Smarter Planet. Smarter Buildings

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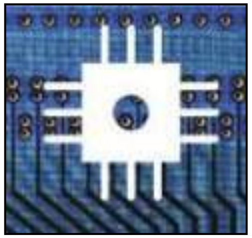
Something profound is happening: our buildings are getting smarter



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INSTRUMENTED

Facilities can be fully instrumented at all levels.

INTERCONNECTED

Building systems are interconnecting in entirely new ways.

INTELLIGENT

Intelligent interaction possible with externalities.

SMARTER

Information is shared to improve building operations and occupant well-being.





What *is* a Smarter Building?

Smarter Buildings are well managed, integrated physical and digital infrastructures that provide optimal occupancy services in a **reliable**, **cost effective**, and **sustainable** manner.

Smarter Buildings…

- Are more cost effective by reducing energy and operating costs.
- Use active and designed-in techniques to achieve reliability, efficiency and environmental responsibility.
- Provide Visibility, Control and Automation to building systems.
- Maintain a safer and more secure workplace.
- Communicate in real-time to supporting infrastructure (i.e. smart grid, broadband, etc.).

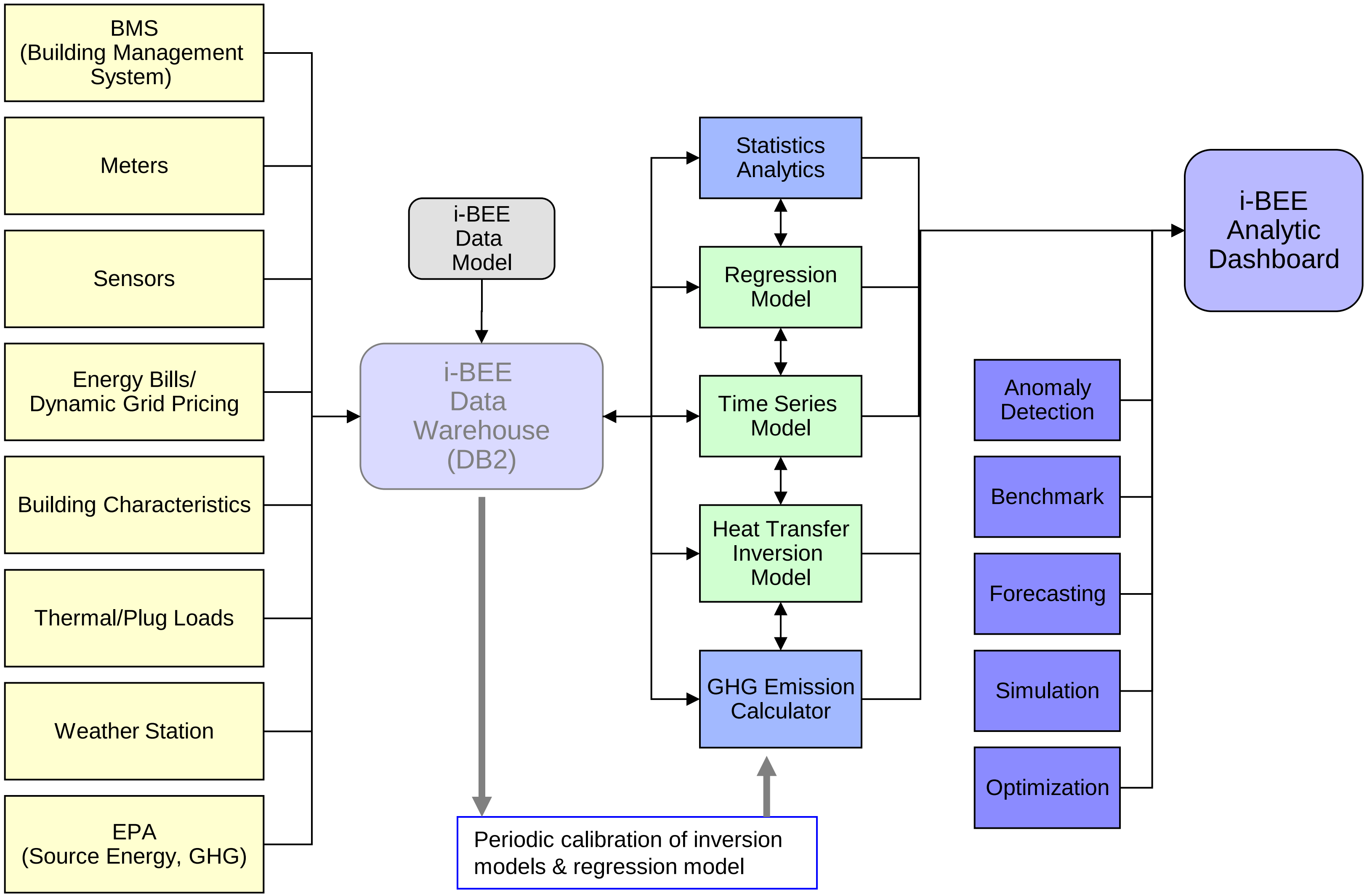
Smarter buildings must achieve the following results

- **Short term**
  - Meet energy and resource efficiency requirements from regulators and stakeholders.
  - Improve building efficiency through upgrades in equipment and materials that meet high energy efficiency ratings or certifications.
- **Medium term**
  - Integrate decision support tools with existing building systems to identify cost savings and optimize performance
  - Provide near real-time monitoring, control and user interaction
- **Long term**
  - Provide dynamic business models driven by real-time data and analytics to create energy-efficient, sustainable and secure buildings
  - Holistic optimization of the built environment, considering energy generation and usage in individual buildings, energy balancing and load shedding

Building Energy Analytics Research

- Develop scientific/mathematical models to understand patterns of energy usage and heat transfer as well as characteristics of building structures, operations and occupant behaviors that influence energy consumption in buildings
- Develop predictive analytics that are based on physics, statistics and mathematics
  - Assess how different energies are used (and GHG is emitted) in different ways
  - Benchmark energy (GHG emission) uses among peer buildings
  - Detect & diagnose faults/anomaly that can lead to failure of equipment and wasted energy
  - Track energy consumption and its changes due the improvement actions (e.g., retrofits)
  - Forecast future energy consumption (and GHG emission)
  - Simulate impacts of various changes (improvements) on energy consumption and GHG emission
  - Optimize energy consumption, efficiency and GHG emission, HVAC operations

Data & Analytics



Client Engagements

- **Client 1: K-12 Public Schools for NYC**
  - Large portfolio of public buildings: 1,400 buildings (150 million sq ft)
  - Minimal instrumentation, minimal automation
  - Mostly aggregated and static data
    - Historic energy consumption (monthly electricity, gas, oil & steam)
    - Building characteristics, operating months/hours, num of students…
    - Weather (HDD, CDD)
    - EPA Energy Star Portfolio Manager
- **Client 2: McMaster University Campus & Hospital, Canada**
  - Smaller portfolio of public buildings: 60 buildings in university campus & a hospital building (10 million sq ft)
  - On-site generation (co-gen)
  - Well-instrumented (meters, sensors, weather station)
  - Automation (BMSs)
  - Dynamic data + static data
- **Client 3: LG Electronics, Korea**
  - 3 Research Office Buildings
  - Well-instrumented
  - Multiple HVAC systems (AHU, EHP)
  - LG's new BMS
  - Dynamic data
    - 15 minutes interval data from over 900 sensor/meter points
    - Weather forecast
    - Operational schedules of various loads
    - Plug load data
- **IBM Watson Research Center, Yorktown Heights, NY**
  - Energy simulation with EnergyPlus
- **EEB Hub (Energy Efficient Buildings Hub)** – DOE funded 5 Year Project with 22+ Institutions
  - Goal: To reduce annual energy use in the commercial buildings sector in Greater Philadelphia by 20 percent by 2020.

Hands-on computer lab iBEE training is incorporated into the nationally-recognized Building Operator Certification curriculum as part of required training for NYC public school custodians beginning April 18, 2011 and continuing over the next 2 years.

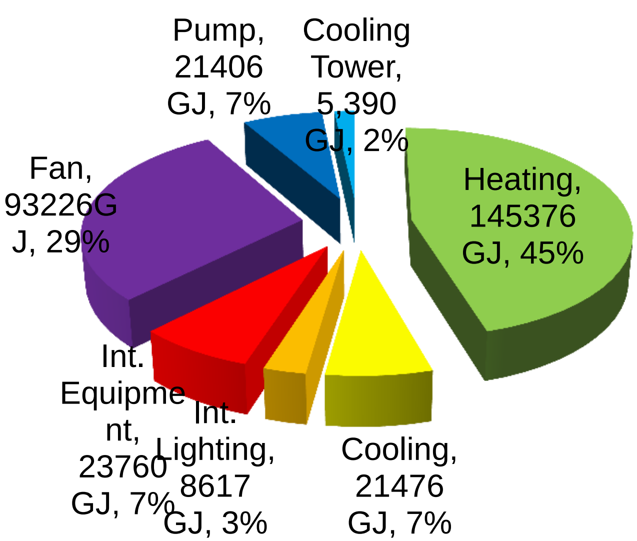

IBM
T.J. Watson Research Center
Research Division
Yorktown
www.ibm.com

IBM Yorktown Watson Research Lab Energy Simulation (with EnergyPlus)

Objective

- Estimate energy savings opportunity from application of thin film to windows of Watson Yorktown building (B/801) using whole building energy simulation tool (EnergyPlus)
  - Window performance analysis
  - Energy savings
  - Simple ROI (Return of Investment) calculation
- Investigate other energy saving opportunities and estimate the savings
  - Replacing the windows to double-pane & triple-pane
  - Other operational changes
    - Set point override
    - Air delivery method modification

Simulated Energy Use Breakdown



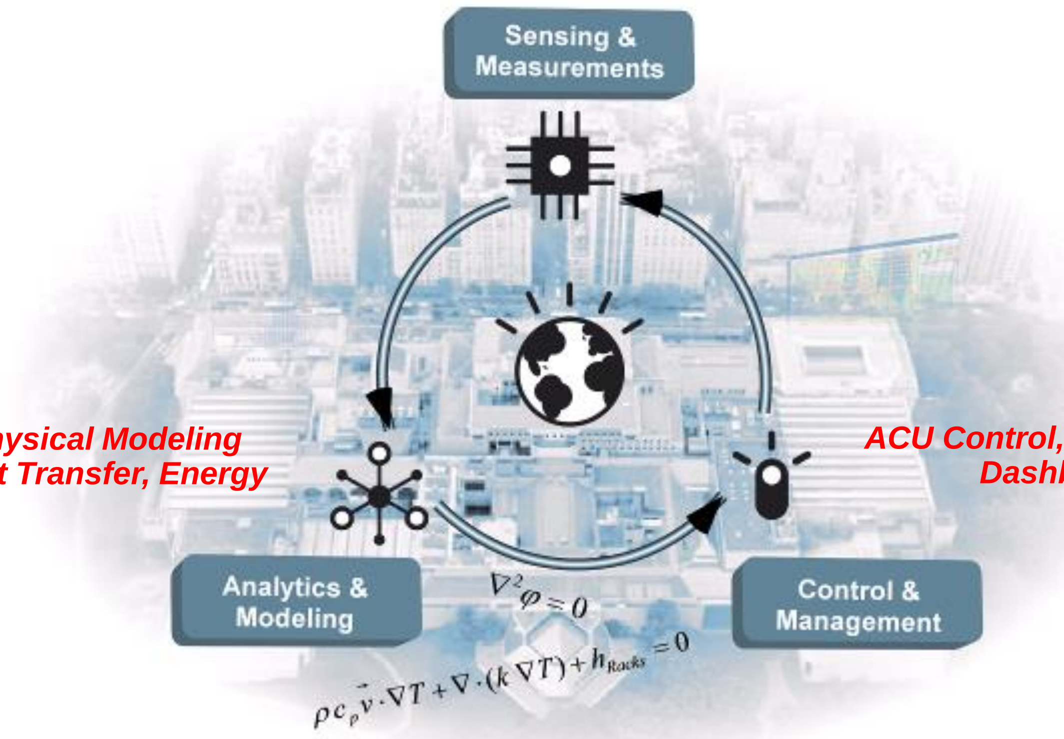
Estimated Energy Saving Potential [$/year]

	Elec.	Cooling	Heating	Total Saving
Original (Baseline)	4,833,808	801,385	1,700,005	-
Original+LE Film	4,771,460	789,982	1,722,540	-51,215
	(62,347)	(11,403)	22,535	
Simple double	4,796,880	799,259	1,645,297	-93,762
	(36,928)	(2,126)	(54,708)	
Double LowE	4,746,656	749,673	1,552,557	-286,311
	(87,152)	(51,712)	(147,448)	
Triple LowE	4,706,531	739,648	1,551,004	-338,015
	(127,277)	(61,737)	(149,001)	
Set point control(office)	4,641,317	781,518	1,739,856	-172,507
	(192,491)	(19,867)	39,851	
Set point control(Lab)	4,614,370	756,352	1,647,760	-316,715
	(219,438)	(45,033)	(52,245)	
Lab System modification (Dual duct Mixing box → VAV Reheat)	4,841,058	750,105	1,611,772	-132,263
	7,251	(51,280)	(88,234)	

A Research Prototyping Vehicle : Measurement and Management Technologies (MMT)

Low Power Mote Technology (LMT) & Novel Sensors

Physical Modeling Heat Transfer, Energy

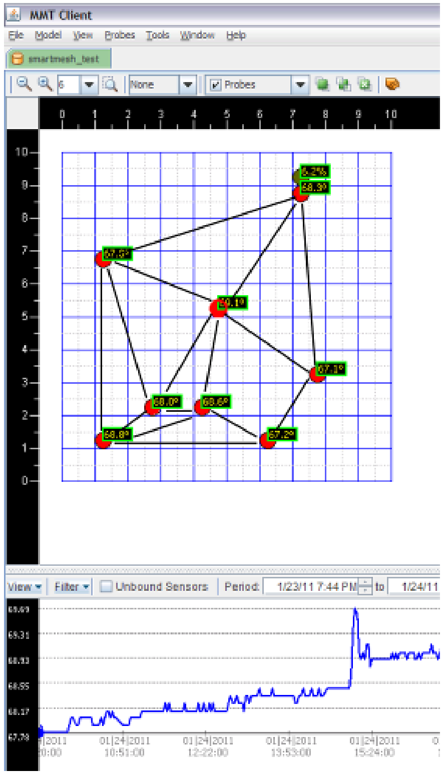


ACU Control, MPC, Alarms, Dashboards

Measurement and Management Technologies (MMT):

- **High resolution and real-time sensing systems**
- **Deep analytics**
- **Management and optimal control**

Low-Power Mote Technology (LMT)



- **LMT—a general wireless data gathering and control technology**
- **World's lowest power consumption**
  - 5 to 7 year lifetime with two AA batteries
  - Forms mesh network, highly reliable, robust and scalable
- **Very flexible and modular design**
- **Only Technology with localization capabilities (down to 1-2 feet)**
- **Environmental sensing:**
  - Temperature and Humidity
  - Dew point
  - Pressure, Air flow
  - Particulates
  - Carbon dioxide
  - Presence and Occupancy
  - Corrosion and Air quality
  - Smell
  - Door positions
  - Assets, Location

NY Metropolitan Museum of Art

- **Customer objective: Improved preservation of art by monitoring, modeling and managing micro-climatic conditions**
- **Monitoring and management solution must be aesthetically pleasing**
  - **No wires, ultra-small footprint**
  - **no disruption to the business**
- **LMT/MMT first deployed at the Cloisters of Metropolitan Museum**
  - **national historic landmark**
  - **assembled from 5 medieval French cloisters from 15th century**
  - **hosts over 5000 works of art**
- **System senses and manages**
  - **temperature, humidity, corrosion, contamination, light levels, air flow, pressure, people movement, door positions etc**

NY Metropolitan Museum of Art - Results

***1. Predictive Analytics* of micro-climatic conditions by forecasting**

- **Onset of increased *condensation risk* (as a function of outside/inside temperatures, humidity and numbers of visitors)**
- ***Air quality* (corrosion, VOC) (as a function of numbers of visitors, temperatures, humidity, wind direction, outside contamination levels)**

***2. Optimization* for improved art preservation**

- **Optimal placement of works of art within the museum's environment**
- **Numbers of visitors**
- **Optimize HVAC control system**

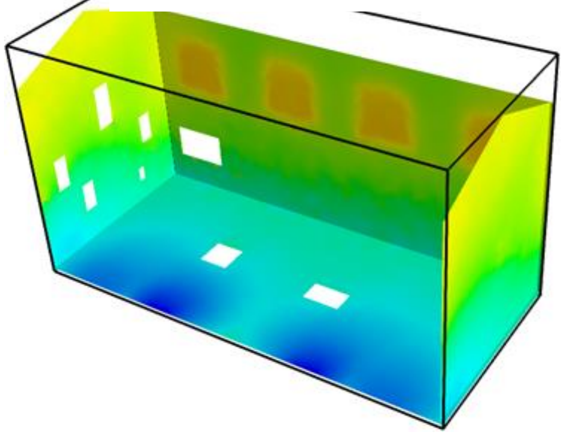
Improved and more scientifically based approach for art preservation in a museum's environment

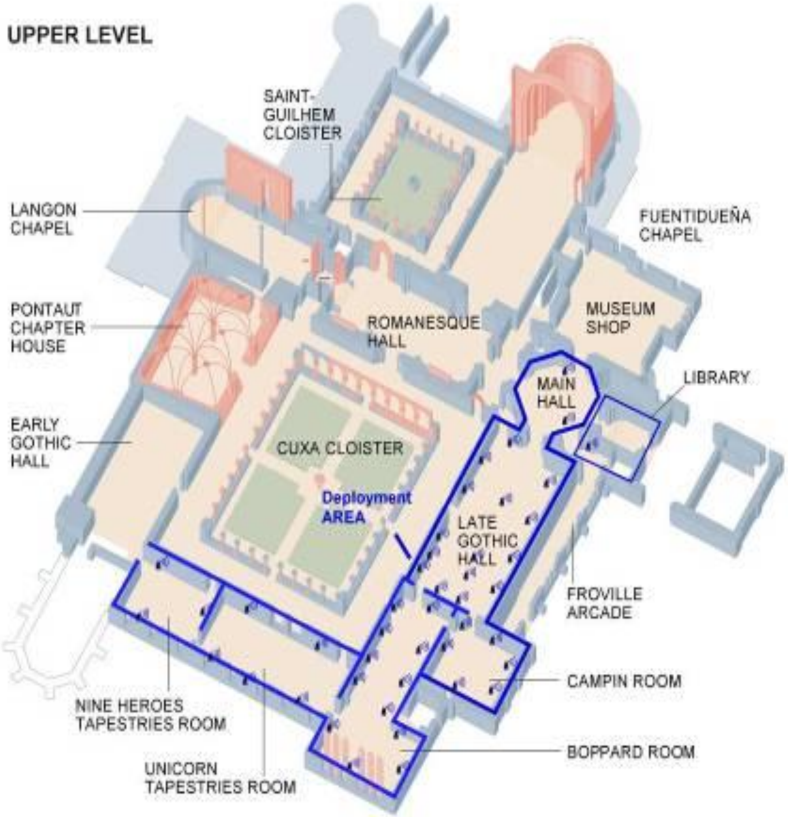
http://www-03.ibm.com/press/us/en/pressrelease/34696.wss

Deep Analytics and Modeling

Late Gothic Hall

3D Heat Distribution





- **Real-time data is directly fed into operational models which leverage deep physical analytics, to derive micro-climatic conditions in the museum.**
- **Models yield 3D temperature, humidity, dew point and contamination variations to guide conservators for optimal placement of works of art.**

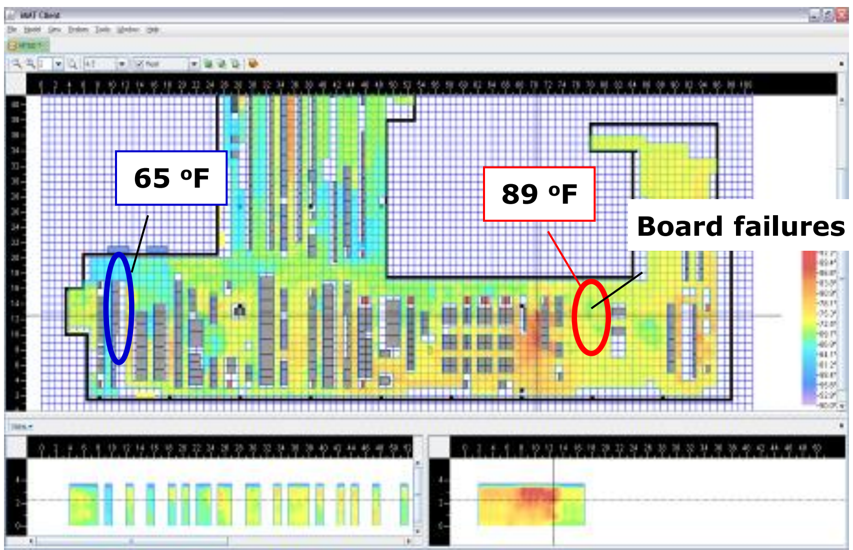
Application or MMT/LMT to Telecommunication Facilities

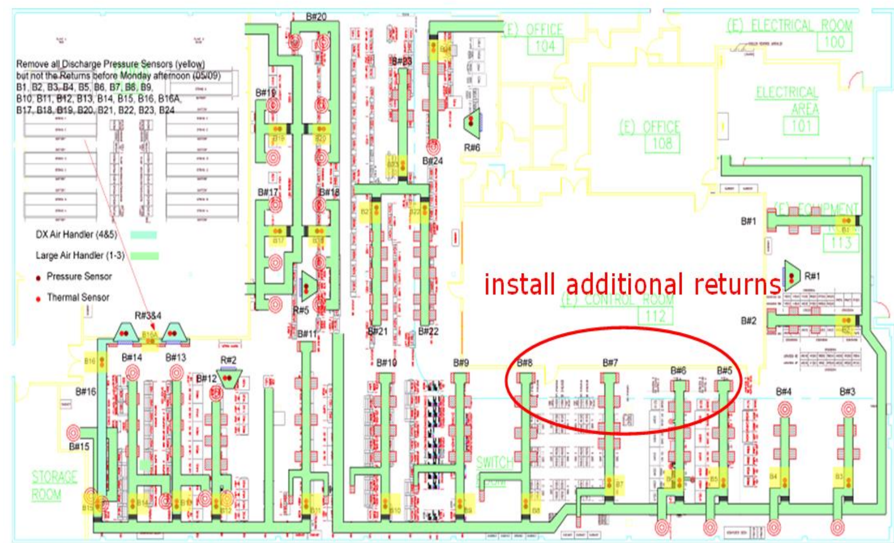
- **Strategic site for a major US telecommunication company**
  - **over 10M voice calls and 6 TB of data daily**
  - **350 kW of network power in 12k square feet**
  - **$1.2M of annual utility cost (more than 50 % for cooling)**

- **Customer Pain Point: Cooling/thermal management challenges are the main inhibitors to support additional network growth**
  - **currently 1-2 heat induced board failures per week ($60k per board)**
  - **countless service outages due to overheating**
  - **similar issues at other sites all over the country**

Application to Telecommunication Facilities

- **Installed dense LMT/MMT solution including air ducts etc.**
- **Installed automatic ACU controls**
- **Enabled free cooling using IBM's corrosion sensing and management technology**
- **Rebalanced of overhead cooling systems and automatic VAV controls**





- **$120k of annual energy savings**
- **No more board failures**
- **Enable an additional 10 % network growth**
- **6 more sites being deployed**

Telecommunication Facilities - Results

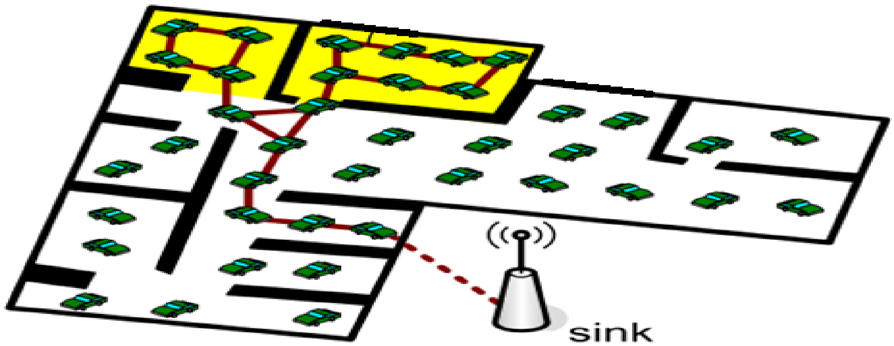
Feature	Benefits	Energy Savings
Real-time heat/humidity/ pressure/flow maps	▪ Prevents hotspots ▪ critical for best practices' implementation	$15k
Power Management	▪ Increases UPS utilization ▪Reduces "stranded" power	0
Operational CFD support	▪ Improves planning and optimize DC layout	$25k
Energy Efficiency Reporting	▪ Enables consistent management of energy efficiency	$15k
Cooling Zones	▪ increases utilization of cooling infrastructure	$15k
Corrosion Management	▪ Outside air economization ▪ Improved reliability / resiliency	$45k
Integrate-able with asset and lifecyle management, BMS etc	▪ Operational improvements	$15k

$120k of annual energy savings

Sinberbest WP3: Wireless Sensor Network in Smart Buildings
Zhili Zhou (IBM), Peter Chong (NTU)

- Challenges for wireless sensor network in smart buildings
  - Cyber Security
  - Energy efficiency
  - Boundary vs. distance
  - Dynamic environment
    - weather / natural lights / human mobility

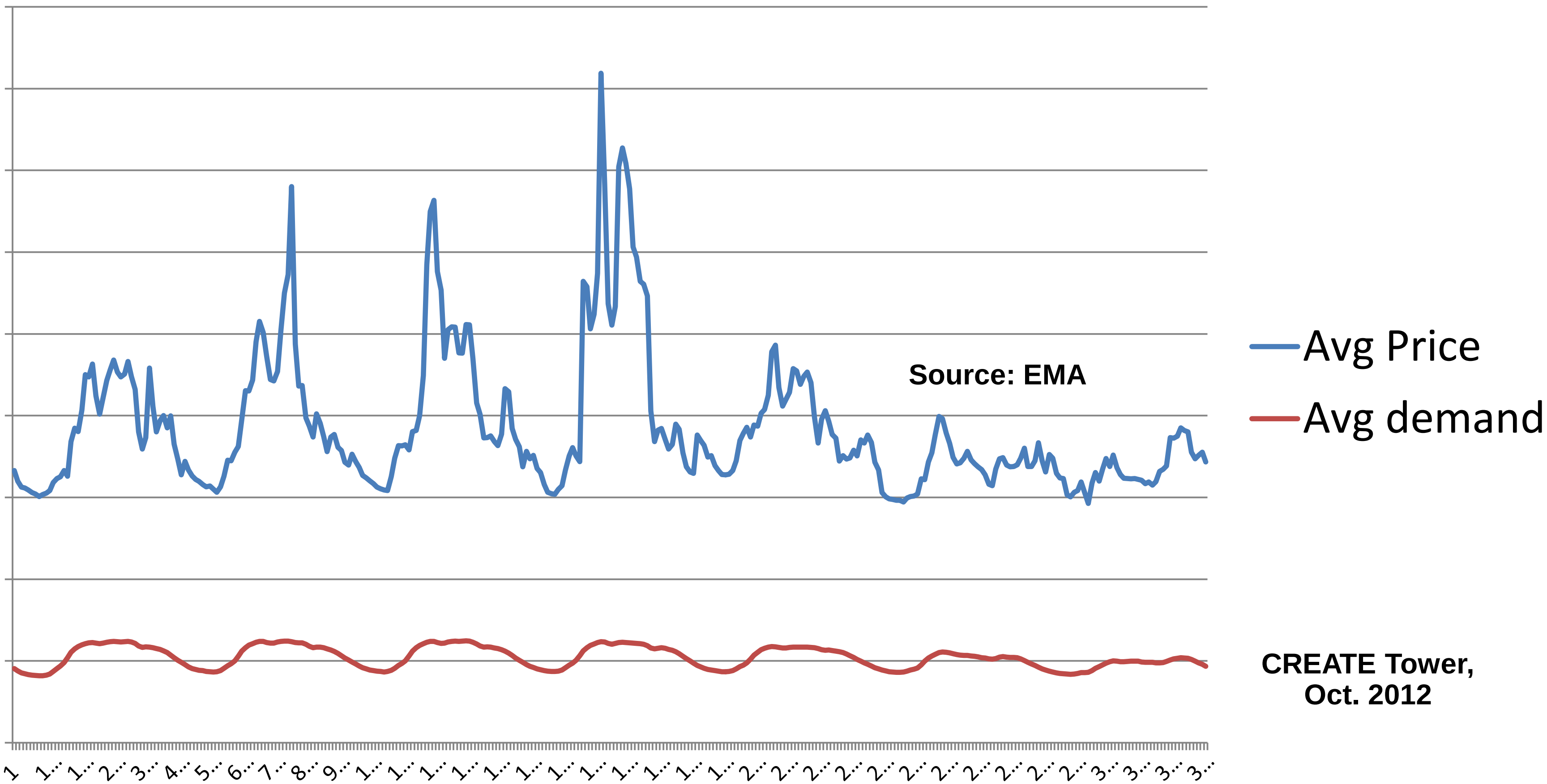
Figure 1: WSN in Building



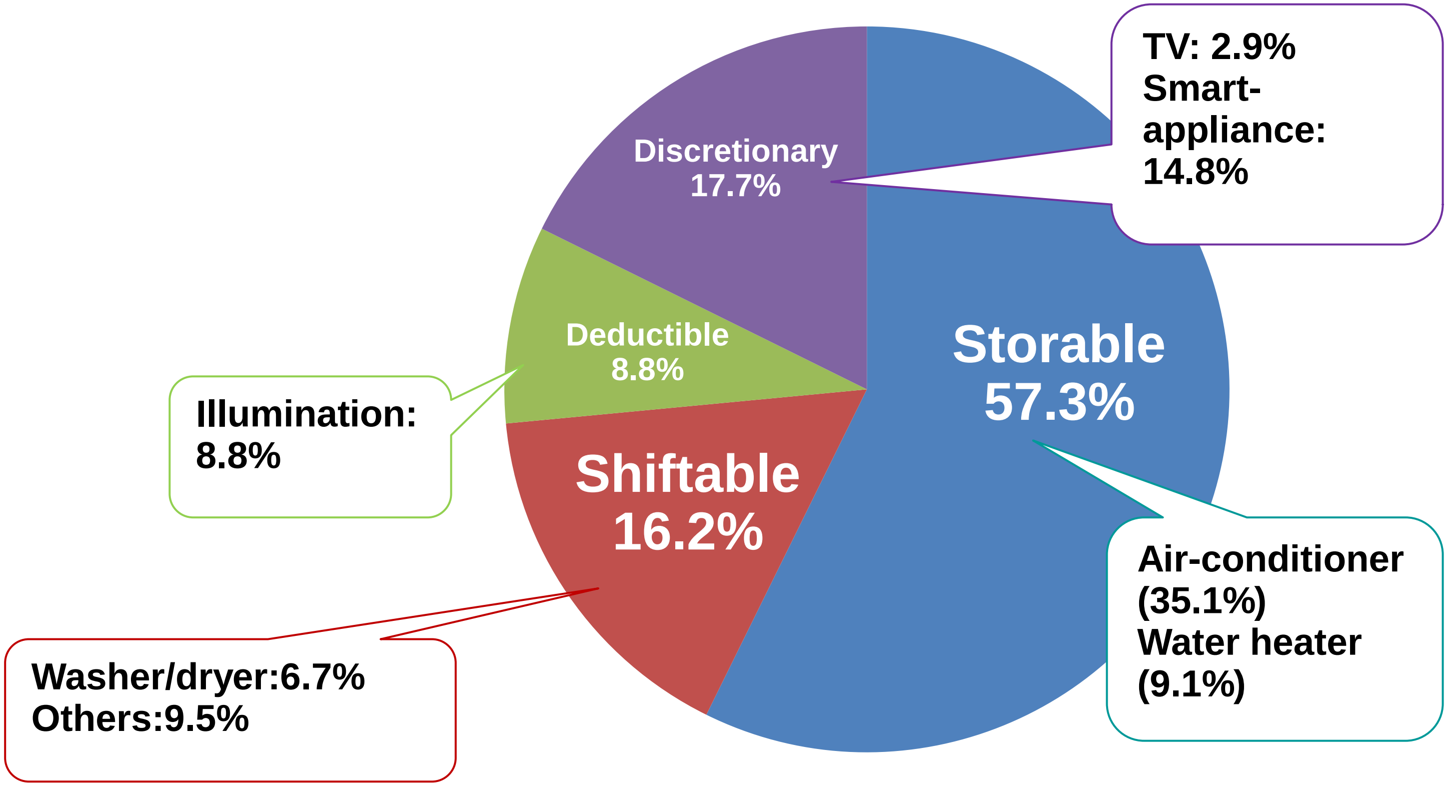
- Survivable network design and survivable communication routing
- Integration of WSN design with optimal task scheduling
- Dynamic communication synchronization for dynamic environment monitoring

Sinberbest WP3: Demand Management for Buildings

Zhili Zhou (IBM), King Jet (NTU)



Categories of Electricity Demand



Demand Reponses with Incentive Price Scheme

- Solution approach: dynamic pricing strategies with stochastic demand
  - Objective: minimizing the cost of energy consumption in buildings

  - Decision variables: rebate price p_t and consumption $q_t : (q_t^i, q_t^a)$
  - Constraints:
    - Space temperature θ_t with lower/upper bounds: $l_t \leq \theta_t \leq u_t$ (t-1)

    - Building model: Cooling system with room temperature
      Heat transform model:

$\dot{Q}_t^{net} = \dot{Q}_t^{in} - \dot{Q}_t^{out} + \Delta_t\,(\overrightarrow{o_t})$ (b-1)

$\theta_{t+1} = \epsilon\theta_t + (1-\epsilon)\left(\omega_t - \frac{\gamma}{hA} q_t^a + \frac{\Delta_t(\overrightarrow{o_t})}{hA}\right)$ (b-2)

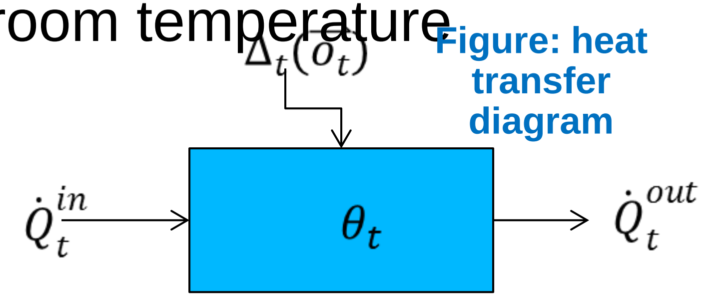
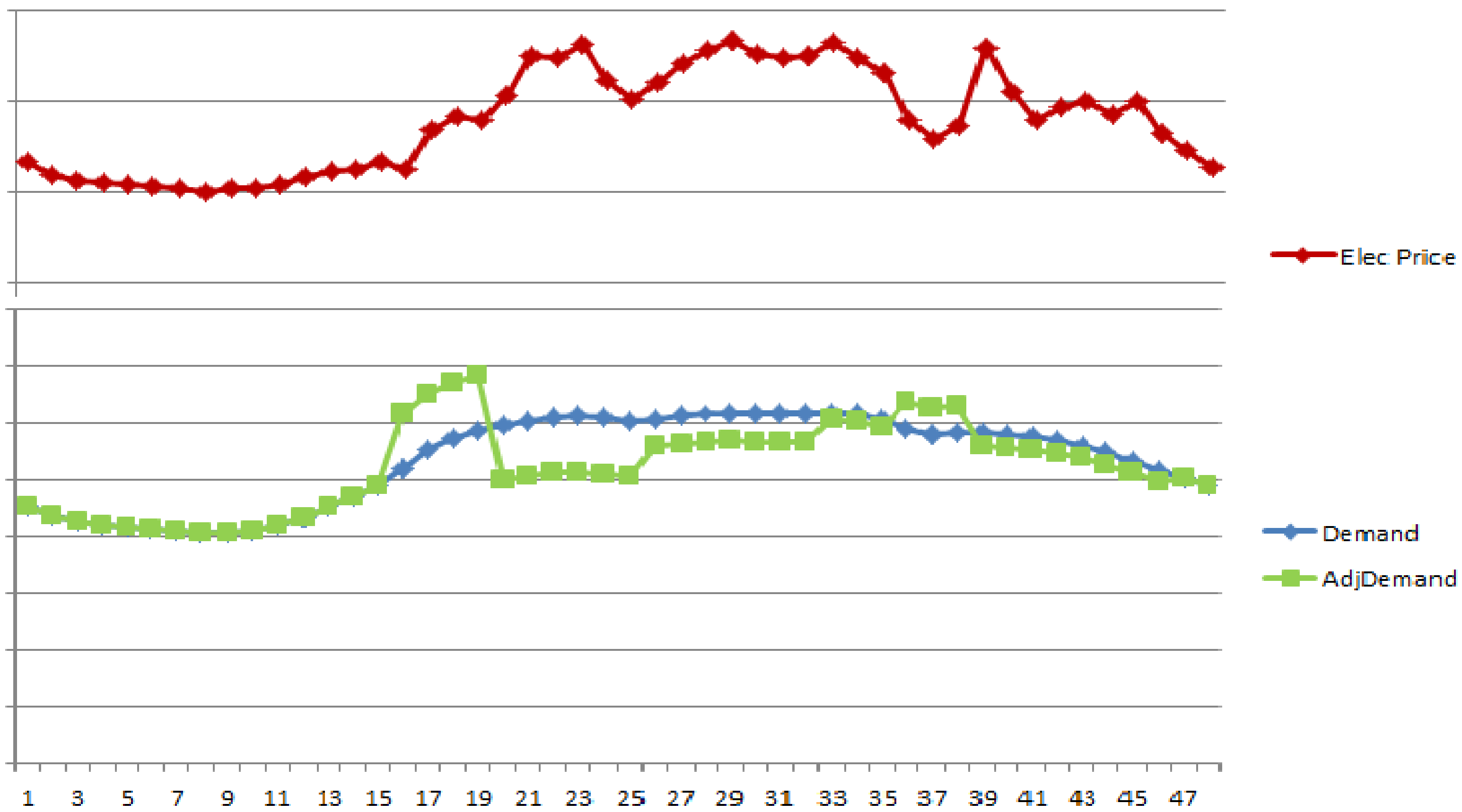


Figure: heat transfer diagram

- Scheduling: deductible electricity consumption q_t^i by illumination
  $I_t \leq q_t^i$ (i-1)

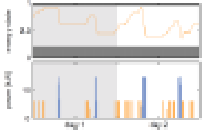
Preliminary Simulation Results

- **Demand response with electricity price**

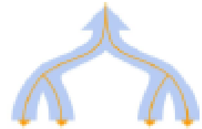


Solution Architecture: IBM Flexible Load Management Solution

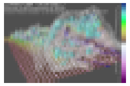
Load Modeling
Accurately models the load capturing the consumption flexibility.
- Energy needs
- Timing, location
- Simulation
- Prediction



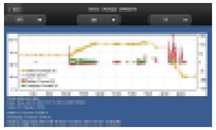
Flexio Optimization
Creates flexible consumption plan considering:
- Load constraints
- Grid state
- Energy availability
- Ancillary services



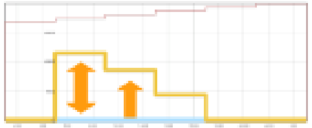
Platform Services
- ILOG CPLEX Optimizer
- Data Warehouse
- Weather Prediction



User Interfaces
- Web, Smart Phone
- End User, Load Manager
- Flexible Load Mgmt Solution GUI



Flexible Load Mgr
Protocols to completely realize available flexibility



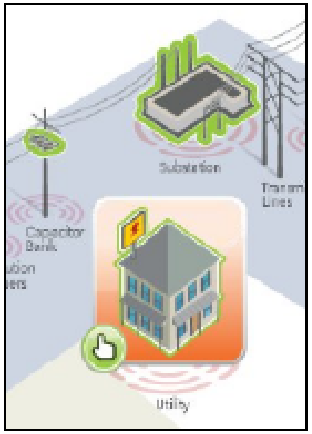
B-to-B Interfaces
- DSO, TSO
- Energy and Regulation Markets
- SCADA, Load Manager, IEC 61850
- Billing, Clearing, Auditing

Communication/Integration
Data Integration | Security

Monitoring and Control

Flexible Load

Utility



Thank You