

Smart Manufacturing: The Energy and Environment Imperative

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Implementing 21st Century Smart Manufacturing

Washington, D.C.

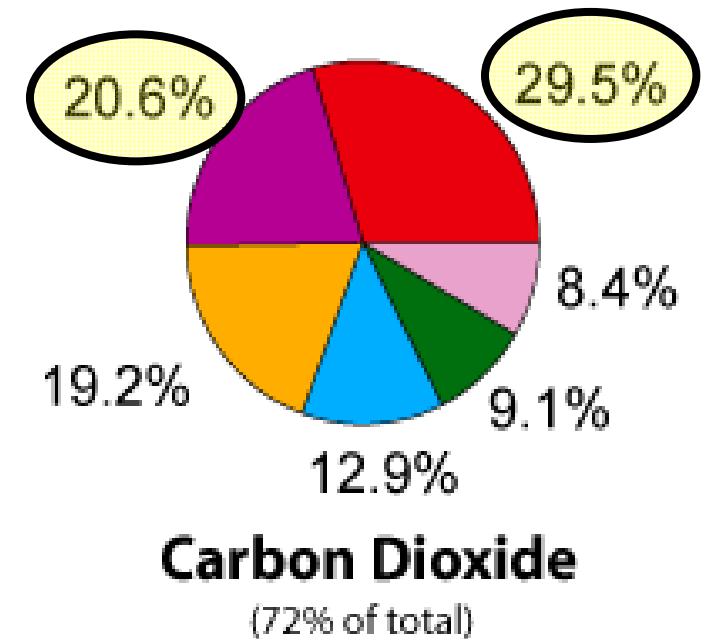
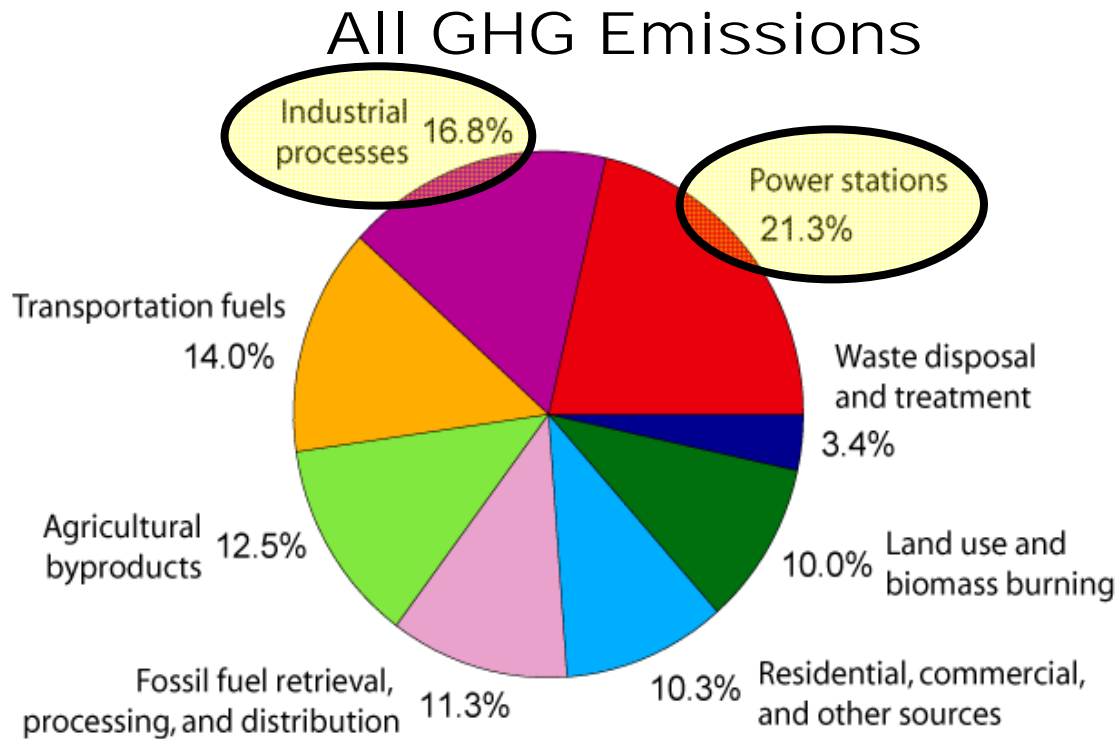
September 15, 2010

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Objectives of this presentation...

- **Bring energy and environment to the foreground of discussion**
- **Illustrate the state of the art in related smart manufacturing areas**

Sources for GHGs and CO₂

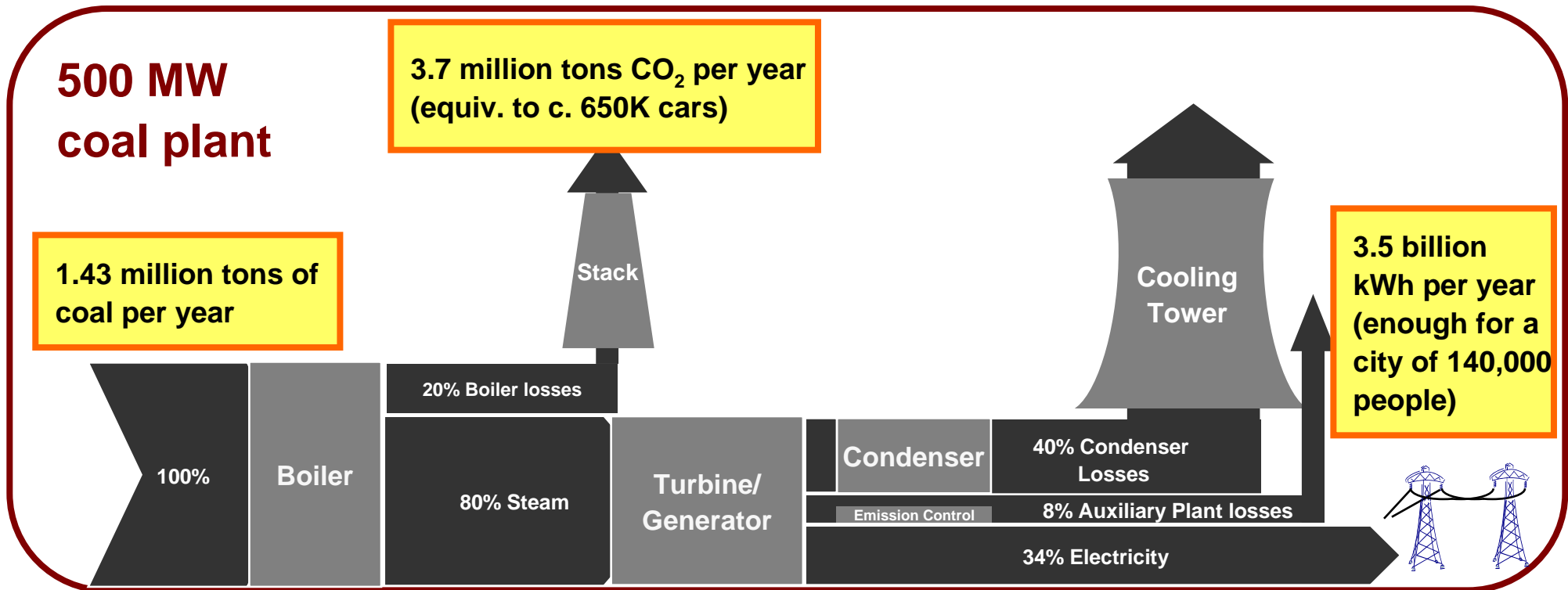


[Robert A. Rohde, Global Warming Art; http://www.globalwarmingart.com/wiki/Image:Greenhouse_Gas_by_Sector.png]

The power sector and industrial processes account for >16 GtCO₂ annually worldwide

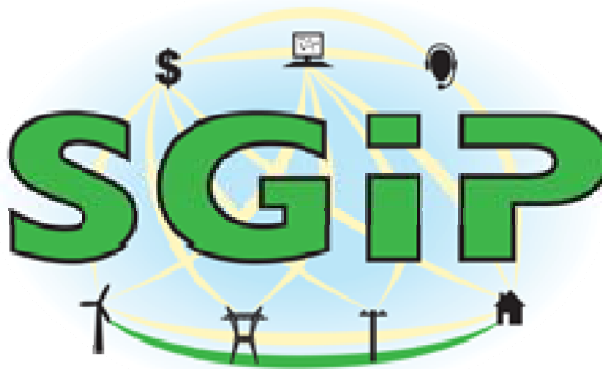
Coal Power Plant—Energy and Environment

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COMMERCIAL AND INDUSTRIAL PERSPECTIVES ON SMART GRIDS

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INDUSTRIAL SECTOR—POWER USE DIVERSITY

Industry sector	Total electricity used (10 ⁶ kWh)
Chemicals	207,107
Primary Metals	139,985
Paper	122,168
Food	78,003
Petroleum and Coal Products	60,149
Transportation Equipment	57,704
Plastics and Rubber Products	53,423
Nonmetallic Mineral Products	44,783
Fabricated Metal Products	42,238
Machinery	32,733
Wood Products	28,911
Computer and Electronic Products	27,542
Textile Mills	19,753
Beverage and Tobacco Products	17,562
Printing and Related Support	13,089
Electrical Equip., Appliances, and Components	12,870

http://www.eia.doe.gov/emeu/mecs/mecs2006/pdf/Table11_1.pdf



(plus smaller contributors)

INDUSTRIAL ENERGY MANAGEMENT—COMPLEXITIES

- Industrial plants can be high consumers of electricity
 - up to 100s of MW at peak load and 100Ms of kWh annual consumption
- Connections to the grid can be at high voltage levels
 - direct to transmission (138 kV and 230 kV) and distribution (4 kV – 69 kV) grids
- Large manufacturing facilities can have substantial on-site generation
 - nationwide industrial generation: 142 B kWh, about 15% of net electricity demand
 - sales and transfers offsite: 19 B kWh
- Automatic generation control (AGC) and ancillary services
 - large plants can (and do) play important roles for grid reliability and frequency regulation
- Some processes require high-speed meter data
 - real-time, not “near-real-time”—milliseconds in some cases
- Industrial users have high interest in ownership and protection of usage data
 - load information is often highly confidential and competition-sensitive
- Manufacturing processes can be inflexible with respect to time
 - interdependencies in process must be respected, for performance and safety
- Many customers require dynamic pricing models for process optimization
 - forecasted pricing and special tariffs from utilities in many cases

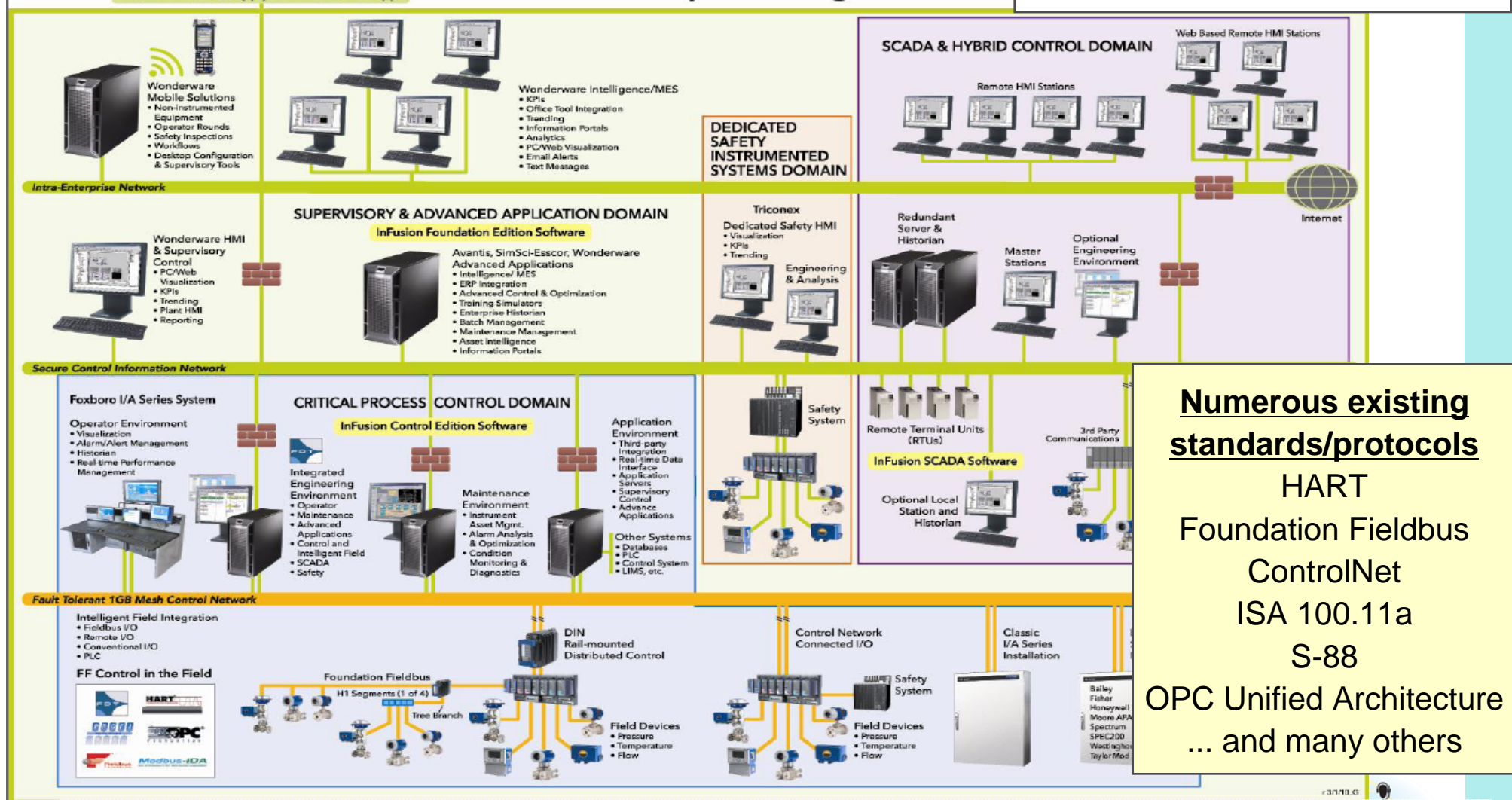
Domain knowledge essential for load management



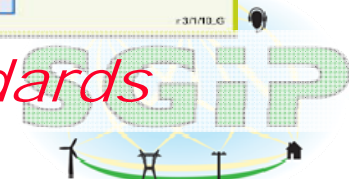
Industrial automation system example

InFusion Enterprise Control System (ECS) Network & Component Diagram

Invensys distributed control system;
figure courtesy of D. Hardin



Complex systems; many existing standards

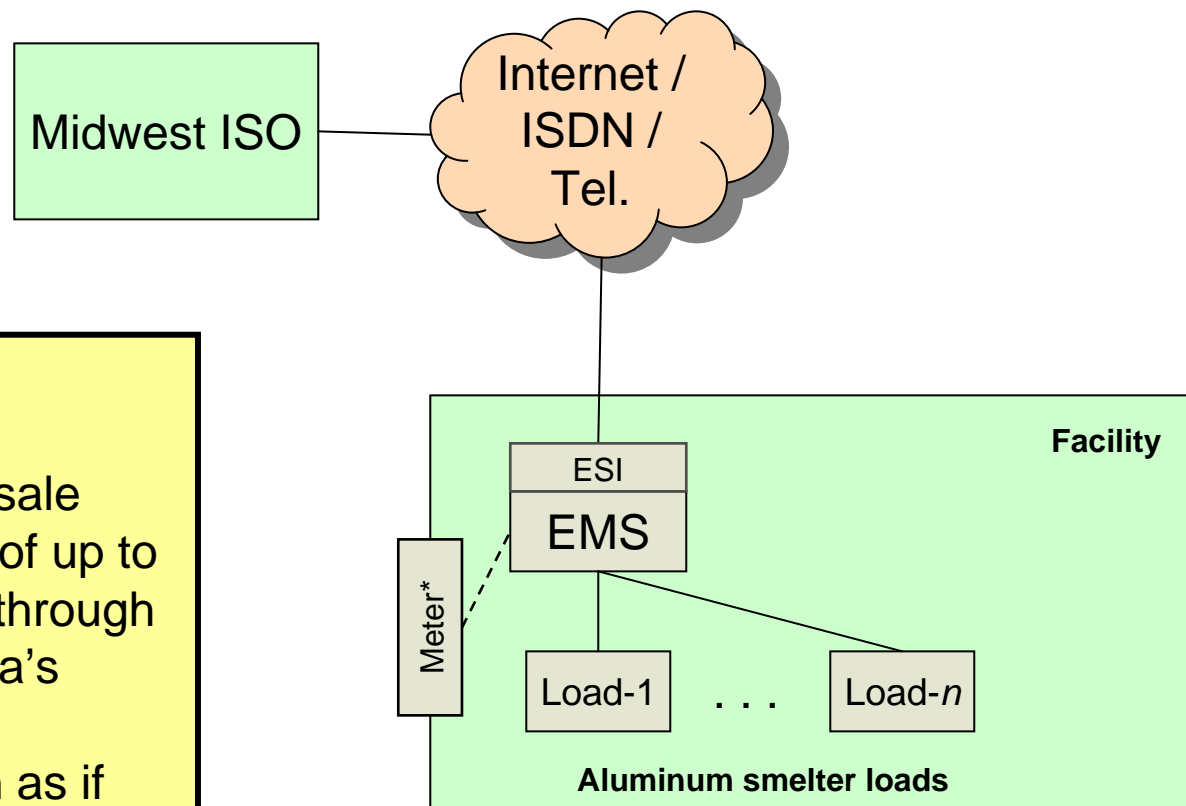


C&I SMART GRID INFORMATION ARCHITECTURE

(4)

C&I smart grid example:

Alcoa Power Generation, Inc. participates in the MISO wholesale market by providing regulation of up to 25 MW as an ancillary service through control of smelter loads at Alcoa's Warwick Plant (Ind.). APCI is reimbursed for load modulation as if the energy was generated. Total facility load is 550 MW. More than 15 GW of regulation capability is available in U.S. industry. Additional capability exists for other ancillary services.



Courtesy of D. Brandt, Rockwell Automation
For more information:

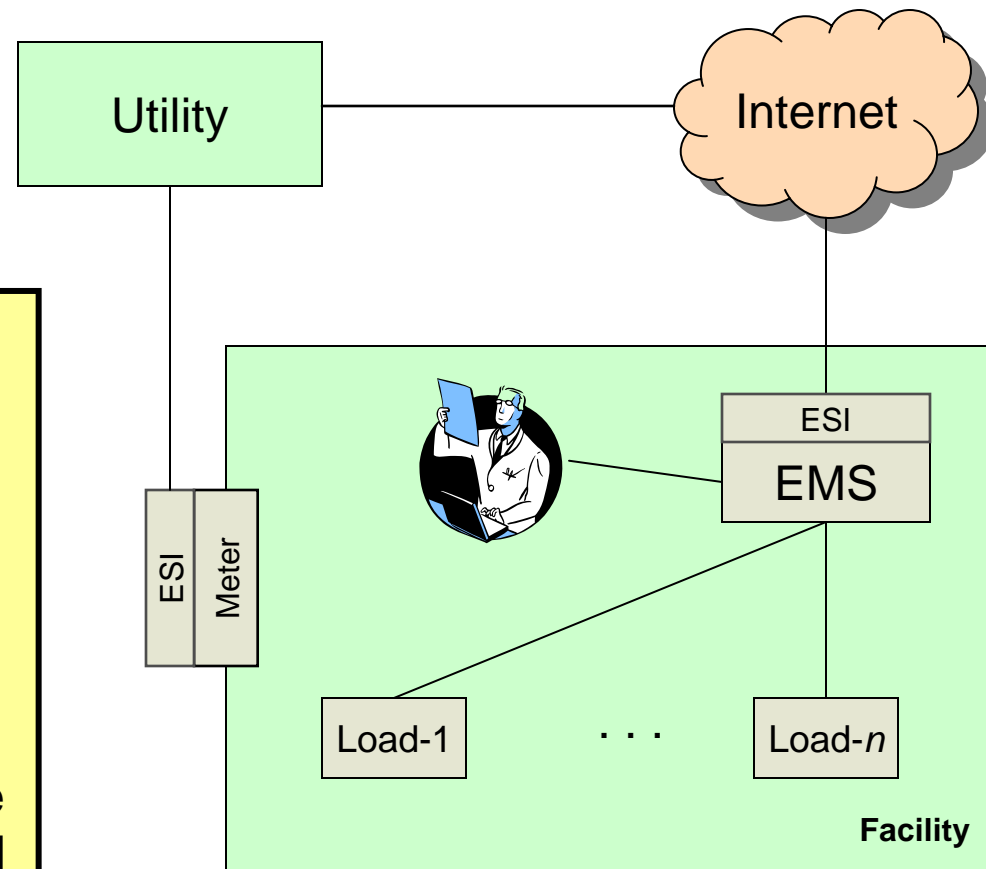
<http://info.ornl.gov/sites/publications/files/Pub13833.pdf>



C&I SMART GRID INFORMATION ARCHITECTURE (5)

C&I smart grid example:

A food manufacturer participates in a CAISO demand response program. Proposed day-ahead events are received from the utility. A person examines the production schedule to decide which (if any) manufacturing loads can be shed. The load shedding is enabled in the EMS for automatic execution based on further events the following day. The site receives utility compensation for participation based on actual meter readings compared to a baseline.



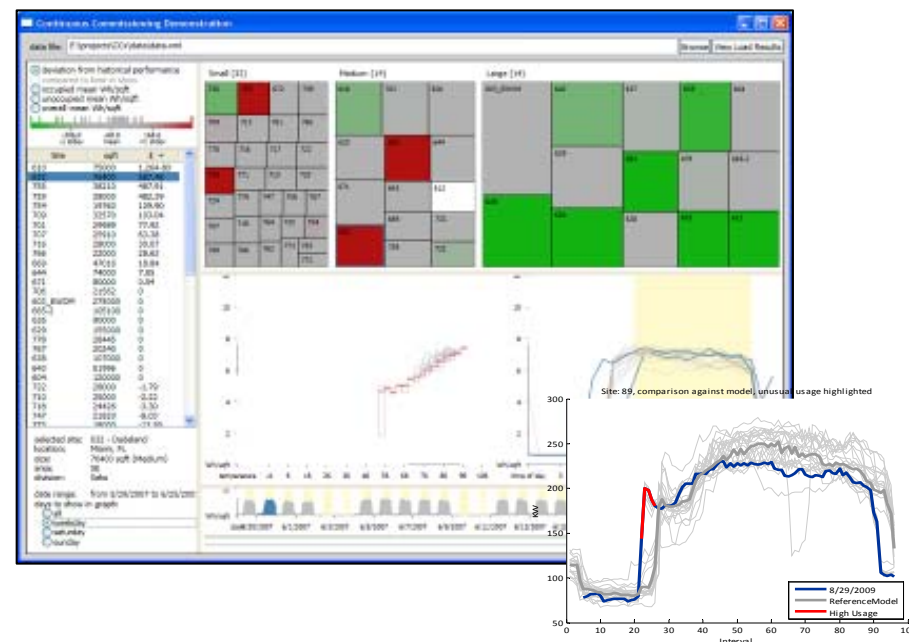
Courtesy of D. Brandt, Rockwell Automation



Novar Remote Energy Management Service

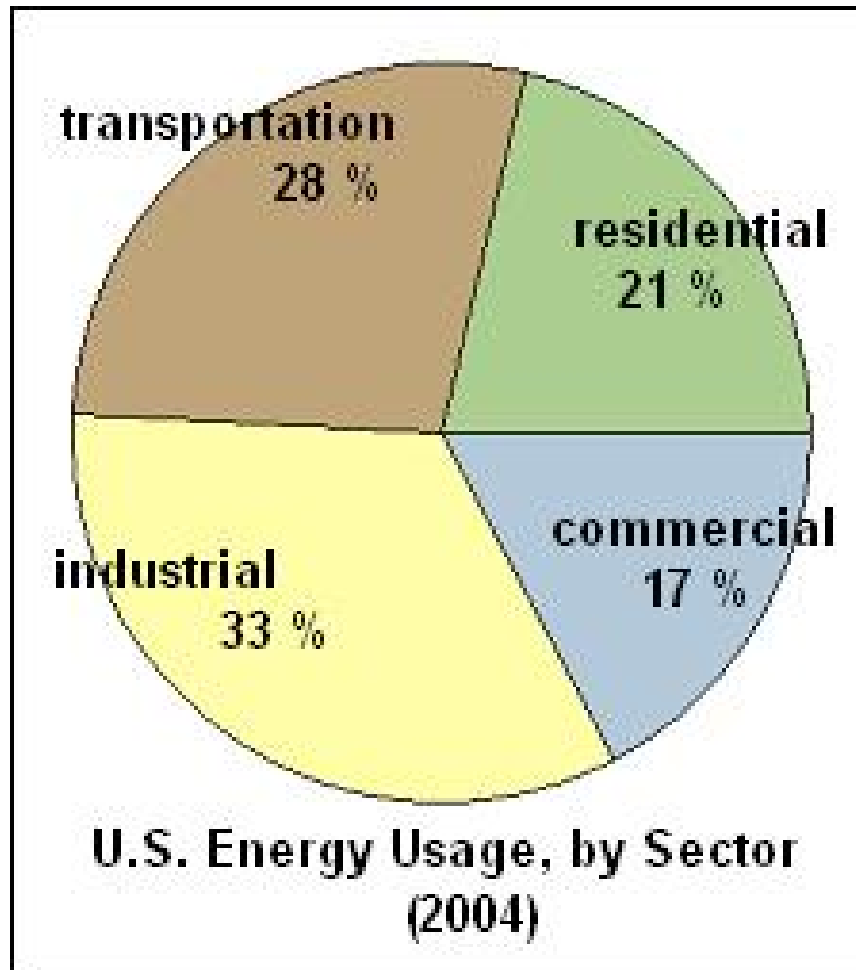
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- Honeywell Novar keeps energy consumption and costs low for multi-site businesses and reduces peak loads for utilities
 - Novar currently manages 6 GW of load
- Top Novar multi-site customers: Walmart, Office Depot, Home Depot, Lowes
- Typical results
 - 20-25% energy efficiency
 - 10-20% peak load reduction
- Analysis & Feedback
 - comparison between buildings and to baseline / model
 - root cause analysis
 - driving behavior change



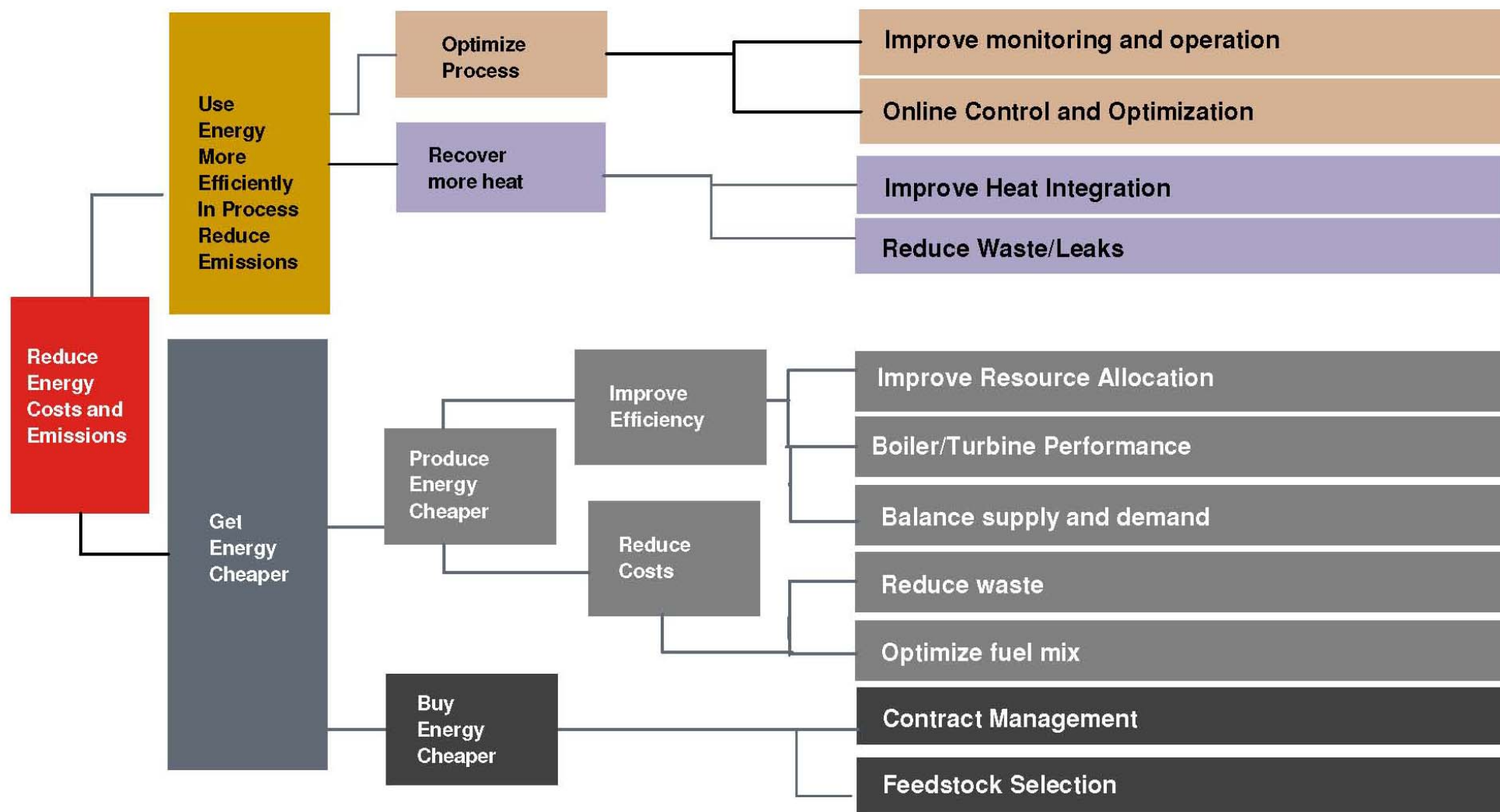
Secure cloud-based energy management

U.S. Energy Consumption (all sources)



Energy Information Administration

Sources for energy savings

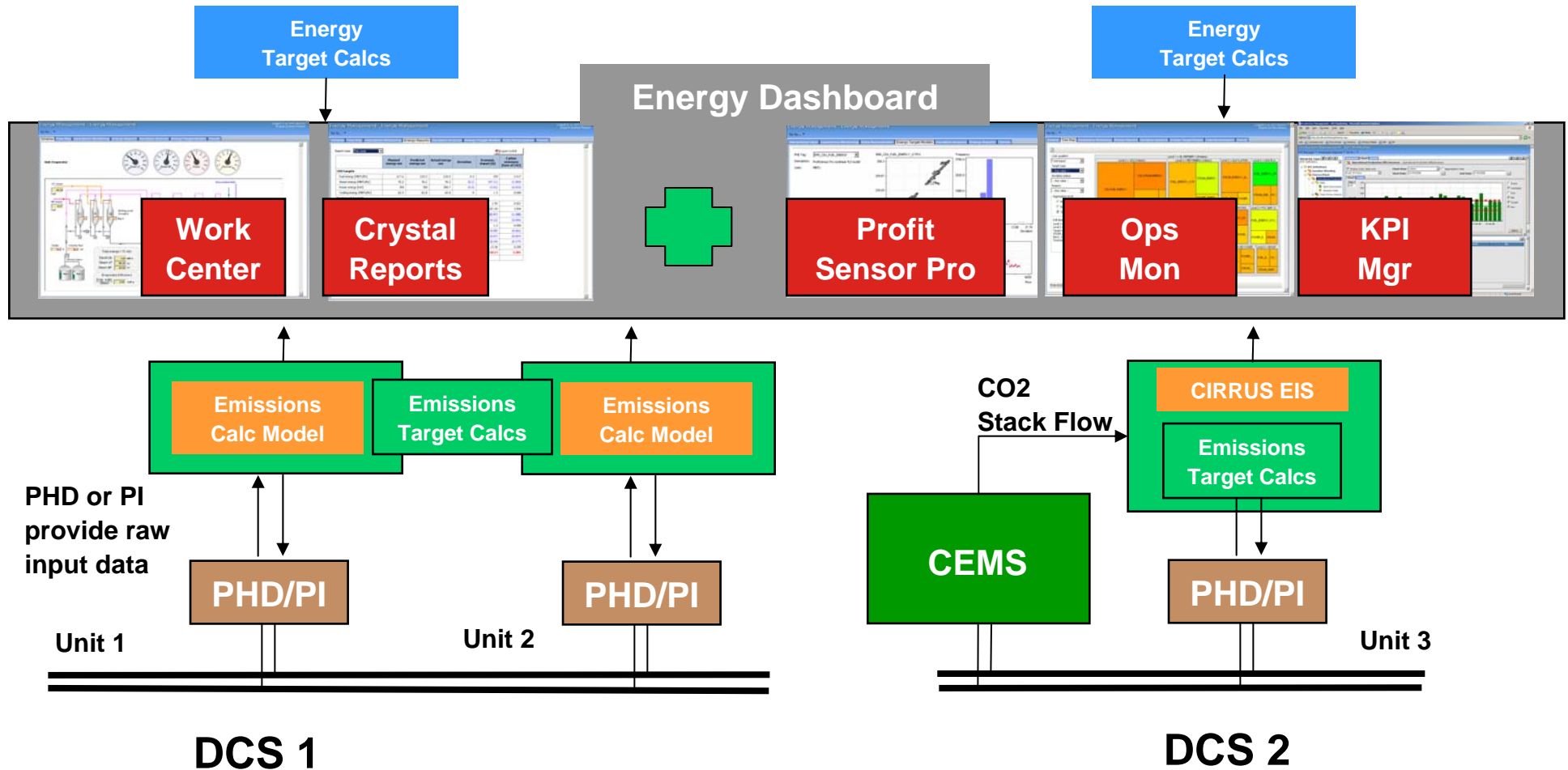


Process technology improvements and process automation can reduce energy consumption by up to 25% (400 kton/yr of CO₂eq) for a typical 125K bbl/d refinery

Integrated Energy and Emissions Reporting

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Emissions and Energy Dashboard



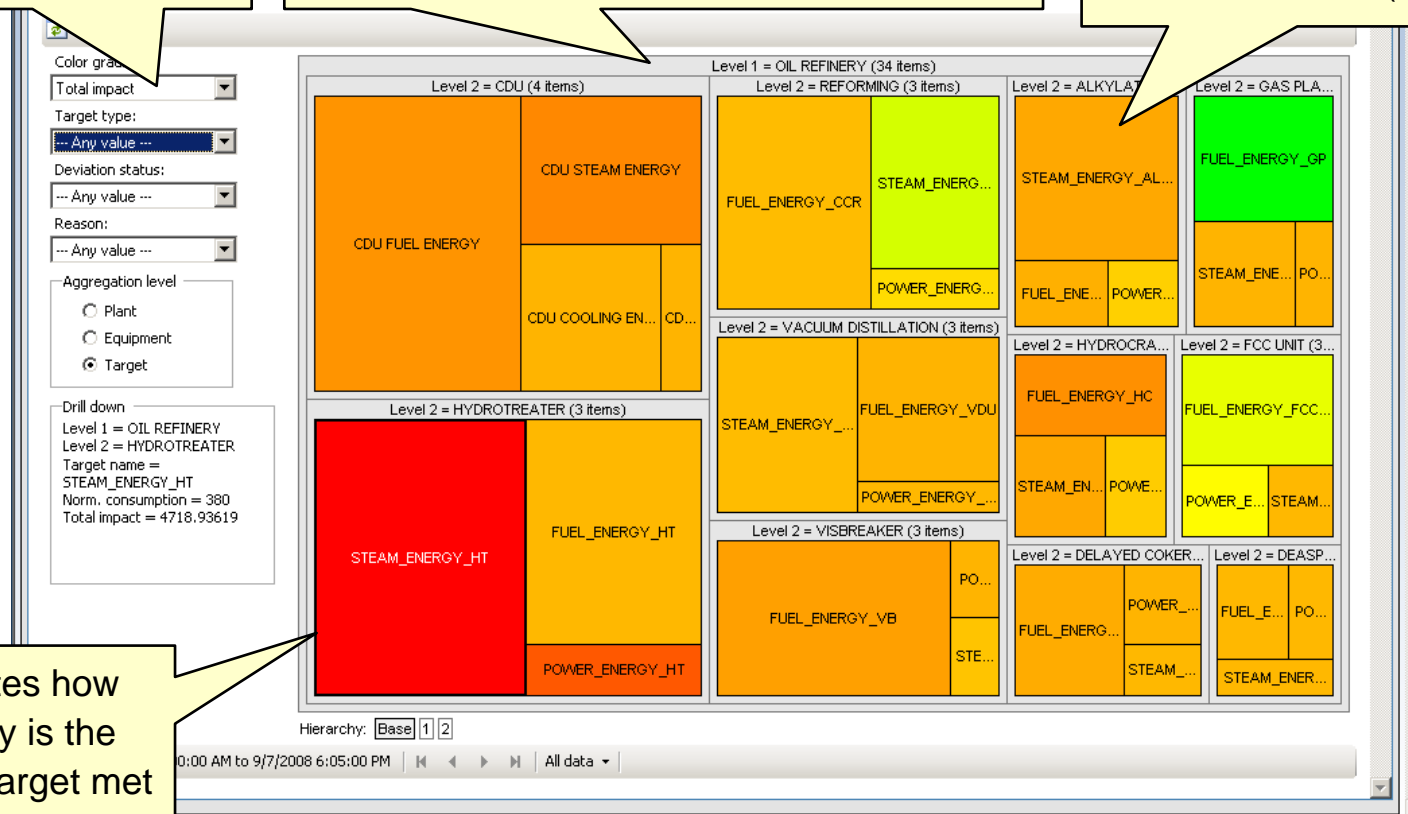
Visualization for Energy Monitoring

Calculated metrics like total economic impact (in \$) of deviating from the target are used to characterize targets

Tree Map visualizes relative energy use in the context of the plant hierarchy. Rectangles correspond to individual targets, and are further grouped by equipment and plant.

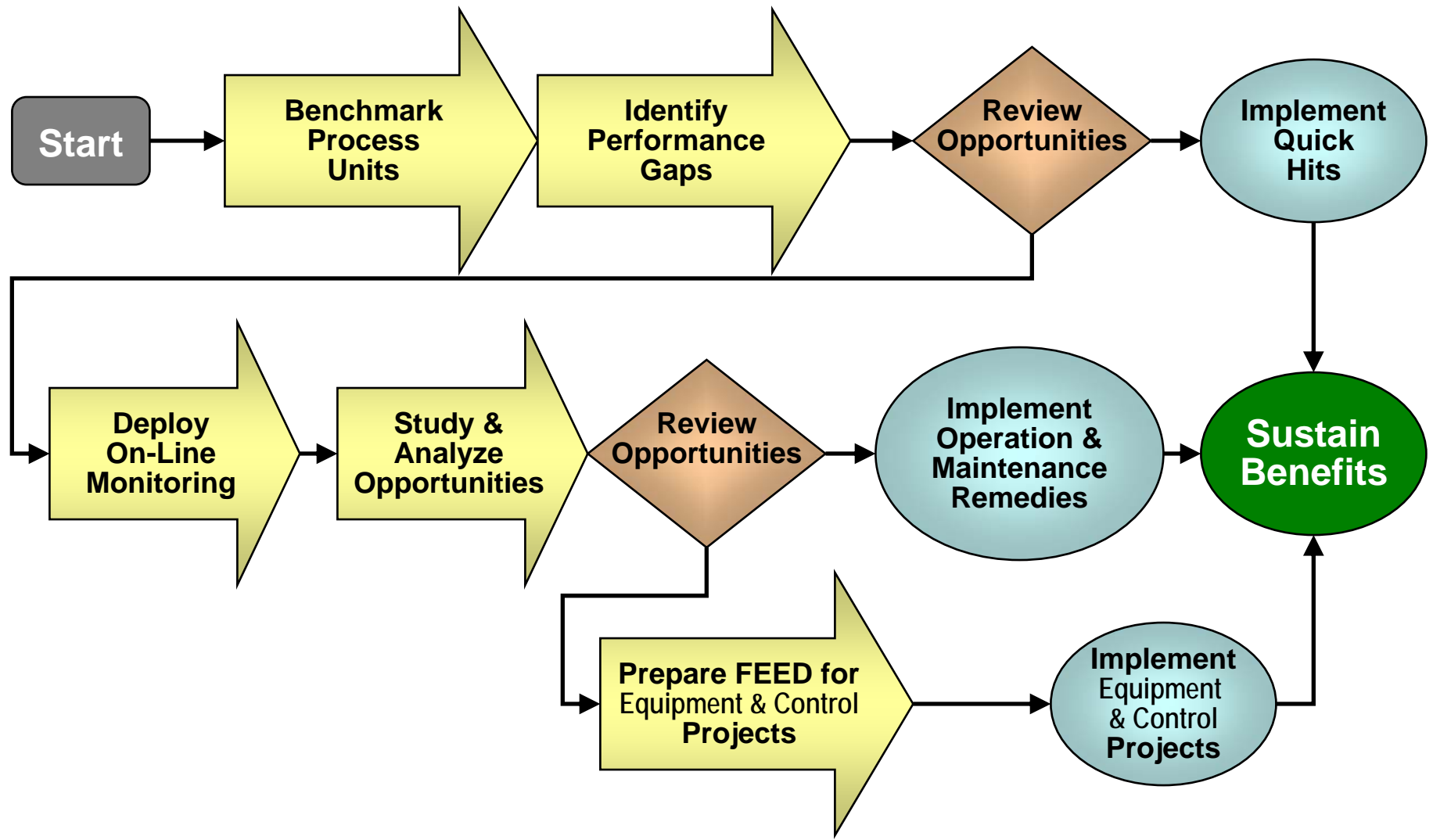
Size of each rectangle corresponds to “nominal” energy use, recalculated to the same basis (MBTU/hr)

Color indicates how well or poorly is the given energy target met



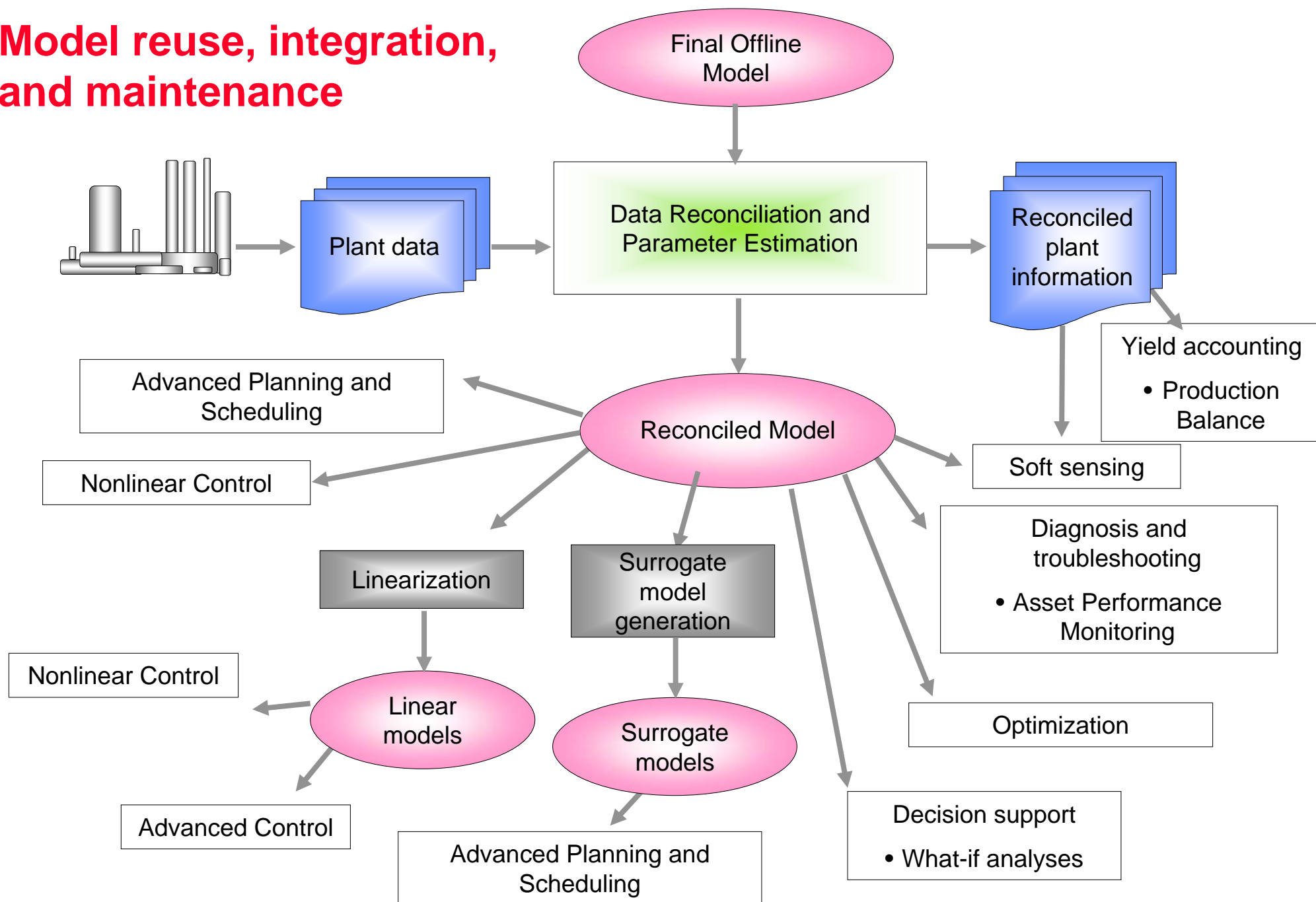
Toward Energy / CO₂ Solution Methodologies

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Toward Unified Modeling Frameworks

Model reuse, integration, and maintenance



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