EE Motor Controller Retrofits for Energy Savings and Other Benefits

Presentation To
Regional Technical Forum

March 4, 2003

POWER EFFICIENCY CORPORATION

Proposed Topics

- Introduction: Power Efficiency Corp.
- Overview: PEC's EE Motor Controllers
- Field Test Data
- C&RD: Proposal and Benefits

Appendices

- ✓ Report on PEC Performance Controllers, Oak Ridge National Laboratory
- ✓ Overspeed Testing, Oregon State University
- ✓ Hawaiian Electric Testing (Elevator World)

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Power Efficiency Corp.

- Power Efficiency Corporation (OTC BB: PREF) was founded to commercialize a proprietary NASA energy savings technology for electric motors
- PEC has held the exclusive NASA license in the U.S. for the basic energy-efficiency controller circuitry
- In addition to the NASA license, PEC holds improvement patents (last issued January 1997); in December 2002, PEC received a DOE "Inventions and Innovations" grant to develop heavy duty (1,000+ HP) motor controllers
- Motor energy savings typically run 15%-40%; energy costs are ~80% of commercial motor life-cycle costs
- PEC has installed over 6,000 controllers worldwide; enormous range of potential applications
- Major government (Oak Ridge NL) and commercial laboratories have found PEC's technology to be superior to all competitive products
- Headquartered in Ann Arbor, MI, with an R&D and marketing office in New Hyde Park, New York

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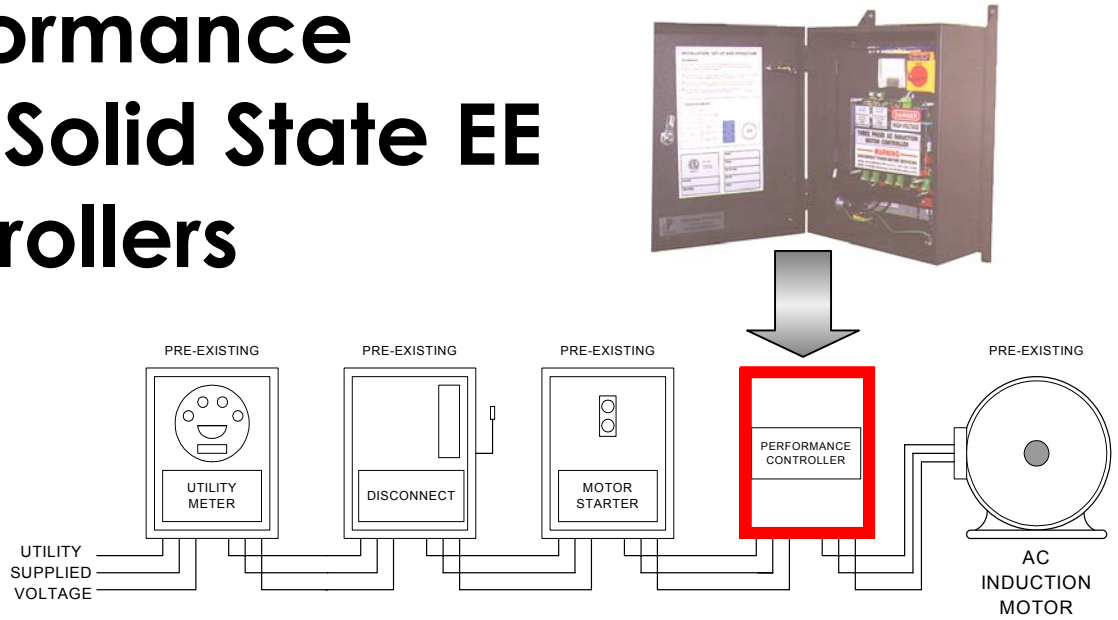
PEC's "Performance Controller" Solid State EE Motor Controllers



BENEFITS: *Life Cycle Savings*

Energy savings
- Reduces kWh up to 40%

Motor & equipment life extension
- Reduces inrush current up to 70%
- Reduced motor temp extends motor life
- Smoother motor start up extends equipment life

Also:
- Always supplies the power needed by the motor
- Simple to install
- Rugged, reliable & maintenance-free

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Wide Range of Applications

Typical Applications

- Conveyors
- Elevators
- Escalators
- Reciprocating pumps
- Oil pump jacks
- Machine tools
- Injection molding
- Industrial saws
- Stamping Presses
- Granulators

MOTOR SPEED \ MOTOR LOAD	VARIABLE	HIGH
FIXED	EE Motor Controllers	High Efficiency Motors
VARIABLE	Variable Speed Drives	High Efficiency Motors / Variable Speed Drives

Keys to Economic Payback:

- ✓ AC Induction motor > 5HP
- ✓ Constant speed, variable load
- ✓ Periods of low Power Factor (below .5)
- ✓ No other motor drives in line
- ✓ Operation over 2000 hours per year

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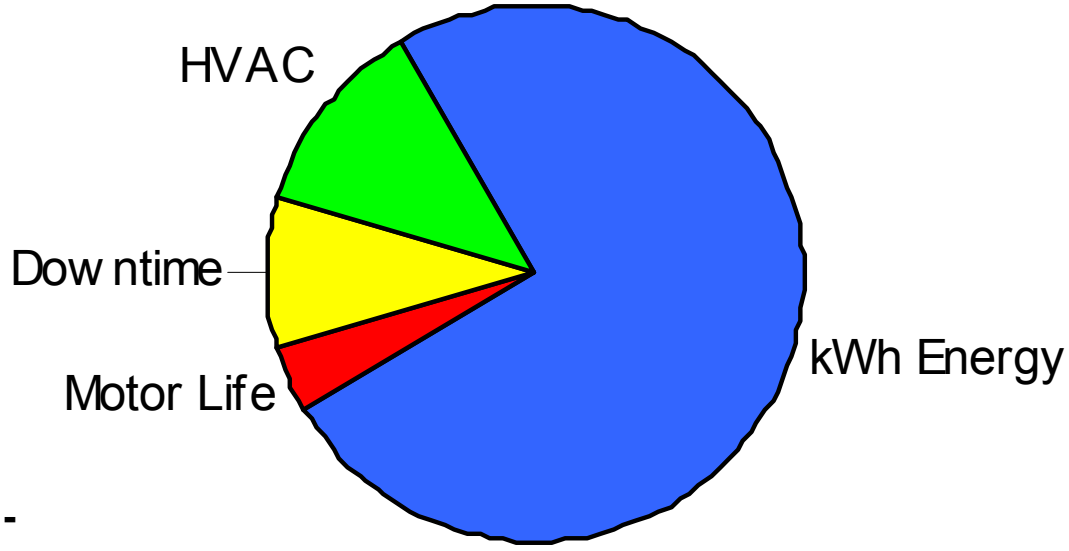
EE and Other Life-Cycle Savings

- **Controller kWh savings: <u>15-40%</u>**
- **Additional controller life-cycle benefits:**
  - **Reduced motor repair and replacement**
  - **Reduced failure-related equipment downtime**
  - **Reduced heat load on the HVAC system (motors run cooler)**
- **Applications: light-duty up to heavy-duty industrial motors (5-500 HP), soon 1,000 HP+**

Typical Estimated Life-Cycle Savings



As shown above, about 75% of total savings result from kWh energy reduction over equipment life (10+ years)

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Large Body of Solid Bench and On-Site Test Data

Testing Facility	Test Motor (HP)	Motor Manufacturer/ Application	Avg. kWh Reduction
Oak Ridge National Laboratory *	10	Lincoln “Hostile Duty”	20%
Oak Ridge National Laboratory *	50	Lincoln “High Efficiency”	43%/47%
Oregon State University *	10	Imperial	N/A +
Oregon State University *	15	GE “Severe Duty”	N/A +
Hawaiian Electric Company	15	Up Escalator	29%
Hawaiian Electric Company	15	Down Escalator	27%
University Hospital	75	Elevator	34%
Petroleum Tech. Transfer Council/Marathon Oil	15	Oil Well Pump	17%
Rapid Granulator USA	10	Plastics Granulator	33%
Wellington Industries	50	Stamping Press	33%
Northeast Utilities/Otis Elevator	53	Elevator ++	12%-60%

* Laboratory bench tests; all others on-site + Escalator motor controller overspeed tests
++ Battery of test runs at up to design elevator loading, to develop deemed savings tables

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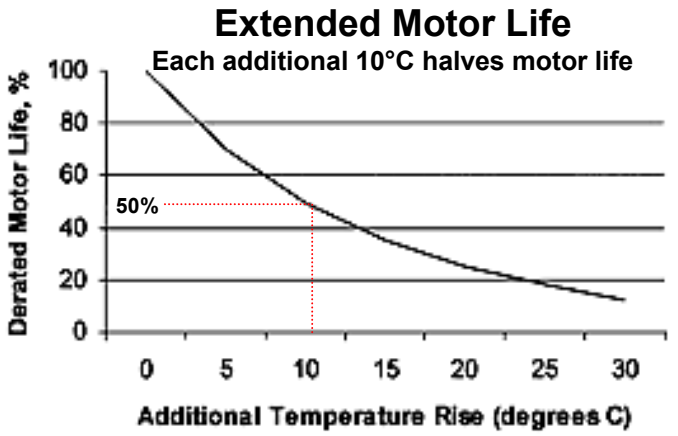
Detail on Other Life-Cycle Savings

Repair/Replacement Savings

- A 10°C (18°F) drop in motor operating temperature doubles the life of the motor
- PEC tests found that the average decrease in motor operating temperature is 12°C (21°F), which should more than double the motor life



Source: "Motor Circuit Analysis for Energy, Reliability and Production Cost Improvements," by Howard W. Penrose, Ph.D., BJM Corp.

Equipment Downtime Savings

Unexpected motor failure causes:

- emergency repair and replacement of the motor itself
- safety hazard to people and inconvenience during repair
- possible damage to ancillary equipment

HVAC Savings

Without the Performance Controller, the motor runs hotter than it needs to:

- The facility HVAC system works harder to eliminate the excess heat

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Performance Controller Specifications

AC Voltage:	208, 380, 460 and 575 VAC (50 or 60 Hz) , 3-Phase
Power:	5-500 HP
Load type:	3-phase AC induction motors
Full load current:	8-477 amps
Output stage:	6 SCRs full wave inline
Operating temp:	-30C to 65C (-22F to 150F) ambient
Enclosure:	vertical mount NEMA 1, 4 or 12 with charcoal gray powder coat
Bypass:	manual bypass switch standard; automatic circuit optional

CERTIFICATIONS

- ETL Listed as conforming to UL 508
- EN 61000-6-2 Electromagnetic Compatibility, Immunity for Industrial Environments
- CSA B44.1 (ASME A17.5) Elevator and Escalator Equipment
- CSA C22.2 No. 14-95 Industrial Control Equipment

LABORATORY TESTING

- Oak Ridge National Laboratory, John Kueck, R.H. Staunton
- Oregon State University, Dr. Alan Wallace

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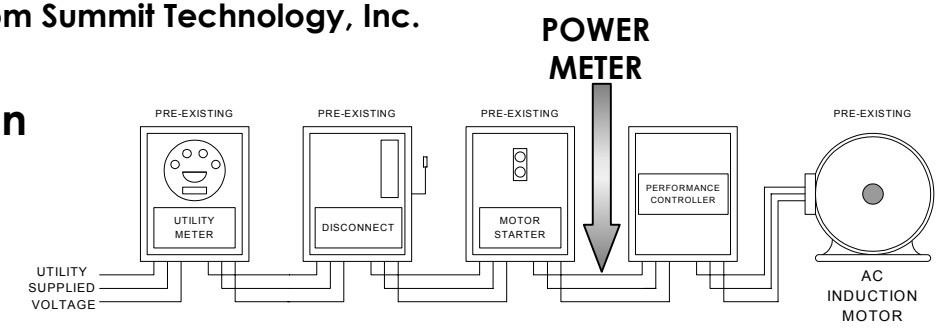
Measuring Energy Savings

- **We recommend a 3-phase True-RMS power digital sampling meter**

  Meeting ANSI C12.16-1991 minimum performance standards

  Example: PowerSight PS3000 Energy Analyzer from Summit Technology, Inc.

- **Power measurements must be taken on the <u>line</u> side of the controller.**



- **Common pitfalls:**
  1. **Measuring power on the motor (output) side of the controller**
  2. **Data acquisition time window too short**
  3. **Motor loading during measurement period not an adequate representation of long-term loading**
  4. **Reversing one current transducer**
  5. **Using a single phase power meter**

- **Follow an accepted procedure such as:**

  International Performance Measurement & Verification Protocol – Concepts and Options for Determining Energy Savings, Office of Energy Efficiency and Renewable Energy, US DOE ("MVP 2001").

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Field Test Data

10 HP Plastic Granulator

15 HP Escalator

25 HP and 53 HP Elevator Motor-Generator "MG" Sets

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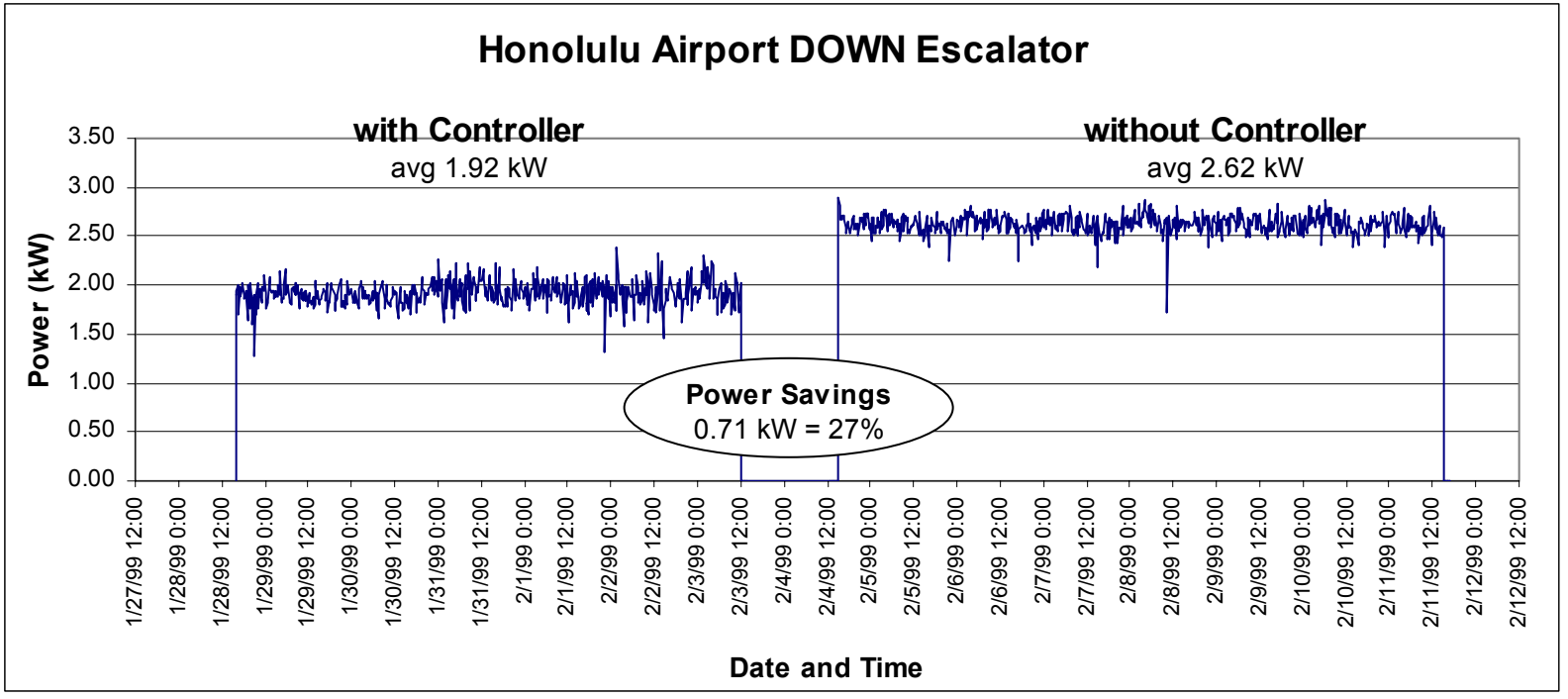
15 HP 460V Escalator

Real Power (kW)



The Performance Controller reduced the average real power (in kW) by **27%.** Two-week test provided an ample window to capture day-to-day load variation. Data were acquired every 15 minutes, 24 hours a day.

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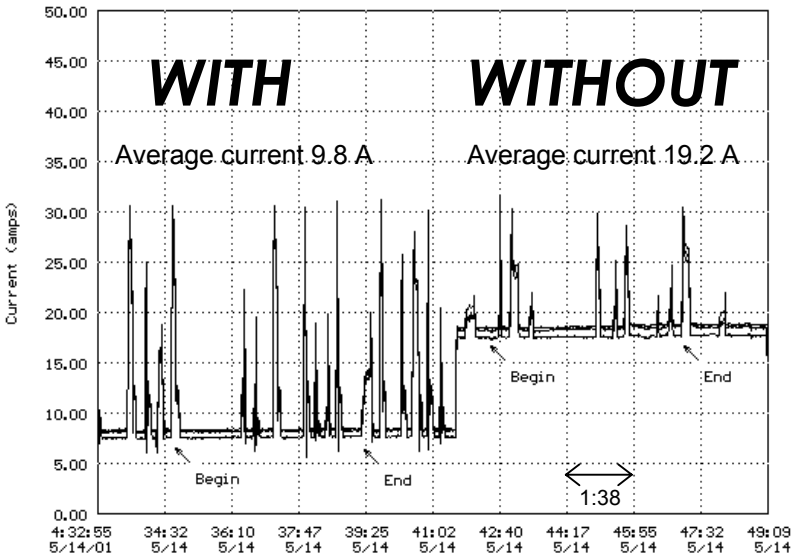
25 HP 460V Elevator MG Set

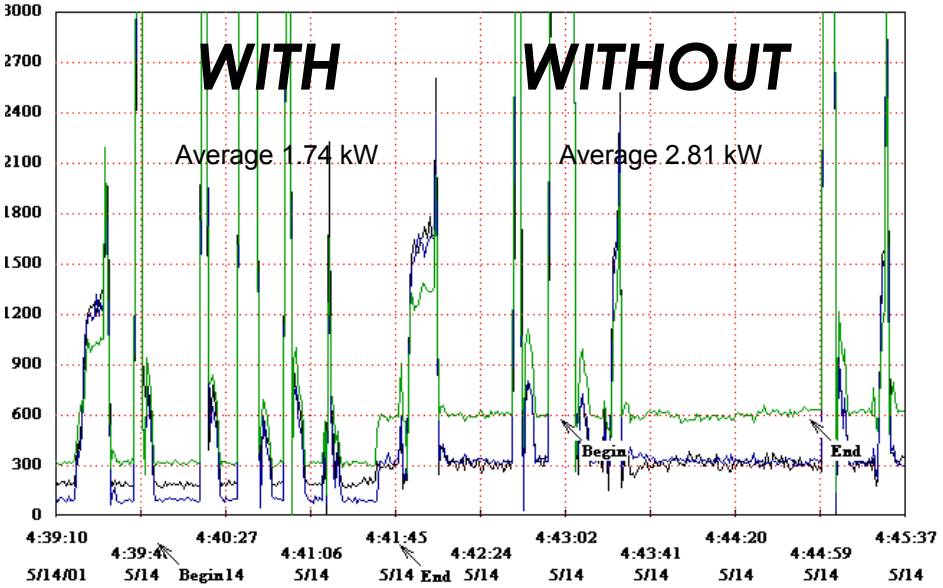
Current (amps)

***With** and **Without** Controller*



Real Power (Watts)

***With** and **Without** Controller*



With Performance Controller in-line, the average current was reduced by **49%** and the average power dropped by **38%.** Current and power spikes are due to intermittent elevator calls.

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Northeast Utilities/Otis Trials

- Comprehensive elevator trials have just been completed by a joint team of Northeast Utilities (New England's largest energy company), Otis Elevator, and PEC
- Results show savings in <u>all operating modes</u> --

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Otis
A United Technologies Company

Operating Mode	Power (kW) w/ Controller	Power (kW) w/o Controller	Savings (kW)	Savings (%)
Empty Elevator				
Elevator at Idle	1.16	2.91	1.75	**60%**
Total Up & Down	17.62	21.39	3.77	**18%**
Elevator with 500 lbs				
Total Up & Down	15.36	18.51	3.15	**17%**
Elevator with 1,500 lbs				
Total Up & Down	14.05	15.95	1.90	**12%**

Connecticut Light & Power
The Northeast Utilities System

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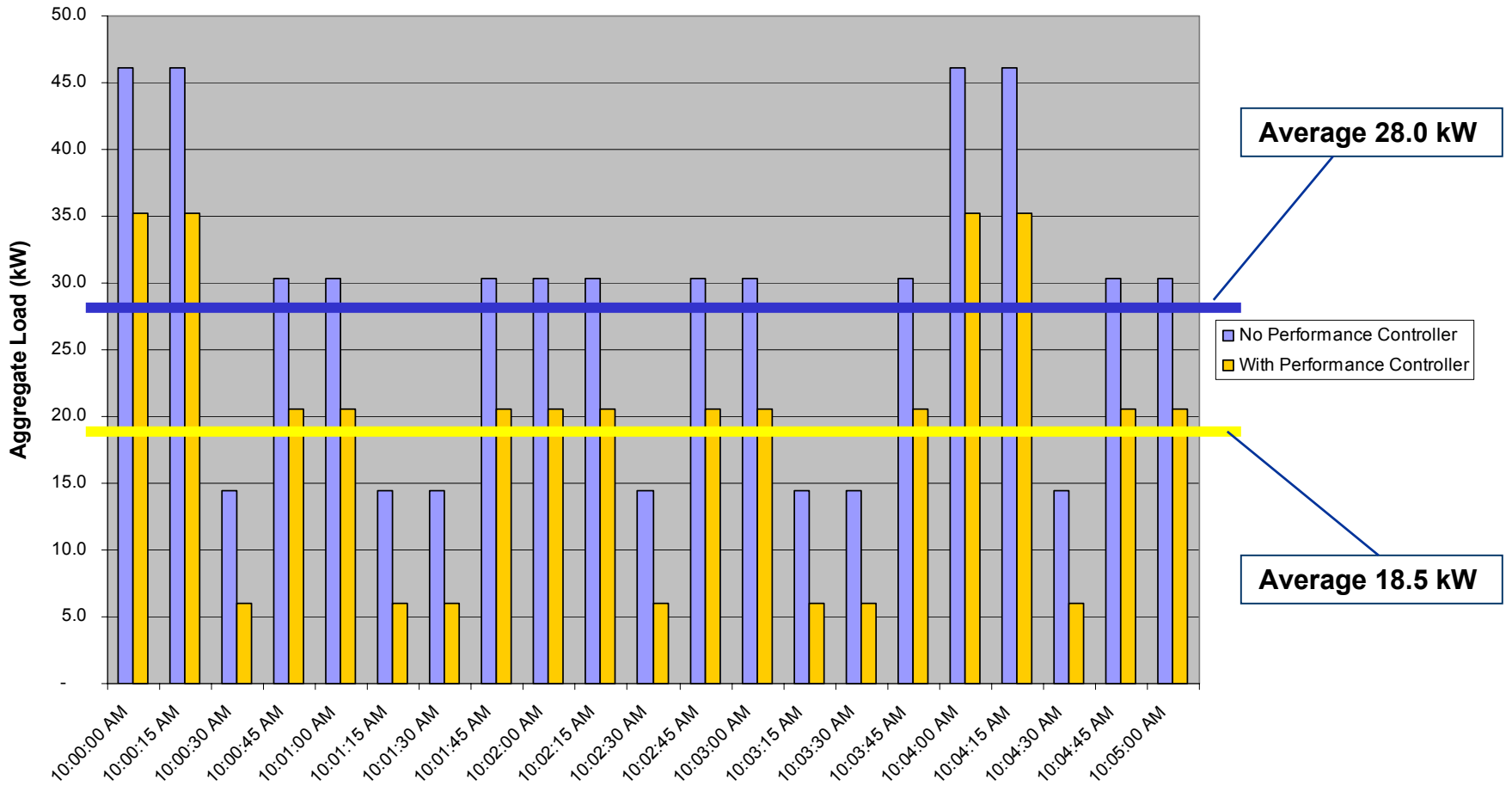
Peak Reduction Illustration



Simulation of (5) 53-HP elevators, varying call rates, using data from Northeast Utilities/Otis/PEC field tests

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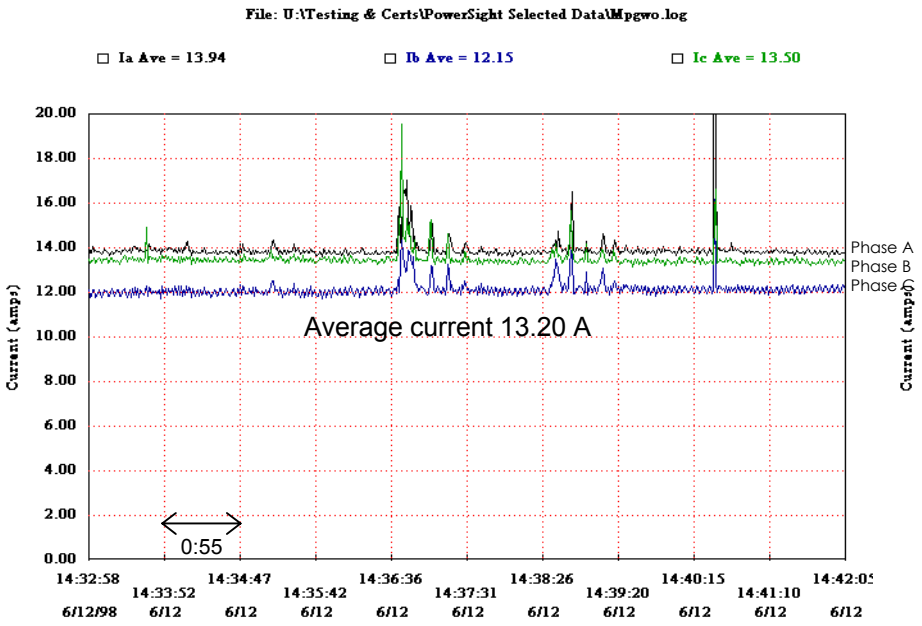
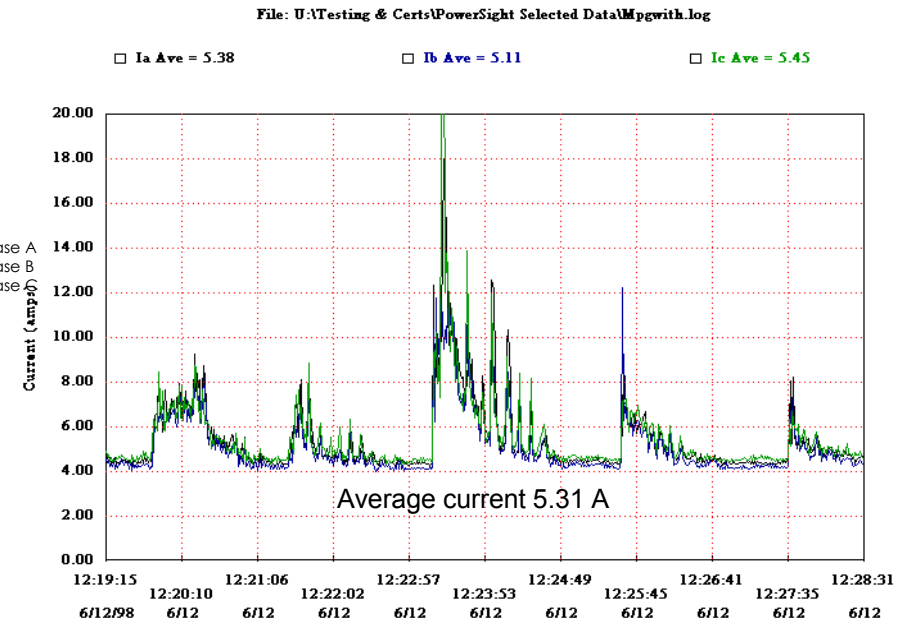
10 HP 460V Granulator

Current (amps)

***without** Performance Controller*



***with** Performance Controller*



The Performance Controller reduced the average current by **60%** and improved the phase imbalance. Peaks are due to intermittent loads of plastic material in granulator.

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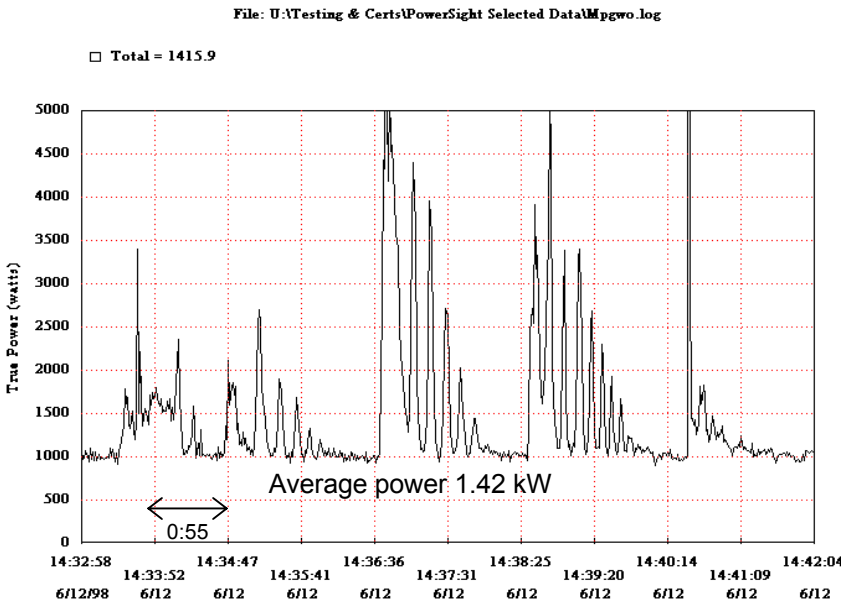
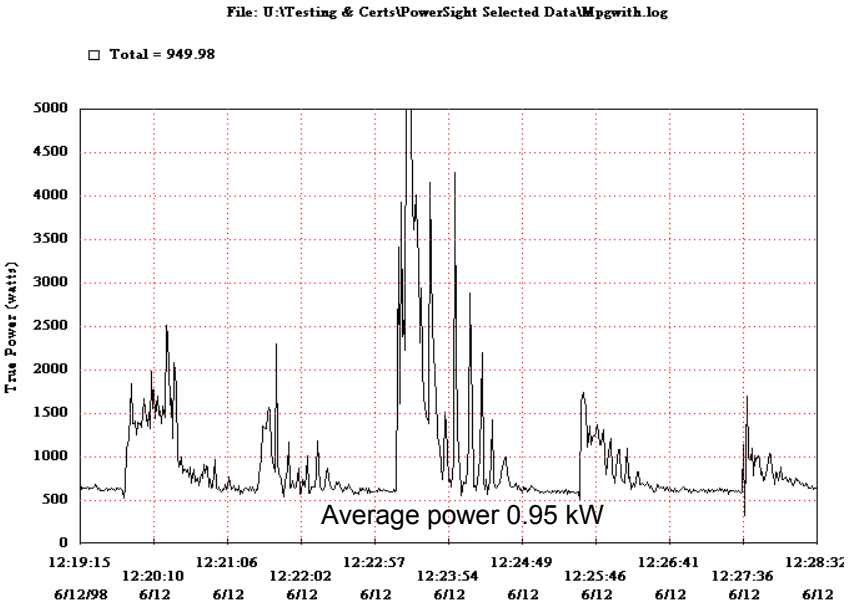
10 HP 460V Granulator

True Power (watts)

***without** Performance Controller*



***with** Performance Controller*



The Controller reduced average Real Power (watts) by 33%.

Peaks are due to intermittent loads of plastic material in granulator.

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C&RD: Proposal and Benefits

- Elevator/escalator installation program
- <u>Pledged, written support of partners Otis (#1 OEM) and KONE of Finland (#4, #1 in escalators)</u>
- Initial proposed targets (over 3 years):
  - Up to 5,000 elevators (~20% of est. installed base)
  - Up to 500 escalators (~ 30% of est. installed base)
- Estimated peak load reduction: <u>13+ MW</u>
- Parallel, optional "custom" program for industrial applications

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Otis
A United Technologies Company

The heart of your building KONE

EE

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Benefits cont'd: Local Manufacturing

- PEC is happy to discuss development of local manufacturing in the service of this contract
- Rugged, patented design is ideal for contract manufacturing
- PEC's manufacturing strategy is specifically based on outsourcing
- Have already initiated research into regional contract electronics/electrical manufacturing capabilities

Washington Business Development

IDAHO small business™ SOLUTIONS

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Benefits cont'd: In Future Innovations

In Development

Single-phase energy saving controller with soft-start for split capacitor appliance motors, .25 to 1 HP

Large energy saving soft-start controller for industrial motors over 1000 HP

Digital controller
embedded in motor housing
(1-phase and 3-phase)

DOE Category 1 "Inventions and Innovations" Grant Awarded (12/02)

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Success Factors

- ***Technology works (and long measure life)***
- ***Cost-effective***
- ***Relatively easy to implement***
- ***Strong, incented team and resources***
- ***High per-installation benefit***
- ***Peak reduction tool***
- ***Organized to succeed***

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Potential Next Steps

- Additional technical reports
- Data for deemed savings calculations
- Arrangement of discussions with OEMs
- Other

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