Variable Frequency Drives (VFDs): Energy Efficiency Opportunities

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Quiz Questions: What do you already know about energy efficiency options for Variable Frequency Drives (VFDs)?

1. Which of the following best describes a benefit of VFDs?
2. What is the typical frequency adjustment range in HVAC applications for VFDs?
3. What is the current ActOnEnergy incentive amount ($/hp) for installing VFDs?
Topics

• What is a VFD?
• Energy Efficiency Opportunities
• ActOnEnergy Program Incentives
• Project Examples
• Questions
What is a VFD?

A Variable Frequency Drive is like the throttle on a car...

- It adjusts the speed of an HVAC fan or pump motor, based on demand, to save energy and prolong motor and mechanical component life
- Without a VFD, an HVAC fan or pump motor is either 100% ‘on’ or 100% ‘off’
- A VFD eliminates the initial power surge and mechanical shock of switching the motor from ‘off’ to ‘on’
- A VFD conserves energy when an HVAC control system senses that a fan or pump motor can meet heating or cooling needs by running at less than 100% power
How does a VFD work?

• A VFD changes the speed of an AC HVAC fan or pump motor by adjusting the frequency.

• Typical frequency adjustment range in HVAC applications is from 10 - 60Hz AC. A VFD is wired in series between main power and motor.

• A Bypass is added to “Bypass” the VFD and run on main line power so HVAC operation is not interrupted if the VFD needs servicing.
How does a VFD save energy?

Affinity Laws:

- Flow vs Speed
  - \( \frac{Q_1}{Q_2} = \frac{S_1}{S_2} \)
- Head vs Speed
  - \( \frac{H_1}{H_2} = \frac{S_1^2}{S_2^2} \)
- hp vs Speed
  - \( \frac{bhp_1}{bhp_2} = \frac{S_1^3}{S_2^3} \)
What industry segment does your facility represent?
Centrifugal Fans

Typical Centrifugal Fan System

- 100% Flow
- Outlet Damper
- Variable Inlet Vane
- VFD
- Theoretical Fan Curve

% Input Power

% Flow
Centrifugal Pumps

Typical Centrifugal Low-Head, Low-Friction Pump System

- Recirc / Bypass
- Throttling Valve
- VFD
- Theoretical Pump Curve

% Flow vs. % Input Power graph.
ActOnEnergy Program Incentives

- VFD energy savings typically 30-70%
- Up to 500 hp - $90/hp (Standard)
- > 500 hp – 8 cents/kWh annual savings (Custom)
- Pre-approval required if over $10,000 incentive
- ActOnEnergy will pay 75% of the installed (external labor) cost of the project (Standard)
- Only for centrifugal fans and pumps. All other uses would need to use a Custom application
Program Eligibility Requirements

• 2,000 operating hours/year minimum

• Must be installed on an AC Motor

• Redundant/backup units do not qualify

• Routine VFD replacements do not qualify

• System must be controlled by differential pressure, flow, temperature, or other control variable

• Application must have significant load diversity

• Applications meant for power conditioning and other non-varying loads do not qualify
Standard Application Input Data

- VFD Use (CT fan, CHW distribution pump)
- Control Before VFD (outlet control valve)
- Cost of VFD plus external labor
- Annual Operating Hours
- hp controlled by VFD
- Energy savings calculation not required
- **W-9 form is required with the incentive application**
## Some Standard VFD Applications

<table>
<thead>
<tr>
<th>Fans</th>
<th>Pumps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Induced/forced draft fans</td>
<td>Chilled water pumps</td>
</tr>
<tr>
<td>Supply air fans</td>
<td>Feed water pumps</td>
</tr>
<tr>
<td>Return fans</td>
<td>Pressure boosting pumps</td>
</tr>
<tr>
<td>Cooling tower fans</td>
<td>Cooling tower pumps</td>
</tr>
<tr>
<td>Condenser fans</td>
<td>Wastewater pumps</td>
</tr>
<tr>
<td>Ventilation fans</td>
<td>Food processing pumps</td>
</tr>
<tr>
<td>Dryer fans</td>
<td>Water injection pumps</td>
</tr>
</tbody>
</table>
**ActOnEnergy: Custom Projects**

<table>
<thead>
<tr>
<th>Custom Incentives</th>
<th>Lighting</th>
<th>$0.06/kWh</th>
<th>Other electric</th>
<th>$0.08/kWh</th>
<th>Gas</th>
<th>$1.20/Therm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Savings Incentive</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum Payback (before and after incentive)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.0 years</td>
</tr>
<tr>
<td>Maximum Payback (before and after incentive)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7.0 years</td>
</tr>
</tbody>
</table>

- Cap of $600,000 (electric) and $600,000 (gas) per facility per year
- Cash incentives paid at rate of 50% after facility receives $200,000
- Incentive capped at 50% of project cost
- Pre-approval *always* required
- Incentives >$25,000 require Large Incentive Request Form
Some Custom VFD Applications

- Conveyors
- Cranes
- Extruders
- Hoists
- Mixers
- Positive displacement pumps
- Screw pumps/compressors
- Reciprocating compressors
Program Participation

- Approximately 200 Standard and Custom projects to date (PY1-PY4)
- Nearly 60 million kWh in annual energy savings
- Assuming 10 cents/kWh, business customers have saved $6 million in annual energy costs
- Approximately $3 million in program incentives
- 35 participants have implemented multiple VFD projects
- Manufacturing/industrial leads the way with 58% of overall participation
- Healthcare (7%) and Grocery/Big Box Retail (10%) are also active participants
Life Cycle Costs

- > 70% of life cycle investment is energy cost
Example Project: Condenser Fan VFD Project

- Condenser Fans
- 2 - 5 hp fans with no control
- Run 1 fan at 100% and the second at 0%
  - Power is equal to 5 hp
- Run both fans with VFDs at 50% speed
  - Power is equal to speed cubed
  - \(0.5^3 = 0.5 \times 0.5 \times 0.5 = 0.125 \times 2 \text{ fans} = 0.25\)
  - \(0.25 \times 5 \text{ hp} = 1.25 \text{ hp}\)
  - Savings = 75%
Example Project: Fan VFD Project

- Process Fans
- 2 - 200 hp VFD controlled
- Project cost: $75,653
- Annual energy savings: 400,000 kWh
- ActOnEnergy incentive $36,000
- % of project cost covered by incentive: 40%
Example Project: Pump VFD Project

- Cooling Tower
- 1 - 60 hp VFD controlled
- Project cost: $14,381
- Annual energy savings: 154,000 kWh (60%)
- ActOnEnergy incentive $5,400
- % of project cost covered by incentive: 30%
Resources

- Website: ActOnEnergy.com/Business
- Phone: 866-800-0747
- Fax: 309-677-7950
- Email: ActOnEnergyBusiness@Ameren.com
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