* + 1. Variable Speed Drives for HVAC Pumps and Cooling Tower Fans

**Description**

This measure is applied to variable speed drives (VSD) which are installed on the following HVAC system applications: chilled water pump, hot water pumps. There is a separate measure for HVAC supply and return fans. All other VSD applications require custom analysis by the program administrator. The VSD will modulate the speed of the motor when it does not need to run at full load. Since the power of the motor is proportional to the cube of the speed for these types of applications, significant energy savings will result.

This measure was developed to be applicable to the following program types: TOS, RF. If applied to other program types, the measure savings should be verified.

**Definition of Efficient Equipment**

The VSD is applied to a motor which does not have a VSD. The application must have a variable load and installation is to include the necessary controls. Savings are based on application of VSDs to a range of baseline load conditions including no control, inlet guide vanes, outlet guide vanes and throttling valves.

**Definition of Baseline Equipment**

The time of sale baseline is a new motor installed without a VSD or other methods of control. Retrofit baseline is an existing motor operating as is. Retrofit baselines may or may not include guide vanes, throttling valves or other methods of control. This information shall be collected from the customer.

Installations of new equipment with VSDs which are required by IECC 2012 or 2015 as adopted by the State of Illinois are not eligible for incentives.

**Deemed Lifetime of Efficient Equipment**

The expected measure life for HVAC application is 15 years;[[1]](#footnote-2) measure life for process is 10 years.[[2]](#footnote-3)

**Deemed Measure Cost**

Customer provided costs will be used when available. Default measure costs[[3]](#footnote-4) are noted below for up to 20 hp motors. Custom costs must be gathered from the customer for motor sizes not listed below.

| **HP** | **Cost** |
| --- | --- |
| 1 -5 HP | $ 1,330 |
| 7.5 HP | $ 1,622 |
| 10 HP | $ 1,898 |
| 15 HP | $ 2,518 |
| 20 HP | $ 3,059 |

**Loadshape**

|  |
| --- |
| Loadshape C42 - VFD - Boiler feedwater pumps <10 HP |
| Loadshape C43 - VFD - Chilled water pumps <10 HP |
| Loadshape C44 - VFD Boiler circulation pumps <10 HP |
| Loadshape C48 - VFD Boiler draft fans <10 HP |
| Loadshape C49 - VFD Cooling Tower Fans <10 HP |

**Coincidence Factor**

The demand savings factor (DSF) is already based upon coincident savings, and thus there is no additional coincidence factor for this characterization.

**Algorithm**

**Calculation of Savings**

**Electric Energy Savings**

ΔkWh = BHP /EFFi \* Hours \* ESF

Where:

BHP = System Brake Horsepower

(Nominal motor HP \* Motor load factor)

Motors are assumed to have a load factor of 65% for calculating kW if actual values cannot be determined[[4]](#footnote-5). Custom load factor may be applied if known.

EFFi = Motor efficiency, installed. Actual motor efficiency shall be used to calculate kW. If not known a default value of 93% shall be used.[[5]](#footnote-6)

Hours = Default hours are provided for HVAC applications which vary by HVAC application and building type[[6]](#footnote-7). When available, actual hours should be used.

| **Building Type** | **Heating Run Hours** | **Cooling Run Hours** | **Heating and Cooling Run Hours** |
| --- | --- | --- | --- |
| Assembly | 4888 | 2150 | 7235 |
| Assisted Living | 4711 | 4373 | 8760 |
| College | 3990 | 1605 | 6103 |
| Convenience Store | 4136 | 2084 | 7004 |
| Elementary School | 5105 | 3276 | 7522 |
| Garage | 4849 | 2102 | 7357 |
| Grocery | 4200 | 2096 | 7403 |
| Healthcare Clinic | 5481 | 1987 | 6345 |
| High School | 5480 | 3141 | 7879 |
| Hospital - VAV econ | 3718 | 2788 | 8760 |
| Hospital - CAV econ | 7170 | 2881 | 8760 |
| Hospital - CAV no econ | 7139 | 8760 | 8760 |
| Hospital - FCU | 5844 | 8729 | 8760 |
| Manufacturing Facility | 3821 | 2805 | 8706 |
| MF - High Rise | 4522 | 4237 | 8760 |
| MF - Mid Rise | 5749 | 2899 | 8760 |
| Hotel/Motel - Guest | 4480 | 4479 | 8760 |
| Hotel/Motel - Common | 3292 | 8712 | 8760 |
| Movie Theater | 5063 | 2120 | 7505 |
| Office - High Rise - VAV econ | 4094 | 2038 | 6064 |
| Office - High Rise - CAV econ | 5361 | 4849 | 5697 |
| Office - High Rise - CAV no econ | 5331 | 5682 | 5682 |
| Office - High Rise - FCU | 3758 | 3069 | 6163 |
| Office - Low Rise | 3834 | 2481 | 6288 |
| Office - Mid Rise | 3977 | 1881 | 6125 |
| Religious Building | 5199 | 2830 | 7380 |
| Restaurant | 4579 | 3350 | 7809 |
| Retail - Department Store | 4249 | 2528 | 6890 |
| Retail - Strip Mall | 4475 | 2266 | 6846 |
| Warehouse | 4606 | 770 | 6786 |
| Unknown | 4649 | 2718 | 7100 |

ESF = Energy savings factor varies by VFD application. Units are kW/HP.

| **Application** | **ESF**[[7]](#footnote-8) |
| --- | --- |
| Hot Water Pump | 0.424 |
| Chilled Water Pump | 0.411 |
| Air Foil/backward incline | 0.354 |
| Air Foil/ backward incline inlet Guide Vanes | 0.227 |
| Forward Curved Fan, with discharge dampers | 0.179 |
| Forward Curved Inlet Guide Vanes | 0.092 |

**Summer Coincident Peak Demand Savings**

ΔkW =BHP/EFFi \* DSF

Where:

DSF = Demand Savings Factor varies by VFD application.[[8]](#footnote-9) Units are kW/HP. Values listed below are based on typical peak load for the listed application.

| **Application** | **DSF** |
| --- | --- |
| Hot Water Pump | 0 |
| Chilled Water Pump | 0.299 |
| Air foil / backward incline | 0.260 |
| Air Foil / backward incline inlet Guide Vanes | 0.130 |
| Forward Curved Fan, with discharge dampers | 0.136 |
| Forward Curved Inlet Guide Vanes | 0.029 |

**Fossil Fuel Impact Descriptions and Calculation**

There are no expected fossil fuel impacts for this measure.

**Water Impact Descriptions and Calculation**

N/A

**Deemed O&M Cost Adjustment Calculation**

N/A

**Measure Code: CI-HVC-VSDHP-V03-160601**

1. Efficiency Vermont TRM 10/26/11 for HVAC VSD motors [↑](#footnote-ref-2)
2. DEER 2008 [↑](#footnote-ref-3)
3. Ohio TRM 8/6/2010 varies by motor/fan size based on equipment costs from Granger 2008 Catalog pp 286-289, average across available voltages and models. Labor costs from RS Means Data 2008 Ohio average cost adjustment applied. [↑](#footnote-ref-4)
4. Del Balso, Ryan J. “Investigation into the Reliability of Energy Efficiency/Demand Side Management Savings Estimates for Variable Frequency Drives in Commercial Applications”, University of Colorado, Department of Civil, Environmental and Architectural Engineering, 2013. [↑](#footnote-ref-5)
5. Ohio TRM 8/6/2010 pp207-209, Com Ed TRM June 1, 2010. [↑](#footnote-ref-6)
6. Hours per year are estimated using the eQuest models as the total number of hours the heating or cooling system is operating for each building type. “Heating and Cooling Run Hours” are estimated as the total number of hours fans are operating for heating, cooling and ventilation for each building type. This may overclaim certain applications (e.g. pumps) and so where possible actual hours should be used for these applications. [↑](#footnote-ref-7)
7. Based on the methodology described in the CT TRM; derived using a temperature BIN analysis of typical heating, cooling and fan load profiles. [↑](#footnote-ref-8)
8. Ibid [↑](#footnote-ref-9)