



EE392N

Intelligent Energy Systems: Big Data and Energy

April 2, 2013

Dan O'Neill
Dimitry Gorinevsky

Today's Program

- Class logistics
- Introductory lecture on Intelligent Energy Systems: Big Data and Energy

Instructors

- Daniel O’Neill, Consulting Professor in EE
 - Network Management and Machine Learning in energy
 - Executive and Startup experience
 - www.stanford.edu/~dconeill
- Dimitry Gorinevsky, Consulting Professor in EE
 - Big Data Analytics for energy and aerospace
 - Information Decision and Control Applications in many industries
 - www.stanford.edu/~gorin

Class Logistics

- 1 unit graded or CR/NC
 - Attendance
 - Pre-requisites
 - Submitting an one page report on in the end
- Weekly on Tuesdays
 - The room and time might change!
 - Watch the class website announcements
- Introductory lecture - today
- Nine lectures by industry leaders

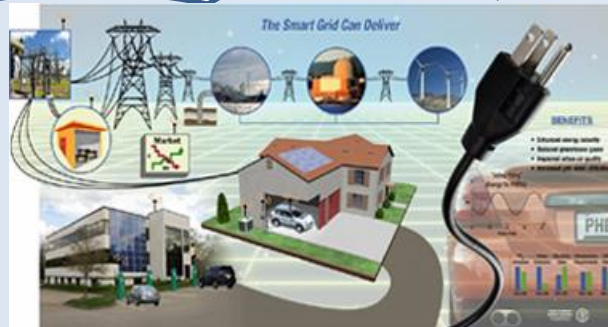
Planned Lectures

- April 2, Introductory Lecture, Dan O'Neill and Dimitry Gorinevsky, **Stanford**
- April 9, Feature Discovery in Energy Data, Sachin Adlakha, **Ayasdi**
- April 16, The Industrial Internet, Marco Annunziata, **GE Energy**
- April 23, Risk Analytics Applications and Vision, Chris Couper, **IBM**
- April 30, Power Plant Big Data Optimization, Jim Schmid, **GE Energy**
- May 7, Monitoring of T&D Systems, Paul Myrda, **EPRI**
- May 14, Energy Insights from Big Data, Drew Hylbert and Jeff Kolesky, **OPower**
- May 21, AMI Data Management and Analysis, Aaron DeYonker, eMeter/**Siemens**
- May 28, Smart Grid Analytics, Ed Abbo and Houman Behzadi, **C3 Energy**
- June 4, Data Center Energy Management, Manish Marwah, **HP**

Intelligent Energy Systems

Analytics: Software Function

Computing
and
Communication



Energy
System

Energy Systems

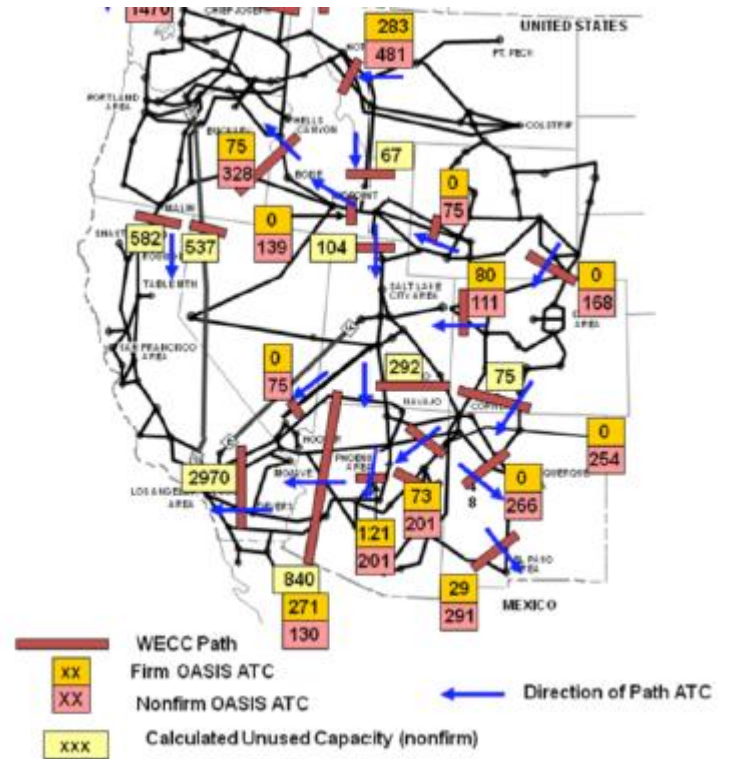
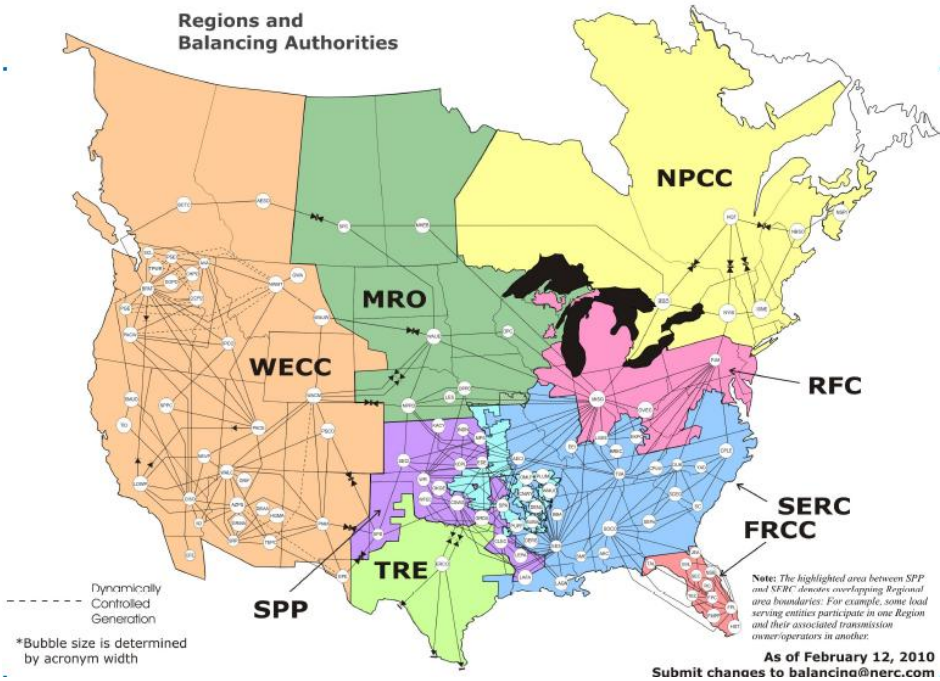
- Power systems
- Physical systems in the focus of the class

The Traditional Grid

- World's Largest Machine!
 - 3300 utilities
 - 15,000 generators, 14,000 TX substations
 - 211,000 mi of HV lines (>230kV)
 - SCADA control
 - Mostly unidirectional
- Capacity constrained graph



Interconnect



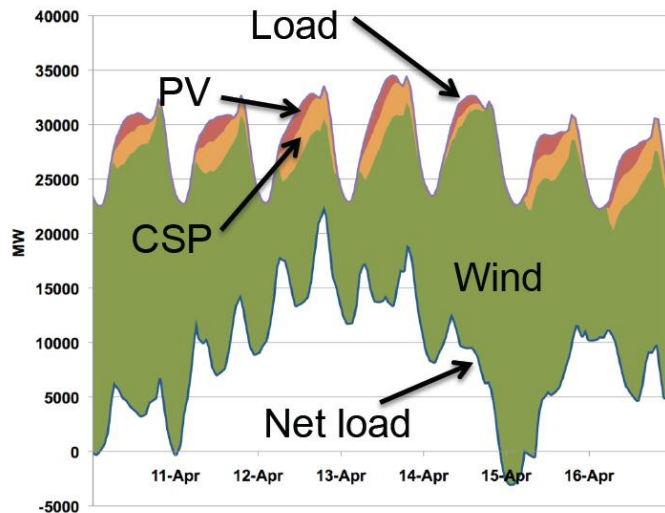
Nearer Term Initiatives

- Renewables
- Demand Response
- Power Flow Management

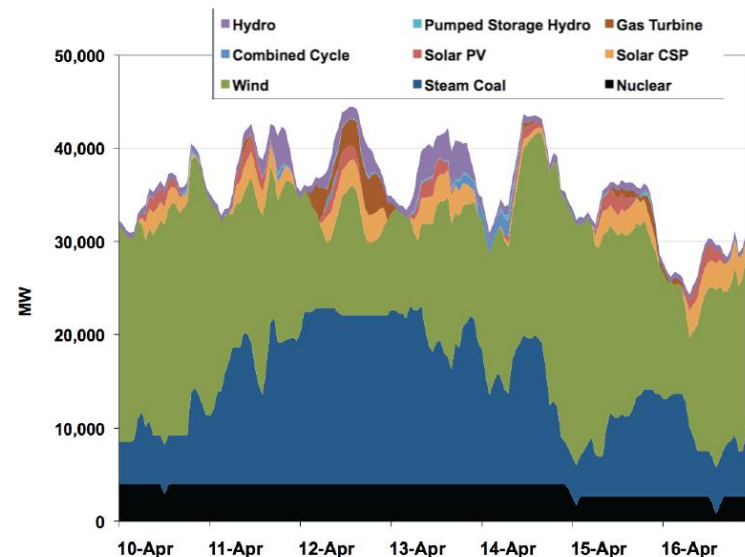


Renewables: The System Problem

Net Load



Dispatch



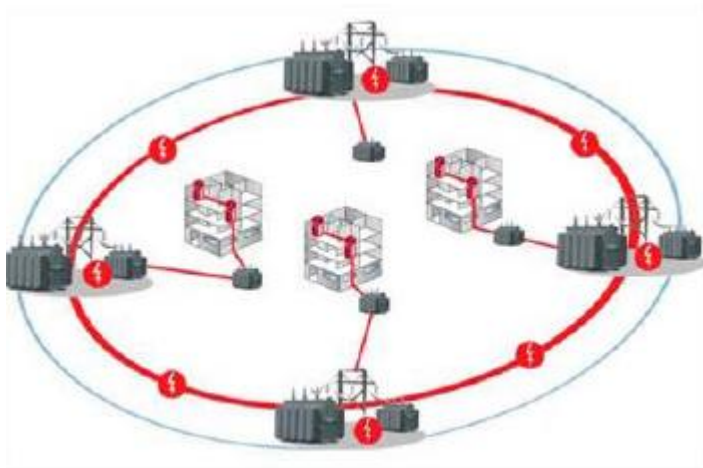
Need for conventional plants to cycle and ramp

National Renewable Energy Laboratory

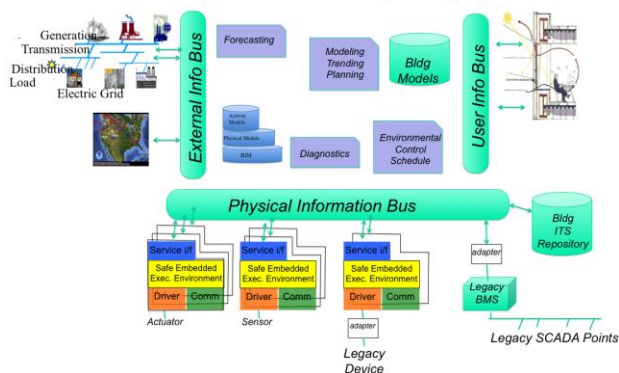
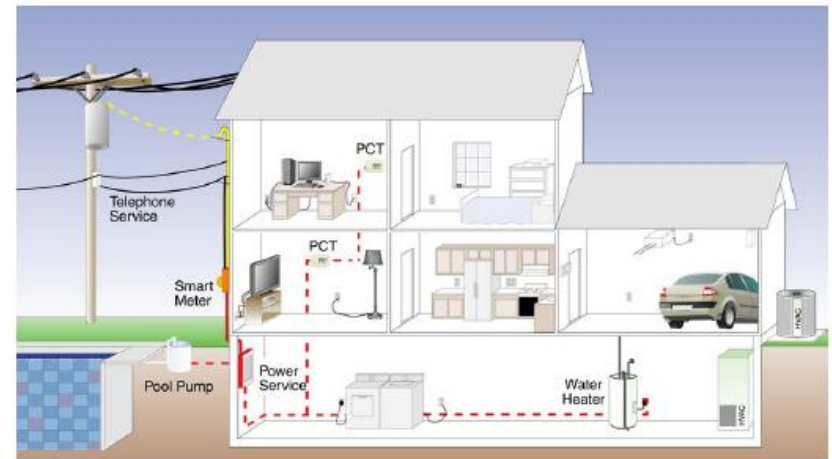
Demand Response

Campus and Buildings

Home



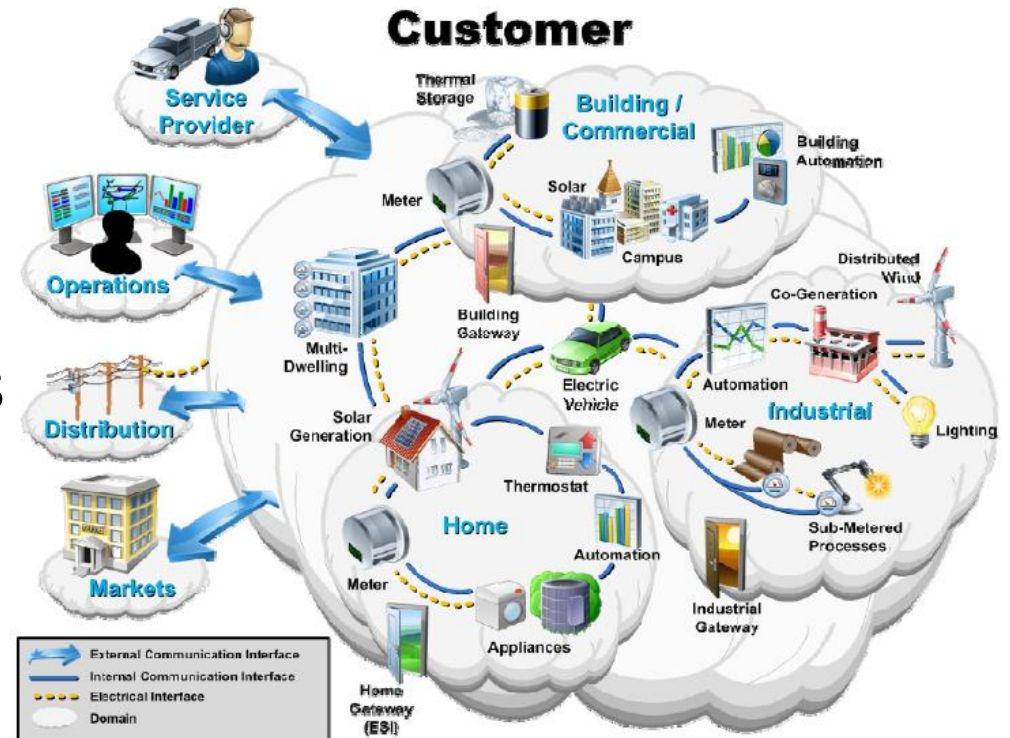
Building-wide Distributed Operating System



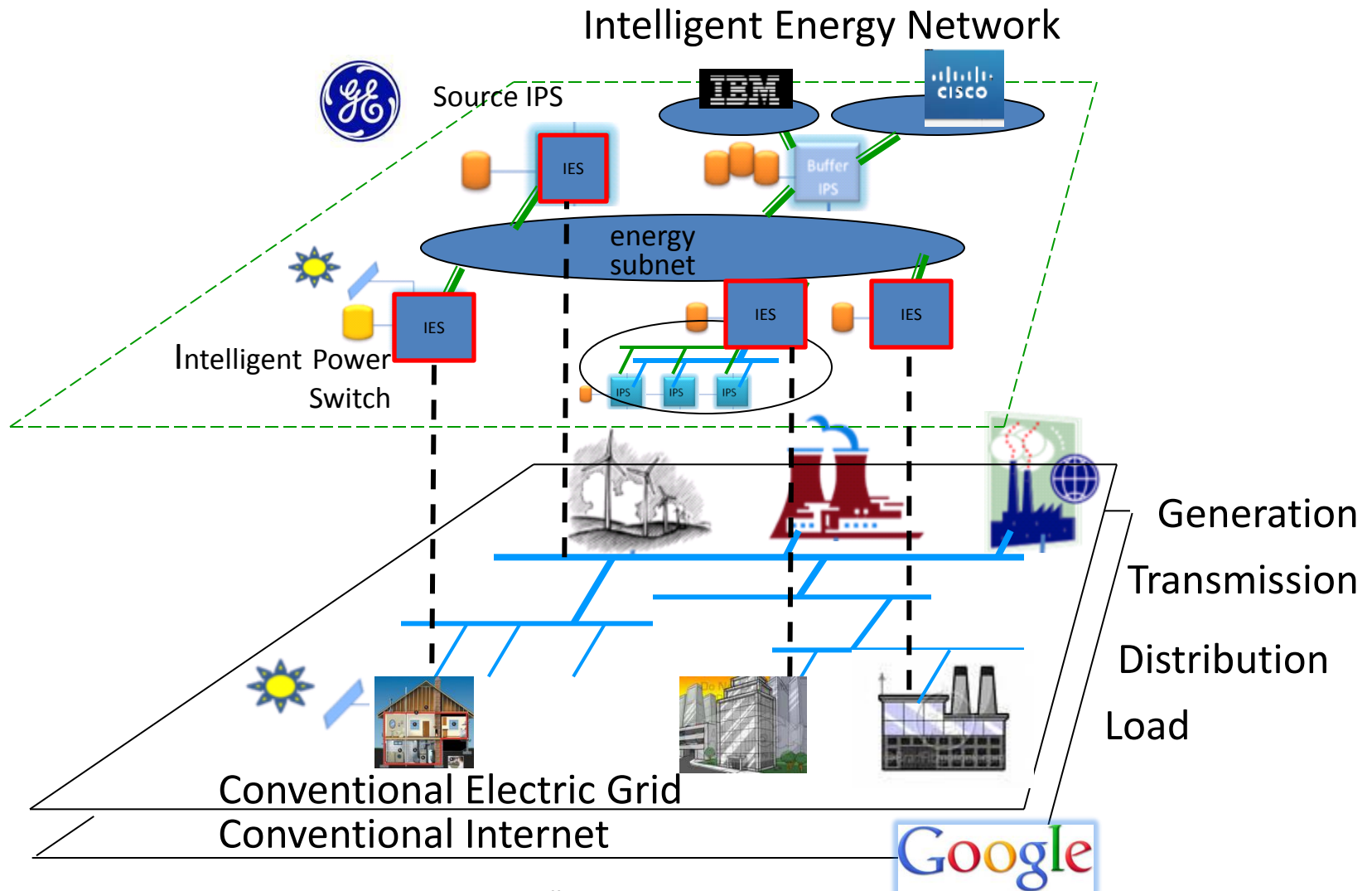
- AMI – Advanced Metering Infrastructure
- EMS – Energy Management System
- Smart devices

Power Flow Management

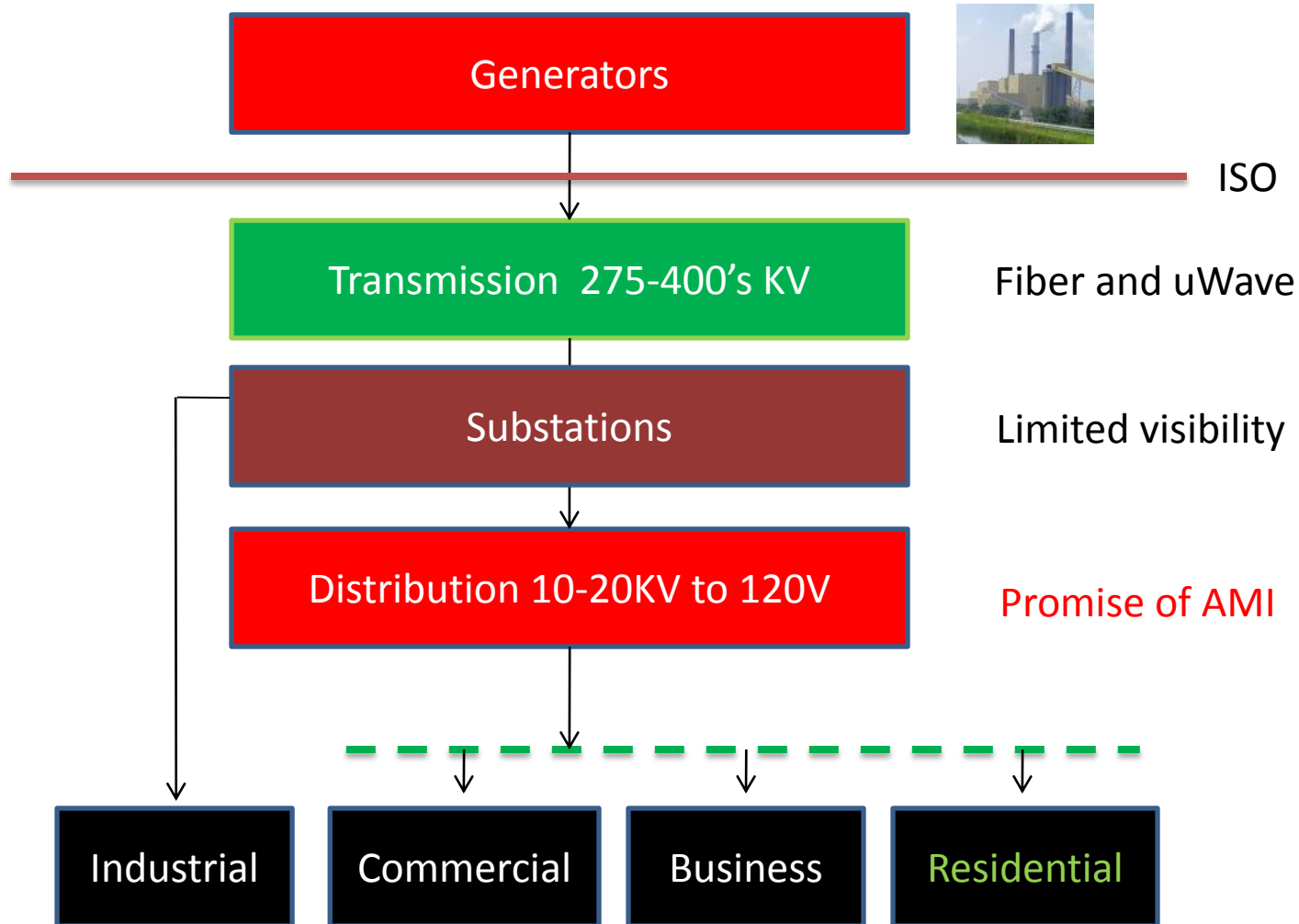
- Adjusting supply
- Routing power flow
- Managing demand
 - for aggregated users
 - for commercial buildings



Computing and Communications

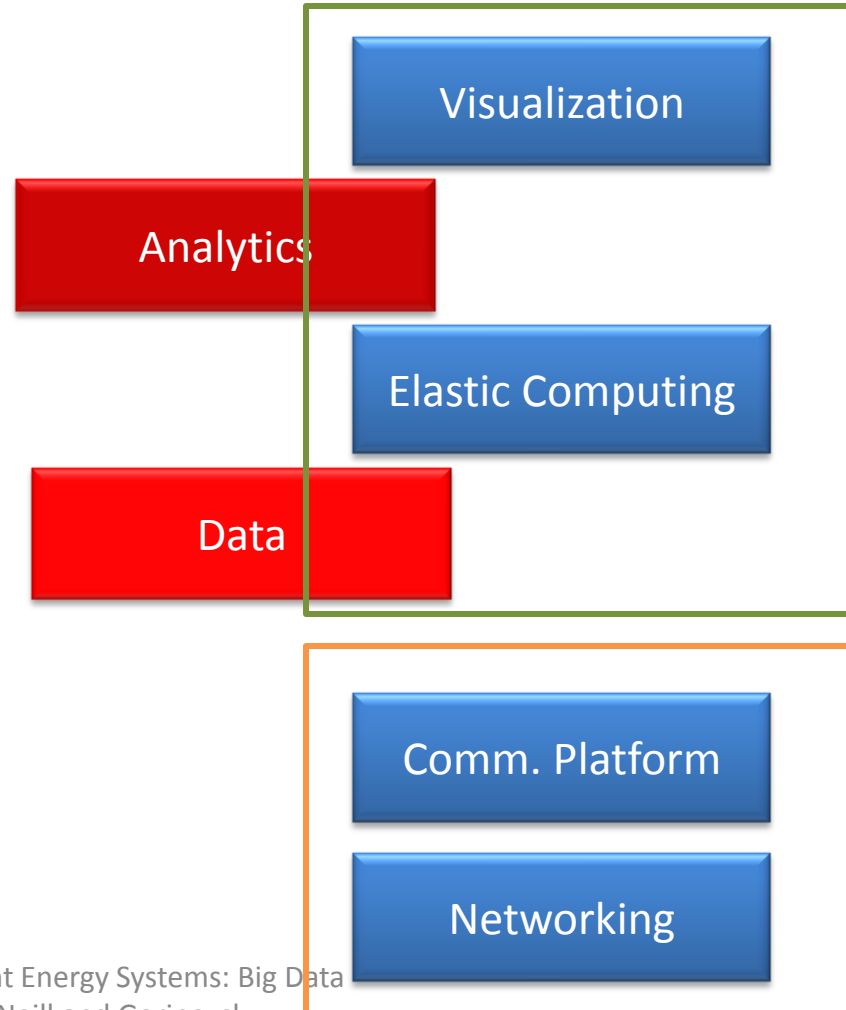


Power and Data Flow

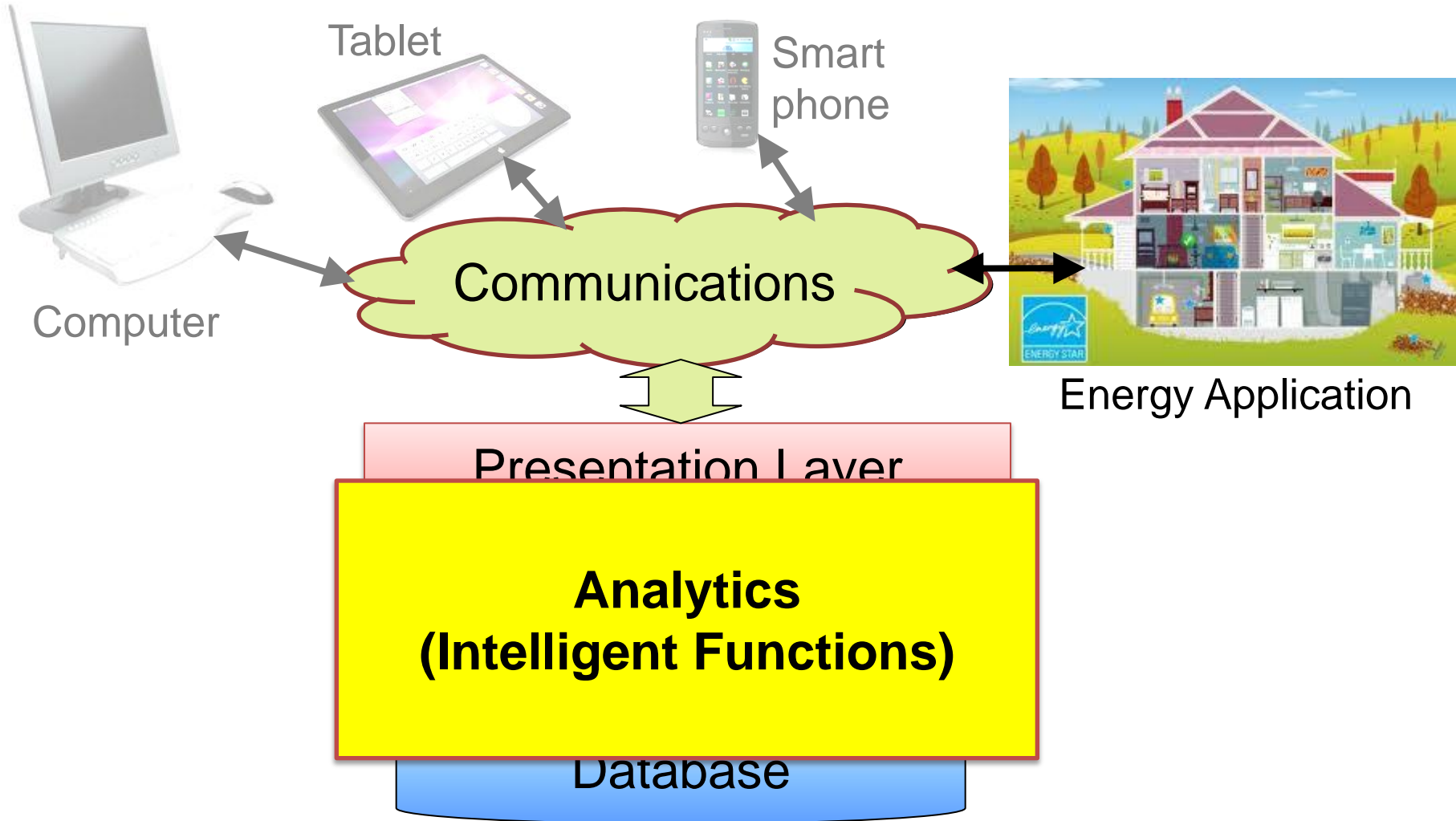


Today...

- Integrated platforms
 - IBM, Oracle. ...
 - GE, Seimens, SAIC,...
 - Itron, Cisco, ...
- But
 - Analytic tools
 - Vertical analytic products
 - Data integration

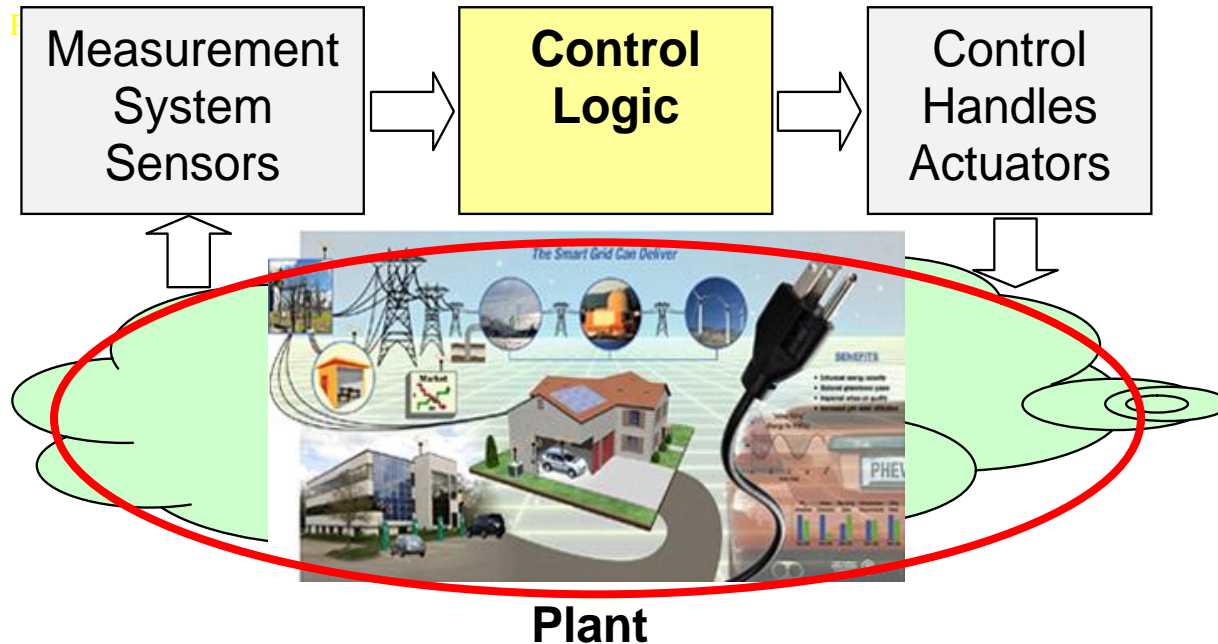


Analytics



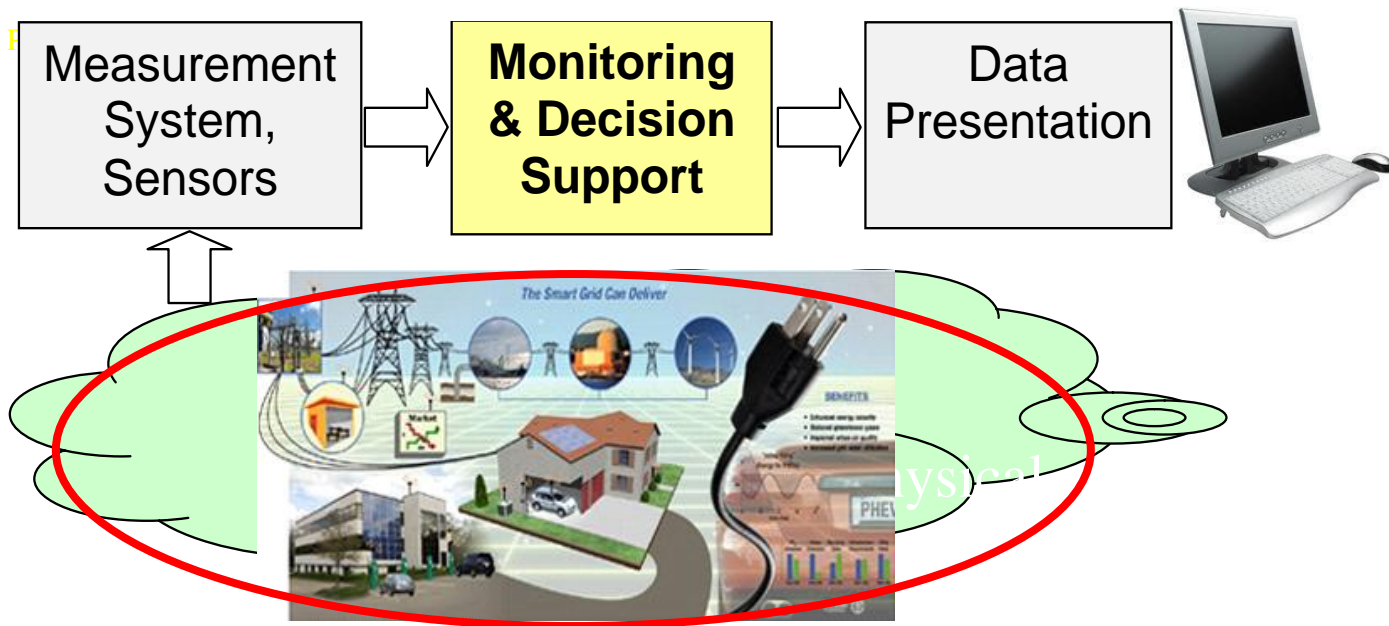
Feedback Control Functions

- Closed loop update



Monitoring and Decision Support Functions

- Open-loop functions
 - Results are presented to an operator



Decision Support Applications

Supply

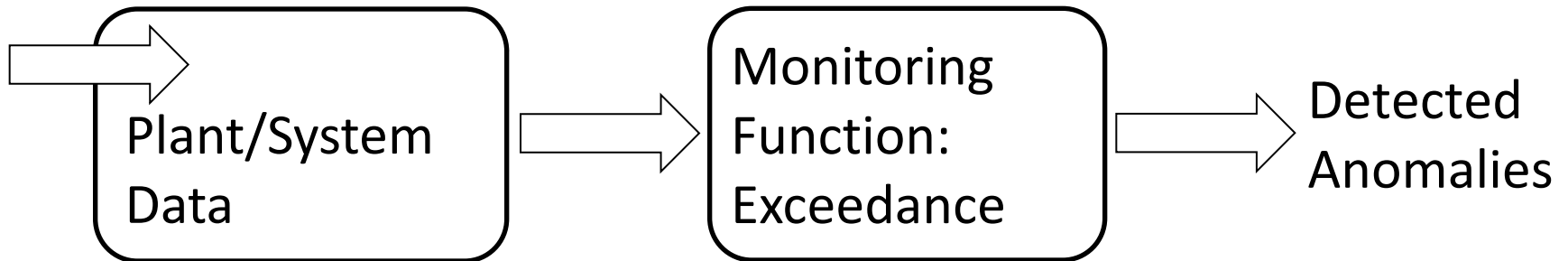
- Asset Management
- Power Quality Monitoring
- Outage Management
- Risk Management
- Renewables Integration
 - forecasting

Demand

- Energy Efficiency Monitoring
- Revenue Protection

Monitoring Approaches

- Most used approach is Exceedance Monitoring
- Example: grid frequency deviation from 60Hz



Big Data

- Tens of Tb to Pb range
- Sequential or parallel processing of data chunks. Each chunk fits into memory
- Much of earlier work involved 'soft' data
- Energy: Machine-to-Machine (M2M) data
- Monitoring and decision support applications
- Data mining

Data Mining Functions

- Data Exploration
 - Performed interactively
- Model Training
 - Known as system identification in control
- Model Exploitation
 - Estimation, eg, forecasting
 - Decision support, eg, monitoring
 - Control, eg, embedded optimization