

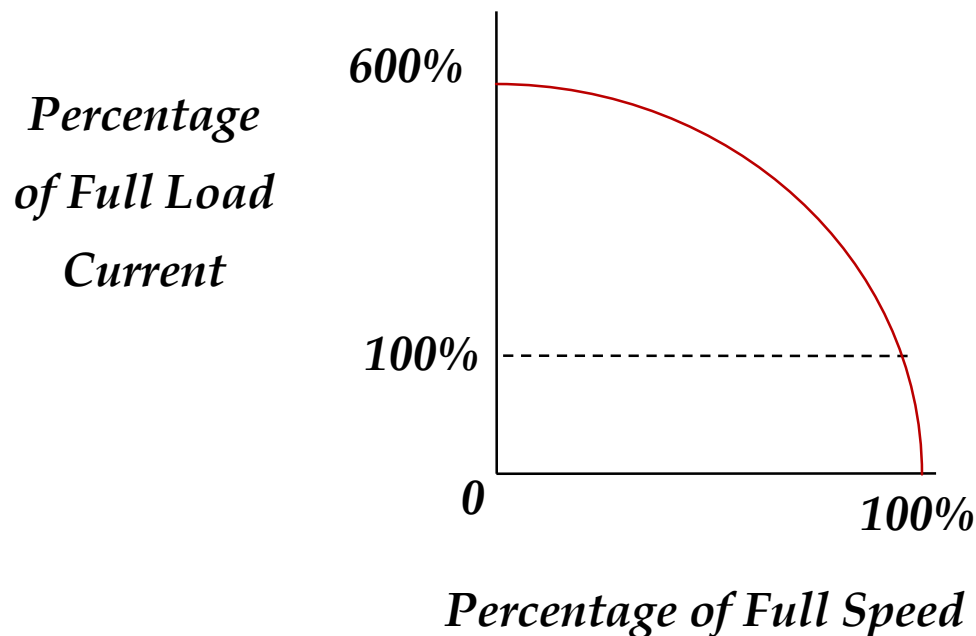
Variable Frequency Drives – Basic Operating Principles and Core Maintenance Considerations

By:
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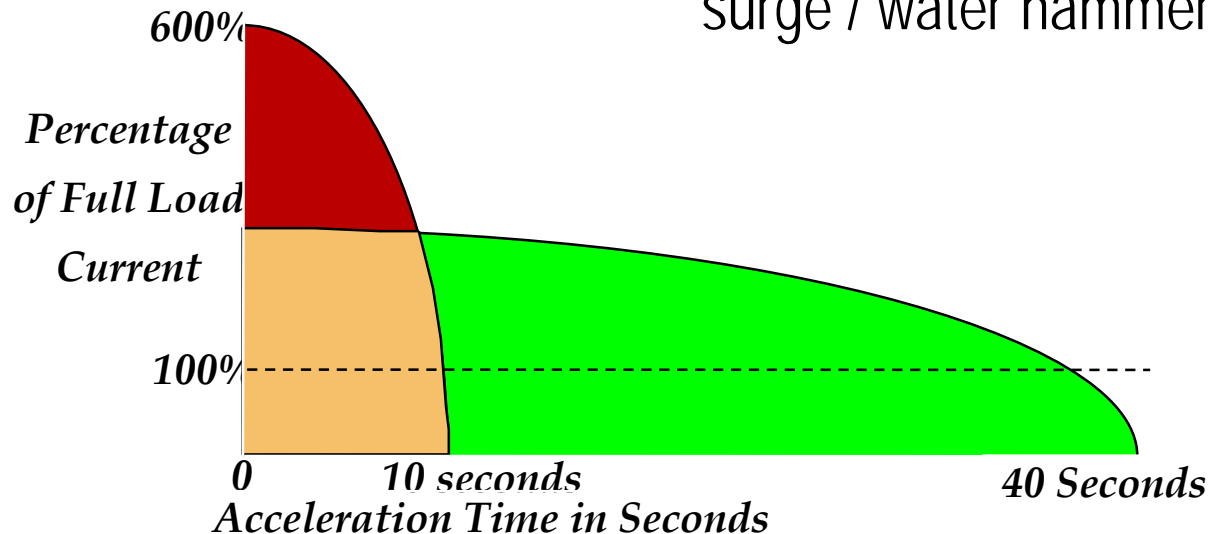
Typical Motor Starting Methods – #1) Full Voltage

- Full Voltage Motor Starters (electromechanical)
 - approx 600% current draw during starting
- 3 Basic Types:
 - Traditional NEMA....robust, HP-rated, replaceable coils, replaceable contacts
 - IEC....current-rated
 - "NEMA-rated"....IEC look-and-feel with NEMA-rated contacts



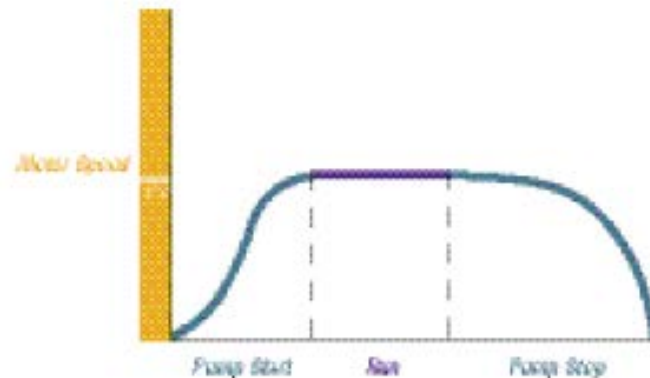
Typical Motor Starting Methods – #2) Reduced Voltage

- Reduced Voltage Motor Starters
 - control of voltage (and thus current and torque) during starting and stopping
 - common types:
 - RVAT...Reduced Voltage Autotransformer (electromechanical)
 - RVSS / SSRV...Soft-Starters (solid-state)
- Advantages:
 - Lowers peak demand by preventing inrush current.
 - Reduces mechanical stress by minimizing surge / water hammer.



Solid-State Reduced Voltage Starters (Soft-Starts)

- Built-in Run Bypass (i.e. "At-Speed" Contacts) to reduce heat, inc life
- Built-in Overload
- Very Small Physical Size
- Modular Power Structure (replaceable parts) above 200A for reduced downtime
- Fraction to 1000HP (480vac)
- Advanced versions include communications, metering, LED display
- Caution when using Large HP Soft-Starts on Generator Power
- Pricing is small premium (5-20%) to NEMA Full Voltage Motor Starters



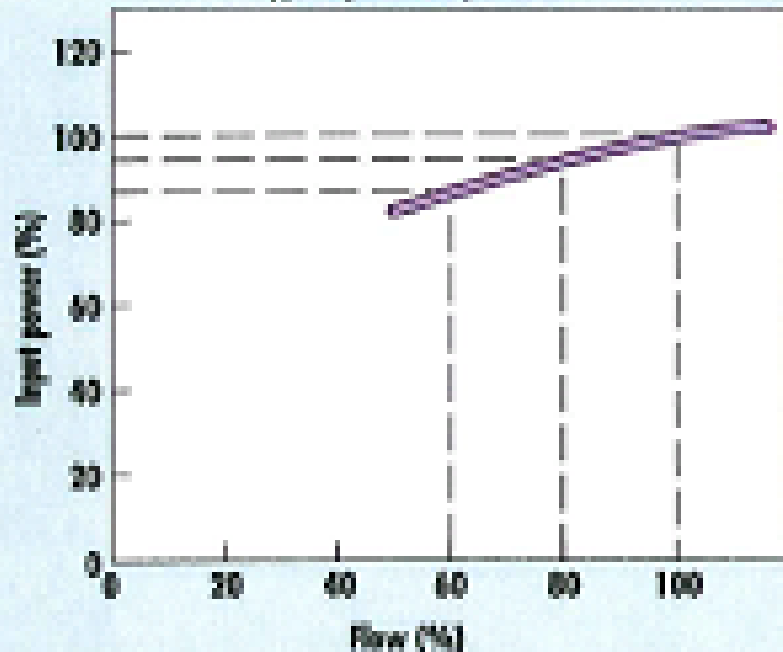
Typical Motor Starting Methods - #3) VFDs

- Variable Frequency Drives (solid-state)
 - control of voltage and frequency during start, stop and throughout the entire speed range
 - "VFD", "AFD", "ASD", "VSD", "VSC", "ASC", "Drive", "Inverter"
 - Significant cost savings in some applications due to reduced energy consumption
 - Fractional to 1900HP (460vac)
 - Intelligent, programmable, diagnostics, communications
 - Standard is a "6-Pulse" design (more on that later)

Basic Principle of Energy Savings Using Variable Speed on Centrifugal Pumps & Fans

Outlet damper

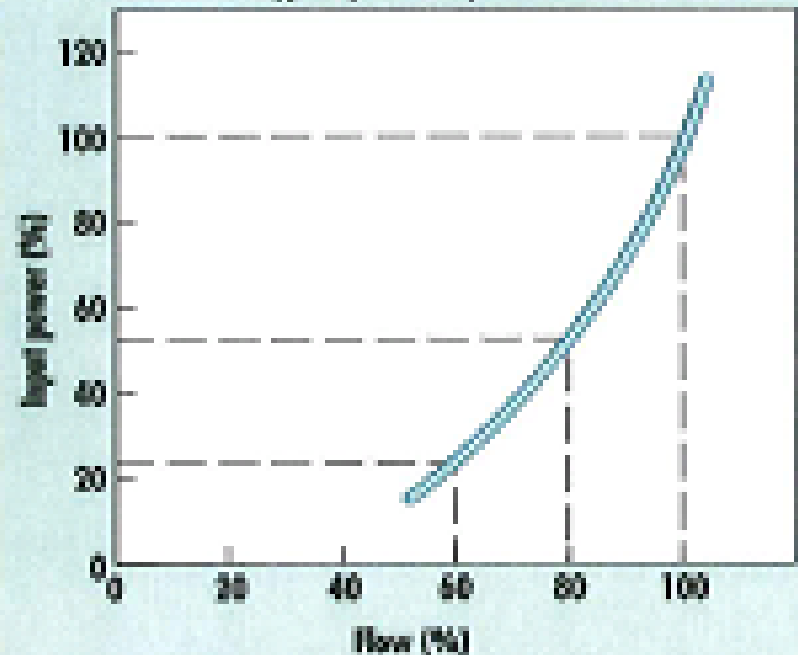
Typical power requirements



Power requirements for outlet-damper systems gradually decrease with flow.

Variable speed

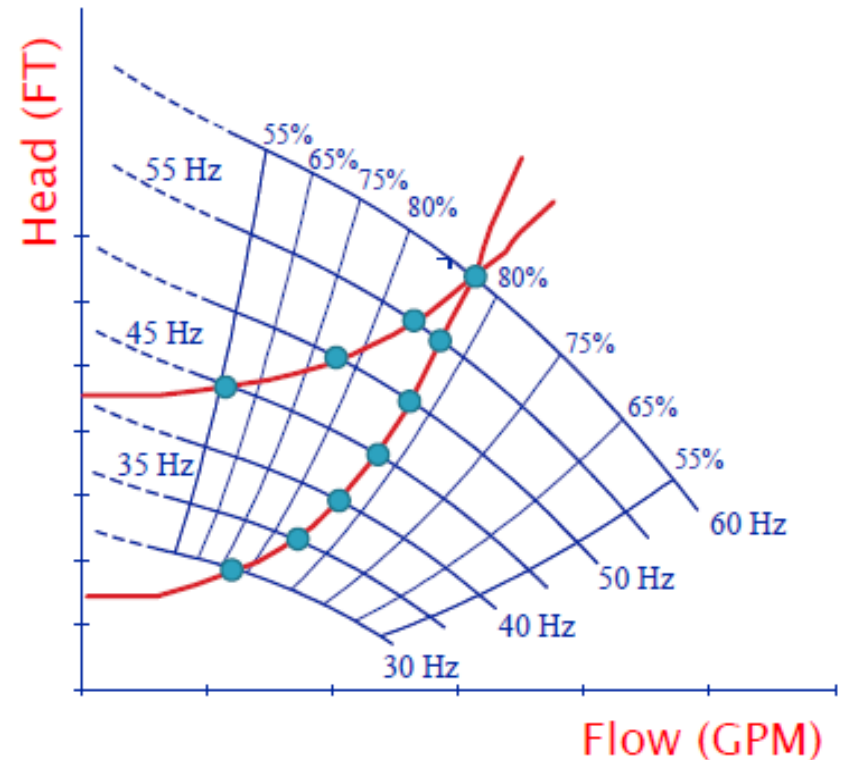
Typical power requirements



Variable-frequency drives significantly reduce power requirements as fan speed decreases.

Two General Rules for Best Applications for VFDs

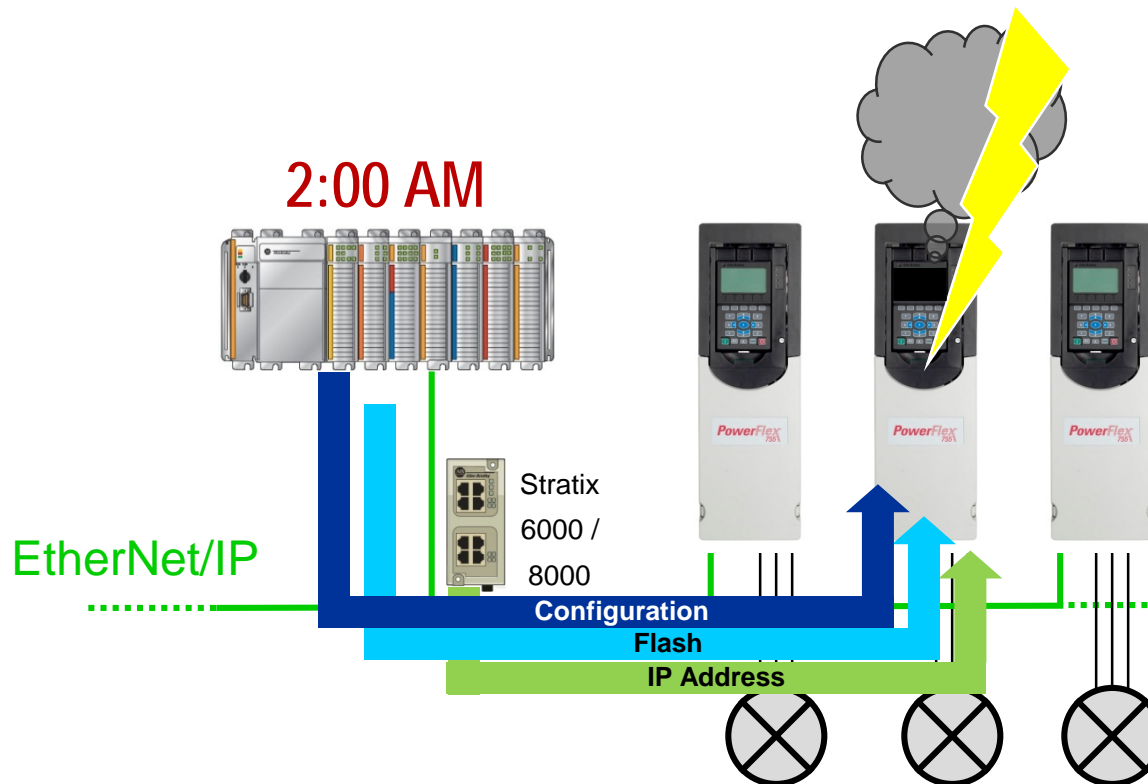
- Applications where the Total Head exceeds the Static Head by 50% or more (i.e. steep System Curve) are generally the best applications for VFDs
- Select pumps so that the primary, full speed duty point is to the right of the Best Efficiency Point (BEP)



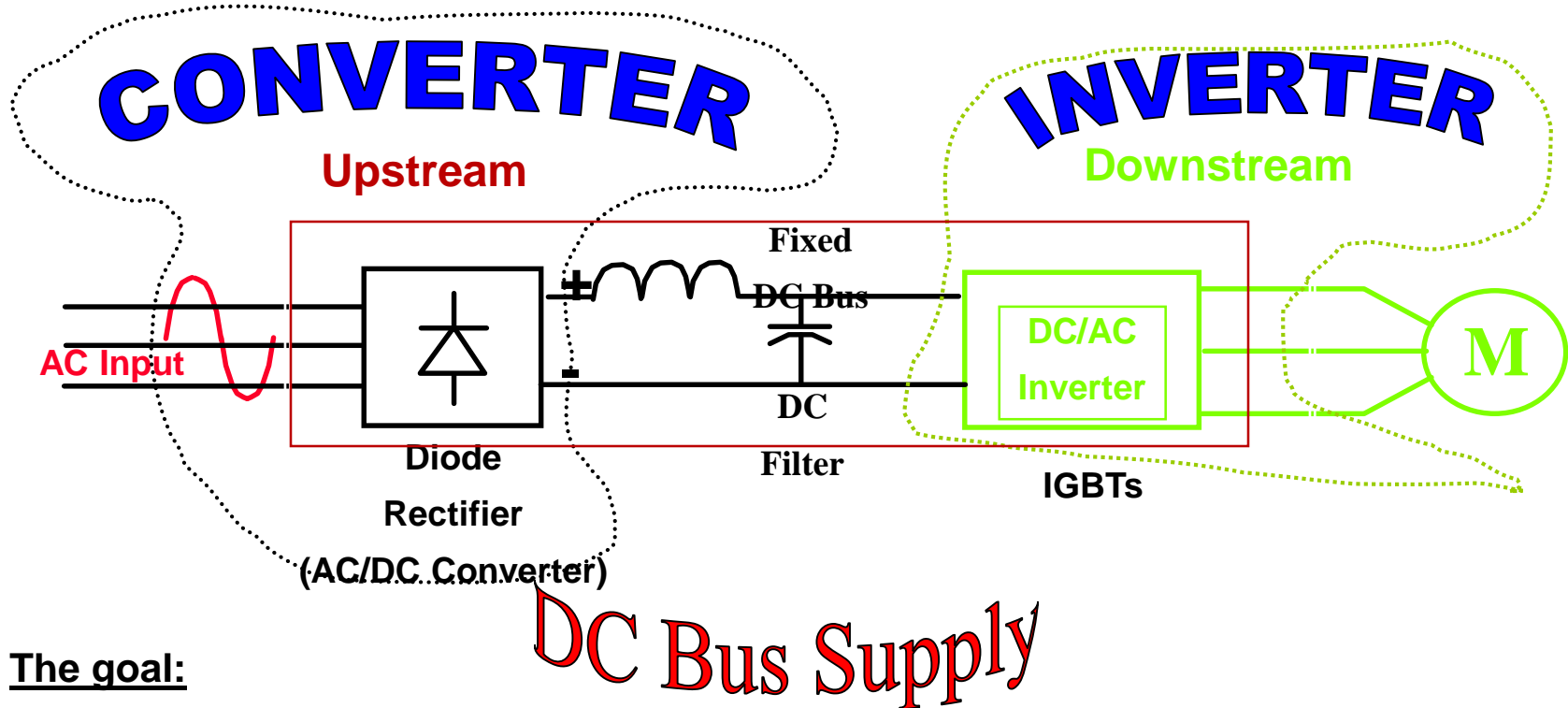
Real-World Benefit of VFDs: Automatic Device Replacement (ADR)

Reduce Downtime when Replacing a Drive

- Configure your PLC system to automatically download a VFD configuration after it has been replaced
 - Configuration data exists in the PLC and the Ethernet Switch



VFDs: What's Really Going On



The goal:

- Convert near-sinusoidal AC power to DC Power
- Control voltage and frequency
- Invert DC power back to PWM-sinusoidal AC power
- To do all of this with the most reliable, readily-available, fastest-switching components for the lowest cost

Four things to note for later on...

- Converter (rectifier) / DC Bus / Inverter
- Input waveform
- DC Bus Voltage = 650v
- Output waveform

Common Benefits of VFDs

- Reduced Operating Costs via Energy Savings....\$\$\$\$\$
- Reduced Mechanical Stress (resulting in longer lifecycle of equipment) via Speed Regulation and Control....\$\$\$\$\$
- Improved Uptime thru Reliability and Decreased Mean-Time-To-Repair...\$\$\$
- Reduced Maintenance Costs due to Preventive Diagnostics from the VFD to Help Avoid Catastrophic Failure...\$\$\$\$
- Greater monitoring and diagnostic capabilities either at the VFD or thru a network....\$\$

Support, Operations and Maintenance

- Do You Own Your Equipment or Does Your Equipment Own You?
- Do You Have the Expertise In-House?
- Do You Have a Training Plan?
- Do You Have Partners to Assist?
- Have You Assessed the Criticality of Your Equipment?
- Do You Have a Spare Parts Plan/Strategy?
- Are You Predictive, Preventive or Reactive?
- Have You Developed a Plan for Downtime Recovery?

Support

- Have a Support Contacts Sheet On Hand
- Be Able to Locate It Easily (i.e. Near the Equipment In Question)
- Include Key Support Personnel Telephone Numbers, Email Addresses, Websites, Order & Serial Numbers
- Have O&M Manuals On Hand



Support Contacts Sheet (Example)

TechSupport



Allen-Bradley Telephone Support: 1-519-740-4790
Press "1" for Technical Support
Or
1-888-382-1583
Press "3" for Technical Support
Follow prompts to specific product

Local
Distributor



Local Allen-Bradley Distributor: Electrical Equipment Co (EECO) –
Winchester, VA
540-678-9000

Keith Park
540-247-7853 (mobile)
Keith.park@eeco-net.com

Local
Manufacturer



Local Allen-Bradley Account Manager: Tom Reilly
704-287-1178 (mobile)
tpreilly@ra.rockwell.com

Allen-Bradley Web-Based Support: www.ab.com

www.ab.com/drives/

<http://support.rockwellautomation.com/knowledgebase>

Emergency
Field Service
And Parts



Allen-Bradley Emergency Field Service Engineer Call-Out:
(During Normal Business Hours)... Call EECO at 1-540-678-9000
(During Non-Business Hours)... Call RA at 1-440-646-3434....Press "1"



Emergency Parts Availability:
(During Normal Business Hours)... Call EECO at 1-540-678-9000
(During Non-Business Hours)... Call RA at 1-440-646-3434....Press "2"

Manufacturer's
Order Number(s)



Finished Water PS: Rockwell Automation Order Number 7051398 / 6502799555
Raw Water PS: Rockwell Automation Order Number 7015150

Operation and Maintenance

- Operator versus Maintenance Strategy
- Check All Diagnostics – Via Pilot Lights, Keypad/Displays, Operator Interface Terminals, SCADA.....The Five Senses
- Keep a Logbook On Hand
- Know How To Navigate the Keypad / Display of the VFD to Understand Operation and Access Key Diagnostic Information
 - Access the Fault Queue
 - Time and Date Stamp
 - Memory Storage
 - Password Access?

Keypad / Display of VFD



Maintenance and Troubleshooting

- Maintenance
 - Fans, Filters, A/C Units (see example on next slide)
 - Thermography
 - VFD Systems Installed 5 Years or More
 - Assess Criticality of Equipment and Develop a Plan
 - Develop a Spare Parts Strategy
- Troubleshooting
 - Troubleshooting Guides in O&M Manuals or User Manuals
 - Hand-Held Voltage Meter and Current Meter (i.e. Fluke)
 - Meggering
 - Understand the "Permissives" for your VFD Applications

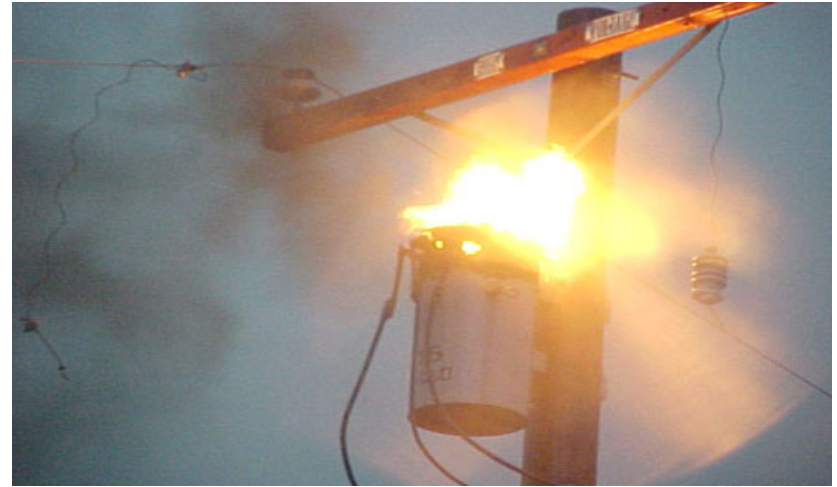
Fans and Filters



Environment (Temp, Humidity, Atmosphere)

- Ambient Temperature....Define "ambient"
 - Stand-alone VFD rated 0-50degC ambient (around the VFD)
 - Assuming minimum enclosure dimensions, UL says you must account for a 10degC temp rise when placed in an enclosure. Thus, the ambient air in the room to be no more than 40degC.
 - NEMA Type 1, 1G, 12, 12 with fans and filters, 12 with air-conditioning, 4, 4X, 3R
 - Flange-mount design (mount the heatsink of the VFD out the back of the enclosure and maintain a NEMA Type 12 rating)
 - Oversize the VFD and de-rate
- Humidity....5-95% non-condensing
- Atmosphere...Corrosive gases
 - Instruct the Electrical Contractor to properly seal the conduits
 - For insurance, specify conformally-coated printed circuit boards

Power Quality Issues – The Grid

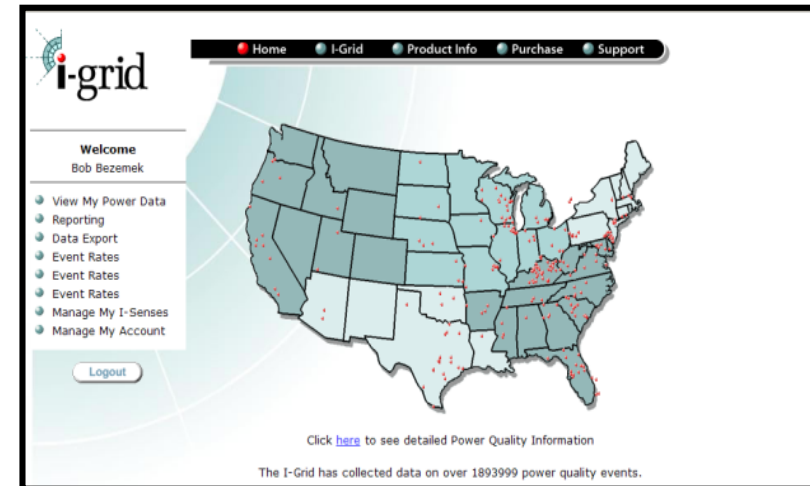
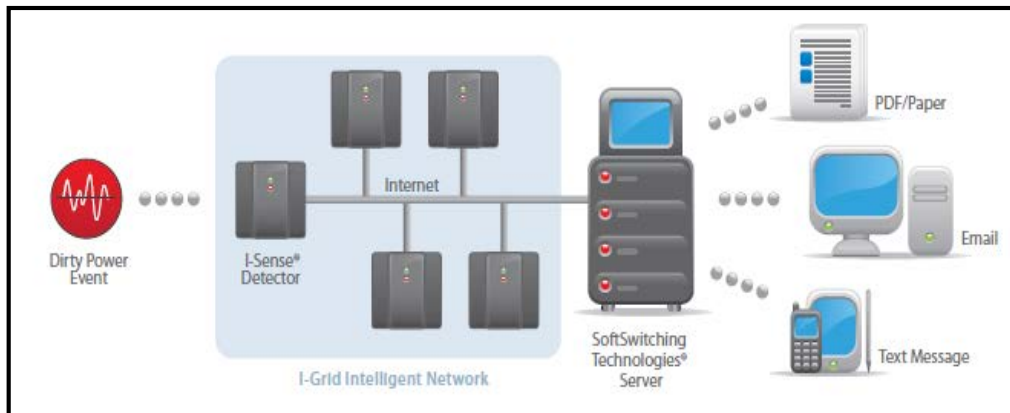


Power Quality Issues – the Weather



Overview of the I-grid

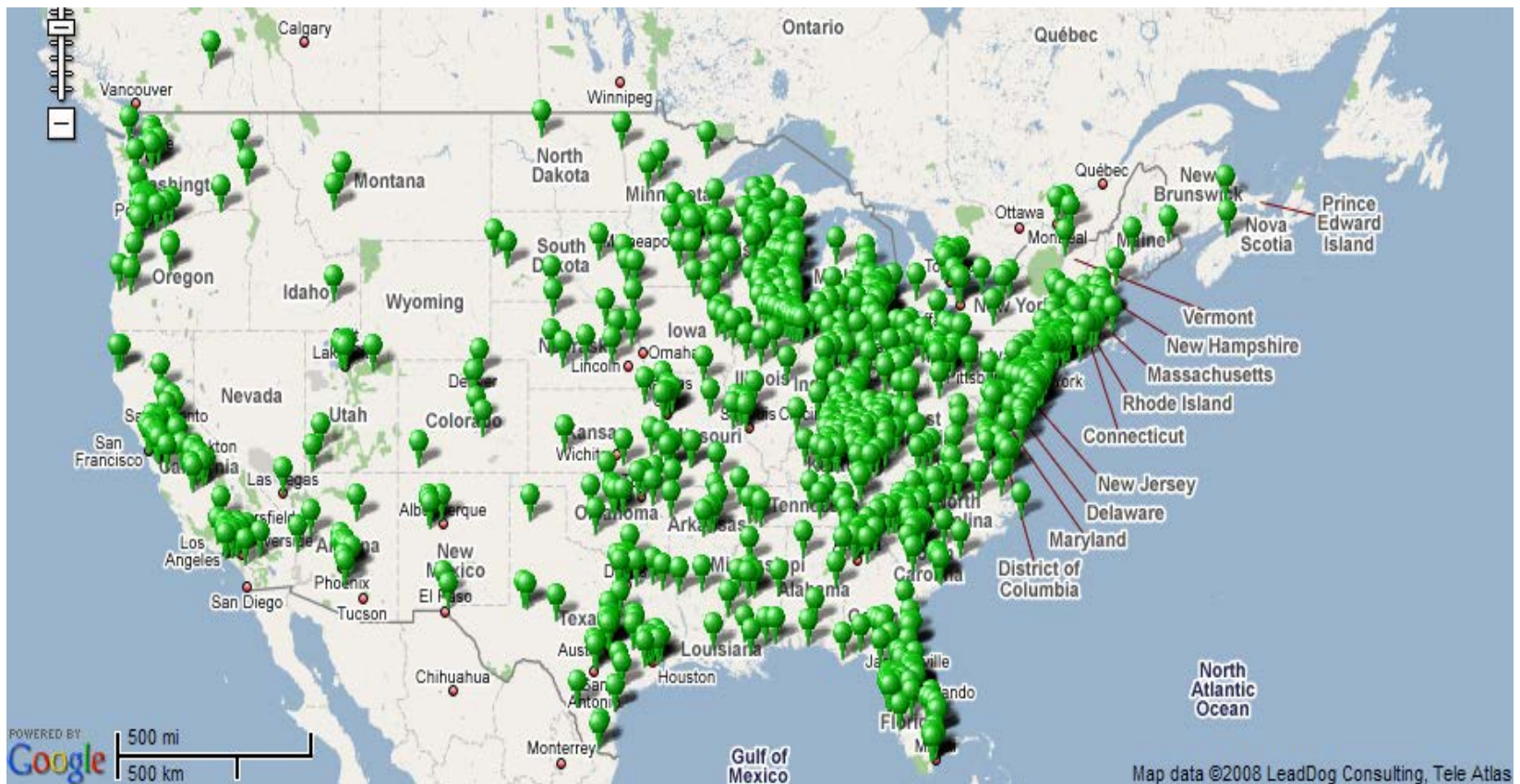
- Distributed Power Quality & Reliability Monitoring and Notification System
 - Independent Web based power grid monitoring network (No Software Required)
 - Over 3,500 monitors tracking voltage and frequency in real time around the world
 - Over 7 Years of Data
 - Over 2 Million Events Captured
 - Synchronized to UTC for absolute “sequence of events” monitoring
 - Linked to National Weather Service
 - Ethernet and Global Modem Capability



Domestic I-Sense Monitoring Locations

“igrid.com”Monitoring the I-Grid with I-Sense

- One pin per postal code
- Over 3500 I-Sense monitors active in the USA today



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Questions?

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