



Smarter Energy for a Smarter Planet

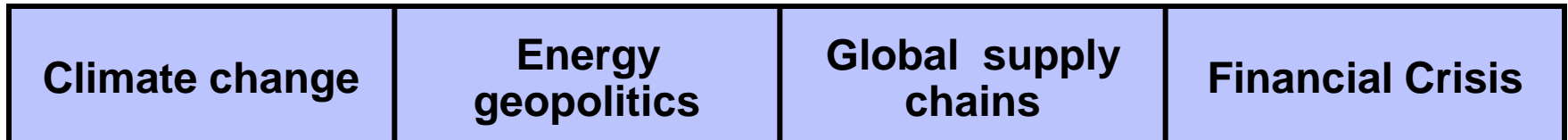


Dr. Dario Gil
Program Director, Smarter Energy
IBM T.J. Watson Research Center

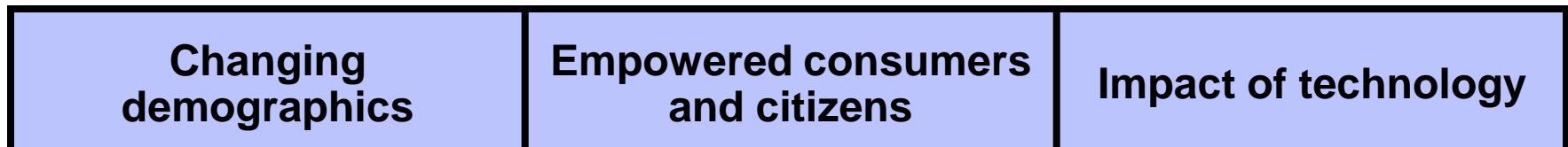
We are experiencing the reality of global integration.



A series of shocks:



Plus rapidly evolving and ongoing significant trends:



We Now have the Ability to Measure, Sense and Monitor the Condition of Almost Everything.

30 billion

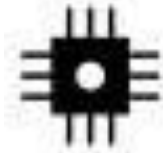
By 2010, 30 billion RFID tags will be embedded into our world and across entire ecosystems.

1 billion

By 2010, there will be more than 1 billion camera phones in existence.

85%

Nearly 85% of new automobiles will contain event data recorders by 2010.



Instrumented



Instrumented



Interconnected



Intelligent



People, Systems and Objects can Communicate and Interact with Each Other in Entirely New Ways.

2 billion

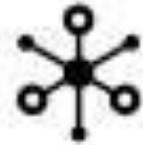
There will be an estimated 2 billion people on the internet by 2011.

4 billion

There are an estimated 4 billion mobile phone subscribers worldwide.

1 trillion

Soon, there will be 1 trillion connected devices in the world, constituting an "internet of things."



Interconnected



Instrumented



Interconnected



Intelligent



We Can Now Respond to Changes Quickly and Accurately, and get better Results by Predicting and Optimizing for Future Events

50 terabytes

Agricultural consultancy Lanworth crunches more than 50 terabytes of satellite images, digital soil maps and weather forecasts to make more accurate crop forecasts.

1 petaflop

Scientists are working to prevent influenza outbreaks by modeling the viruses with a super-computer that can operate at one petaflop, or one quadrillion operations per second.

100,000

Electronic medical records could prevent an estimated 100,000 deaths a year from medical error.



Intelligent



Instrumented



Interconnected



Intelligent



Building A Smarter Planet: The Next Agenda for Technology

Interconnected Technologies Are Changing The Way The World Literally Works



An opportunity to **think and act in new ways** — economically, socially and technically.



Our world is becoming

INSTRUMENTED



Our world is becoming

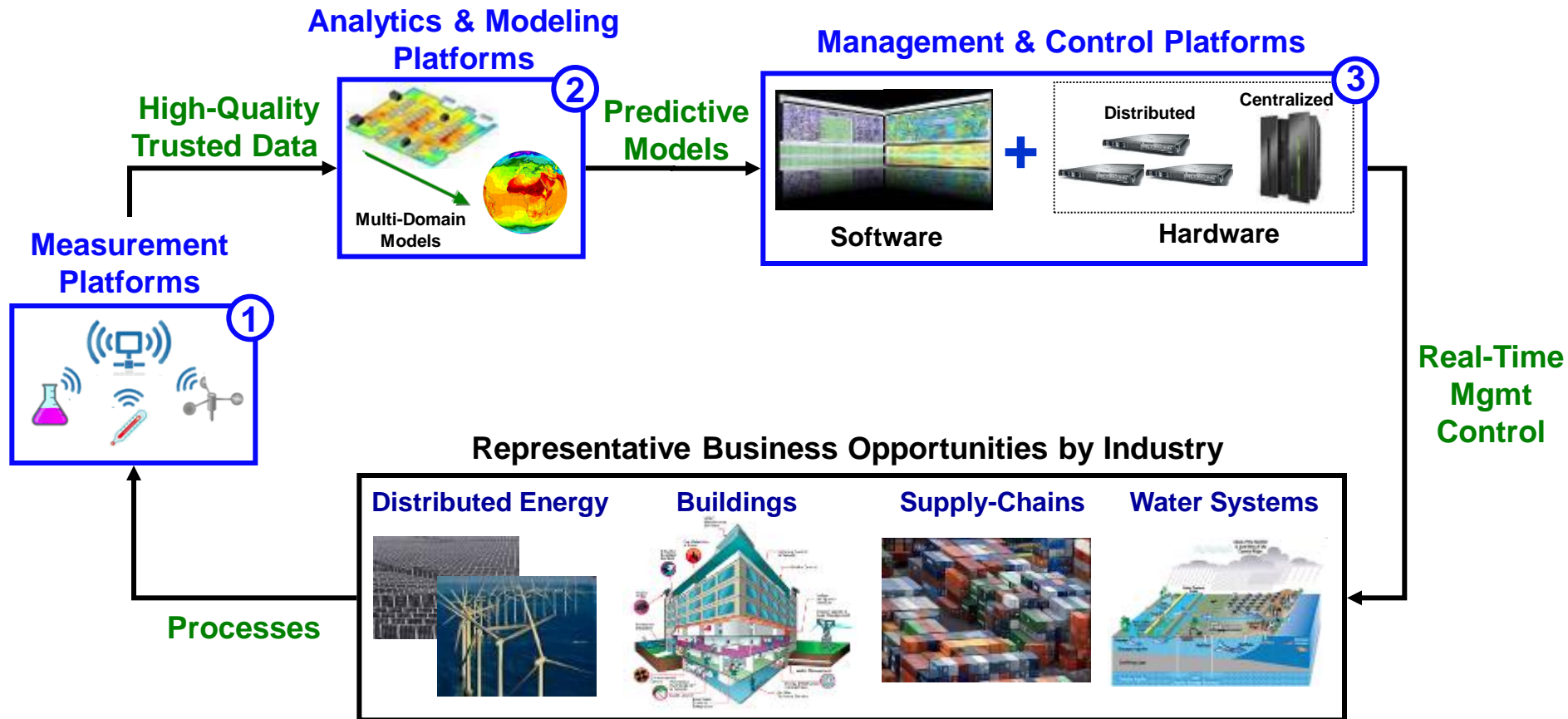
INTERCONNECTED



Virtually all things, processes and ways of working are becoming

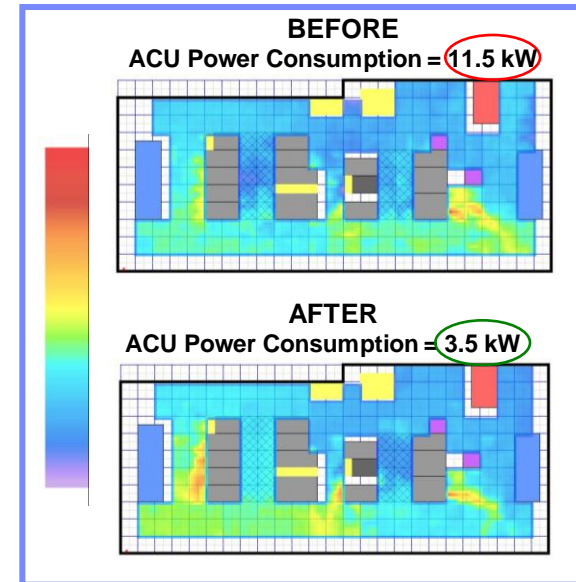
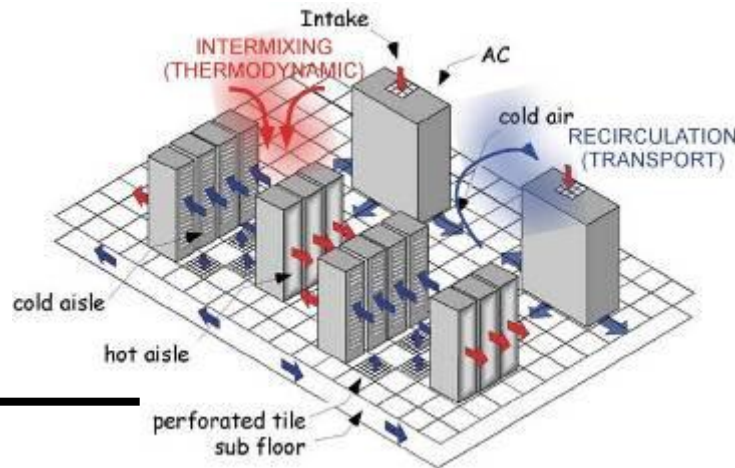
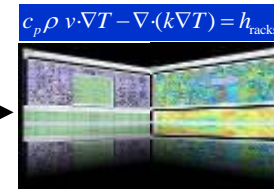
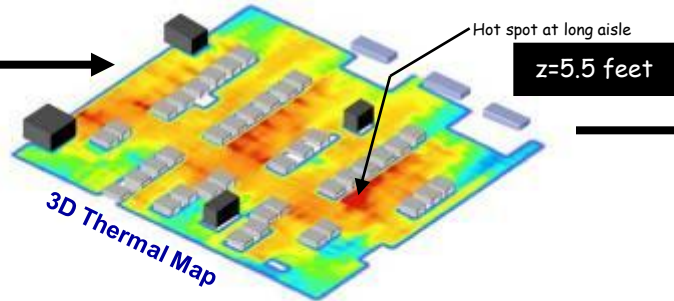
INTELLIGENT

Real-Time Measurement, Modeling & Control Platforms will Drive a Smarter Planet Through the Broad Implementation of Feedback Control



Interconnected Systems: The Role of Physical Modeling

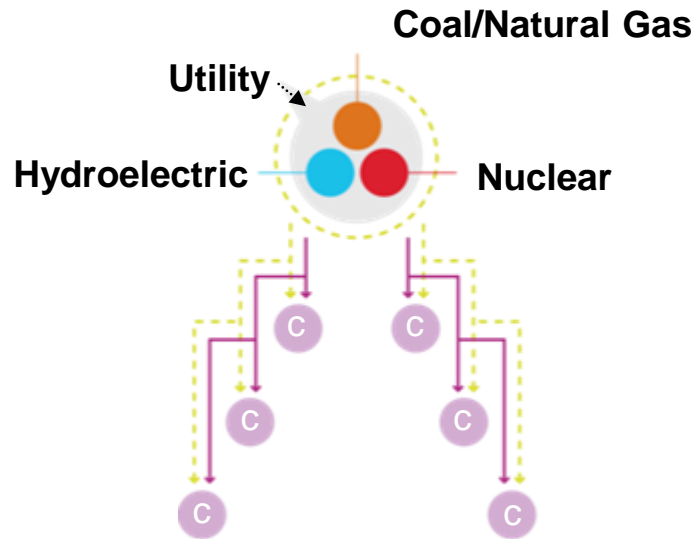
Case Study: Energy Management of Data Centers:
Average Result: 20% Total Energy Reduction



Data Centers Consume ~2% of Electricity in the US (consumption growth is >12%)

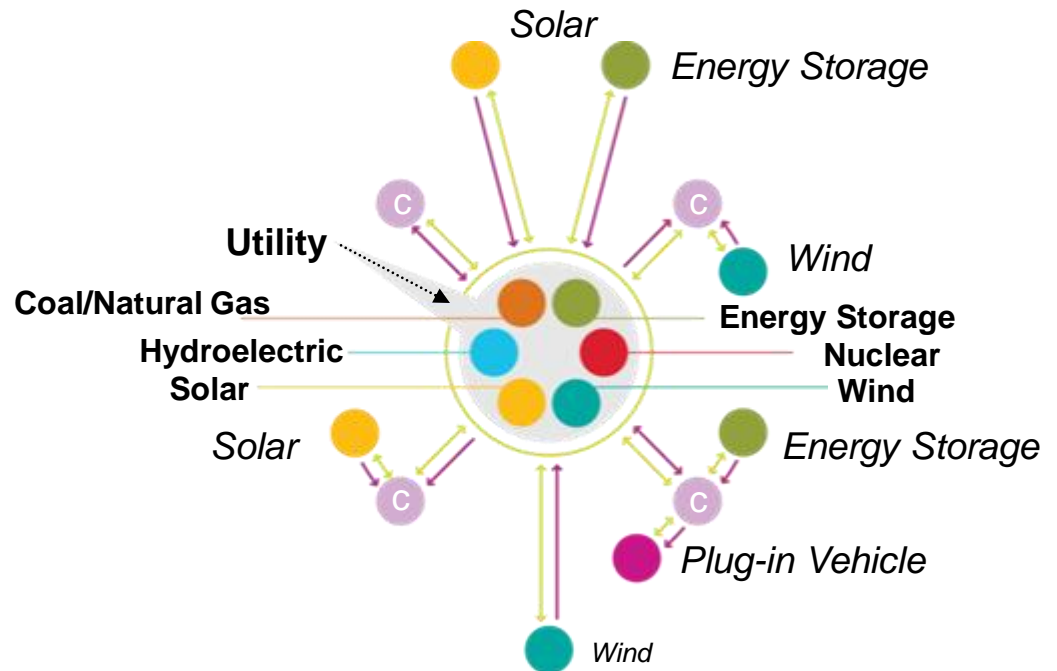
Energy and Utilities Market Forces are Creating the Need for an Evolution in the Energy Value Chain

TRADITIONAL ENERGY VALUE CHAIN



- Consumer
- Power Flow
- Periodic Information Flow
- Continuous Information Flow

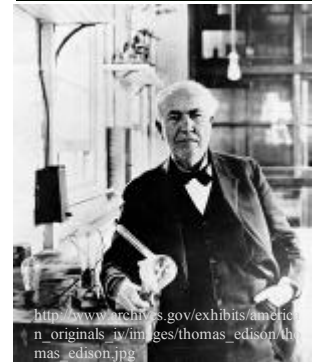
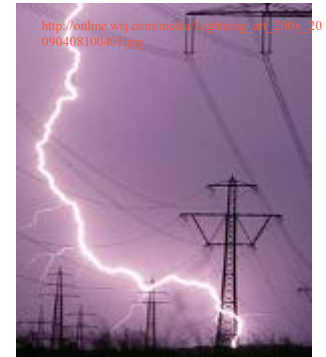
TRANSFORMED ENERGY VALUE CHAIN



Drives Transformation Of Policy And Business Models

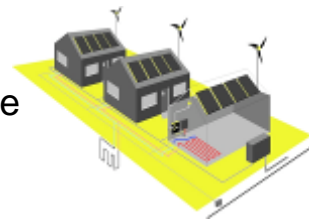
Major electric grid challenges facing the US

- Aging limited infrastructure to capacity constraints as demand continues to grow, about 25% since 1990, while construction decreased by ~30%¹.
- Heterogeneous mix of equipment that dates back to the 1880's and the days of Edison, but it is also the heart of much of the critical U.S. infrastructure of not only energy, but communications, transportation, water and more.
- The transmission system represents over 211,000 miles of high voltage transmission lines (>230kV) with limited growth due to physical and societal constraints. Likewise the distribution system and even consumer side management have only seen limited upgrades.

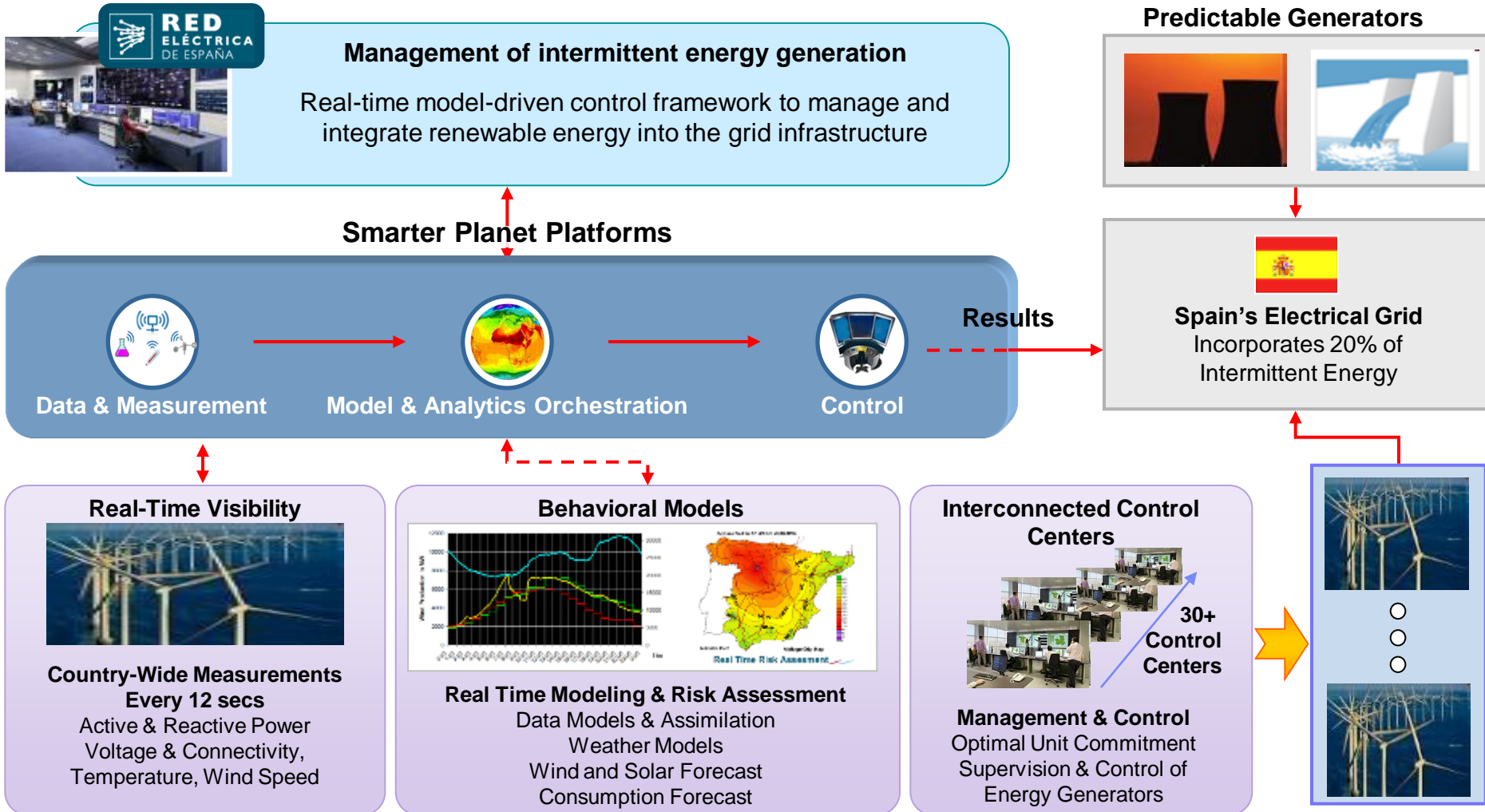


Challenges of the Evolving Smart Grid

- **Renewable Portfolio Standards (RPS) mandates or renewables** (e.g. wind, solar) from the ~1% today to 20-30% **by 2025, while *managing intermittency***.
- **Eroding transmission capacity margin and investment in transmission infrastructure has lagged the growth in demand, yet long haul transport is needed for renewables.**
- Plug-in electric vehicles, **battery storage devices and smart appliances can fundamentally transform our energy, but need to be *quantified, managed & leveraged***.
- New sensing technologies **enable *real-time information, analysis, and control capabilities*, to be more observable, controllable, and automated for example:**
 - PMU's Phasor measurement units synchronized by GPS signals collect and report dynamic data.
 - FACTS devices, Intelligent Electronic Devices (IEDs) and sensors for observation and control of power flow.
 - Hundreds of millions of smart meters are being deployed to enable load response.
- Real-time energy markets **require new more comprehensive, integrated and faster tools to ensure safe, fair and effective *real-time operation***.
- **With smart grid communications, observability and controllability come the need to develop effective *cyber-physical security***.
- Government oversight **driving the need *to monitor, optimize and control* carbon generation and emissions across this mix of new capabilities and options**



Smarter Energy - model-driven optimization enables substantial electricity (>20%) generated through renewable energy



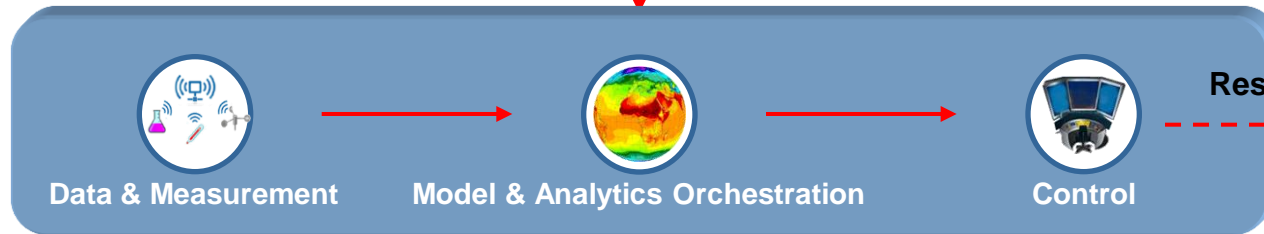
Smart Grid solutions continuously optimize the expected outcome using real-time data assimilation & behavioral models.



Making decision choices to optimize outcomes

A common orchestration platform optimizes outcomes by applying behavior models to real-time information.

Smarter Planet Platforms



Intelligent Utility Network

Real-Time Visibility
Usage Pattern

Behavioral Models

Environmental Models Demand Models

Real-time Interaction with ground crew

Optimal dynamic load Shedding and Demand management

Optimal plan & schedule for restoration and reenergize the Grid after a disaster

Case Study: The Olympic Peninsula Had Increasing Demands for Power



- But physical, public and environmental issues prevented hauling new transmission capacity across the peninsula

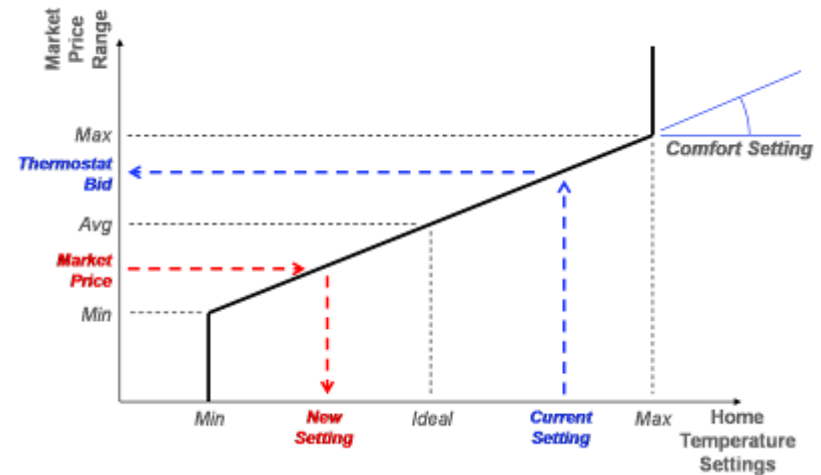


Automating Home Power Usage *Through Customer Preferences*

Occupancy Modes

The screenshot shows a thermostat interface with the following elements:

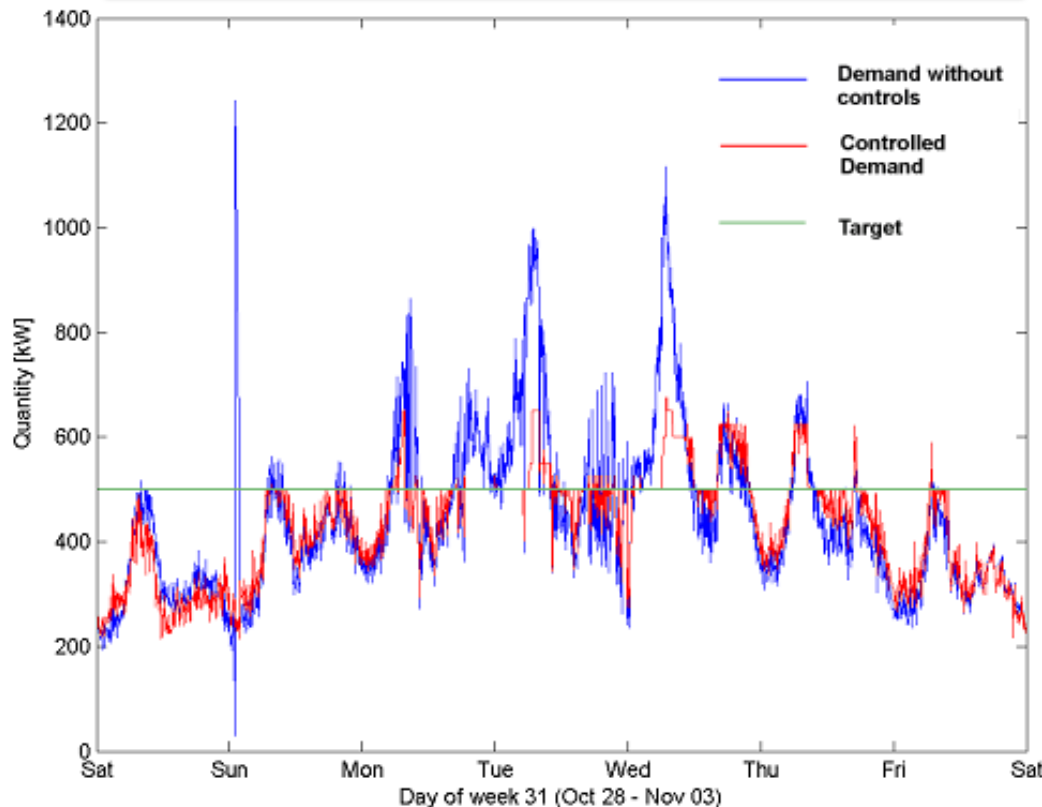
- Occupancy Modes:** Home (selected), Away, Sleep, Vacant.
- When my home is in Home mode:** Active (checked).
- Use the following settings for the areas controlled by:**
 - Cooling setpoint: 72 °F
 - Heating setpoint: 68 °F
- use:** A dropdown menu is open, showing various profiles:
 - Balanced Comfort (selected)
 - No Price Reaction
 - Maximum Comfort, no pre-heat
 - Balanced Comfort, no pre-heat
 - Economical Comfort, no pre-heat
 - Comfortable Economy, no pre-heat
 - Balanced Economy, no pre-heat
 - Maximum Economy, no pre-heat
 - Maximum Comfort
 - Balanced Comfort
 - Economical Comfort
 - Comfortable Economy



- Homeowners trade off comfort versus price, which defines a virtual thermostat model
- Virtual thermostats then bid into the real-time energy market to buy electricity
- By changing the energy market model, grid optimization can factor in any metrics or constraints necessary, such as outages, weather, or even carbon intensity

Feeder capacity management: Load flattening under high-load conditions

How the System Responded



- **Current Status: Expansion from a single area demonstration to an entire region of the country**
 - Spans Idaho, Montana, Oregon, Washington, and Wyoming, 11 utilities, \$178M over 5 years



Pacific Northwest Smart Grid Regional Demo

- **Objectives:**
 - Validate smart grid technologies and business models
 - Provide two-way communication between distributed generation, storage, and demand assets and the existing grid infrastructure
 - Quantify smart grid costs and benefits
 - Advance standards for interoperability and cybersecurity approaches

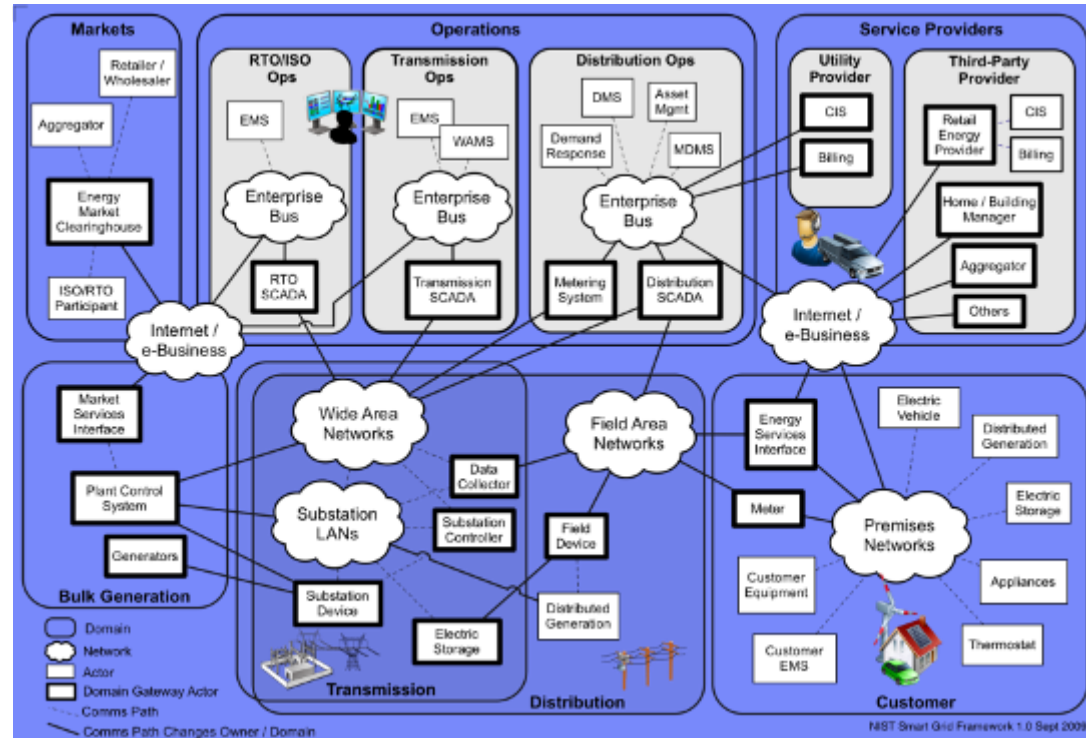
- **Team will implement a unique distributed communication, control, and incentive system**

- **IBM Research team leading overall system architecture and interoperability/integration and contributing to cybersecurity, analytics (for DER), and secure messaging**



Smart Grids: Complex Ultra Large-Scale Systems

- Smart grids are complex *systems of systems* that must integrate and interoperate across a broad spectrum of heterogeneous business and operations domains
 - Involves multiple enterprises and customers in multiple industries
 - A loosely-coupled distributed system approach is required
 - Application-level interoperability standards are critical to success
 - Ultimately, we want to enable global optimization that achieves continual balance across the many constraints involved



It's a data driven world...

Smart Grid Modeling and Optimization

- **The smart grid drives the need for dynamic, real-time simulation and analytics – from generation through distribution**

- Ensuring a resilient, reliable and secure grid, incorporating renewable generation
- Leveraging supercomputing and workload-optimized systems, analytics, weather modeling, integration of broadly distributed sensor networks and real-time visualization

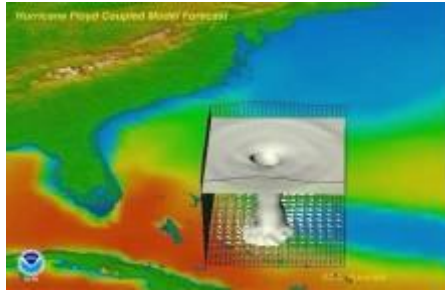


Coupled Earth and Human Systems

EARTH SYSTEM MODELING

- WEATHER MODELING
- GEOSPATIAL STATISTICS
- DATA ASSIMILATION

EARTH SYSTEMS



HUMAN SYSTEMS



BEHAVIORAL MODELING

- SIMULATION OF AGENTS
- PREFERENCE MODELING
- ENERGY USE SCHEDULING

PORTFOLIO PLANNING

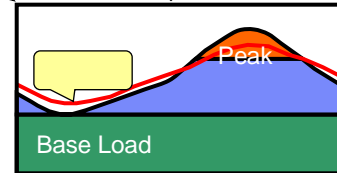
- WIND/SOLAR FARM LAYOUT
- CONDITION BASED MNGT

RENEWABLES



SUPPLY UNCERTAINTY

DEMAND UNCERTAINTY



CONVENTIONAL GENERATION



DEMAND MANAGEMENT

- DEMAND PLANNING & LOAD FORECASTING
- DEMAND RESPONSE ESTIMATION USING SMART METERS
- VALUE-BASED SIGNALING
- Transactive Control

RESOURCE/MARKET MGMT, OPERATIONS

- GENERATION PLANNING WITH UNCERTAINTY SUPPLY/DEMAND
- STOCHASTIC UNIT COMMITMENT
- REAL TIME CONTINGENCY ANALYSIS

Analytics & Optimization

PHYSICAL CONSTRAINTS

- NETWORK TOPOLOGY & CAPACITY
- POWER FLOW

MODELING & SIMULATION

- REAL-TIME STATE ESTIMATION OF GRID (DATA ASSIMILATION)
- SIMULATION OF POWER FLOW
- CONDITION BASED MNGT
- STREAM ANALYTICS



Smart Grid and Social Computing

■ The social computing perspective

- The “smartness” of smart systems comes from **technology AND people**, not just technology alone
- People **actively participate** in smart systems, **supplying local knowledge** about where they work and live that complements sensor-derived data;
- Smart systems that include people as active participants are more likely to be seen as **legitimate**, and thus be socially and politically acceptable



■ Social computing research issues

- **Social Intelligence.** How do we design systems that tap human knowledge to support more sustainable energy use?
- **Crowdshifting.** How can our systems support the widespread behavioral change required by smart grid applications?
- **Legitimacy.** How to design systems (and policies) that mitigate the fears of ‘Big Brother’ provoked by use of sensors and monitoring of energy use?



Vision for the Future of the Grid

- **A highly dynamic grid that incorporates large amounts of distributed energy resources**
 - Distributed renewable generation
 - “Virtual Generation” through demand response
 - Electric Vehicles
 - Distributed Storage

- **A grid that is designed to be resilient to points of failure without catastrophic cascading collapses**

- **A grid that benefits from, and drives, new communications and information technology advances and applications**

- **A participatory grid that transforms the relationship with the consumer.**

- **A grid that enables an energy economy as a new source of economic growth**

धन्यवाद

Hindi

Thank You

English

ขอบพระคุณ

Thai

Ευχαριστώ

Greek

Gracias

Spanish

Спасибо

Russian

多謝

Traditional Chinese

Obrigado

Brazilian Portuguese

شكرا

Arabic

Dziękuję

Polish

Danke

German

Mulțumesc

Romanian

多谢

Simplified Chinese

Merci

French

Grazie

Italian

நன்றி

Tamil

ありがとうございました

Japanese

감사합니다

Korean