Energy Savings Using Variable Speed Drives

Robin Priestley
Rockwell Automation
A dollar not spent on energy is a dollar of NET PROFIT:

• A company generating 5% return on net assets (RONA) has to sell $____ in products to generate $50,000 in profit?

$1,000,000.00

• If your solution saves $10,000.00 in energy costs, how much is that really worth?

$200,000.00 in top line revenue

$ savings x 1/(RONA % provided by management)

• Energy costs are rising.

• Motors are the largest consumers of energy in North America.
Basic Electrical Costs

• Demand
• Power factor
• Kilowatt hours consumed
Demand Charge – Hard To Justify

Demand charge – 15 minute average peak usage
  • Staggered starts
  • Soft starts
  • Variable speed drives
Power Factor – Easier To Justify

Power factor – charge or credits (depending on the power factor)

• Decreases efficiency if power factor is below 85%
• May be credited if power factor is above 95%
Power Factor As A Cost

Your ‘Apparent’ Consumption
(i.e. required generation capacity)

Real Work – Billed kWh

Lagging PF
+20%
+10%

Standard
-10%
-25%

Unity PF

Power Factor
Power Factor As A Cost

Your ‘Apparent’ Consumption
(i.e. required generation capacity)

Real Work – Billed kWh

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Power Factor
Power Factor As A Cost

- Your ‘Apparent’ Consumption (i.e. required generation capacity)
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Lagging PF:
- +20%
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- -10%
- -25%
- Unity PF
- Power Factor
Variable Speed Drives

Electrically located at motor – looks like a power factor correction capacitor to distribution system
Capacitor Location?

- Metering
- Service Entrance
- Distribution Infrastructure
- Utility
- MCC
- Capacitor

focus on energy
Partnering with Wisconsin utilities
Reducing True Consumption Benefits

Reducing consumed kW

- Provides quickest paybacks
- Easiest to justify
- Tools eliminate guess work
VSD – Big Payoff

Exponential reduction in consumed kW:

• Variable torque – fans, pumps
• Variable load characteristics – systems that cycle, i.e. injection molders
• Throttled loads – restricted flows, i.e. dampers, control valves, recirculation
Affinity Laws

Affinity laws apply to all centrifugal devices.

Flow (Q) Changes Linearly with Speed (N)

\[ \frac{Q_2}{Q_1} = \frac{N_2}{N_1} \]

Pressure (P) is Proportional to the Square of Speed (N) or Flow (Q)

\[ \frac{P_2}{P_1} = \left( \frac{N_2}{N_1} \right)^2 \]

Power (HP) is Proportional to the Cube of Speed (N) or Flow (Q)

\[ \frac{HP_2}{HP_1} = \left( \frac{N_2}{N_1} \right)^3 \]
Affinity Law In Action

Variable torque ‘ideal’ loads:

• Energy increases exponentially with speed
• Energy consumed = \( (\text{speed})^3 \)
Affinity Law In Action (continued)

Energy Consumed

Insignificant Speed Reduction

Speed
Affinity Law In Action (continued)

Large Reduction In Consumed Energy

Energy Consumed

Speed

Insignificant Speed Reduction
Affinity Law In Action (continued)

Reasonable Speed Reduction
Affinity Law In Action (continued)

FANTASTIC Opportunity

Reasonable Speed Reduction

Energy Consumed

Speed
Motor Example

Consumption_{reduction} = (\text{Speed}_{reduction})^3

100 \text{ kW motor @ 50\% speed} - \text{what does it cost?}

E_r = (1/2)^3

12.5 \text{ kW}
Pump Example

Pumps may have limited speed ranges due to system constraints.

100 HP motor @ 85% speed – how much HP are you using?

\[ HP_{used} = (\text{Motor HP}) \times (\% \text{ Speed})^3 \]

\[ HP_{used} = (100 \text{ HP}) \times (.85)^3 \]

61 HP
Fan Example

What if a fan worked at 45 Hz?

\[
\text{% Speed} = \frac{\text{Operating speed}}{\text{full speed}} = \frac{45 \text{ Hz}}{60 \text{ Hz}} = 75
\]

\[
\text{HP}_{\text{required}} = (\text{Motor HP}) \times (\text{% Speed})^3
\]

\[
\text{HP}_{\text{required}} = (100 \text{ HP}) \times (0.75)^3
\]

42 HP
Financial Justification

• Need basic data to calculate savings – multiple tools available
• Value exceeds kWh cost – what is this worth to top line revenue?
• Does system performance justifies VSD regardless of savings?
  o Example – water authority pumping just 4 hours/day – fire main pressure, no broken mains, better aquifer management
Energy Saving Calculation Example

- 25 HP fan moves air three shifts/day, 5 days/week, for a year.
- Cost of fan running at full speed entire year:

  $$25 \text{ HP} \times 0.746 \text{ kW/HP} \times 6240 \text{ hrs} \times 0.075 \text{ kWh} = \$8,728.00$$

Assuming fan does not have to run constantly at full speed:
  - 20% time at 100% speed
  - 60% at 80% speed
  - 20% at 60% speed

Cost of running fan with a variable speed drive:

  $$25 \text{ HP} \times 0.746 \text{ kW/HP} \times 1248 \text{ hrs} \times 0.075 \text{ kWh} \times (1.00)^3 = \$1,746$$

  $$25 \text{ HP} \times 0.746 \text{ kW/HP} \times 3744 \text{ hrs} \times 0.075 \text{ kWh} \times (0.80)^3 = \$2,681$$

  $$25 \text{ HP} \times 0.746 \text{ kW/HP} \times 1248 \text{ hrs} \times 0.075 \text{ kWh} \times (0.60)^3 = \underline{\$377}$$

Total = $4,804

Potential annual savings = $8,728 – $4,804 = $3,924
ROI Calculators And Engineering Aids

• Projects typically authorized based on return on investment.
• Project viability determined by facts rather than feelings.
• Focus on hard costs.
• Eliminate subjective content.
• Your goal is to build a bullet proof justification that stands on its own!
Fastest Payback?

Common traits

• Long hours of operation
• Load isn’t constant
• Load may be throttled
• Significant downtime cost
Design Parameters – Constant Volume System

- Outside air temp:
  - 72°F
  - 47°F
  - 100°F

- Fan speed on 100%:
  - 0°F
  - 70°F
  - 72°F

- Space temp:
  - 68°F
  - 70°F
  - 72°F

- % Heating:
  - 0%
  - 100%

- % Cooling:
  - 0%
  - 100%

- Fan speed %:
  - 0%
  - 100%

- Fan speed Hz:
  - 0Hz
  - 60Hz
Constant Volume System With VSD

Fan speed varies based on CO₂ and building controls demands.

- Outside air temp:
  - 72°F
  - 47°F
  - 100°F

- Space temp:
  - 68°F
  - 70°F
  - 72°F

- Temperature range:
  - 100°F to 0°F

- Fan speed %:
  - 100%
  - 0%

- Fan speed Hz:
  - 60Hz
  - 20Hz
  - 0Hz

- Economizer:
  - 0%
  - 100%

- Fan speed – economizer running:
  - 76°F (RTU3-3)
  - 54% (RTU 3-3)

- Minimum fan speed:
  - 33%

- RTU3-3:
  - 54%
Focus on Energy VSD Incentives

• Standard incentives
  o $60/ horsepower up to 30% of invoiced cost
• Custom incentives
  o 1.5 to 4 year energy payback
• Contact your Energy Advisor or call 800.762.7077
Resources

Thank You!

For additional information or questions:
Robin Priestley
Power Control Manager
rspriestley@ra.rockwell.com
563-445-6323