

# HVAC Variable Frequency Drives (VFDs) Custom Express Overview



## For ESPs, Vendors, End-Users

### Presenters:

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## Agenda:

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- **Overview of HVAC VFDs and the Custom Express process**
- **Benefits**
- **PIF or Application Form Review**
- **Minimum Requirement Document / Post Inspection**
- **Review Actual PIF, MRD, Offer Letter (Company Commitment)**
- **Q&A**



# Overview of HVAC VFDs & Custom Express

Eugene Hickok



# National Grid's HVAC VFD Custom Express Offering

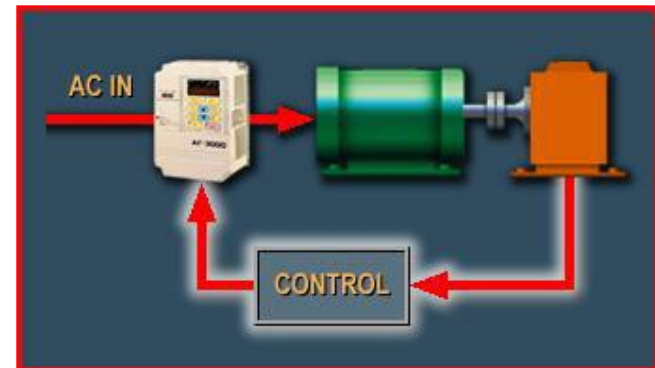
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- Quick/easy way to provide incentives for installation of VFDs on HVAC equipment
- Available to customers beginning August, 2014
- Fixed incentives offered based on size of motors being controlled (1 HP up to 200 HP)
- Incentives range from \$450 up to as high as \$6,500 per VFD
- Primary customer market for these HVAC upgrades is light commercial buildings

# Overview of Variable Frequency Drives (VFDs)

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- Motors operate at constant speed while load can vary
- VFDs save energy by adjusting motor speed to match load requirements
- Buildings with long operating hours and fluctuating load are ideal candidates for VFDs



# Overview of HVAC VFDs

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## How VFDs Work

- VFD is an electronic controller
- Adjust to the speed of a motor by modulating the power being delivered
- VFDs readout in Hertz (Hz); 240v/3phase/60Hz, 120v/1phase/60Hz is the normal cycle. Reduce Hz and reduce RPMs
- VFDs are controlled by Energy Management System (EMS) by means of an analog (variable) input

# Overview of HVAC VFDs

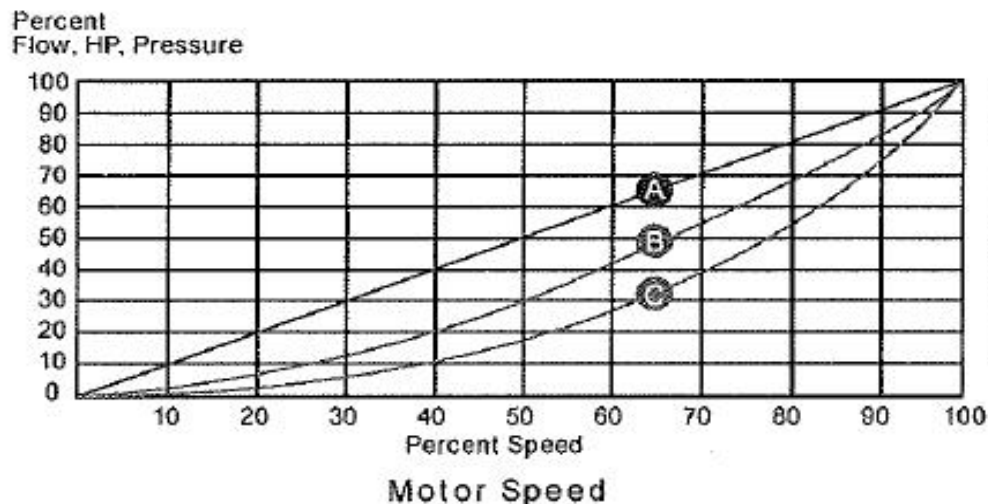
## Energy Efficiency

Square D E-Flex enclosed drive controllers can increase system energy efficiency by providing a means to reduce the motor speed of HVAC equipment based on the needs of the building environment (lower motor speed = lower energy costs).

Energy savings can be realized because of the Affinity laws of physics:

- Flow = f (motor speed)
- Pressure = f (motor speed)<sup>2</sup>
- Horsepower = f (motor speed)<sup>3</sup>

A motor running at 50% full speed capacity has a motor torque of 25% of full speed. In addition, electricity required to operate the motor at 50% of full speed is 12.5% of the amount of electricity required if the motor was running at 100% full speed capacity. Thus, reducing motor speed can significantly reduce the electrical energy consumption.



- A** = Flow as a function of motor speed
- B** = Pressure as a function of motor speed
- C** = Horsepower as a function of motor speed

## Overview of HVAC VFDs

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### An Example Energy Saving Calculation\*\*

A fan with a 20 horsepower motor supplies air 10 hours a day for 260 days a year and the energy cost is \$0.10 cents per kilowatt-hour.

Cost of running full speed:

$$20 \text{ hp} \times 0.746 \text{ kW/hp} \times 2600 \text{ hours} \times \$0.10/\text{kWhr} = \$3879.20$$

Assuming the fan does not need to run at full speed all of the time, let's use an example of:

- | Running full speed (100%) for 25% of the time
- | 80% speed for 50% of the time
- | 60% speed for the remaining 25% of the time

Cost of running with an AC drive controlling the motor:

$$20 \text{ hp} \times (1)^3 \times 0.746 \text{ kW/hp} \times 650 \text{ hours} \times \$0.10/\text{kWhr} = \$969.80$$

$$20 \text{ hp} \times (0.8)^3 \times 0.746 \text{ kW/hp} \times 1300 \text{ hours} \times \$0.10/\text{kWhr} = \$993.08$$

$$20 \text{ hp} \times (0.6)^3 \times 0.746 \text{ kW/hp} \times 650 \text{ hours} \times \$0.10/\text{kWhr} = \$209.48$$

$$\text{Total} = \$2172.36$$

Annual savings:  $\$3879.20 - \$2172.36 = \$1706.84$

- | In many instances, the payback period for using an adjustable frequency drive in place of other flow control methods is less than 18 months.



# Overview of HVAC VFDs

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## VFDs used for:

- Variable torque pumps and fans
- HVAC in commercial buildings

## VFDs used in these building types:

- Community College
- Dormitory
- Elementary/High School
- Grocery
- Hospital / Health
- Hotel / Motel
- Multifamily
- Offices
- Restaurants
- Retail
- University
- Warehouse



# Overview of HVAC VFDs

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## Benefits

- kWh & kW savings
- Increased equipment life
- Improved control
- Low maintenance

## Disadvantages

- Harmonic distortion
  - Was a problem in the past with old electronic ballast, phone systems, etc.
- Line reactors needed
  - Without a line reactor the VFD could trip off line.

# Detailed Review of PIF

ENERGY INITIATIVE | RETROFIT

## Custom Express Variable Frequency Drives (VFDs) for HVAC

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2014 project information form for upstate New York

This Project Information Form provides a template to collect project systems and equipment information and specifications. In addition, this form serves as a general overview of eligibility criteria for incentives as well as a guide to Custom Variable Frequency Drive HVAC Energy Efficient Projects and products. This form is intended for use by individuals experienced with National Grid's Custom Program. Contact your National Grid representative for complete details on this program and to submit an application. Prior to the start of any installation of equipment or systems, please contact your National Grid representative to arrange a convenient time to perform an inspection of existing equipment and systems. This pre-inspection is required for all applications.

### CUSTOMER FACILITY INFORMATION

CUSTOMER FACILITY NAME: CONTACT PERSON: STREET ADDRESS: CITY:  STATE:  ZIP: E-MAIL ADDRESS: 

CLASSIFICATION TYPE:   $\geq$  2MW (LARGE)  
  $<$  2MW (MID-SIZE)  INDUSTRIAL  COMMERCIAL

\*  $\geq$  2MW LARGE COMMERCIAL CUSTOMER USE THE  $<$  2MW CLASSIFICATION TYPE

DATE OF APPLICATION: SQ. FT. COVERED BY APPLICATION: FEDERAL ID NUMBER: 

COMPANY TYPE:

 INCORPORATED  EXEMPT  NOT INCORPORATED
PHONE NUMBER: FAX NUMBER:

# Detailed Review of PIF

Customer of Record Information: Billing Account Number: \_\_\_\_\_ **REQUIRED**

**BUILDING TYPE (SELECT ONE)**

- |  |  |   |                                       |
|--|--|---|---------------------------------------|
| <input type="checkbox"/> Assembly          | <input type="checkbox"/> Full Service Restaurant | <input type="checkbox"/> Light Industrial       | <input type="checkbox"/> Small Office |
| <input type="checkbox"/> Auto Repair       | <input type="checkbox"/> Grocery                 | <input type="checkbox"/> Motel                  | <input type="checkbox"/> Small Retail |
| <input type="checkbox"/> Big Box           | <input type="checkbox"/> High School             | <input type="checkbox"/> Multifamily high-rise  | <input type="checkbox"/> University   |
| <input type="checkbox"/> College Dormitory | <input type="checkbox"/> Hospital                | <input type="checkbox"/> Multifamily low-rise   | <input type="checkbox"/> Warehouse    |
| <input type="checkbox"/> Community College | <input type="checkbox"/> Hotel                   | <input type="checkbox"/> Refrigerated Warehouse | <input type="checkbox"/> Other _____  |
| <input type="checkbox"/> Elementary School | <input type="checkbox"/> Large Office            | <input type="checkbox"/> Religious              |                                       |
| <input type="checkbox"/> Fast Food         | <input type="checkbox"/> Large Retail            |   |                                       |

**INSTALLATION CONTRACTOR INFORMATION**

Installation Performed By:\*  Customer  Installation Contractor (Vendor) *\*If contractor has not been selected, select **Customer***

Complete this section if installation is not by the customer

INSTALLATION COMPANY: \_\_\_\_\_ STREET ADDRESS: \_\_\_\_\_

CONTACT PERSON: \_\_\_\_\_ CITY: \_\_\_\_\_ STATE: \_\_\_\_\_ ZIP \_\_\_\_\_

E-MAIL ADDRESS: \_\_\_\_\_ PHONE NUMBER: \_\_\_\_\_

**APPLICATION INFORMATION**

EXPECTED COMPLETION DATE: \_\_\_\_\_

PROPOSED INCENTIVE RECIPIENT:  Customer (Account Credit or Check)  Installation Contractor\*\*

\*\* Complete this section if Installation Contractor has been selected

FEDERAL ID NUMBER: \_\_\_\_\_ COMPANY TYPE:  INCORPORATED  EXEMPT  NOT INCORPORATED

# Detailed Review of PIF

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## Instructions:

Use this form to apply for incentives through the Custom Express Variable Frequency Drive incentive program.

The incentives set forth in this form will be provided for the installation of HVAC Variable Frequency Drives (VFD) retrofits on constant speed systems. Incentives are ONLY for the installation types outlined in Table 1. Only motor sizes ranging from 1 HP to 200 HP for the system types outlined below are eligible to receive incentives through this program. VFD installations on applications larger than 200 HP and all other VFD applications not specified in this form will be analyzed using National Grid's Custom Program which requires more detailed energy savings calculations. Please contact your National Grid representative for additional information. VFDs installed on back-up motors (used only in case of emergency) are not eligible.

- 1) Fill in the Customer information datasheet on page 1
- 2) Fill in the project cost including material and labor on page 3.
- 3) Enter the Proposed Variable Frequency Drive information in the Equipment Specification Table on page 3.  
Attach specification sheets and other relevant information to this application.
- 4) Submit completed application to your National Grid representative and schedule a time for inspection of existing equipment.

# Detailed Review of PIF

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## Eligibility Requirements:

- 1) Used or rebuilt equipment is not eligible.
- 2) Replacement of existing VFD units or failed equipment is not eligible.
- 3) VFDs must be controlled automatically in response to modulating air/water flow requirements as a result of differential pressure, flow or temperature feedback signal.
- 4) Motors must operate a minimum of 2000 hours annually.
- 5) VFDs used to regulate over sized motors are not eligible under this program.
- 6) Back up equipment is not eligible for incentives.
- 7) The following VFD applications are not eligible under this program.
  - a. Forward curve fans with inlet guide vanes.
  - b. Variable pitch vane axial fans.
  - c. Two speed or constant speed (soft start) applications or constant torque applications such as conveyors.
  - d. VFDs used for balancing flow.
  - e. VFD applications for industrial processes.

# Detailed Review of PIF

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## Existing or Baseline Conditions:

The following existing or baseline conditions apply:

- 1) Chilled water and hot water pumps: Variable volume demand but motor running at constant speed.
- 2) Supply fans: VAV systems with inlet vane control.
- 3) Return fans: VAV system with discharge damper control.
- 4) Cooling tower fans: One speed constant volume fan.
- 5) Condenser water pumps: Constant speed, constant flow.

# Detailed Review of PIF

**Table 1: Variable Frequency Drive System Installation Types**

Device Code	Application	Device Code	Application
CHWP	Chilled Water Pump	HWP	Heating Hot Water Pump
CWP	Condenser Water Pump	RFA	Return Air Fan
EXF	Exhaust Fan	SFA	Supply Fan
FWP	Boiler Feed Water Pump	WLHP	WLHP (Water Loop Heat Pump/Circulating Pump)
MAF	Make Up Air Fan	CTF	Cooling Tower Fan

**Table 2: Variable Frequency Drive Installation Size and Incentives \***

Horsepower	Incentive	Horsepower	Incentive	Horsepower	Incentive	Horsepower	Incentive
1	\$450	7.5	\$1,300	30	\$2,750	100	\$5,500
1.5	\$450	10	\$1,350	40	\$3,000	125	\$5,500
2	\$600	15	\$1,600	50	\$3,500	150	\$5,500
3	\$700	20	\$1,850	60	\$4,000	200	\$6,500
5	\$1,000	25	\$2,500	75	\$4,500		

*\* If the controlled HP falls between the HP listed on the VFD Incentive amounts in the table above, the incentive is based on the lower controlled HP.*

**Total Cost of Labor and Materials for installed VFD equipment: \$**  

- An actual invoice is required to be submitted to National Grid before final payment of incentive.



# Detailed Review of PIF



**Table 3: Proposed Equipment Specification Table (Facility Detail)**

Enter data from Tables 1 and 2 above, fill in using one line for each VFD.. Attach copies of specification sheets for VFDs to this application.

Location (1)	System Type (2)	Facility Type (3)	Quantity	HP	Incentive Per VFD (4)	Anticipated Incentive (5)
Example 1: FWP Boiler 2	FWP	Warehouse	2	20	\$ 1850	\$ 3700
					\$	\$
					\$	\$
					\$	\$
					\$	\$
					\$	\$
					\$	\$
					\$	\$
					\$	\$
					\$	\$
					\$	\$
					\$	\$
					\$	\$
					\$	\$
					\$	\$
					\$	\$
Attach a separate list for additional unit(s)					Total Incentive(this page)	\$

- 1) Location describes where VFD will be installed
- 2) System Type is from Table 1 above
- 3) Facility Type is Office, Hospitals/Health, Elem/High Schools, Retail, Dormitory, University, Community College or Multi-Family
- 4) Choose incentive amount from Table 2 based on Horse Power (HP)
- 5) Multiply the Quantity by the Incentive Per VFD to get the Anticipated Incentive

# Detailed Review of PIF

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## Important Information on Variable Frequency Drives

**VFDs must be controlled by an automatic signal in response to modulating air/water flows. The VSD speed must be automatically controlled by differential pressure, flow or temperature.** Applicants must demonstrate significant load diversity that will result in savings through motor speed variations.

VFDs can be sensitive to over-voltages that occur when power factor correcting capacitor banks on the utility power system are switched on. To qualify for an incentive payment, each VFD must include a series reactor (*inductor, choke*) in its AC input connections. Your VFD supplier should assist in the sizing of the reactor. Minimum requirement is a 3% impedance reactor, based on the horsepower of the VFD to be installed. *Note: A "DC choke" does not meet this requirement as it does not provide this level of protection for over-voltage conditions.*

In some instances your supplier may find it necessary to install 5% reactors and, rarely, additional filtering devices to meet acceptable current and voltage harmonic distortion requirements.

If your power factor is less than 0.8 (80%), we recommend that you consider power factor correction concurrent with the installation of drives.

The use of VFDs which incorporate pulse width modulation (PWM) may produce over-voltages which may cause premature failure of AC induction motors not rated for use with an inverter. We recommend that when installing PWM drives, you consider utilizing inverter rated motors.

# Minimum Requirement Document Post Inspection

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## MINIMUM REQUIREMENTS DOCUMENT AND POST INSPECTION REPORT FOR CUSTOM EXPRESS - HVAC VARIABLE FREQUENCY DRIVES

Customer Name	Any School	TRC Method	Add-On
Location	12 Any School, Any City, NY 12345	Application #:	146578
ECM:	HVAC Variable Frequency Drives (Custom Express)		

# Minimum Requirement Document

## Post Inspection

Instructions:

This document is used to record post inspection results for variable frequency drive applications that are processed through “Custom Express”. **NOTE: The “project information form” and invoice must be attached to this form and taken on the post inspection appointment. These are used during the post inspection**

Post Inspection	EQUIPMENT DESCRIPTION: Provide a list of equipment or materials installed as part of this project. Include mfr, model, HP, kW, efficiency ratings, etc.
YES <input type="checkbox"/> NO <input type="checkbox"/>	<p>From the project information form and invoice, verify that all of the variable frequency drives have been installed. Verify 1-3 below using the Project Information Form (PIF)</p> <ol style="list-style-type: none"> <li>1. Installation Type (e.g. “boiler feed pump”)</li> <li>2. Horse power</li> <li>3. Quantity of each installation type and horsepower</li> <li>4. Verify that each VFD incorporates a 3% line reactor. Document any VFD that doesn’t comply</li> </ol> <p>Document any discrepancies and bring them to the attention of the CEC or EEA for resolution.</p>
Post Inspection	SEQUENCE OF OPERATION: Provide a description of equipment operating sequences, set points, operating schedules, balancing requirements (flow, velocity, head, etc) or any other required operating parameters.
YES <input type="checkbox"/> NO <input type="checkbox"/>	<p>Verify that each of the variable frequency drives is controlled by an automatic signal in response to modulating air/water flows. The VSD speed must be automatically controlled by differential pressure, flow or temperature. The customer should demonstrate that the system is modulating. Systems should not be in by-pass mode.</p> <p>Document any discrepancies and bring them to the attention of the CEC or EEA for resolution.</p>

# Minimum Requirement Document

## Post Inspection



Post Inspection	DOCUMENTATION: List written documentation required to train, verify, operate, or maintain the equipment being installed or controlled. This may include specification sheets, test reports, construction drawings, sequence of operations, etc.
YES <input type="checkbox"/> NO <input type="checkbox"/>	Note: the sequence of operation is evidence that shows that the system is being controlled automatically and is modulating through a signal triggered by differential pressure, flow and/or temperature.
Post Inspection	POST INSTALLATION M&V or COMMISSIONING: Provide a list of Trending Requirements required to verify proper system operation. Trends should document operational sequences, set points and scheduling of equipment as described in sequence of operations or TA Study
YES <input type="checkbox"/> NO <input type="checkbox"/>	
Post Inspection	OTHER REQUIRMENTS: Describe any requirements for demolition, removal, etc of existing equipment.

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Post Inspector's Signature

Date

Name of Customer present at post inspection

## National Grid Contact Info

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- **Phone: (800) 787-1706**
- **Fax: (315) 460-9803**
- **Email: [Efficiency@nationalgrid.com](mailto:Efficiency@nationalgrid.com)**
- **Website:**  
**[www.nationalgridus.com/EnergyEfficiencyServices](http://www.nationalgridus.com/EnergyEfficiencyServices)**

# Questions

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