1</td>
<td>USEM</td>
<td>UJS18FMI</td>
<td>84</td>
<td>MM3615T</td>
<td>88.9</td>
<td>$375.51</td>
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<tr>
<td>LINE 8_CORNELL PUMP (TEGRA OUTFEED</td>
<td>1</td>
<td>Reliance</td>
<td>P21G4915</td>
<td>89.5</td>
<td>EM3714T</td>
<td>91.7</td>
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<tr>
<td>CALDERA 1 DRYER MTR</td>
<td>1</td>
<td>WEG</td>
<td>00718EP3E213T</td>
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<td>EM3710T</td>
<td>91.7</td>
<td>$105.29</td>
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<tr>
<td>LINE 5_PASTEURISADOR</td>
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<td>Baldo r</td>
<td>M3710T</td>
<td>89.5</td>
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<td>91.7</td>
<td>$105.29</td>
<td>3.06</td>
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<tr>
<td>LINE 6_PPASTEURASER</td>
<td>1</td>
<td>GE</td>
<td>5KE213BC2050</td>
<td>89.5</td>
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<td>LINE 7_ATER PUMP FOR FILLER</td>
<td>1</td>
<td>GE</td>
<td>S231</td>
<td>89.5</td>
<td>EM3710T</td>
<td>91.7</td>
<td>$105.29</td>
<td>3.06</td>
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</tr>
<tr>
<td>WATER PUMP_HACIALOS COOKERS</td>
<td>2</td>
<td>Baldo r</td>
<td>CM3219T</td>
<td>87.5</td>
<td>DEM3219T</td>
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<td>$101.44</td>
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<td>P56S13/3</td>
<td>82.5</td>
<td>JM3542</td>
<td>75.5</td>
<td>$44.14</td>
<td>N/A</td>
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<tr>
<td>LINE 6_PALITEZ SISTEM_FEED LOWERIN</td>
<td>2</td>
<td>TeXtron</td>
<td>ILH</td>
<td>75.5</td>
<td>MM5550</td>
<td>82.5</td>
<td>$44.14</td>
<td>N/A</td>
<td>Replace motor at failure</td>
</tr>
<tr>
<td>LINE 6_PALITEZ SISTEM_ROLLER CONV</td>
<td>2</td>
<td>Allen-Bradley</td>
<td>ENP56H6603C-CJ</td>
<td>82.5</td>
<td>DNN3542</td>
<td>78.5</td>
<td>$72.78</td>
<td>N/A</td>
<td>Replace motor at failure</td>
</tr>
<tr>
<td>ATLAS COMPRESSOR #5</td>
<td>1</td>
<td>Siemens</td>
<td>1L05209-2AA99-ZT7</td>
<td>122.4</td>
<td>EM20372-58</td>
<td>94.1</td>
<td>$378.85</td>
<td>N/A</td>
<td>Replace motor at failure</td>
</tr>
</tbody>
</table>

*Please verify prior to ordering*

**Total Savings** | $14,998.80
Emerging Motor Technology

- Motors – NEMA Premium® to Permanent Magnet
- Average energy savings of 3% (over premium efficient motors)
- PM reduces rotor efficiency losses
- Power density improvements:
  - Drop in replacement mounting
  - Same NEMA shaft height
Emerging Motor Technology

PM versus NEMA Premium® Efficient Motor

- Efficiency Comparison
- 30 HP Motor Example

<table>
<thead>
<tr>
<th>Type of Motor</th>
<th>Premium Efficient</th>
<th>PM Rotor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency</td>
<td>93.6%</td>
<td>96.6%</td>
</tr>
<tr>
<td>Annual Cost</td>
<td>$10,042</td>
<td>$9,730</td>
</tr>
<tr>
<td>Annual kWh</td>
<td>143,457</td>
<td>139,000</td>
</tr>
</tbody>
</table>
SynRM Two new high-performance motor and drive packages
For industrial applications

The High Output package
- Power range from 1 to 315 kW
- Powerful, yet highly compact motor with up to two frame sizes smaller than conventional motor
- Enables cost effective machine designs

The IE4 Super Premium Efficiency package
- Power range from 11 to 200 kW
- Energy losses reduced by up to 40%
- Compliant to the upcoming efficiency class IE4
- Payback time less than two years – from energy savings alone

Both packages are based on perfectly controlled synchronous motor technology without permanent magnets materials. Optimized for VSD operation, they combine motor, drive and advanced software into complete solutions.
SynRM New revolutionary motor and drive package
For industrial applications

• Similar functionality compared to traditional induction motor and drive package

• Suitable for general purpose industrial applications such as pumps, fans and compressors

• Same stator technology with induction motor combined with novel synchronous reluctance rotor

• Performance comparable to permanent magnet motors, but without magnets

• Optimized for VSD operation – not suitable for direct-on-line fixed speed operation
LARGE HP VERTICAL GEAR MOTOR
Product Description

- High Horsepower Product
  - 1000 – 10,000 HP

- Vertical Configuration

- Motor Direct Coupled to Custom Gearbox
  - Single Stage Reduction (4:1 through 10:1)
  - Torque ranges from 550K in-lbs to 7,000,000K in-lbs
  - Slow speed applications (100 – 600 RPM)

- Design based on existing Baldor-Dodge Product
  - Strong foundation in bulk material handling/conveying
  - Extensive Installed base in Mining Industry (> 3000 globally)

- Technology to Consider in place of:
  - High pole count induction motors or synchronous motors
  - Horizontal motor with right angle gearbox
Applications

- High capacity, Low Head, Slow Speed Pumping Applications:
  - Wastewater (1000 – 7000 HP)
  - Flood Control (1000 – 7000 HP)
  - Irrigation (1000 – 12,000 HP)
  - Water Transfer and Distribution (1000 – 2000 HP)
  - Circulating Water/Cooling Water (1000 – 9000 HP)
  - Desalination (2000 – 6000 HP)
Product Design Overview

- Made to Order Product
- Vertical Configuration
- Fabricated steel housing (Custom Fit)
- Unit designed to fit on an existing pump flange
- Features planetary gear reducer
  - Single stage reduction *(4:1 to 10:1)*
  - Hydro viscous clutch can be added, providing controlled start-up and shut down without using a VFD.
- Gear coupled to a large HP AC low pole count motor
  - 4, 6, 8 - pole designs.
Cooling Tower Fan Direct Drive

Existing System
- Induction Motor, couplings, drive shaft, reducer & oil lubrication system

New System
- Direct Drive PM Motor and Drive
- All mechanical components eliminated
- Fan couples directly to the motor shaft
- Significant energy and maintenance savings

-AC Motor
-Drive Shaft & Couplings
-Gearbox

-Direct Drive Motor
Cooling Tower Fan Direct Drive

Existing System

- High Mechanical Maintenance
  - Gearbox failures
  - Oil leaks & contamination
  - Failed & misaligned drive shafts
  - Excessive vibration

- Mechanical components average 10% additional efficiency losses

- Peak loading for short durations, lightly loaded inefficient operation

- Started across the line, high inrush currents and mechanical stresses

- Seal and bearing wear when fan “windmills”
Cooling Tower Fan Direct Drive

New Direct Drive System

- Minimize maintenance; eliminates mechanics & existing motor
- Lower installation cost; no alignment issues mechanical components
- Reduces cooling water contamination from gearbox oil and leakage
- Soft-Start Capability: 60 seconds adjustable ramp time standard
- Increases safety due to fewer components
- Runs Quieter & Saves Energy
## Cooling Tower Fan Direct Drive – Example

### New Direct Drive System – The Exploration

- **Existing Motor Horsepower**: 60 HP
  - 44.76 HP load measured
- **Fan Diameter**: 10 feet
- **Voltage**: 460 VAC
- **Gearbox Ratio**: 4.1:1
  - 439 RPM fan speed
- **Airflow Issues (YES / NO)**: No
- **Height Restriction (YES / NO)**: No
- **Drive in a control room or outside?**: Control Room
Cooling Tower Fan Direct Drive – Example

Based on 9 months operation / 3 months idle, Energy cost 5.5 c/kwh, 91% efficient motor

Existing Gearbox, drive shaft Solution using two speed motor

<table>
<thead>
<tr>
<th>Avg. Operating hours</th>
<th>Fan Speed</th>
<th>Motor Hp</th>
<th>Motor Rating kW</th>
<th>Power Usage kWh</th>
<th>Energy cost Per cust 5.5 c/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>6570 Full speed</td>
<td>439</td>
<td>60</td>
<td>44.8</td>
<td>336506</td>
<td>$18,508</td>
</tr>
<tr>
<td>2190 Off</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>8760 Total</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>336506</strong></td>
<td><strong>$18,508</strong></td>
</tr>
</tbody>
</table>

New direct drive 10.2% efficiency gain by removal of mechanical loses, Motor Efficiency 94.30%

<table>
<thead>
<tr>
<th>Avg. Operating hours</th>
<th>Fan Speed</th>
<th>Motor Hp</th>
<th>Motor Rating kW</th>
<th>Power Usage kWh</th>
<th>Energy cost Per cust 5.5 c/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>1896 Full</td>
<td>160</td>
<td>50</td>
<td>37.3</td>
<td>74996</td>
<td>$4,125</td>
</tr>
<tr>
<td>621 90%</td>
<td>144</td>
<td>36.5</td>
<td>27.2</td>
<td>17907</td>
<td>$985</td>
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<tr>
<td>621 80%</td>
<td>128</td>
<td>25.6</td>
<td>19.1</td>
<td>12576</td>
<td>$692</td>
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<tr>
<td>621 70%</td>
<td>112</td>
<td>17.2</td>
<td>12.8</td>
<td>8425</td>
<td>$463</td>
</tr>
<tr>
<td>621 60%</td>
<td>96</td>
<td>10.8</td>
<td>8.1</td>
<td>5306</td>
<td>$292</td>
</tr>
<tr>
<td>2190 50%</td>
<td>80</td>
<td>6.3</td>
<td>4.7</td>
<td>10828</td>
<td>$596</td>
</tr>
<tr>
<td>2190 Off</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>8760 Total</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>130038</strong></td>
<td><strong>$7,152</strong></td>
</tr>
</tbody>
</table>

The example above has taken the full speed operating hours and distributed them over the same period.

Total Yearly Savings $11,356 Per Tower
Conclusion

- Perform a Plant Survey
- Develop Repair / Replace Policy
- Follow Through with Supplier Quotes
- Evaluate a System in Facility
- Consider Future Technologies
Questions and comments

Together, we can help improve productivity and use electric power efficiently
Power and productivity for a better world™