

VFD Smart Drive Technology

Saving Electric Motor Energy

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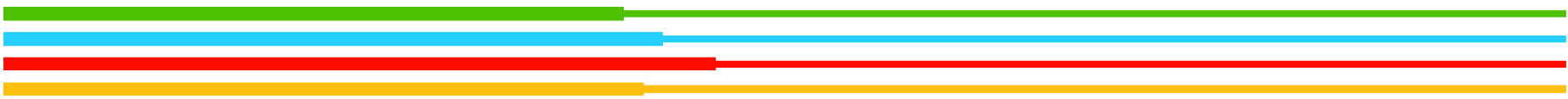
Presenter:

Roger Fritz

Managing Director

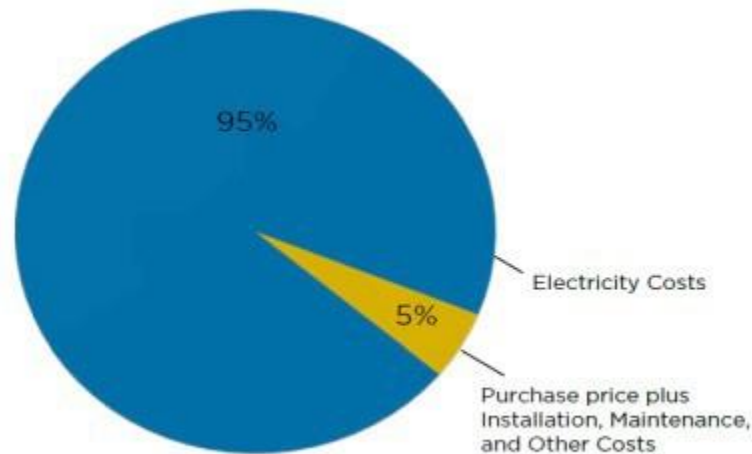
[www. ac-dc-hotline.com](http://www.ac-dc-hotline.com)

engineering@ac-dc-hotline.com

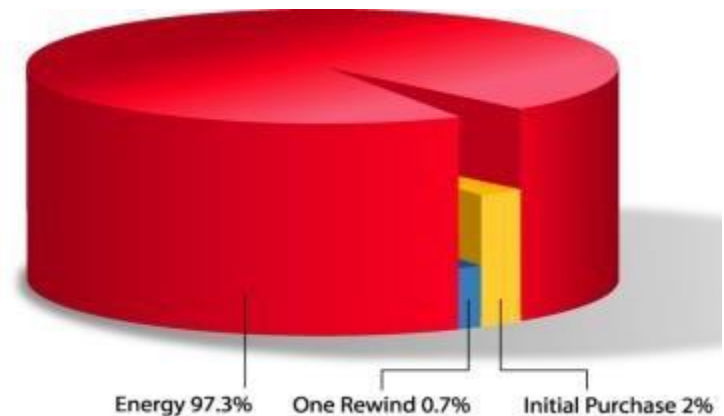


Electric Motors

- **Electric Motors Use 70% of the World's Power**
 - We impact that load 30 – 50%
 - Savings can be as much as 20% to 30% on overall bill
 - Look for 1hp and above operating at least 2,000 hrs/yr

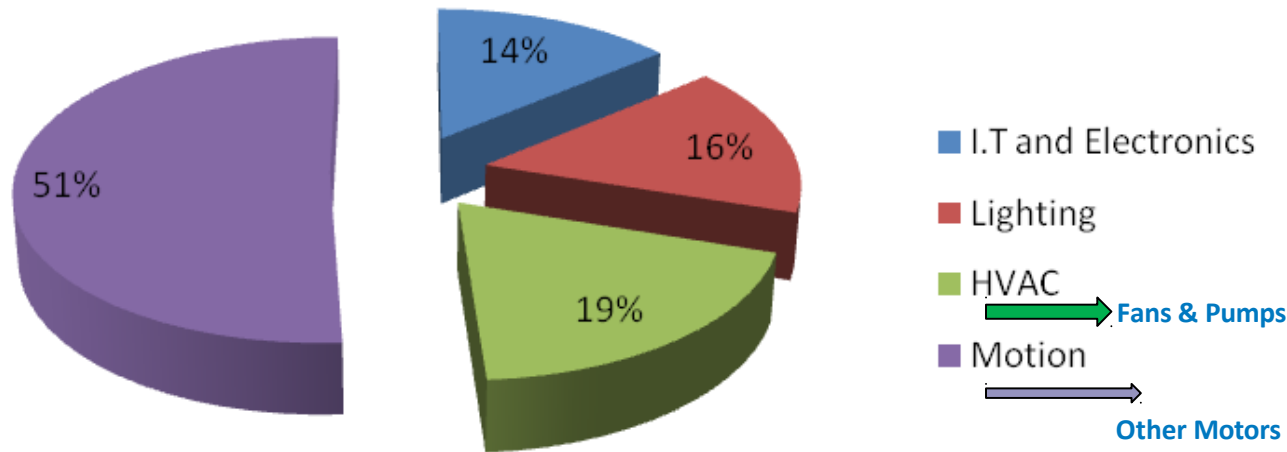


Source: MDM "Motor Planning Kit", www.motorsmatter.org



Global Electrical Energy Consumption by Sector

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Electric Motors Account for 70% of Total World Energy

Source : IMS Research 2005

Motor Life Time Cost Example

The purchase price of a motor represents only a tiny fraction of the life time costs of the motor.

e.g. 15 HP 4 Pole Standard Motor, typical price approx. \$ 450

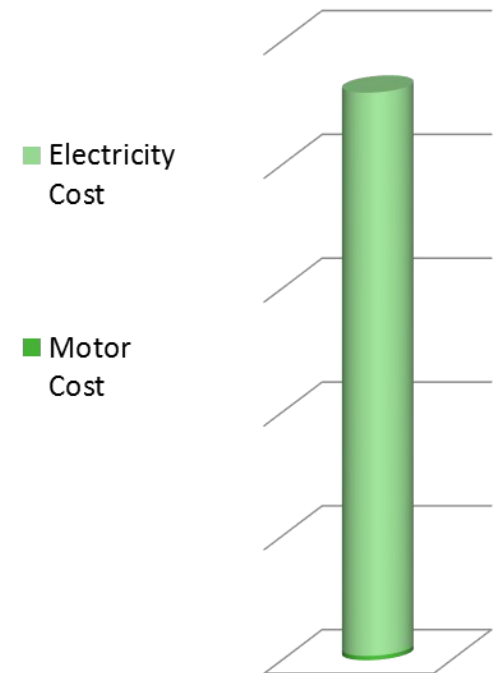
Assuming

- Typical Industrial Electrical Cost of 0.11\$ / kWh
- Motor operates
 - 12 Hours Per Day
 - 6 Days Per Week
 - 48 Weeks Per Year
- Motor Efficiency 92%

Over a 10 Year operating period, the electricity used will be :-
(11kW x 12 Hours x 6 Days x 48 Weeks x 10 Years) / 92% Efficiency
= 413217.4 kWh!

... At a cost of \$45,454.00!

The purchase price represents less than 1% of this cost!



Variable Frequency Drive (VFD)

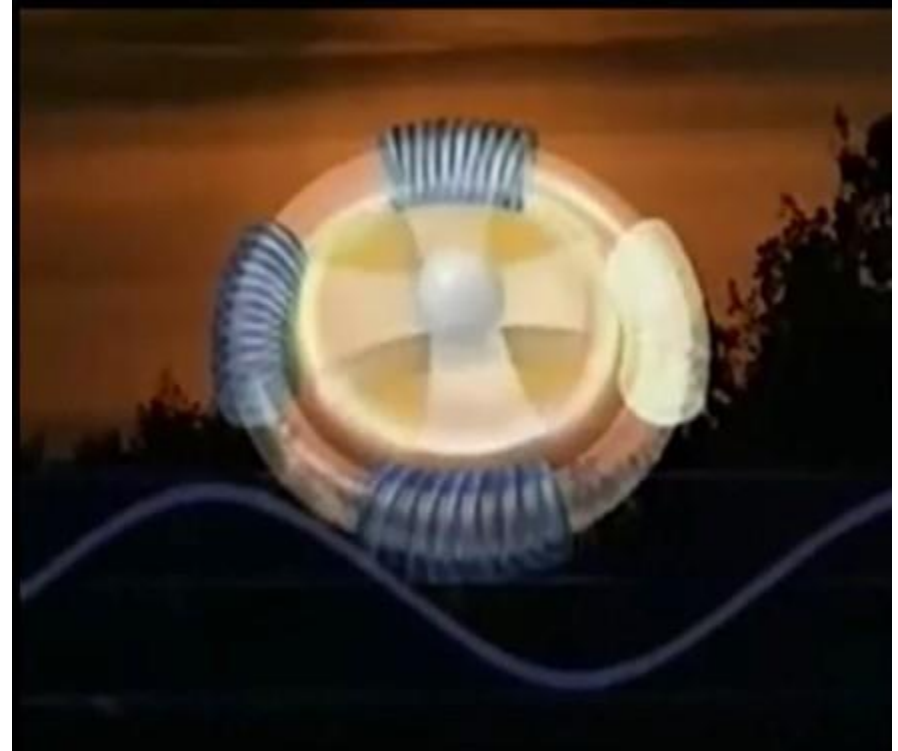


■ Variable Frequency Drive Defined

- An electronic package when connected to the motor has capability to control the speed of an AC motor
- Packaged Design – similar to a UPS (uninterrupted power supply)
- Converts a fixed power supply to a variable frequency and variable voltage source to feed the motor
- Controls the torque and speed produced by the motor
- A/C Power and D/C Power – Edison & Tesla

Flow of Current In a Motor

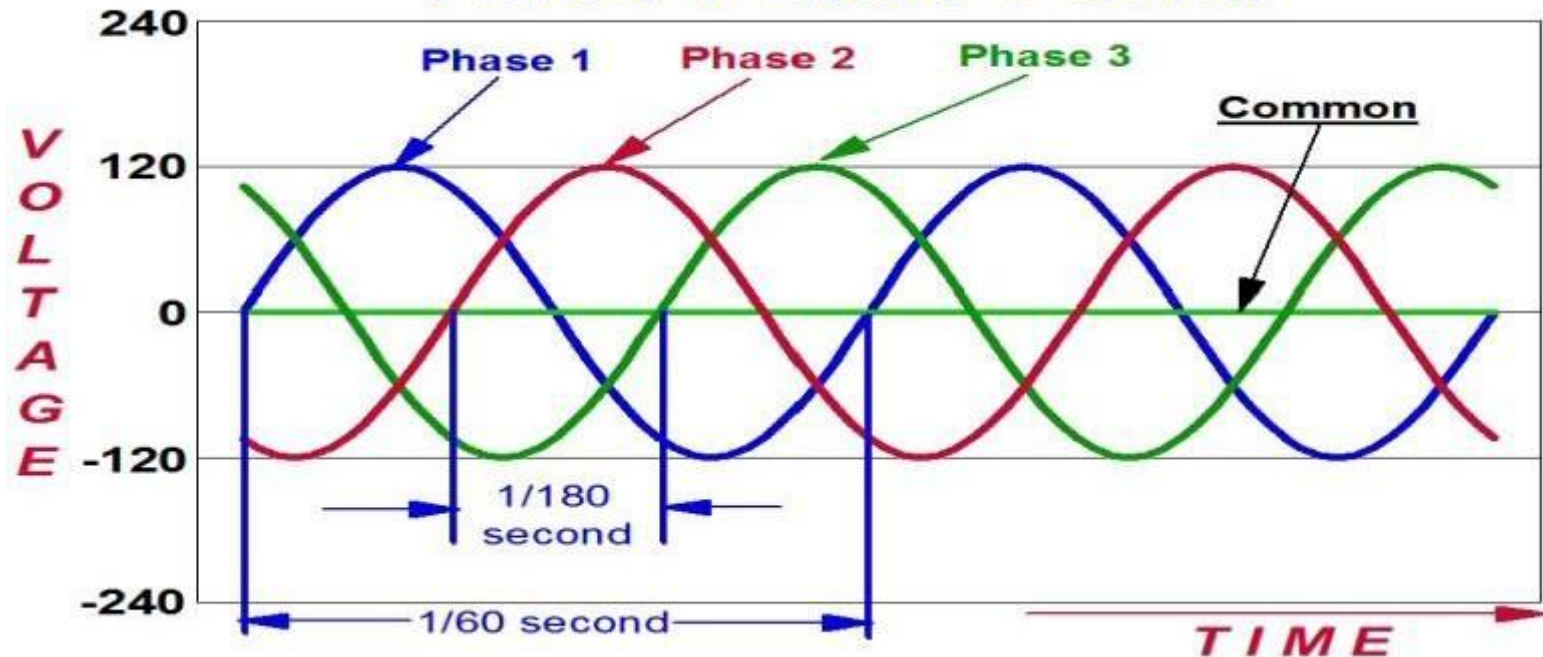
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Electric Motors Simplified

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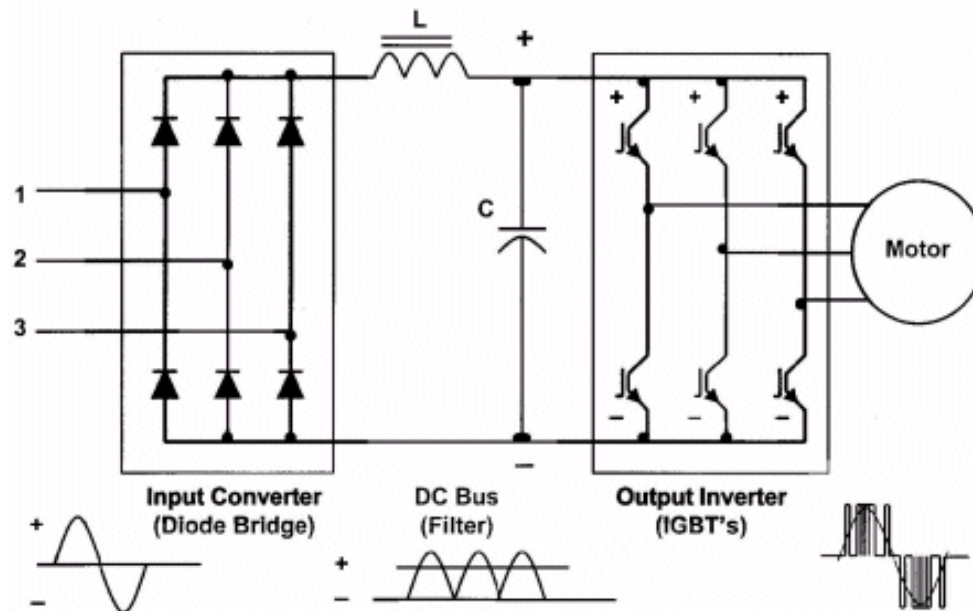
Three Phase Power



The Rest of the Story *if these guys stayed Friends*

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- How Smart Motor Controls function. Converts Alternating Current to Direct Current then With Transistors - Variable Alternating Current.



Variable Frequency Drive (VFD)



■ Why use a VFD?

- Reduce electricity costs (up to 70%)
- Increase equipment & motor life
- Improve processes with:
 - Better speed control
 - Better torque control
 - Better acceleration and deceleration control

■ Utility Incentives Make It Cost-Effective!

Variable Frequency Drive (VFD)

Typical Applications



- **Light Commercial
(Hotels, Dry Cleaners,
Retail)**

- Fans (all types)
- Air Compressors
- Chillers
- Cooling Tower Pumps
- Vacuum Pumps

- **Large Commercial (Hospitals,
Colleges, Large Buildings)**

- Exhaust Fans (all types)
- Compressors
- Process Cooling Pumps
- Chillers
- HVAC Motors
- Other Large Equipment

Variable Frequency Drive (VFD)

Typical Applications

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■ Industrial & Manufacturing

- Conveyors
- Presses
- Casting Equipment
- Injection Molding Machines
- Large Scale Food Processing (ovens, bottlers, mixers, etc.)

■ Municipal

- Water Supply Pumps
- Exhaust Fans
- Cooling Tower Fans
- Hot Water Circulating Pumps
- Compressors
- Pumping Stations

Variable Frequency Drive (VFD) In Real Life Operation

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Reducing Fan Speed Saves Energy

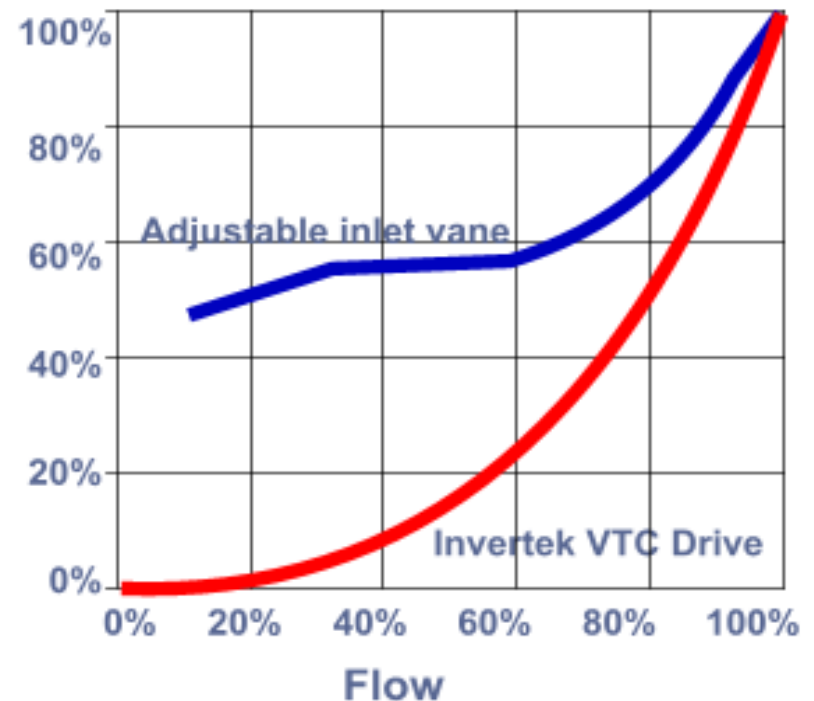
An example of fan power curve in applications such as Air Handling Units, Roof Units, Inlet and Extraction Centrifugal Fans.

In many existing installations, fan airflow volume is controlled by dampers or vanes.

As the airflow is reduced, the energy consumption is reduced, by only a small amount.

By using a drive to reduce the fan speed, far greater energy savings can be found.

Typical centrifugal fan power graph



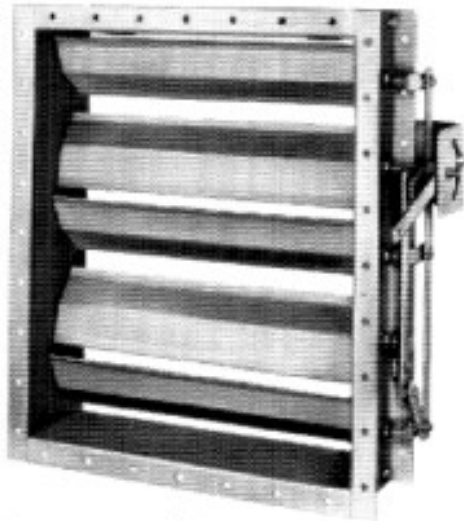
Historic methods of speed control

- Fixed Speed Changes
 - Belts & Pulleys
 - Chains and Sprockets
 - Gear Drives
 - Multi-speed motors
- Variable Speed
 - Variable pitch belts & pulleys, hydro-static drives, etc.
 - AC Variable Frequency Drives

Historic methods of flow control

- Size motor and system for maximum flow
- Use throttling devices on fans and pumps to reduce flow rates using:
 - Valves
 - Vanes & Dampers, etc.

Flow Control without VFD's



Opposed
blade

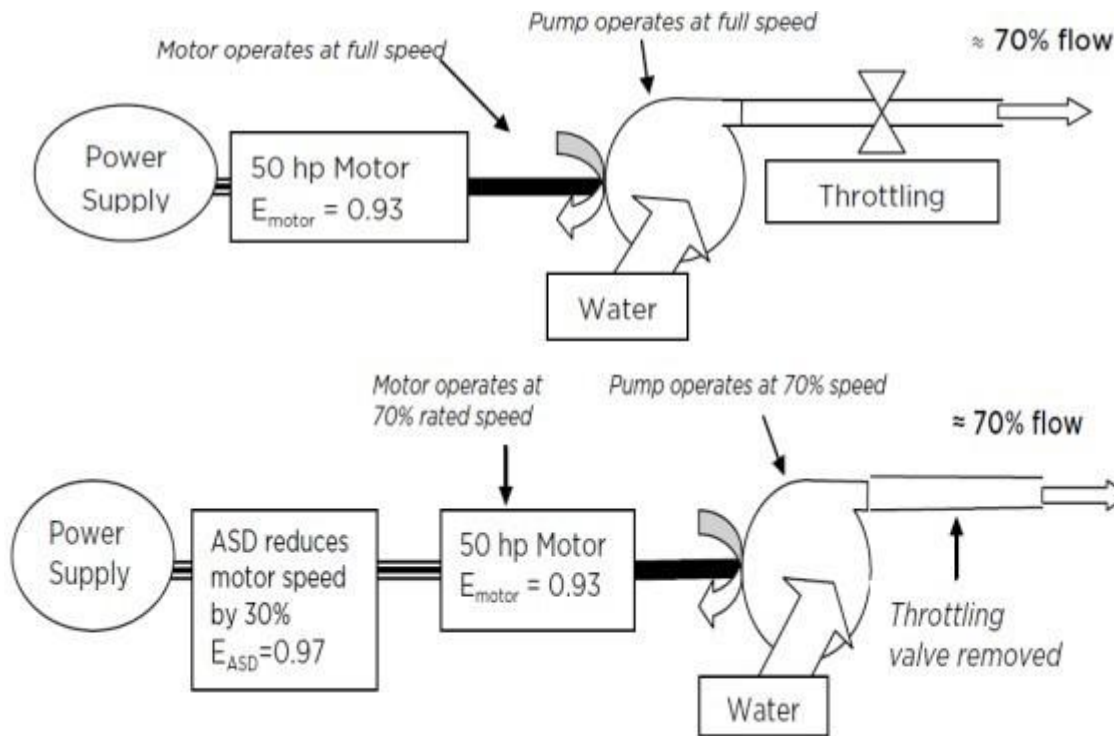


Dampers and Valves used to throttle flow (very inefficient)

Variable Frequency Drive (VFD) Typical Installation Example

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- Pump with VFD in this case saving about 19kW of electric demand



Annual savings with a variable speed drive of approx. \$4,000 operating 4,000 hrs/yr at \$0.07/kWh or \$20,000 in 5 years

Illustrations from: "Motor Efficiency, Selection and Management, A guidebook for Industrial Efficiency Programs" published by the Consortium for Energy Efficiency. www.cee1.org © 2013 Consortium for Energy Efficiency, Inc. All rights reserved.

Variable Frequency Drive (VFD) Application Energy Considerations

Motor Load Type	Common Applications	Energy Considerations
Variable Torque Load - Power [hp] varies as the cube of the rotational speed - Torque varies as the square of the rotational speed	- Centrifugal fans - Centrifugal pumps - Blowers - Axial fans - HVAC systems	Lower speed operation results in significant energy savings as shaft power of the motor drops with the cube of the rotational speed.
Constant Torque Load - Torque remain constant at all rotational speeds - Power [hp] varies in direct proportion to rotational speed	- Mixers - Conveyors - Compressors - Printing presses	Lower speed operation saves energy in direct proportion to the rotational speed reduction.
Constant Power [hp] Load - Develops the same power [hp] at all rotational speeds - Torque varies in inverse proportion to the speed	- Machine tools - Lathes - Milling machines - Punch presses	No energy savings at reduced speeds; however, energy savings can be realized by attaining the optimized cutting and machining speeds for the part being produced. A time limiting switch device controlling no-load operating time saves energy, too.

Table from: "Motor Efficiency, Selection and Management, A guidebook for Industrial Efficiency Programs" published by the Consortium for Energy Efficiency. www.cee1.org
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Types of Loads

- Constant Torque Loads
 - Load does not change with speed
 - Industrial loads such as presses, conveyors, extruders, mills, etc.
 - Minimal energy savings potential
- Variable Torque Loads
 - HVAC, Pumps & Fans in industrial processes
 - Huge energy savings potential

Pumps & Fans

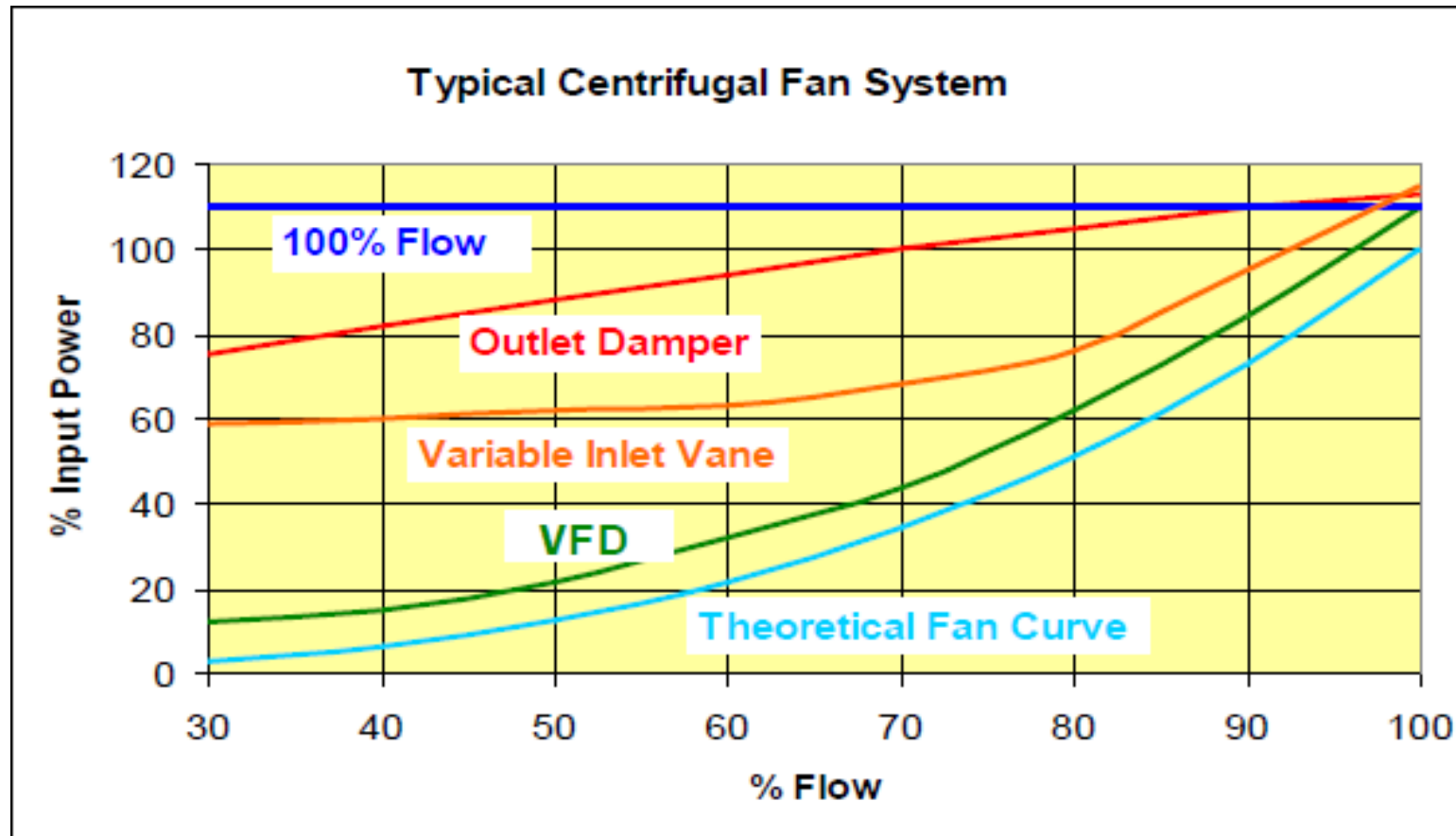
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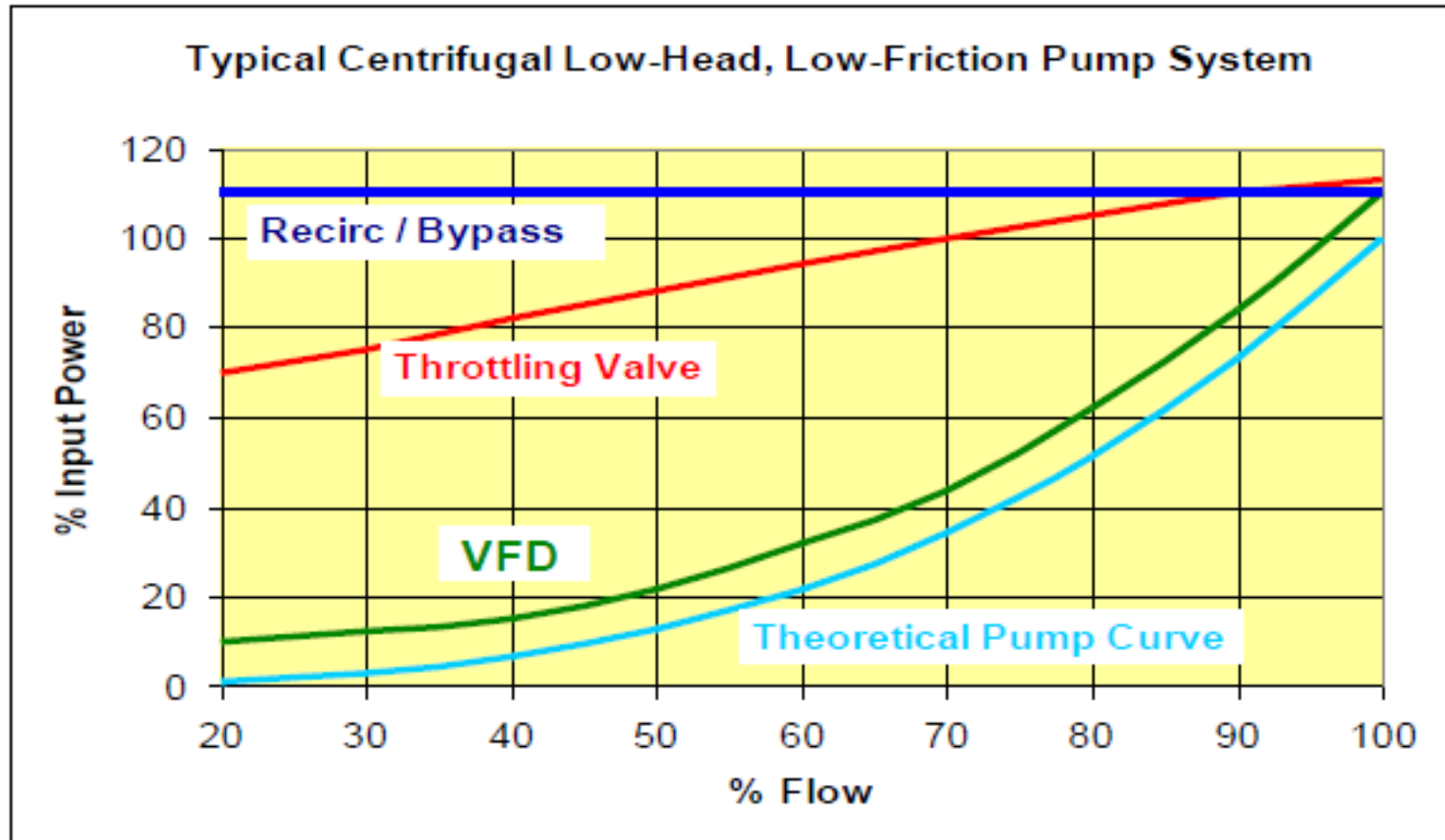
Pumps & Fans represent some of largest commercial and industrial loads

Typical Fan Curves

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Typical Pump Curves



Affinity Laws

Affinity Laws:

- Flow vs Speed
 - $Q_1/Q_2 = S_1/S_2$
- Head vs Speed
 - $H_1/H_2 = S_1^2/S_2^2$
- hp vs Speed
 - $bhp_1/bhp_2 = S_1^3/S_2^3$

Recent Case Studies



It's Happening NOW!



Case Study #1

Cleaners, Lowell, MA



- **Utility Incentive: \$31,800**
- **171,290 kWh Annual Savings**
- **Power Rate: 12 cents/kW**
- **\$20,554.80 Saved Annually**
- **\$102,744: Five Year Savings**

Case Study #2

1,000,000 Sq. Foot Complex

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- **Utility Incentive: \$305,450**
- **1,785,005 kWh Annual Savings**
- **Power Rate: 12 cents/kW**
- **\$214,200 Saved Annually**
- **\$1,071,003: Five Year Savings**

Case Study #3

Water Supply Plant

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- **Utility Incentive: \$179,200**
- **1,150,102 kWh Annual Savings**
- **Power Rate: 12 cents/kW**
- **\$138,012 Saved Annually**
- **\$690,061: Five Year Savings**

Case Study # 4

Metal Finishing Facility



Exhaust Ventilation System Upgrade

- **Utility Incentive: \$6,712**
- **151,390 kWh Annual Savings**
- **Power Rate: 7.3 cents/kWh**
- **\$16,485 Saved Annually**
- **\$82,425: Five Year Savings**
- **7,760 therms Annual Savings**



Case Study # 5

Light Industrial Shipping Facility



6 HVAC Makeup Air Unit Upgrade

- **Utility Incentive: \$57,000**
- **365,100 kWh Annual Savings**
- **Power Rate: 6.9 cents/kWh**
- **\$25,200 Saved Annually**
- **\$126,000: Five Year Savings**

Evaluating Your Client's Needs



Existing and Potential Variable Speed Drives



Typical vs. Not Typical VSD Applications

Where To Look



Typical

- Exhaust Fans
- HVAC Motors
- Pumps and Compressors
- Boiler Feed Pumps
- Water Feed Pumps
- Hot Water Recirculation Pumps

Not Typical

- Chillers (they CAN be done!)
- Injection Molding Equipment
- Conveyors
- Hydraulic Lifts
- Ice Rinks – Brine Pumps
- Pool Pumps

Poll Question

- What is your biggest roadblock to completing a VSD project?
 1. Up front cost
 2. Estimating savings over time
 3. Commissioning and control system integration
 4. Motor compatibility
 5. Timing when to install
 6. Other

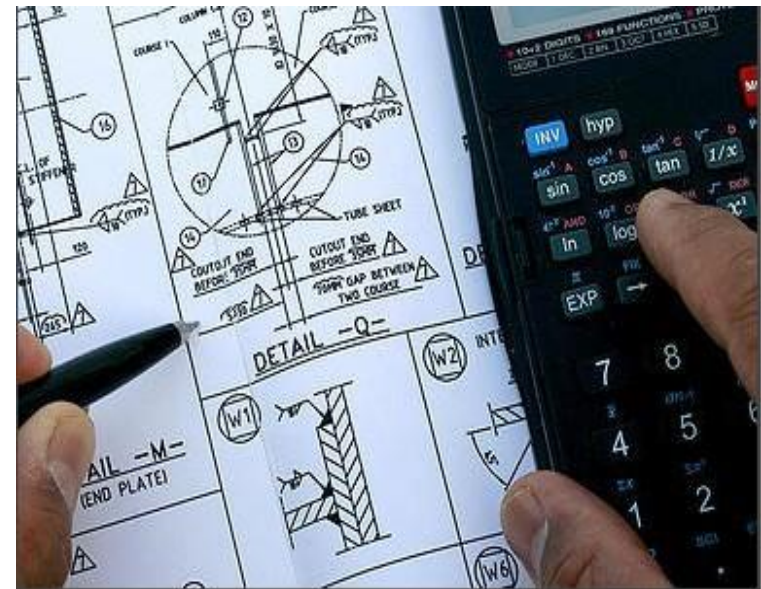
Your Client's Facility Conducting a Pre-Inspection

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- Assessing the impact on operations
 - Drive settings and minimum equipment power needs
 - Testing for highly specialized equipment & processes



- Projecting Cost Savings
 - Accounting for all pre-inspection considerations
 - Proving viability of each application – *by the numbers*



Your Client's Facility *Conducting a Pre-Inspection*

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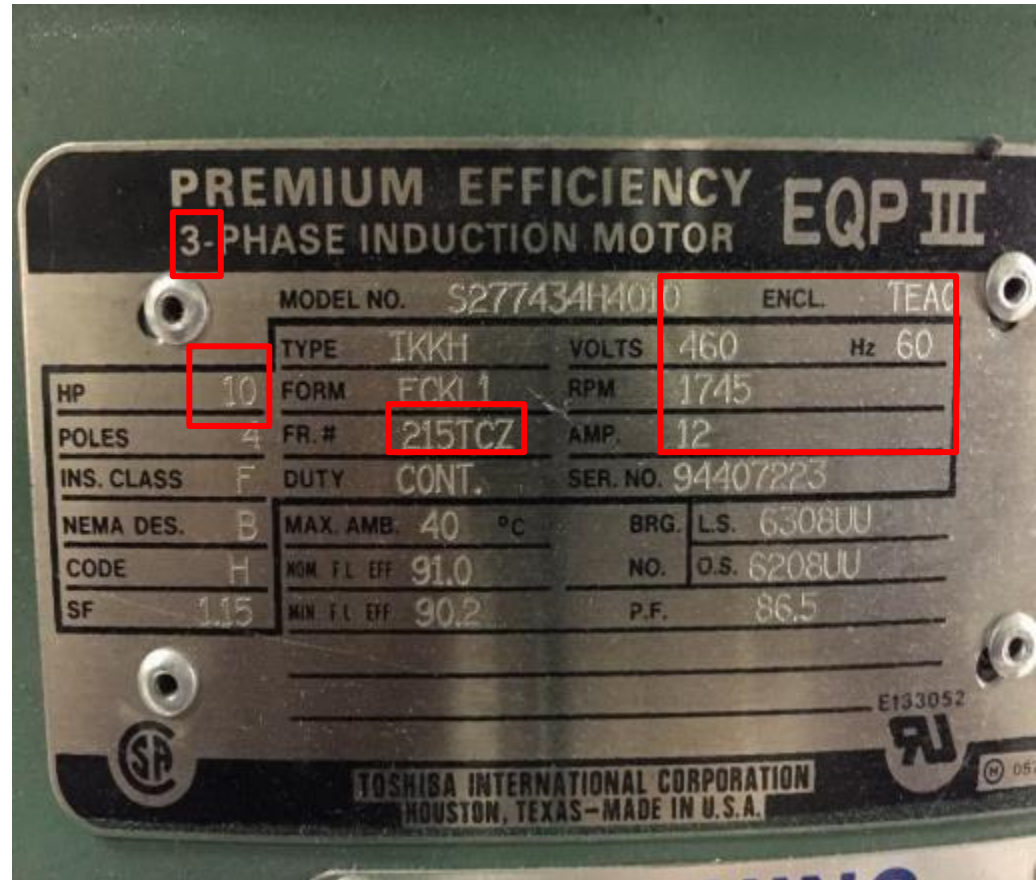
- Evaluating existing VFDs
 - Proper drive for the application?
 - Properly installed and configured?
 - Quality product?
 - Environmental Considerations
 - Ambient Temperature
 - Dirt & Dust



Your Client's Facility Conducting a Pre-Inspection

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- Identifying eligible equipment
 - Parameters & Capacity
 - Prescriptive Applications vs. Custom Applications
- Identifying worthwhile applications
- Measuring and metering
- HP Ratings and Annual Run Hours



Examples of Industrial Motors

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Boiler Feed Pump 1

Forced Draft Fan



Boiler Feed Pump 2

Selecting a Quality Variable Frequency Drive



It's More Than Just The Drive . . .



Quality VFD Installations

The Drive



■ Construction

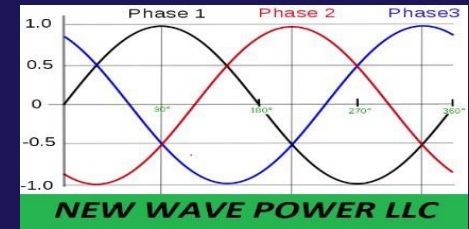
- Design capacity and rated capacity
- Components

■ Reliability

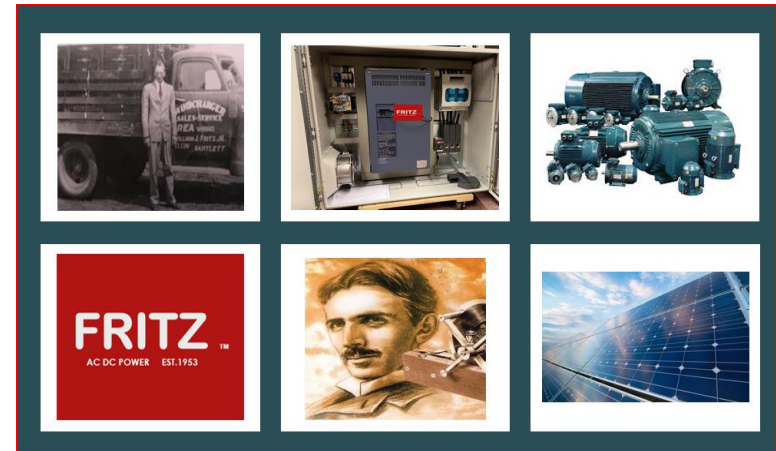
- Proven track record
- Manufacturer Support
- Proven in specific applications

Quality VFD Installations

The Drive



- Enclosure
 - Proper air flow and ventilation
 - Proper material for environment
- Serviceability
- Ease of Use
- Ease of Adjustment, Programming and Tuning
- User-Friendly



Quality VFD Installations

Installation Design

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- **Using The Correct VFD For The Application**
 - Importance of pre-installation assessment & Engineering review
 - Parameters – checked, rechecked and cross-checked
- **Equipment Evaluation**
 - Motor load
 - Motor condition
 - Suitability



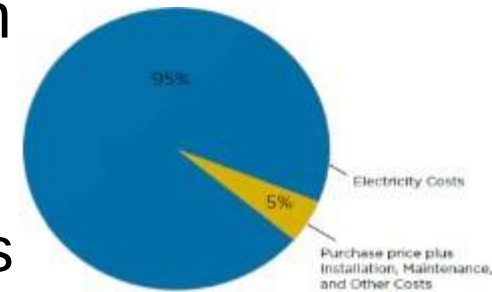
VFD Drives – Ancillary Benefits



- Soft start capability built into drive package
- Drives also integrate reversing feature to help with trouble shooting mechanical driven equipment
- Could help with peak load reduction strategies
- Less mechanical wear and tear on driven equipment
- Reliability and maintenance benefits are taken into consideration for cost / benefit screening by National Grid
- Improved process control

Potential Issues with VFD Drives

- Higher initial capital cost for purchase & installation
- Ensure appropriate control strategy and controls are selected for proper operation
- Harmonics to be addressed with installation
- Design characteristics of existing motor
- Turn down needed to suit application needs
- Feedback controls required to ensure energy savings



Easy To Use Software

Building Management System compatible

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Smart-Grid Building and System Integrations

Networking with your Management System

Our equipment has built-in Microprocessors to network with all of the latest Building Management Systems (BMS) through input methods including Open Protocol Networks, Ethernet, Digital, Analog, Mod buss, and more.

Our experience with old and new technologies allows us to seamlessly integrate with a multitude of systems and networks. Our System Engineers will make sure that all of your equipments works together seamlessly.

Easy To Use Software



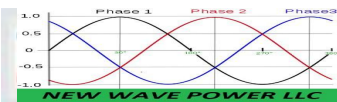
Supports two key functions
Drive Programming &
Commissioning

Parameter Upload,
Download & Storage
Changed Parameter
Highlighting
Parameter List Printing

Quality VFD Installations

Key Performance Drive Indicators

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Condition Monitoring
Intelligent analysis of operating and status values through real time



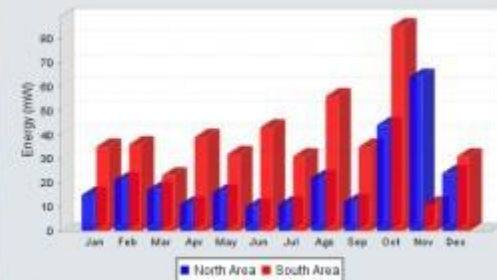
SACADA Automation
State of the art process visualization for machines, production plans and facility management



Energy
Energy management system for production and facility management



Alarm System
Get notified of any number of alert.



Implemented Mesurements [Daily mesurements]



Implemented Mesurements [Monthly mesurements]



Alarm Status				
☐ Active Time	Display Path	Name	Current State	Priority
☐ 1/20/16 10:41 PM	Level	H H	Active, Unacknowledged	Critical
☐ 1/20/16 11:31 PM	Tank 2	Lo	Active, Unacknowledged	Medium

VSD Incentive Program Nation Wide



Too Good To Be True *(Almost)*

VSD Incentive Program



- Two Types Of VSD Rebate Incentives
 - Prescriptive
 - Custom
- Low & Medium Voltage Applications
- Energy Management System

■ Prescriptive Applications

- Covers many common VSD installations
- Quick approval of properly completed applications
- May be used for new installations AND replacements
- Pre-determined incentive amounts
- Fast turnaround and funding
- Examples include exhaust fans, water pumps, recirculation pumps and cooling tower fans

VSD Incentive Program

Prescriptive Application Form

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ENERGY INITIATIVE | RETROFIT

Custom

Energy efficiency projects

2015 project information form for Upstate New York

nationalgrid
HERE WITH YOU. HERE FOR YOU.

Variable Speed Drive Application 2016 Retrofit Program

nationalgrid
HERE WITH YOU. HERE FOR YOU.

This Project Information Form provides a template to collect project information. In addition, this form serves as a general overview of eligibility criteria for Efficient Projects and products. Prior to the start of any installation, a National Grid representative to arrange a convenient time to perform this preinspection is required for all applications.

CUSTOMER FACILITY INFORMATION

CUSTOMER FACILITY NAME:

CONTACT PERSON:

STREET ADDRESS:

CITY: STATE: ZIP:

E-MAIL ADDRESS:

CLASSIFICATION TYPE: ☐ ≥ 2MW (LARGE)
☐ < 2MW (MID-SIZE) ☐ INDUSTRIAL ☐ COMMERCIAL

* ≥ 2MW LARGE COMMERCIAL CUSTOMER USE THE < 2MW CLASSIFICATION

Customer of Record Information: Billing Account Number:

BUILDING TYPE (SELECT ONE)

- | | | |
|---|--|--------------------------|
| ☐ Assembly | ☐ Full Service Restaurant | ☐ |
| ☐ Auto Repair | ☐ Grocery | ☐ |
| ☐ Big Box | ☐ High School | ☐ |
| ☐ College Building | ☐ Hospital | ☐ |

The Retrofit Program is designed for commercial and industrial customers to help replace aging, inefficient equipment and systems with energy efficient technology. The Retrofit Program provides a customer with incentive and technical services that will facilitate the installation of premium efficient equipment. Call National Grid to arrange a convenient time to perform an inspection of the existing equipment or systems.

Prescriptive Retrofit Application & Instructions For Replacement of Operating Equipment

1. Is your project eligible?
 - Equipment shall be new and shall be installed in a commercial, within National Grid's electric service territory
2. Is the equipment you intend to buy eligible?
 - Product types listed in this form are eligible for prescriptive incentives using the Custom Retrofit Application
3. Pre-Approval requirements:
 - Contact your National Grid representative before purchasing and
 - To see if the energy efficient measure (EEM) qualifies for an incentive
 - i. Review the Terms and Conditions governing the program, the
 - signature

2016 Variable Speed Drive Application Retrofit Program



The Retrofit Program is designed for commercial and industrial customers to help replace aging, inefficient equipment and systems with energy efficient technologies. The Retrofit Program provides a customer with incentives and technical services that will facilitate the installation of premium efficient equipment. Call your Program Administrator ("PA") to arrange a convenient time to perform an inspection of the existing equipment or systems.

Prescriptive Retrofit Application & Instructions For Replacement of Operating Equipment

1. Is your project eligible?
 - Equipment shall be new and shall be installed in a commercial, industrial, institutional, educational, or municipal building within an electric Program Administrator's (PA's) service territory
2. Is the equipment you intend to buy eligible?
 - Product types listed in this form are eligible for prescriptive incentives. However, other measures not listed here may be eligible for custom incentives using the Custom Retrofit Application
3. Pre-Approval requirements:
 - Contact your Program Administrator before purchasing and installing the equipment
 - To see if the energy efficient measure (EEM) qualifies for an incentive:
 - i. Review the Terms and Conditions governing the program, then submit a completed application form with an authorized signature
 - ii. Submit a copy of the Manufacturer's technical specification sheets ("cut sheets") for each type of eligible equipment to be purchased
 - iii. Once pre-approved, a "pre-approved incentive letter" will be issued
4. Installation and incentive requirements:
 - Once pre-approved, purchase and install the qualifying equipment within twelve (12) months of PA's pre-approval
 - Return the required information to your Program Administrator within 30 days of the installation:
 - i. A copy of the completed and signed pre-approval application
 - ii. If there is a change in equipment, please submit a new manufacturer's technical specification sheets ("cut sheets") for each type of eligible equipment purchased
 - iii. A copy of your invoice indicating Proof of Purchase must indicate type, size, make, and model number of the equipment and date of purchase and installation
 - iv. At the post-installation verification, the customer is required to sign the post-installation customer acknowledgement section of the original application

NOTE: If you are interested in financing your project, please contact your energy efficiency Program Administrator to discuss terms and eligibility prior to purchasing your qualifying equipment. Further information can also be found on masssave.com/financing.

VSD Incentive Program

Prescriptive Application Form

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RETROFIT

2016 Variable Speed Drive Application

ALL FIELDS ON THIS PAGE ARE REQUIRED TO COMPLETE YOUR APPLICATION.

Indicate Program Administrator for Application: ☐ Cape Light Compact ☐ Eversource ☐ National Grid ☐ Unitil

CUSTOMER/ACCOUNT HOLDER INFORMATION

COMPANY NAME		CONTACT PERSON		APPLICATION DATE	
INSTALL SITE		PHONE		FAX NUMBER	
EMAIL ADDRESS				SQUARE FEET (COVERED BY THIS APPLICATION)	
STREET ADDRESS		CITY		STATE	ZIP
MAILING ADDRESS (IF DIFFERENT)		CITY		STATE	ZIP
ELECTRIC COMPANY NAME				ELECTRIC ACCOUNT NUMBER	
GAS COMPANY NAME				GAS ACCOUNT NUMBER	

BUILDING TYPE (PLEASE PLACE "X" IN APPROPRIATE BALLOT BOX)

- | | | | | | |
|--|--|---|--|---------------------------------------|---------------------------------------|
| ☐ ASSEMBLY | ☐ FAST FOOD | ☐ HOTEL | ☐ MULTI STORY RETAIL | ☐ RELIGIOUS | ☐ SMALL RETAIL |
| ☐ AUTOMOTIVE | ☐ FULL SERVICE RESTAURANT | ☐ LARGE REFRIGERATED SPACE | ☐ MULTIFAMILY HIGH-RISE | ☐ K-12 SCHOOL | ☐ UNIVERSITY |
| ☐ BIG BOX | ☐ GROCERY | ☐ LARGE OFFICE | ☐ MULTIFAMILY LOW-RISE | ☐ SMALL OFFICE | ☐ WAREHOUSE |
| ☐ COMMUNITY COLLEGE | ☐ HEAVY INDUSTRIAL | ☐ LIGHT INDUSTRIAL | ☐ OTHER: | | |
| ☐ DORMITORY | ☐ HOSPITAL | ☐ MOTEL | | | |

VSD Incentive Program

Prescriptive Application Form



Table 1: Select VSD Installation Type

BDF	Boiler Draft Fan	HWP	Hot Water Circ Pump	RFA	HVAC Return Air Fan
BEF	Building Exhaust Fan	MAF	Make-up Air Fan	SFA	HVAC Supply Air Fan
CTF	Cooling Tower Fan (Single Speed only)	PCP	Process Cooling Pump	WHP	WS Heat Pump Circ Loop
CWP	Chilled / Cond Water Pump	PE	Process Exhaust and Make-up Fan	WSP	Water Supply or Waste Water Pump
FWP	Boiler Feed Water Pump				

Table 2: Select VSD Size

Horsepower	Incentive	Horsepower	Incentive	Horsepower	Incentive	Horsepower	Incentive
1-3	\$1,000	15	\$3,450	30	\$5,250	60	\$8,250
5-7.5	\$2,850	20	\$3,900	40	\$5,700	75	\$9,000
10	\$3,150	25	\$4,650	50	\$6,750	100-150	\$12,500

Table 3: Controlling Parameters

DP	Pressure Differential	DT	Temperature Differential	OTH	Other Specify
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■ Custom Applications

- Used for specific equipment, such as chillers and air compressors
- Used for specialized equipment, such as conveyors, presses and injection molding equipment
- Requires metering of equipment and processing of information by an engineer
- Slightly longer application process

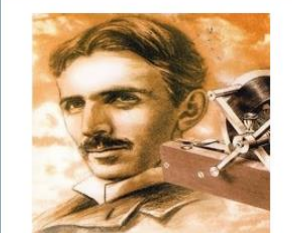
Useful Resources



- Office of Energy Efficiency and Renewable Energy (EERE):
<http://energy.gov/eere/amo/downloads/adjustable-speed-drive-part-load->
- Facilitiesnet – VFD application and specification support
<http://www.facilitiesnet.com/search.aspx?cof=FORID%3A9&cref=http%3>
- Motor Decisions Matter www.motorsmatter.org
- Consortium for Energy Efficiency www.cee1.org
- NEMA Application Guide for AC Drives www.nema.org

Thank you for attending this webinar

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