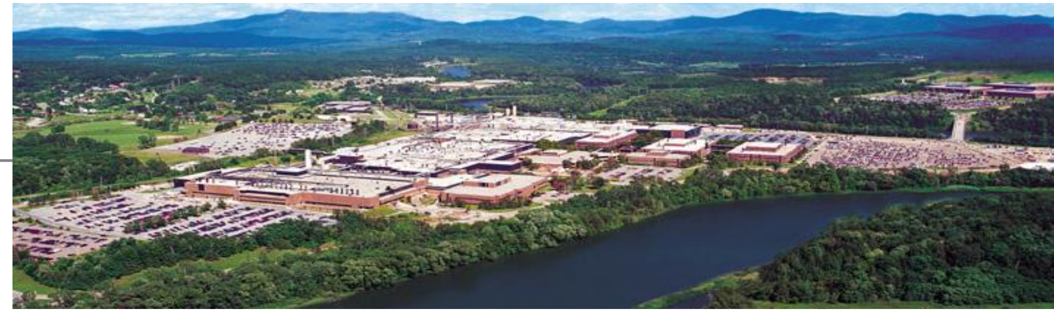
Systems and Technology Group

IBM Vermont Case Study: Advanced Industrial Water & Energy Management saves $10 M annually

Jeff Chapman, Ultra Pure Water Engineer
Senior Technical Team Leader
Center of Excellence for Enterprise Operations

IBM

Burlington 200mm Manufacturing



- Founded in 1957, 50+ Years of Semiconductor Technology Leadership
- Mission: Provide world class semiconductor products through a diverse technology portfolio, manufacturing, and engineering excellence.
- Wafer Size: 200mm
- Capacity: ~1600 WSD
- Litho Technology nodes ranging from 500nm to 90nm
- Diverse offerings include CMOS, RF CMOS, SiGe, SOI, eDRAM
- Industry's first production ramp of:
  - ✓ DUV Litho
  - ✓ SOI
  - ✓ SiGe
  - ✓ Cu wiring

IBM semiconductors…throughout the communications infrastructure

Optical Networks

(ASIC, SiGe BiCMOS, RF CMOS)

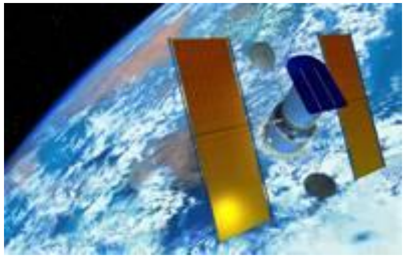
Wireless access points

Routers, Switches, WAP

(ASIC, Power Architecture)

Edge routers/firewall

Stackable switches



Communications Satellites

(ASIC)

Wireless Base Stations

(ASIC, Power Architecture)

Servers and Storage

(Power Architecture)

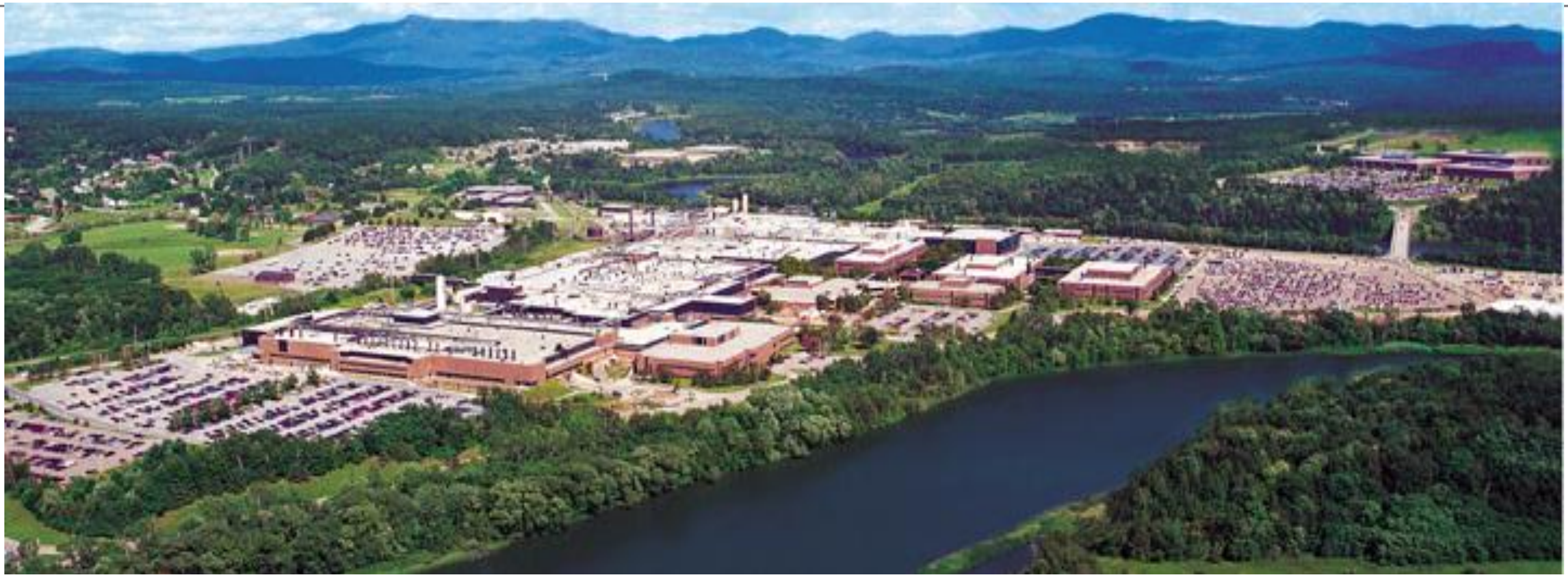
Radio Telescope Antennas

(SiGe)

WiMAX

(ASIC, SiGe BiCMOS, Power Architecture)

IBM Vermont: “A SMART Enterprise”
Unique in location, operation and skill set



Water Use

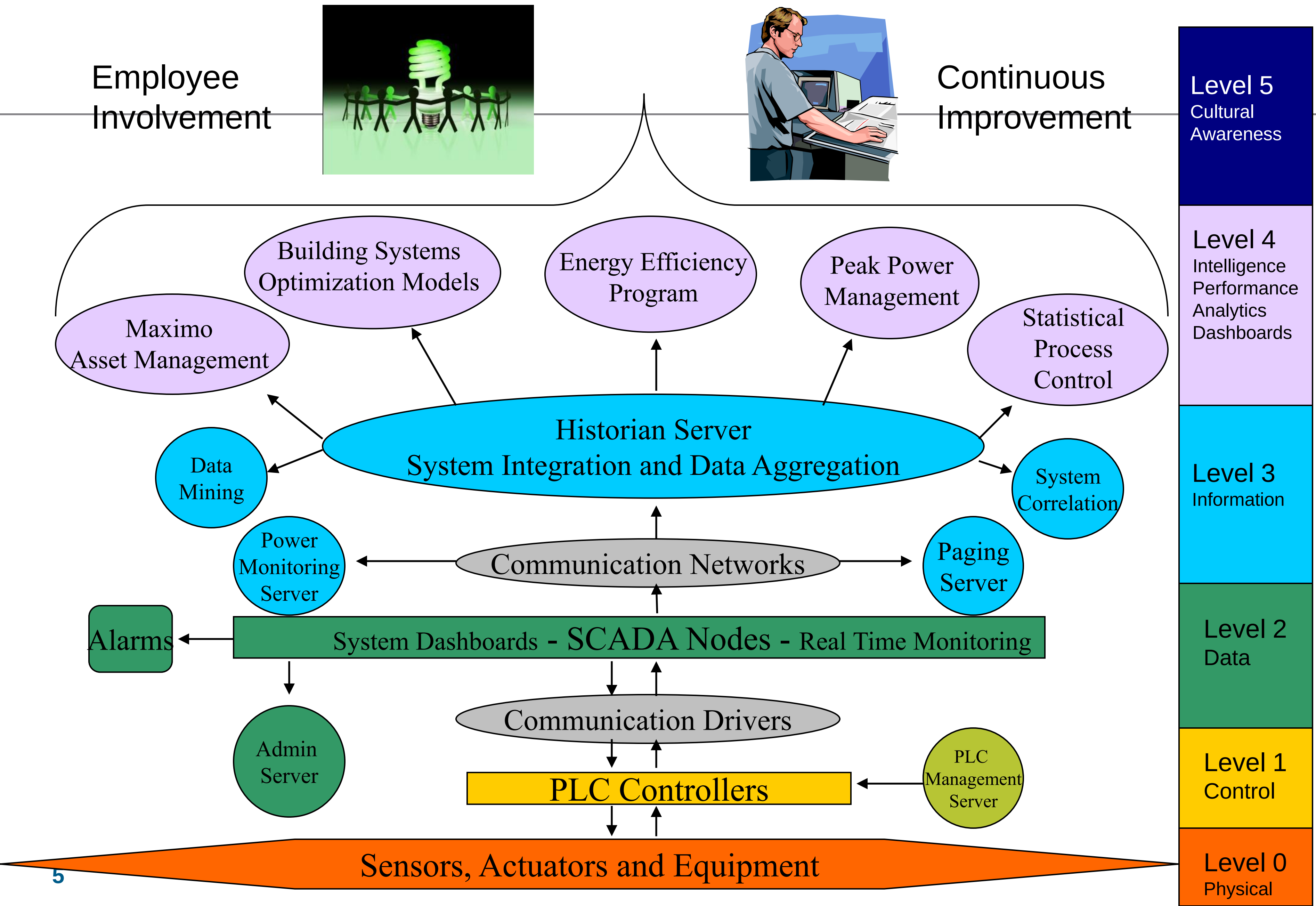
- Fed from regional High Service Mains
- 3.2 MGD (similar to the City of Burlington)
- 2 MGD Ultra Pure Water
- Waste water treatment 3 MGD

Electrical Use

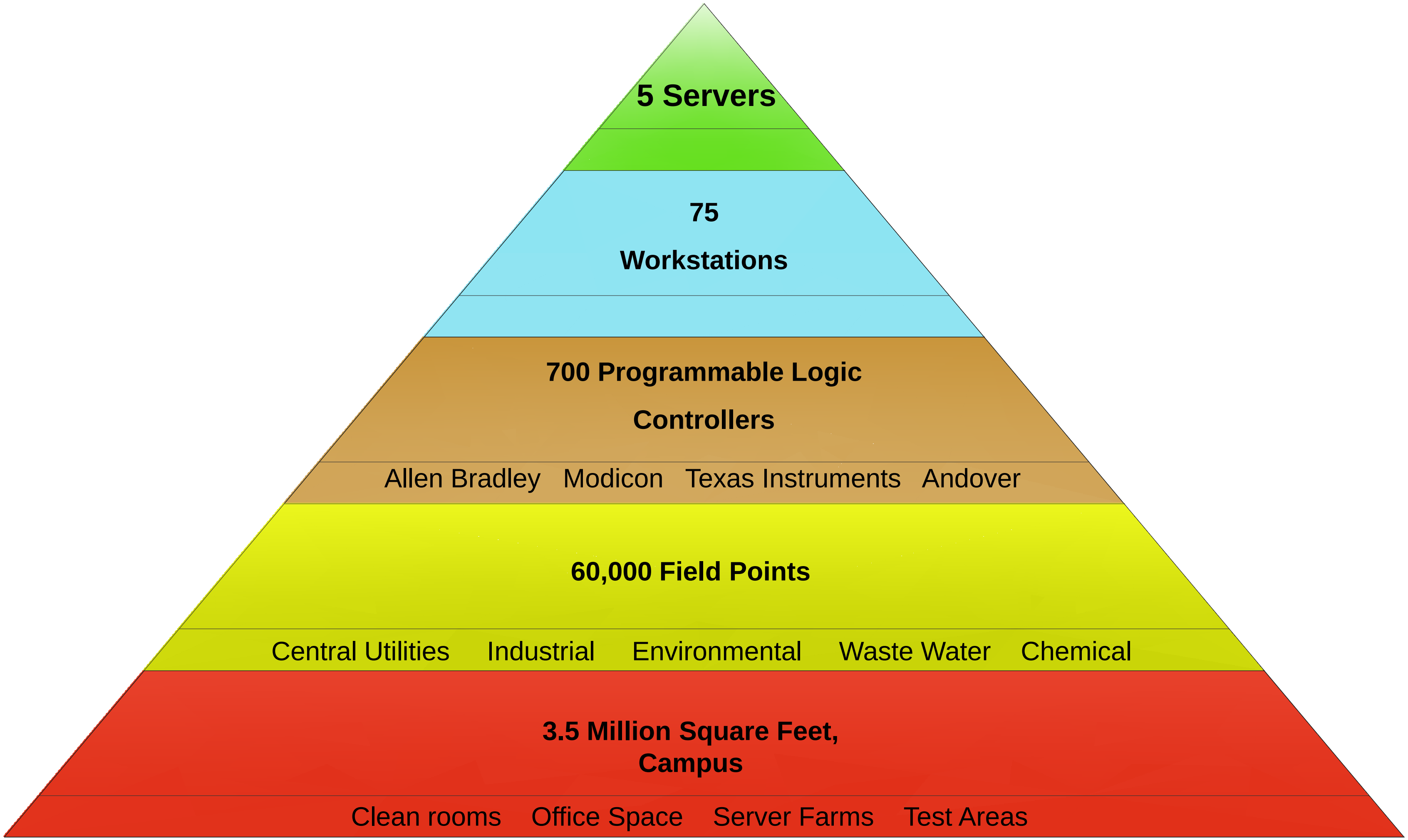
- Transmission Line Fed
- Own and operate Electrical Grid (similar to a Utility)
- Peak 65 Mega Watts (larger than Burlington)
- 60 miles high voltage lines
- 136 substations

SMART Attributes

- 60,000 field pts
- 700 PLCs
- 75 Work stations
- 5 servers
- Advance data analysis
- Load management
- Cost Control
- Quality


Employee Involvement
Continuous Improvement
Level 5
Cultural Awareness
Level 4
Intelligence
Performance
Analytics
Dashboards
Level 3
Information
Level 2
Data
Level 1
Control
Level 0
Physical
Maximo Asset Management
Building Systems Optimization Models
Energy Efficiency Program
Peak Power Management
Statistical Process Control
Historian Server
System Integration and Data Aggregation
Data Mining
System Correlation
Power Monitoring Server
Communication Networks
Paging Server
Alarms
System Dashboards - SCADA Nodes - Real Time Monitoring
Admin Server
Communication Drivers
PLC Controllers
PLC Management Server
Sensors, Actuators and Equipment

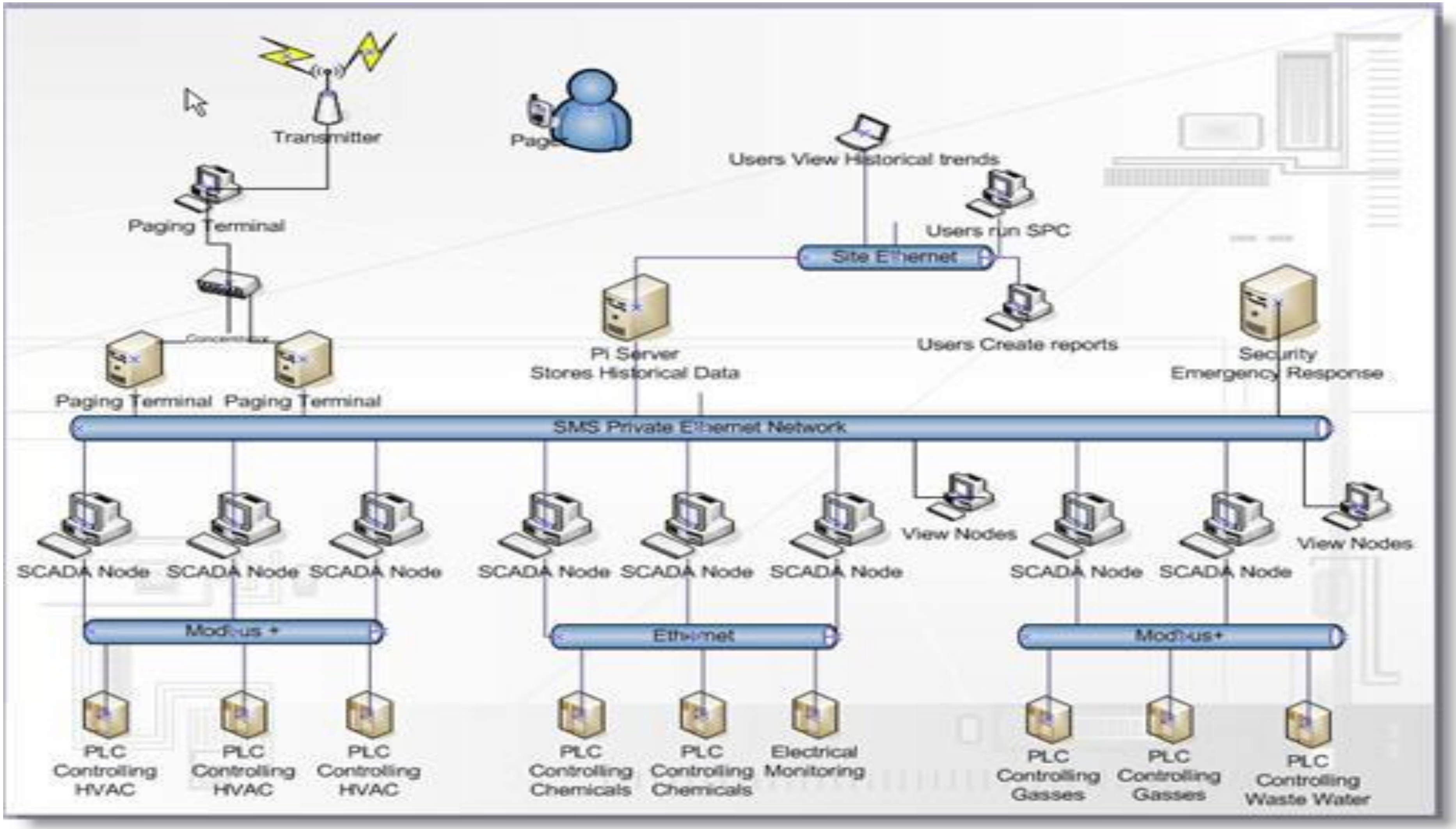
Controls Hierarchy



Interconnected

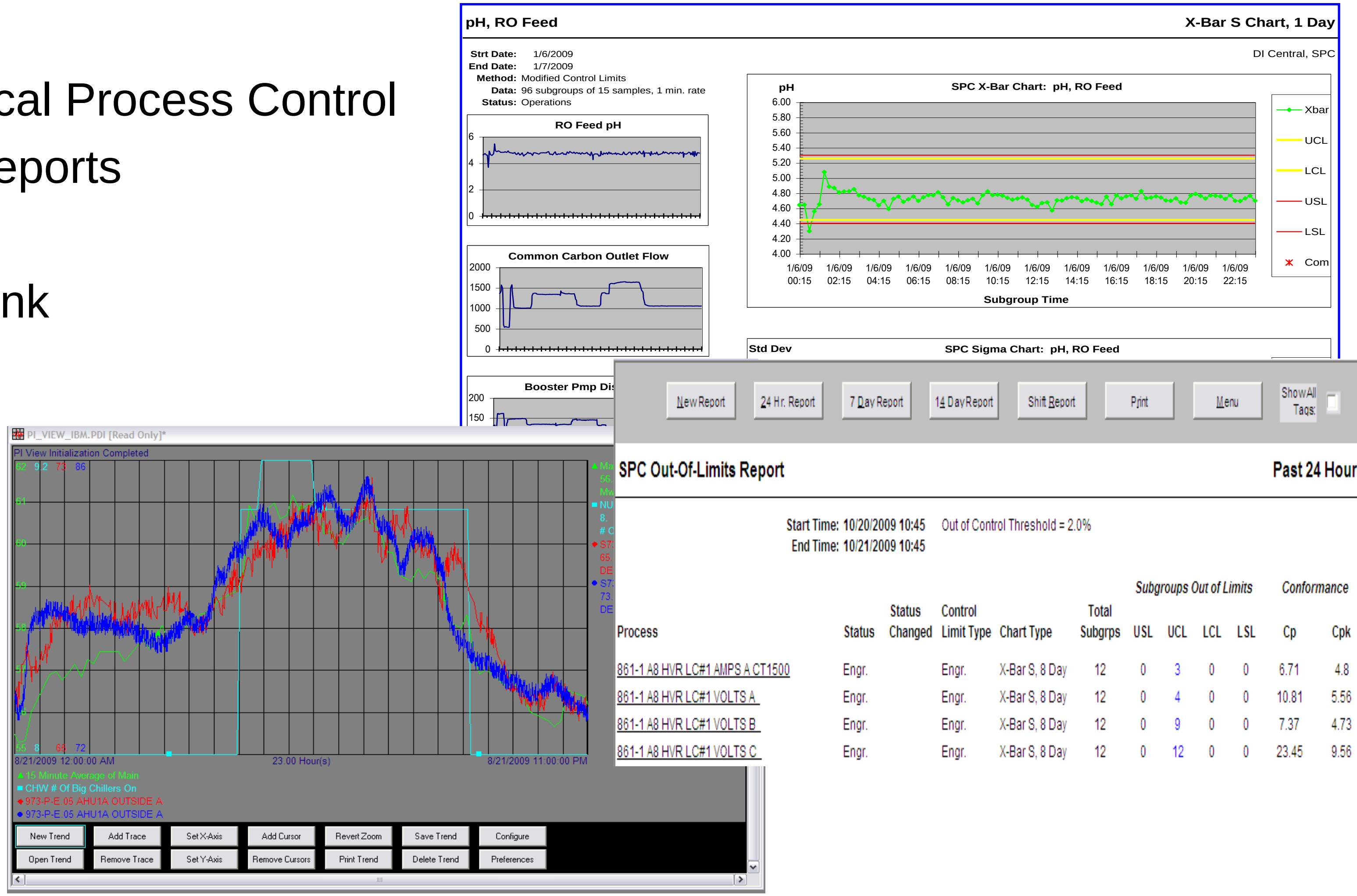
System Overview, SCADA System

Interconnected



PI System Historical Reporting; User Applications

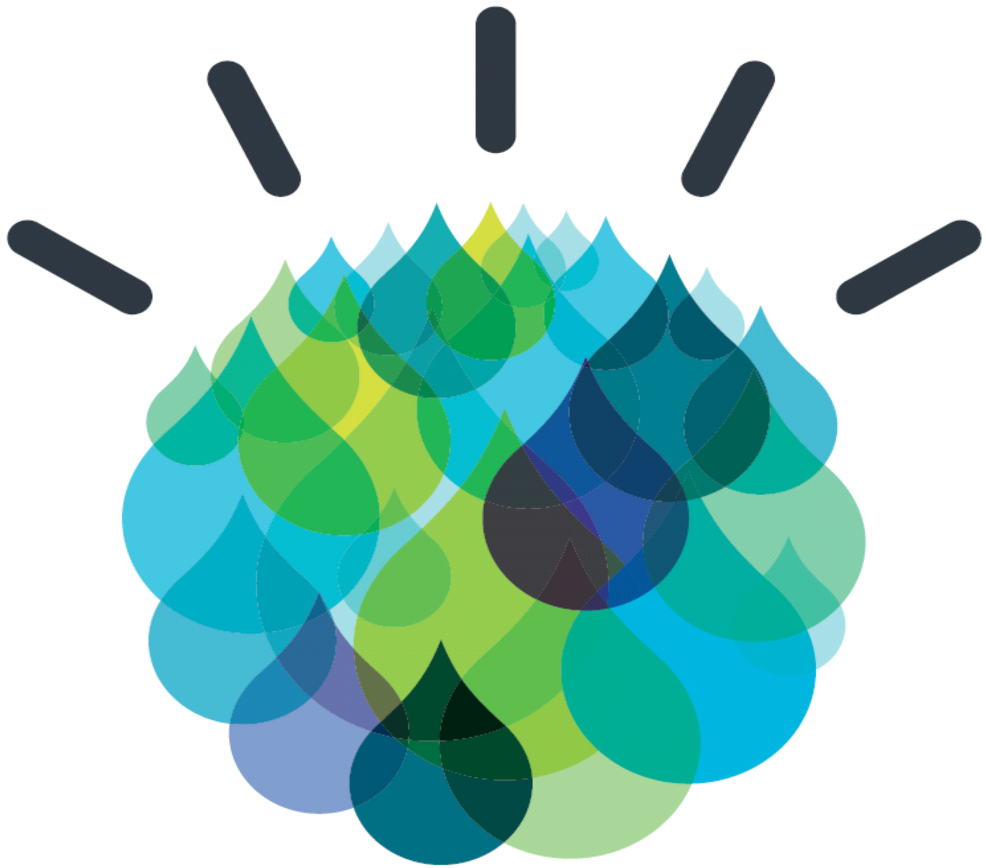
- Statistical Process Control
- Shift Reports
- Trends
- Data Link



How do we analyze all of our data???

- Statistical Process Control (SPC)
  - Is a quality control method used to reduce process variation and improve product quality.
  - The SPC Applications are software tools that allows user to implement SPC techniques on their system processes with the goals being to improve the stability, reliability, and quality of those processes.
  - To realize the quality improvement, changes in system maintenance and process methods must be put in place. The SPC Applications are used as tool to monitor the success or failure of the methods used to improve product and process quality.

IBM, Vermont: Center of Excellence for Enterprise Operations
SMART Water



Advanced Water Management Case Study:
IBM 200 mm Wafer Fabricator Burlington, Vermont

- **Challenge**
  - Reduce water consumption (and associated need for energy, chemicals, maintenance and labor) to reduce operating cost and minimize environmental impacts
  - Leverage end-to-end data acquisition, storage and visualization techniques to monitor water usage and improve efficiency
- **Approach**
  - Implemented data collection and storage infrastructure: sensors, IT network and servers
  - Statistical process control techniques used to continually analyze vast amounts of operational data and present information in efficient, concise interface
  - IBM's Green Sigma methodology breaks down water usage by process:
    - Dashboards convey key process indicators
    - Identifies process improvements that reduce water consumption and provide other benefits, such as reduced electrical power consumption, heat recovery, cooling load reduction, process efficiency etc.

- **Results**
  - IBM has achieved over $3.6M in annual savings, reduced water usage by 27% while increasing manufacturing capability over 30%

Center of Excellence for Enterprise Operations

Advanced Water Management: SMART and Sustainable

Lake Champlain

Vermont's
Greatest
Water
Resource

Close Supplier Relations

Kinetic Energy Recovery

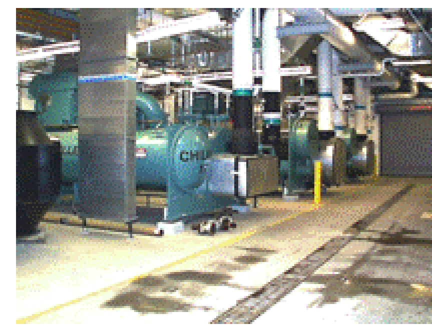
Ultra Pure Water Treatment Efficiency

Instrumented – Obtain and collect real time data

Interconnected – Data analysis and visualization

Intelligent – Analysis becomes action, transform how we operate

Heat Energy Recovery



Manufacturing Use Efficiency

Stewards of the Resource

Waste Water Treatment

Smarter water for a smarter planet

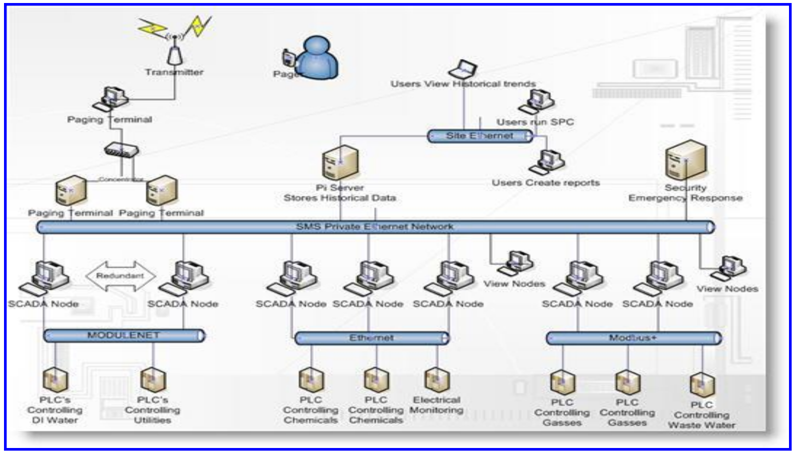
IBM Center of Excellence for Enterprise Operations
SMART Water

Smarter water
for a smarter planet

Instrumented

5000 data points
600 msec scan rates
400 Million data packets each day

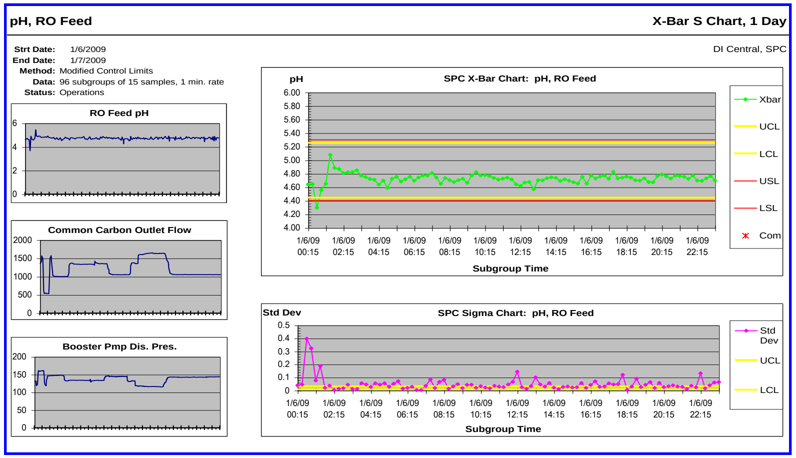
Interconnected



5 data servers
Optical highways
Instant access anywhere
via LAN or Intranet

Intelligent

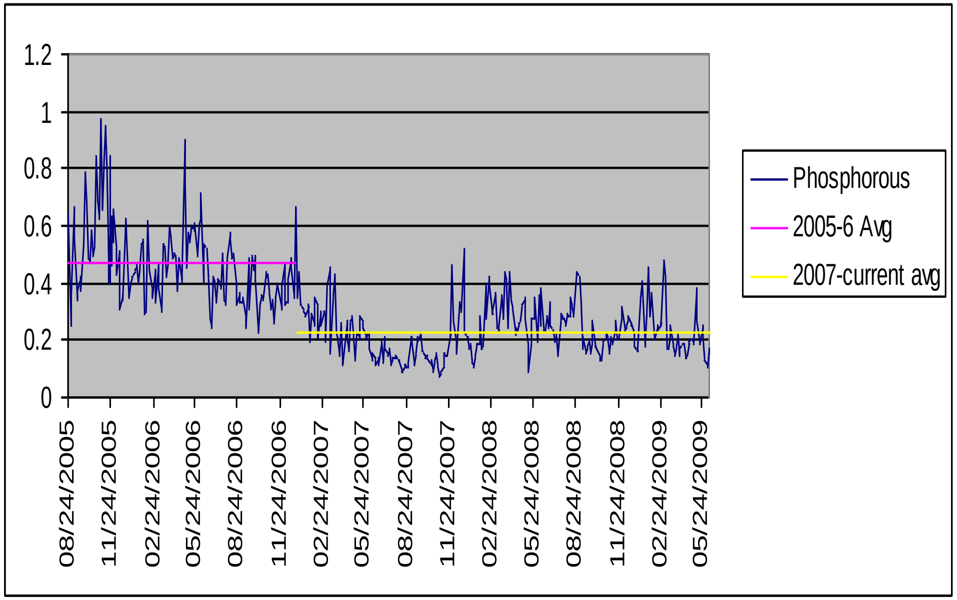
Statistical Analysis
Predictive Modeling
Transforms data to information,
Information -> Action



Center of Excellence for Enterprise Operations
SMART Waste Water Results

Burlington Waste Water Management Goals
- **Quality:** Meet or exceed regulatory requirements
- **Reliability:** Zero manufacturing down time
- **Cost:** $450K/year reduction in annual cost

Phosphorus Discharge



Units mg/l
NPDES limit 1.2 mg/l

NPDES Discharges

Phosphorus: - 48%
Fluoride: - 44%
TDS: - 54%

Waste Water Sludge

Disposal Cost: - $49K/yr
Generation: - 600K lbs/yr

Water & Waste Water Chemical Usage

Annual Costs: -$401K/yr
Reduction: - 2,162K lb/yr

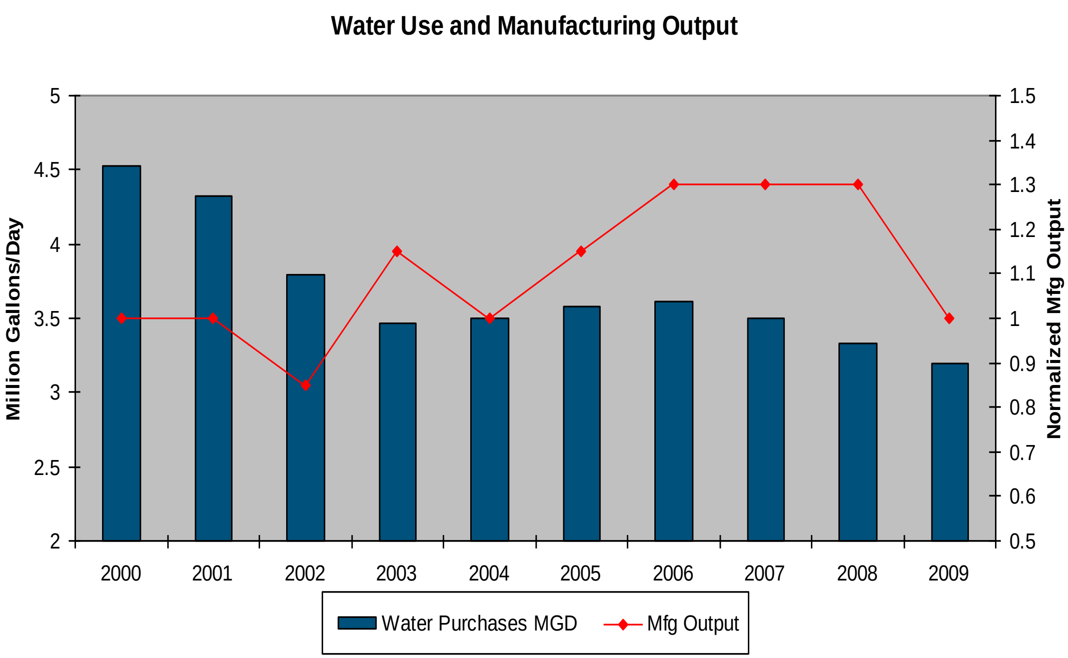
Manufacturing Capability

Up 30% since 2000
(excluding 2009)

Center of Excellence for Enterprise Operations
SMART Water Results

Burlington Water Management Goals

- **Quality:** 6 Sigma conformance to Specification
  No impact to product yields
- **Reliability:** Zero manufacturing down time
- **Cost:** $3.6M/year reduction in annual cost



Water Usage

Rates: + 66% since 2000
Usage: - 29% since 2000
Purchases: -$742K/yr

Water Treatment Costs

Annual Costs: - $598K/yr

Water Related Energy Costs

Annual Costs: -$2,278K/yr

Manufacturing Capability

Up 30% since 2000
(excluding 2009)

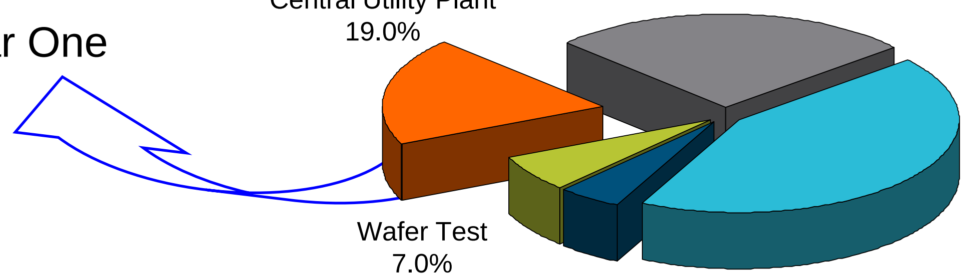
Only a small handful of Electrical Engineers and technicians design, operate and maintain the entire Electrical Distribution System at the IBM Burlington Site.

SMART Electrical Grid Technology

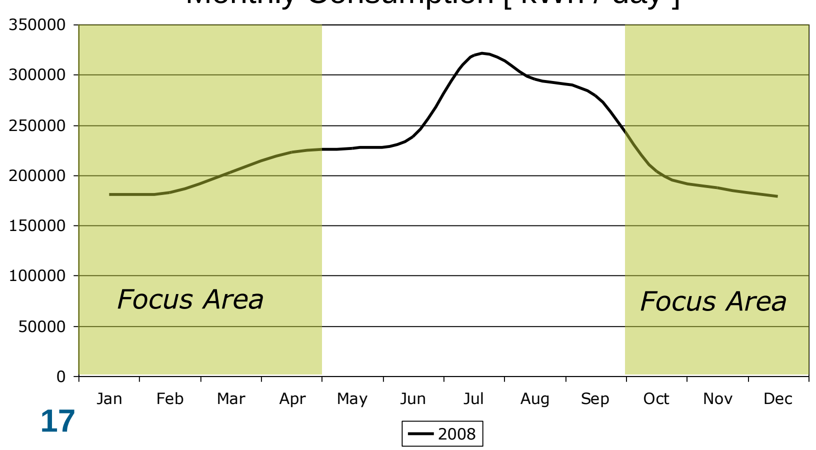
Central Utility Plant Energy Breakdown
Goals and Idea Generation

- Energy Goals Established:
  - Central Utility Plant usage: [~$6,500,000 annually]
  - Conservation Stretch Goal:
    - $350,000 energy savings Year One

IBM Burlington Site Energy Breakdown [2008]

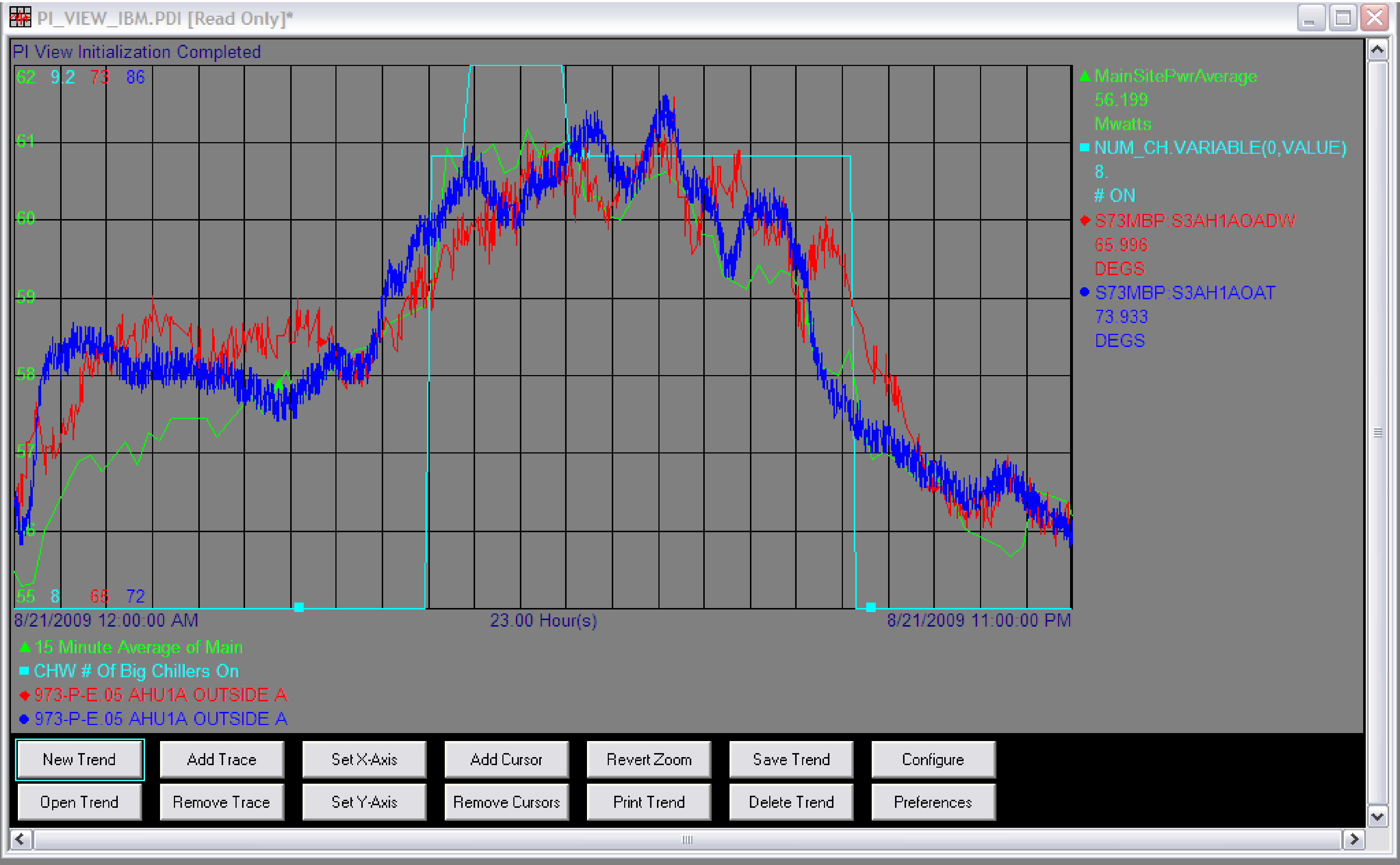


2008 Central Utility Plant Electricity Curve
Monthly Consumption [kWh / day]



- Idea Generation and Prioritization:
  - Continuous Team Interactions and Input
  - Site Cooling Water Investments – Winter Free-Cooling
    - Focused Application and Opportunity
  - High Return vs. Investment

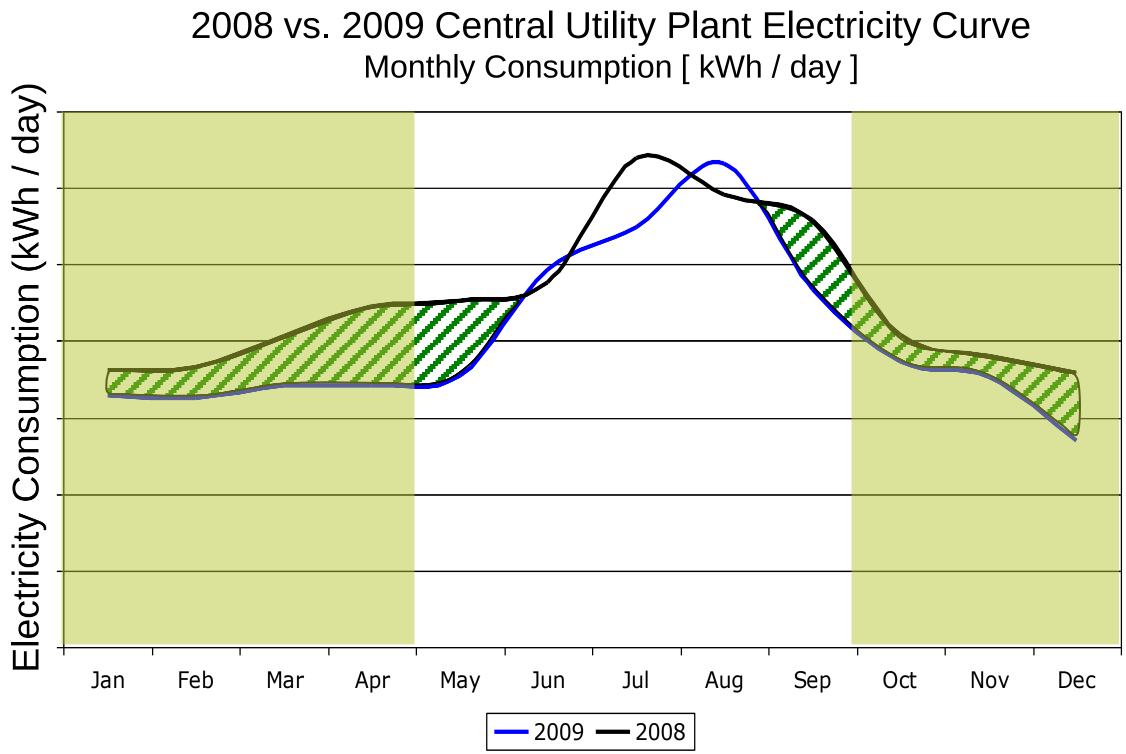
Peak Load – August 21, 2009



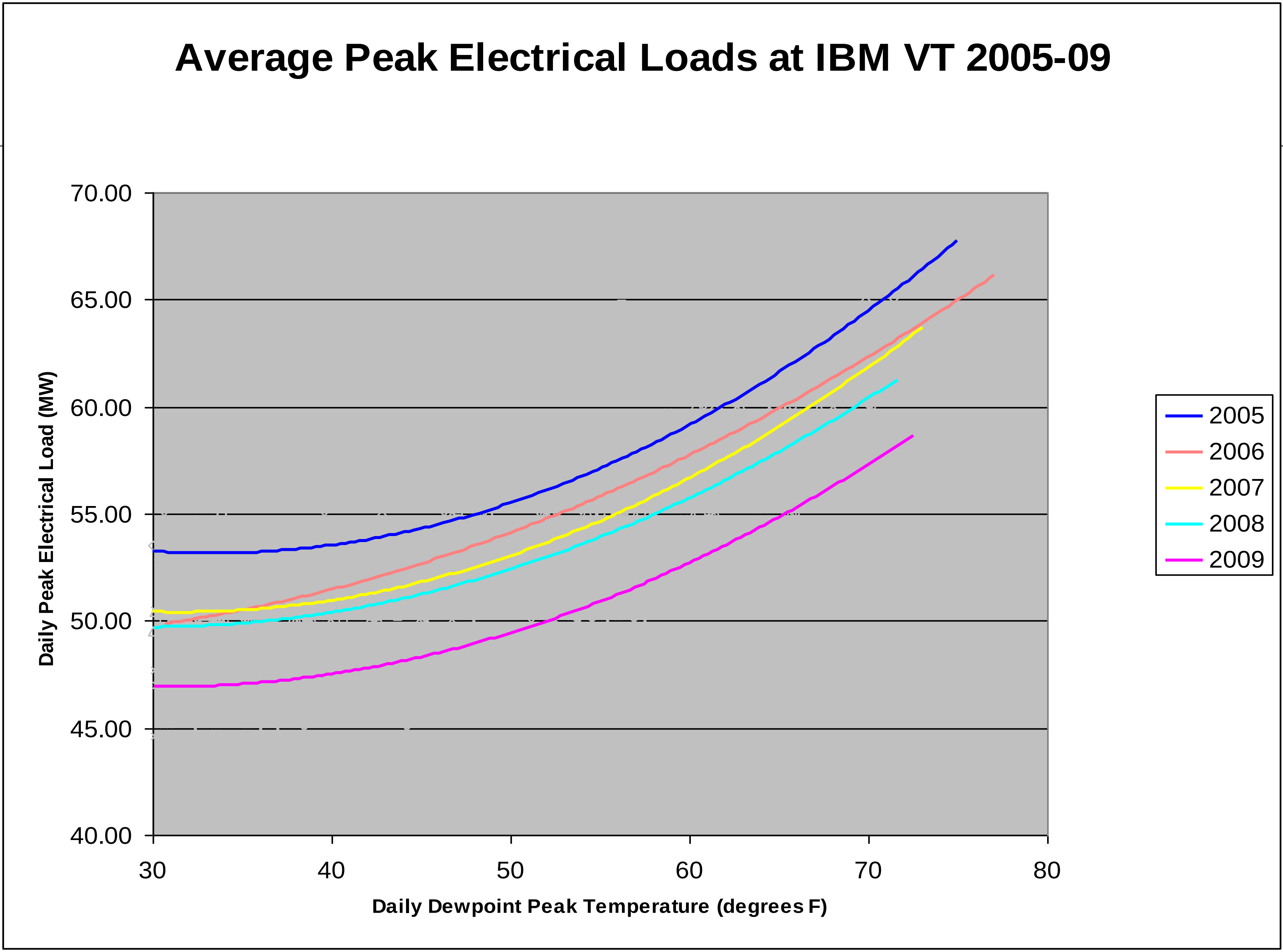
B963 / B971 Central Utility Plant
Reporting Results

- Reporting Results:
  - Energy Savings: 4,800,000 kWh
  - Money Savings: $390,000

  - Annual Energy Savings equal to 650 homes electricity consumption [Vermont]



- Results Exceeded Expectations
  - Central Utility Plant personnel clearly recognized and understood goals
  - Energy Savings exceeded Goal by $40,000
  - Winter Free-Cooling Utilization exceeded expectations by 60 days


Average Peak Electrical Loads at IBM VT 2005-09
Daily Peak Electrical Load (MW)
70.00
65.00
60.00
55.00
50.00
45.00
40.00
30
40
50
60
70
80
Daily Dewpoint Peak Temperature (degrees F)
2005
2006
2007
2008
2009

Value-Engineering Requires Real-Time Data
Employee Interaction is Critical

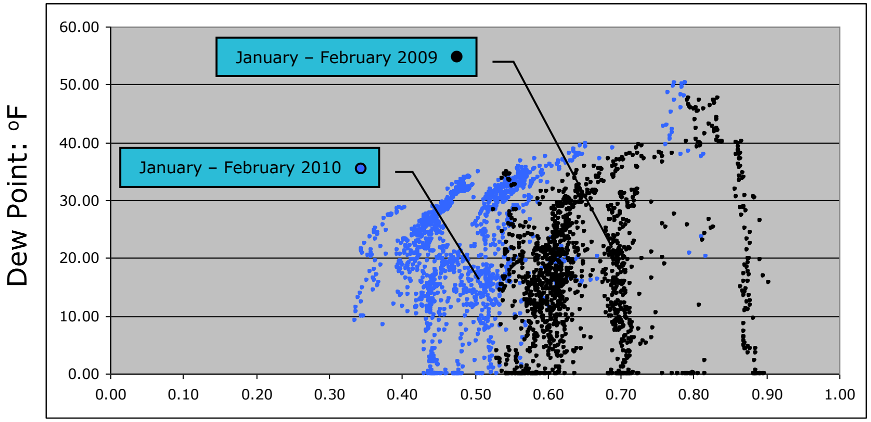
- Value-Engineering Requires Data
  - **Significant Data-Streams** are necessary for tracking results
  - Real-Time Response is critical for operational enhancements
  - Daily or Monthly Averages are not always adequate

- Employee Understanding and Interaction
  - Expectations must be at a working level
    - **“give them a knob to turn”**
  - Get Employees Involved…
    - Daily Logging of results

Winter Free-Cooling Daily Results

1	$2756.34	12	$3241.88	23	$4209.67
2	$3245.77	13	$3357.24	24	$4562.08
3	$3405.67	14	$3198.04	25	$4162.78
4	$3378.09	15	$3009.88	26	$4465.33
5	$3108.55	16	$3462.59	27	$4209.73
6	$2825.88	17	$3190.42	28	$4772.74
7	$3098.45	18	$3652.82	29	$4513.78
8	$3231.73	19	$3892.04	30	$4390.72
9	$2978.13	20	$3765.31	31	$4952.27
10	$2673.63	21	$3674.02		
11	$2995.43	22	$3841.53		

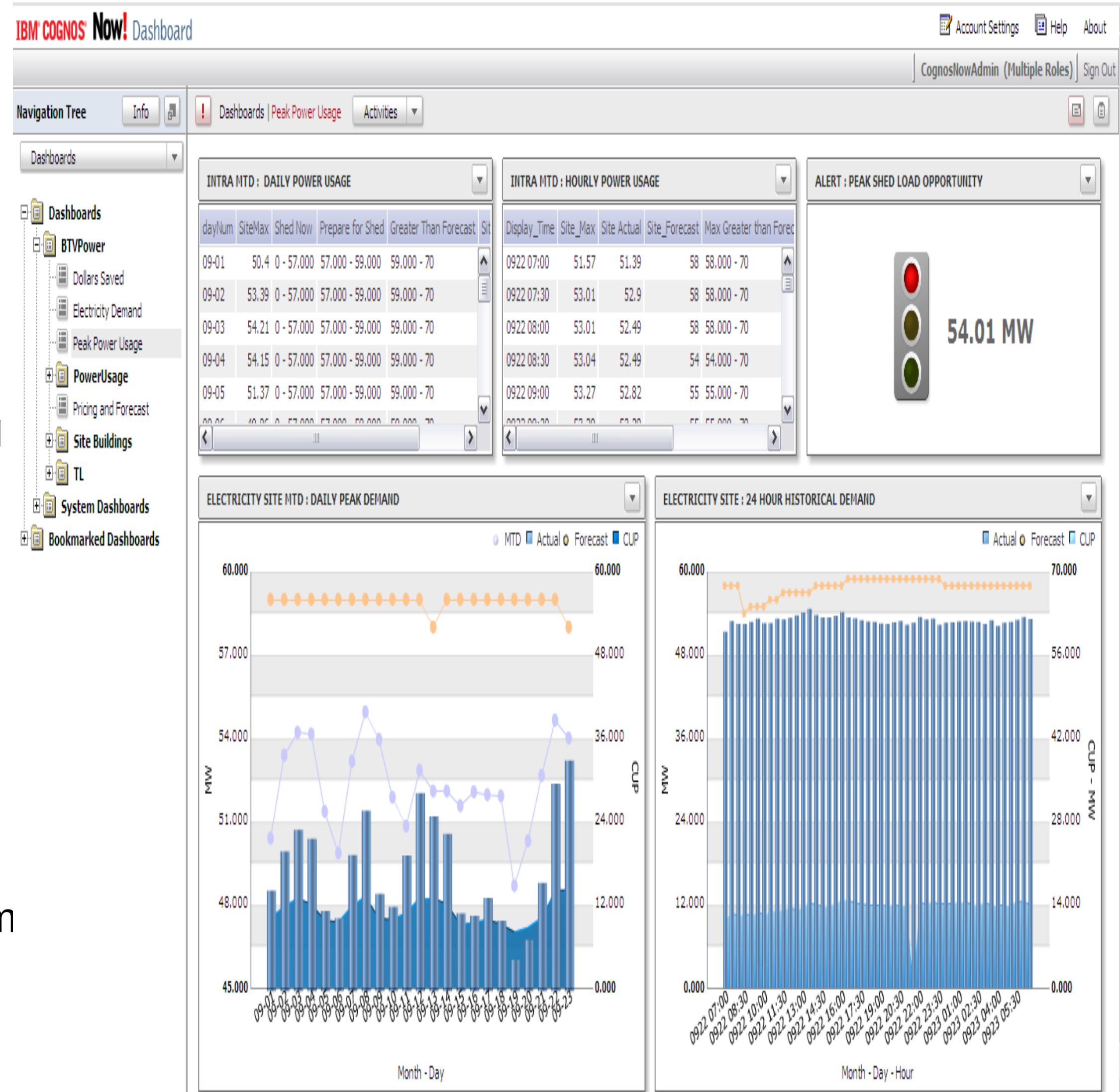
Chilled Water Energy Consumption Comparison
Dew Point vs. kW / ton [hourly data]



Chilled Water Production: kW / ton

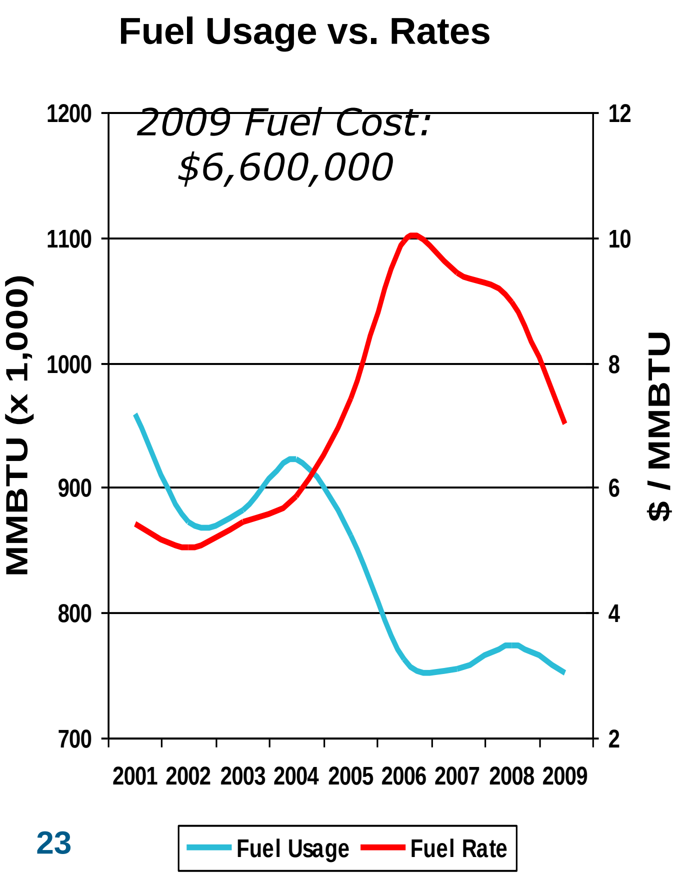
Smart City Application Development Dashboard for Peak Power Management

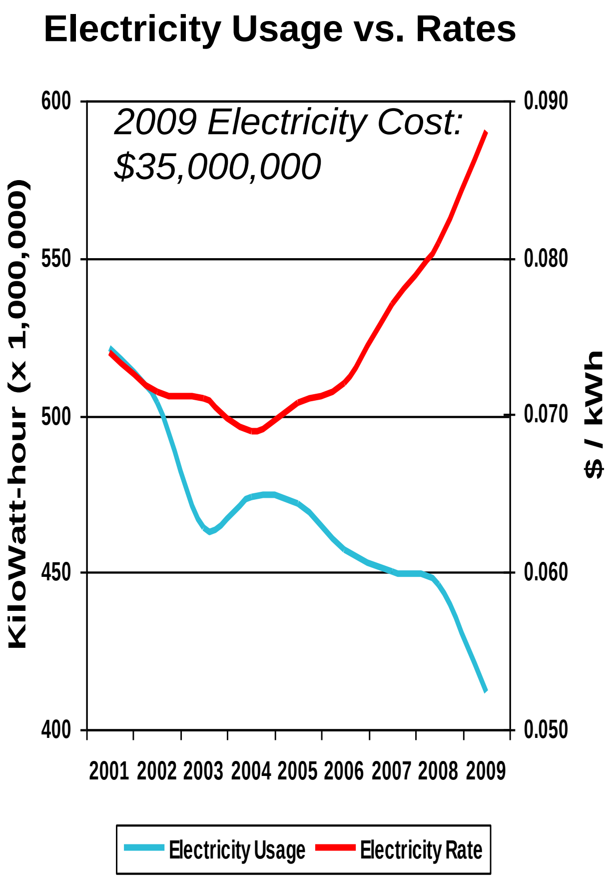
- Manage maximum power consumption to:
  - Lower Electrical Cost
  - Avoid infrastructure investments
  - Reduce Green House Gas emissions
- Requires complex data gathering and analysis
  - Multiple data sources
    - Deep Thunder
    - ISO-NE Market Pricing
    - Power Meters
    - Site Data
  - Predictive capability to forecast load shedding opportunities
    - ISO-NE 24 Hr Ahead Program



Energy Management Results

Quality: Strive for NO Power Quality Impacts to Manufacturing
Reliability: Continuous Operations – NO Manufacturing Down Time
Cost: Sustained minimum 4% Reduction per year





SINCE 2001

Fuel Usage
Rates: + 30%
Usage: - 21%

Electricity Usage
Rates: + 19%
Usage: - 21%
Cost: -$6.5M/yr

Plant Capability
Up > 30%

Key to Success: Consistent Process

Ultra Pure Water 2010 Objectives

Establish & Deploy Goals → Idea Generation → Evaluate and Prioritize → Implement → Monitor → Report & Feedback

Establish & Deploy Goals
RO Eff 87%
1M kw-hrs
Complete

Idea Generation
RO & UV Oxidation Low Cost
Complete

Evaluate and Prioritize
Ongoing
Data Analysis
Cost Model
Eng Evaluations

Implement
2Q2010
3Q2010

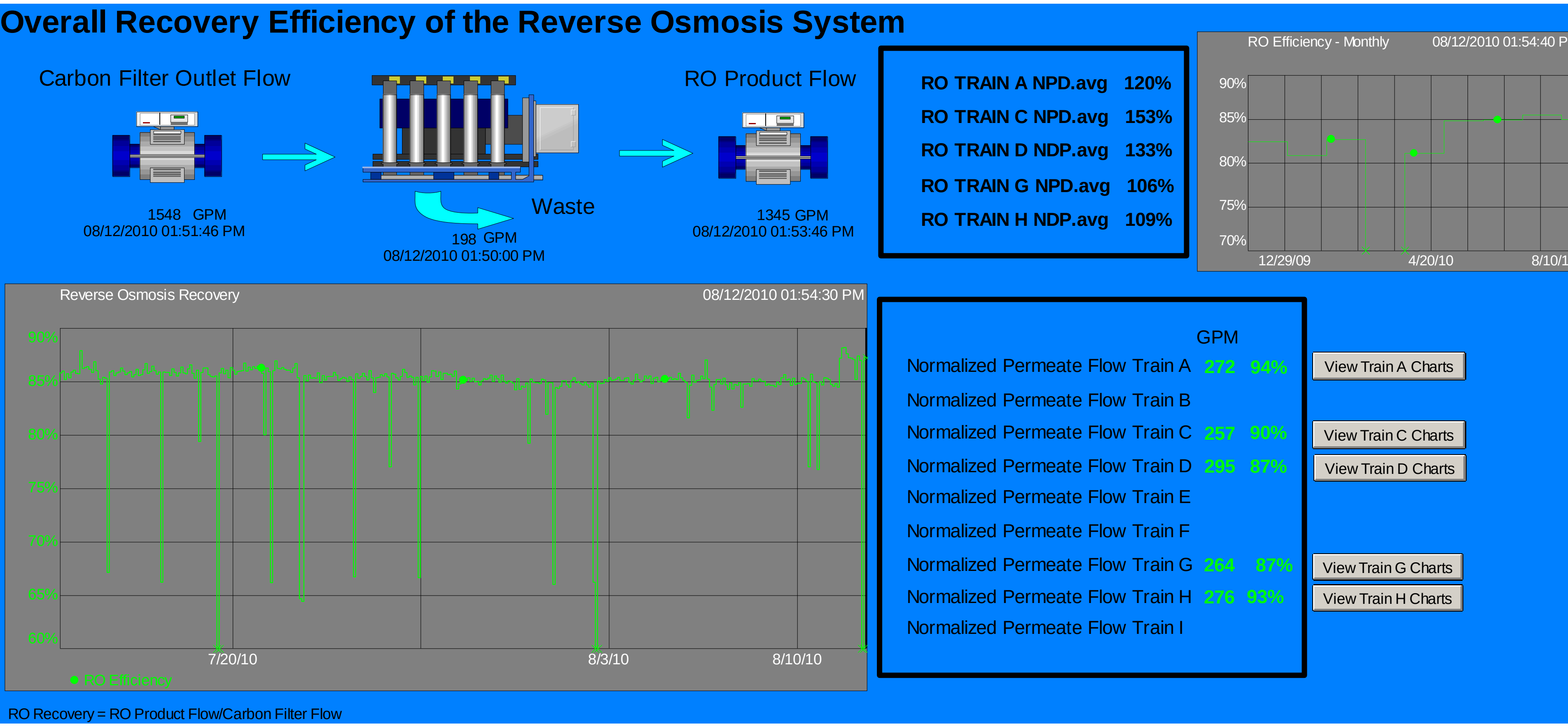
Monitor
In Place
Objective Specific Dashboards
Statistical Process Control

Use Structured Problem Solving Techniques for the more challenging ideas

2010 Goal: Ultra-Pure Water [RO Efficiency Metric]

Reduce Waste by 7%

Process Book Dashboard



Data Driven Decisions

Data Sources | **Analytics** | **Performance Monitoring**

Data Sources
- PI data
- Power Logic
- Web Services
- Lab Data
- GIS

Analytics
- Cost Models
- Statistical Analysis
- Predictive Models
- Deep Data Mining
- Process Models
- Trend Correlation

Performance Monitoring
- Process Book Dashboards
- SPC Shift Reports
- Cognos Dashboards
- Green Sigma Dashboards

IBM Vermont Environmental Recognition

- **EPA Climate Protection Award – 1998 & 2006**
  - **Energy Conservation, PFC Reduction**
- **EPA New England Merit Awards: Received in 2001 and 2003**

- **IBM Environmental Affairs Technical Excellence Awards**

- **National Pollution Prevention Roundtable 2007**
  - Most Valuable Pollution Prevention Idea – Wafer Recycling
  - Honorable Mention – Energy / Water Conservation Programs

- **2005 Environmental Protection Magazine Facility of the Year**

- **VT Dept of Environmental Conservation -Governor's Excellence Awards**
  - **1993 – 2009, 15 Consecutive Awards**

- **SONY Green Partner Certification**
- **2009 Green Mountain Water Environment Association**

- **2009 National Pollution Prevention Roundtable 2009**
  - **Most Valuable Pollution Prevention Idea**
    - **Wastewater Treatment Plant Improvements**