Motors & Drives: Energy Savings

Greg Rushby, P. Eng
Rushby Energy Solutions
Thursday June 22, 2017
Outline

<table>
<thead>
<tr>
<th>Topic</th>
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<tr>
<td>Motors</td>
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<td>Variable Frequency Drives</td>
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<tr>
<td>Utilizing the saveONenergy Incentives</td>
</tr>
<tr>
<td>Discussion / Questions</td>
</tr>
</tbody>
</table>
Why Care About Motors?

Source: Natural Resources Canada, Commercial & Institutional Sector Energy Use (2014)
Motor Types

- Majority of motors used in commercial / industrial sector are AC induction
Motor Energy Savings Opportunities

- Majority of motors are operated at constant speed

- Typical flow controls
  - Fans: dampers or inlet vanes
  - Pumps: bypass or throttling valves
  - Analogous to holding down the accelerator and using the brake to control car speed

- Many motors run for longer than needed

- Newer motors *slightly* are more efficient than older motors
Motor Efficiency

• Historically, standard and high efficiency motors were available

• Presently, only NEMA Premium (or better) motors are available for most frame sizes
# Motor Starters

<table>
<thead>
<tr>
<th>Type</th>
<th>Pros</th>
<th>Cons</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Across-the-line</td>
<td>Simple, low-cost</td>
<td>No variable speed operation</td>
<td>&lt;5 hP</td>
</tr>
<tr>
<td>Soft starter</td>
<td>Variable speed operation</td>
<td>Inefficient part-speed operation</td>
<td>Motors that cycle frequently</td>
</tr>
<tr>
<td>Variable Frequency Drive</td>
<td>Efficient, active variable speed control</td>
<td>High cost (relative to other starters)</td>
<td>Systems that operate at part-load frequently</td>
</tr>
</tbody>
</table>
Motor Maintenance – Buy vs. Rewind

• An excellent opportunity to upgrade

• Motor rewind cost ~60-75% of new motor cost

• Motor rewind results in a 1-2% efficiency loss

• New motor is ~3-5% more efficient than a rewound motor
Turning Off Motors

• Motors use zero energy when turned off

• >95% of a motor’s lifetime cost is energy-related

• Just 1-minute of additional run-time consumes more energy than restarting a motor
Smaller Motors (<5 hp)

- Permanent split capacitor (PSC) motors are common
  - Low efficiency (~60%)
  - Single speed

- Consider ECM replacements
  - High efficiency (~80%)
  - Multiple speeds

- Typical applications:
  - Small HVAC
  - Refrigeration evaporators
Variable Frequency Drives (VFD)

- VFD
  - Adjustable speed drive
  - Vary frequency (Hz) and voltage going to the motor

- VFDs save energy when the load varies
  - Equipment is sized for peak loads
  - Peak conditions are ~1% of annual operating hours
VFDs on Constant Torque Loads

• Power varies linearly with motor speed / frequency

• Examples:
  • Conveyors, mixers, vacuum pumps, compressors, etc.
VFDs on Variable Torque Loads

- Relationship between power and motor speed is **cubic**!
  - 20% motor speed reduction = ~50% power reduction
  - 50% motor speed reduction =~85% power reduction

- Examples:
  - Centrifugal pumps and fans

![Graph showing cubic relationship between % Speed and % Torque](image)
Common VFD Applications

- Air handling unit and make-up air unit fans
- Exhaust fans
- Booster pumps
- Cooling / hot water pumps
- Chillers
- Air compressors
VFD Opportunity – Centrifugal Pumps

Image Source: Eaton
VFD Opportunity – Centrifugal Fans

Source: ASHRAE 2012 Handbook
Typical VAV Load Profile

Source: ASHRAE 2012 Handbook
Benefiting from VFDs

- VFDs are **not** plug & play

- To realize energy savings VFD applications must be properly:
  - Designed
  - Controlled
  - Commissioned
VFD and Motor Incentives – RETROFIT Program

- Program available throughout Ontario until December 31st, 2020
- Apply online at www.saveonenergy.ca
- Two types of incentives:

<table>
<thead>
<tr>
<th>Track</th>
<th>Incentive Rate</th>
<th>Energy and Demand Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prescriptive</td>
<td>Fixed $ per unit*</td>
<td>Assumed</td>
</tr>
</tbody>
</table>
| Custom      | Lighting ** $400/kW or $0.05/kWh  
Non-Lighting** $800/kW or $0.1/kWh | Calculated by the Applicant                |
Motor Incentives - Prescriptive

- Prescriptive incentives are available for motors that exceed NEMA premium efficiency (1 to 200 hp)

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Simple application requirements</td>
<td>• Low incentives</td>
</tr>
<tr>
<td></td>
<td>• Few motors qualify</td>
</tr>
</tbody>
</table>
Motor Incentives - Prescriptive

• Prescriptive incentives are also available for:
  • ECM for walk-in coolers / freezers
  • VAV fan-powered box ECM motor retrofit
  • New VAV fan-powered box w/ ECM
Motor Incentives - Custom

• Prescriptive Worksheet assumes a NEMA premium motor is being replaced
• If an older motor is being replaced, savings will be higher

<table>
<thead>
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<th>Advantages</th>
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</tr>
</thead>
<tbody>
<tr>
<td>• Potential for higher incentive</td>
<td>• Requires calculations</td>
</tr>
</tbody>
</table>
Simple Motor Savings Calculations

For fixed speed motors:

$$kW\ Savings = hP \times L \times 0.746 \times \left[ \frac{100}{E_{\text{Old}}} - \frac{100}{E_{\text{New}}} \right]$$

$$kWh\ Savings = hP \times L \times 0.746 \times Hrs \times \left[ \frac{100}{E_{\text{Old}}} - \frac{100}{E_{\text{New}}} \right]$$

- hP = Rated horsepower
- L = Load factor (%)
- $E_{\text{old}}$ = Existing motor efficiency
- $E_{\text{new}}$ = New motor efficiency
- Hrs = Annual operating hours
Prescriptive vs. Custom Incentive - Example

<table>
<thead>
<tr>
<th>Existing Motor</th>
<th>Proposed Motor</th>
</tr>
</thead>
<tbody>
<tr>
<td>• 50 hp</td>
<td>• 50 hp</td>
</tr>
<tr>
<td>• TEFC</td>
<td>• TEFC</td>
</tr>
<tr>
<td>• 92.4% efficiency</td>
<td>• 95.1% efficiency</td>
</tr>
<tr>
<td>• 75% loaded</td>
<td>• 75% loaded</td>
</tr>
</tbody>
</table>

• Prescriptive Incentive = $155
• Custom Incentive = 0.86 kW x $800 / kW = $687
Prescriptive VFD Incentives

- Incentive is ~10% demand savings on a 75% loaded motor (at $800 per kW saved)

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Simple application requirements</td>
<td>• Engineered / Custom usually has higher incentives</td>
</tr>
<tr>
<td>• Incentive often ~50% of materials costs</td>
<td>• Does not cover motors &gt;100 hP</td>
</tr>
</tbody>
</table>
## Prescriptive VFD Incentives

### Variable Frequency Drive (VFD) Incentives

<table>
<thead>
<tr>
<th>Motor Size on which VFD is installed (HP)</th>
<th>1</th>
<th>1.5</th>
<th>2</th>
<th>3</th>
<th>5</th>
<th>7.5</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>25</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>60</th>
<th>75</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant Incentive ($/VFD)</td>
<td>$50</td>
<td>$80</td>
<td>$105</td>
<td>$160</td>
<td>$265</td>
<td>$400</td>
<td>$535</td>
<td>$805</td>
<td>$1,070</td>
<td>$1,340</td>
<td>$1,610</td>
<td>$2,145</td>
<td>$2,565</td>
<td>$3,220</td>
<td>$3,980</td>
<td>$4,835</td>
</tr>
</tbody>
</table>

### Required Information

<table>
<thead>
<tr>
<th>Information</th>
<th>Example</th>
<th>#1</th>
<th>#2</th>
<th>#3</th>
<th>#4</th>
<th>#5</th>
<th>#6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reason: &quot;N&quot;=New or &quot;F&quot;=Failed</td>
<td>N</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Location: Building and Room</td>
<td>North Pump</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VFD Manufacturer</td>
<td>ABC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VFD Model Number</td>
<td>GH553</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motor Size in Horsepower</td>
<td>1.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motor Speed in RPM</td>
<td>1800</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motor Efficiency</td>
<td>94.20%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual Run Hours (actual)</td>
<td>5000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quantity</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Participant Incentive ($/VFD) (Table)</td>
<td>$80</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Participant Incentive</td>
<td>$80</td>
<td>$0.00</td>
<td>$0.00</td>
<td>$0.00</td>
<td>$0.00</td>
<td>$0.00</td>
<td>$0.00</td>
</tr>
</tbody>
</table>

*Note: The Eligible Measures Lists and Eligible Measures Worksheets are based on assumptions and are subject to change and the incentive amounts do not include HST or other applicable taxes.*
Custom VFD Incentives

• Projects where >10% savings are being achieved typically achieve higher Custom incentives
• Engineered Worksheets are available for pumps / fans
• Projects where incentives are >$10,000 require measurement and verification (M&V)

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<tr>
<td>• Potential for higher incentive</td>
<td>• Savings must be calculated</td>
</tr>
<tr>
<td>• May require M&amp;V</td>
<td>• May require M&amp;V</td>
</tr>
</tbody>
</table>
Example Custom VFD Project

Domestic Cold Water Booster Pump Upgrade
• 25 floor apartment building

Base Case
• 2 x 25 hP constant speed pumps

Efficient Case
• 3 x 7.5 hP pumps w/ VFD & controls
• $40,000 installed

<table>
<thead>
<tr>
<th>Base Case kW</th>
<th>Efficient Case kW</th>
<th>Savings kW</th>
<th>Incentive $11,900</th>
<th>Payback 2.4 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>kWh</td>
<td>kWh</td>
<td>kWh</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>153,000</td>
<td>4</td>
<td>34,000</td>
<td>119,000</td>
</tr>
</tbody>
</table>
Summary

• **Motors**
  • Are a significant user of electricity in commercial and industrial buildings
  • Consider inventorying your motors
  • Consider upgrading to a new motor instead of rewinding
  • Most motors run at full speed
  • Many motors run for longer than needed

• **VFDs**
  • Are a cost-effective and energy efficient way to control flow

• Incentives are available for motors & VFDs

• Thank you for your participation!
Questions

Greg Rushby, P.Eng
Rushby Energy Solutions Inc.
226-747-5066
grushby@rushbyenergy.com

www.rushbyenergy.com