Pacific Northwest
NATIONAL LABORATORY

Benefits from Integrating Smart Buildings with Smart Grid

November 9, 2018

Srinivas Katipamula, Ph.D.
Staff Scientist

Smart Buildings Internet of Things Workshop
University of Nebraska, Omaha, NE

U.S. DEPARTMENT OF ENERGY BATTELLE

PNNL is operated by Battelle for the U.S. Department of Energy

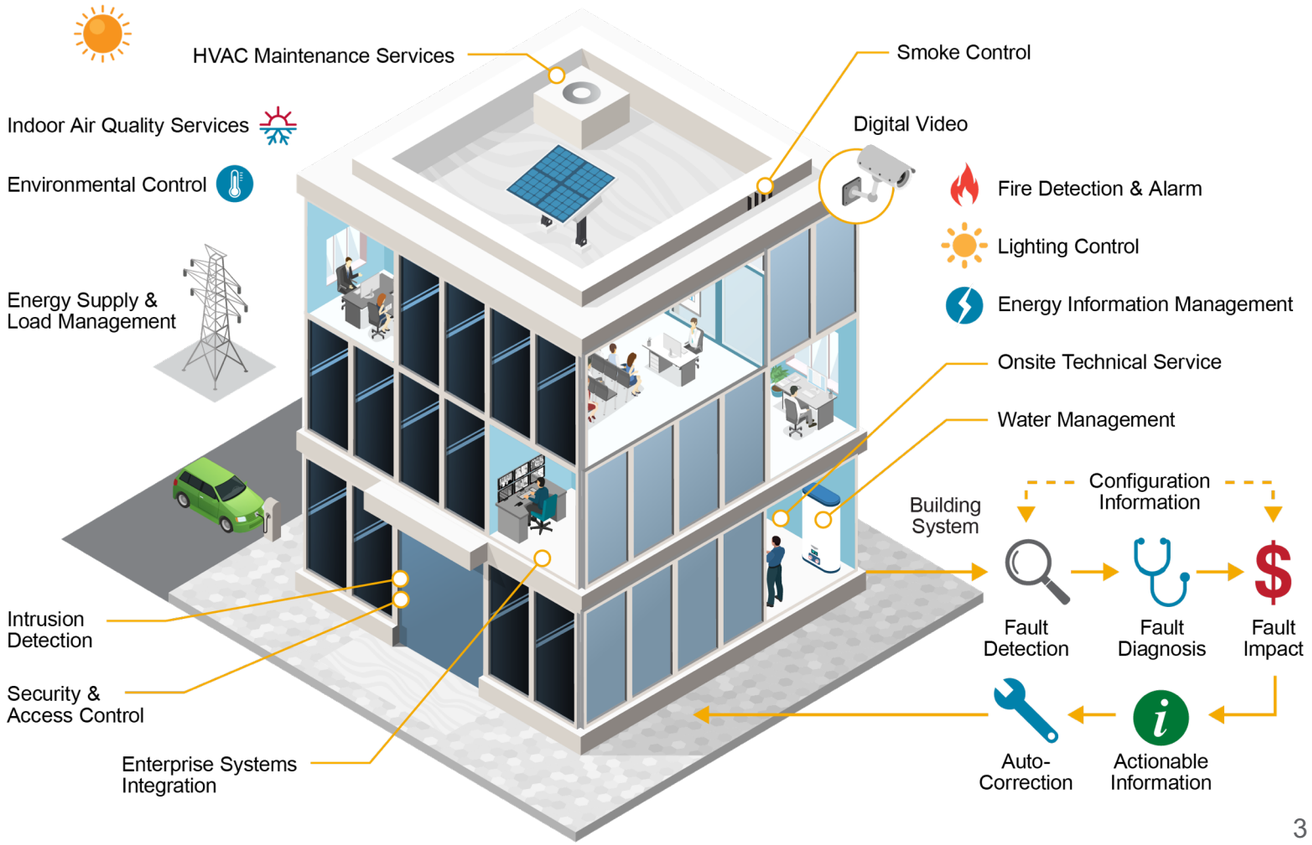
PNNL-SA-139476

Outline of the Presentation

- Definition and Attributes of Smart Building and Smart Grid
- Challenges to Making Buildings “Smarter”
- How we can Make Buildings “Smarter”
- Benefits from Integration of Smart Buildings with Smart Grid
- Closing Thoughts

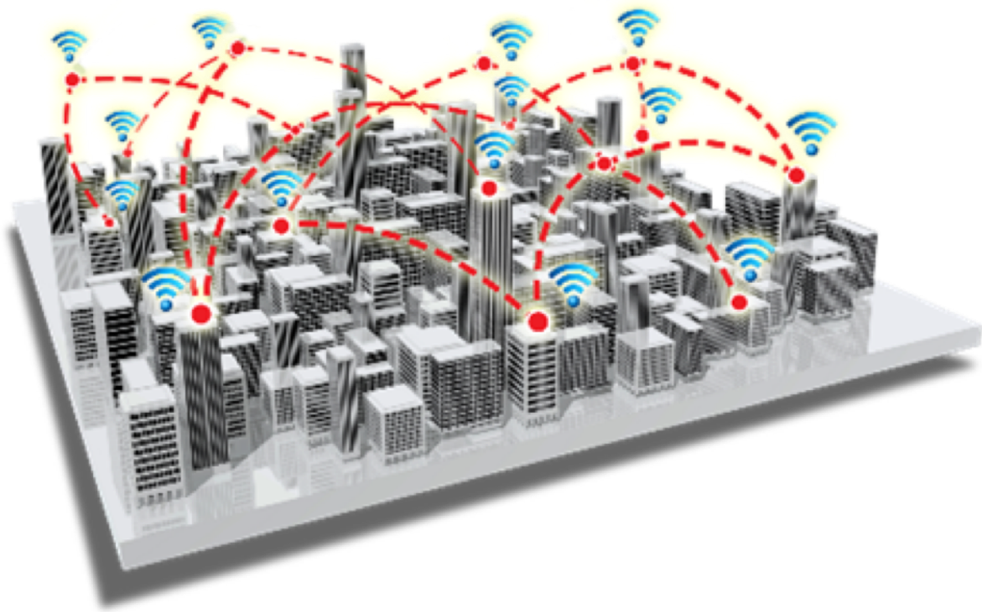
Definition of “Smart” Building

- Buildings that take advantage of dynamic characteristics of building shell and heating, ventilation and air conditioning (HVAC) system, automation, communications, and data analysis technologies to optimize its operations
  - Systems that take advantage of network of sensors; advanced controls; intelligent automation; and modern communications to monitor, operate and maintain a building in the most efficient and cost-effective manner
  - Integrated HVAC and lighting controls with security and access systems



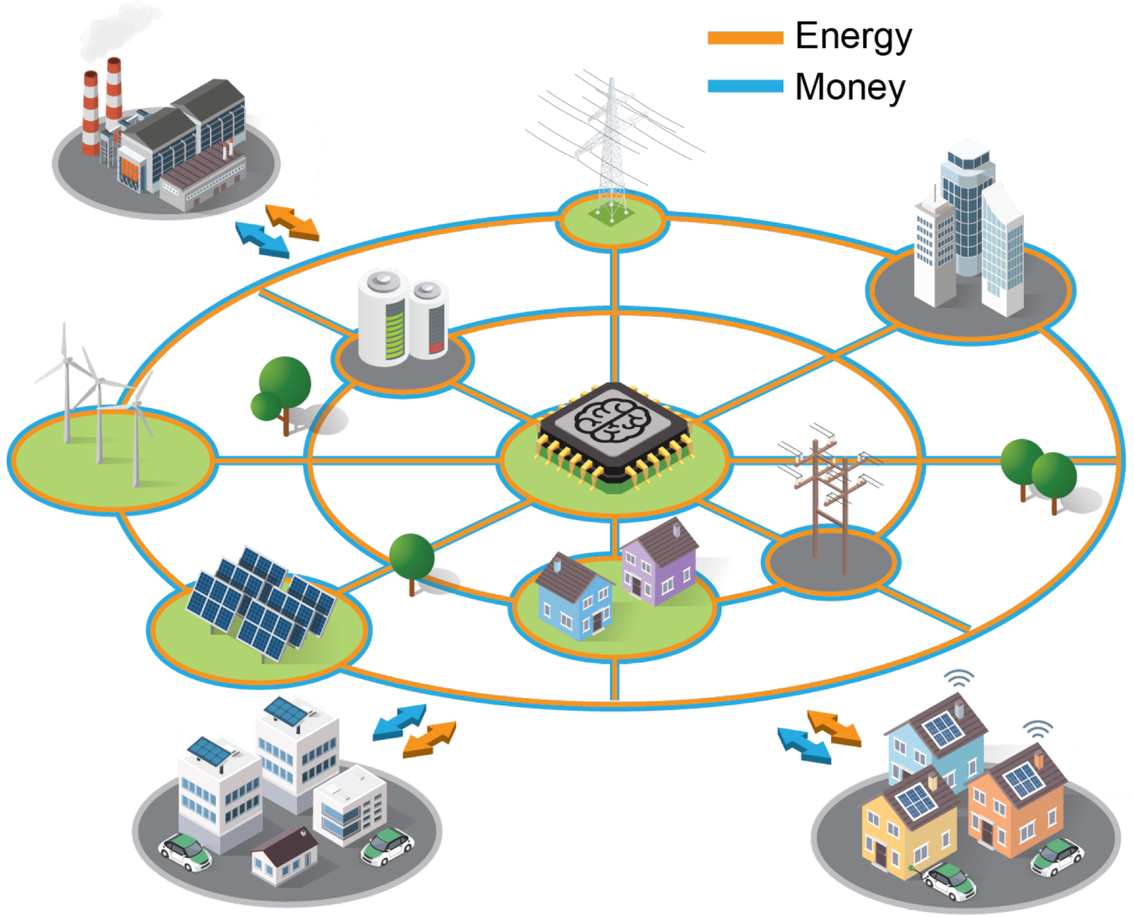
Attributes of Smart Buildings

- Systems in smart buildings will be self-configuring, self-commissioning, self-learning, self-diagnosing, self-healing, and self-transacting – leading to a self-aware building
- Systems in smart buildings will operate automatically and continuously at peak energy efficiency over their lifetimes and interoperate effectively with systems external to the building, including the electric utility grid
- Better indoor environmental quality
- Lowered overall building operating costs and increased asset valuation



Definition of “Smart” Grid

- Smart grid comprises a federation of interoperable systems that leverage information and automation technologies to balance supply and demand while minimizing cost (energy and emissions) and enhancing reliability
  - Dynamic balancing of supply and demand on the grid requires both smart grid and end-use loads that are responsive - smart buildings with smart systems, smart appliances and smart control technologies
  - On the supply side, the smart grid also supports integration of widely variable distributed renewable generation, distributed dispatchable generation and storage technologies



Attributes of Smart Grid

- Smart grid that consists of:
  - Two-way flow of power, information, and communications to facilitate management and optimization of the grid
  - Meet changing consumer demands
  - Incorporate distributed energy resources (DERs), such as electric vehicles, microgrids, solar, wind, storage and flexible end-use building loads
  - Ensure continued and increasing reliability, resilience, security, flexibility, and affordability
- Smart grid infrastructure could include:
  - Network of sensors, controls, and software
  - Communications networks, as well as data analytics, and
  - Hardware, such as transformers, poles, wires, and relays

Source: GridWise® Alliance

Challenges to Making Buildings “Smarter”

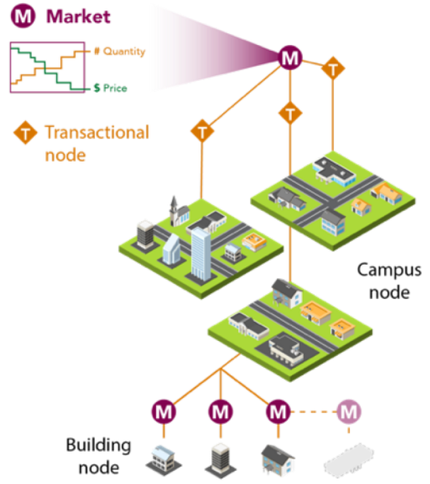
Only 14% (43% of conditioned space) of the building stock has building automation systems

Source: 2012 Commercial Building Energy Consumption Survey

Even buildings that have a modern control infrastructure are not managed efficiently, leading to excess energy consumption between 10% and 30%

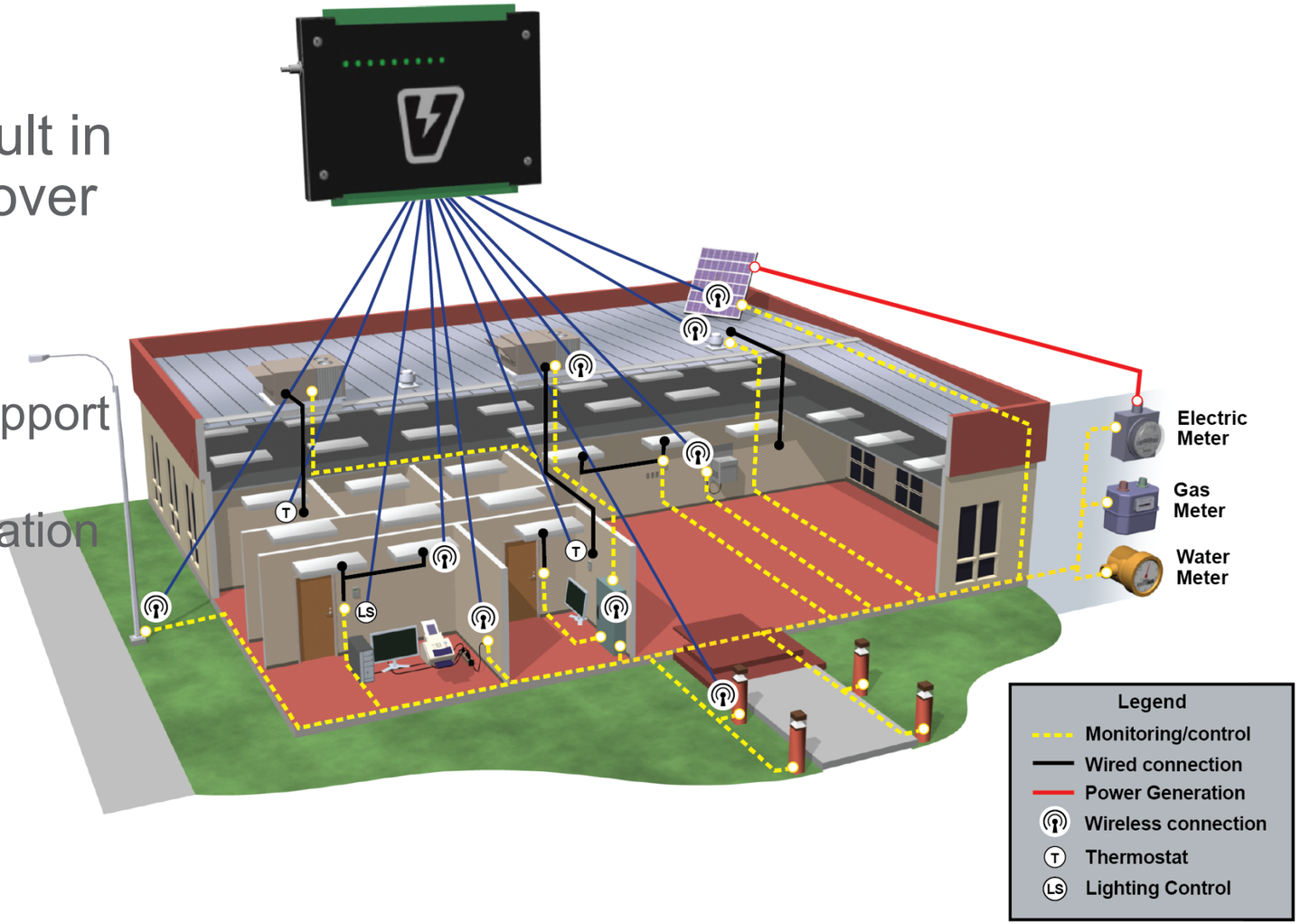
How we can Make Buildings “Smarter”

- Develop and install low cost building automation systems (BASs) for 86% of the commercial buildings that currently do not have a BAS
- Improve operations in all buildings by making buildings and their systems “self-aware”
- Create multiple value streams
  - Spreading the cost of technology and on ongoing operations
  - Grid or energy efficiency services alone may not be sufficient
  - Simultaneous deployment of both grid and energy efficiency services are needed



Low-Cost BAS for Small/Medium Size Buildings

- Enforcing schedules and managing set points will result in energy and cost savings of over 20%
- Beyond demand response
  - Intelligent load controls to support grid reliability
  - Supporting renewable generation technology integration
  - Will result in 10% to 20% reduction in demand



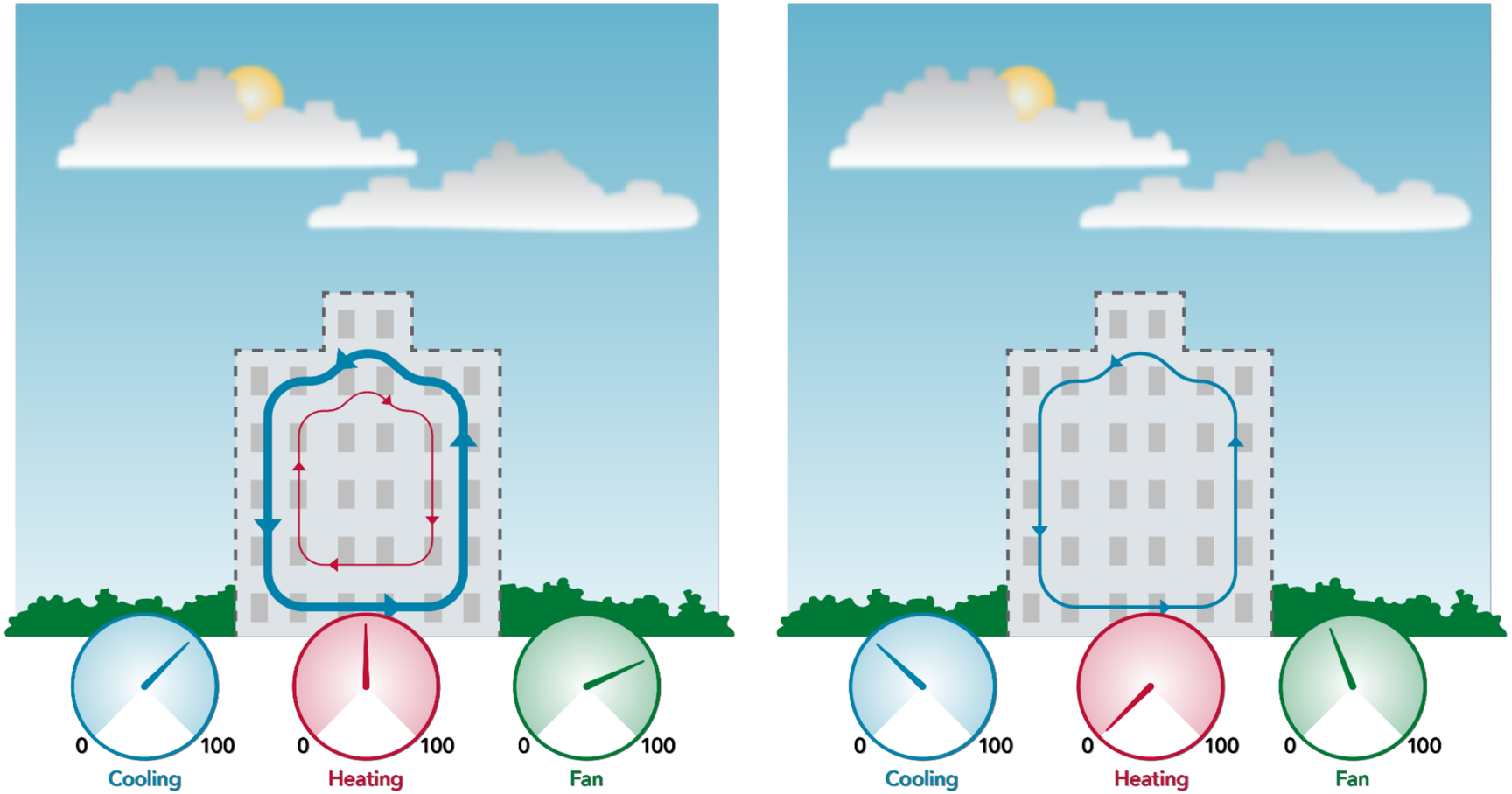
”Self-Aware” Smart Buildings

Systems are designed and sized to provide comfort for a “design” day …

… but not every day is a design day, so smart systems will to adapt to diurnal and seasonal changes…

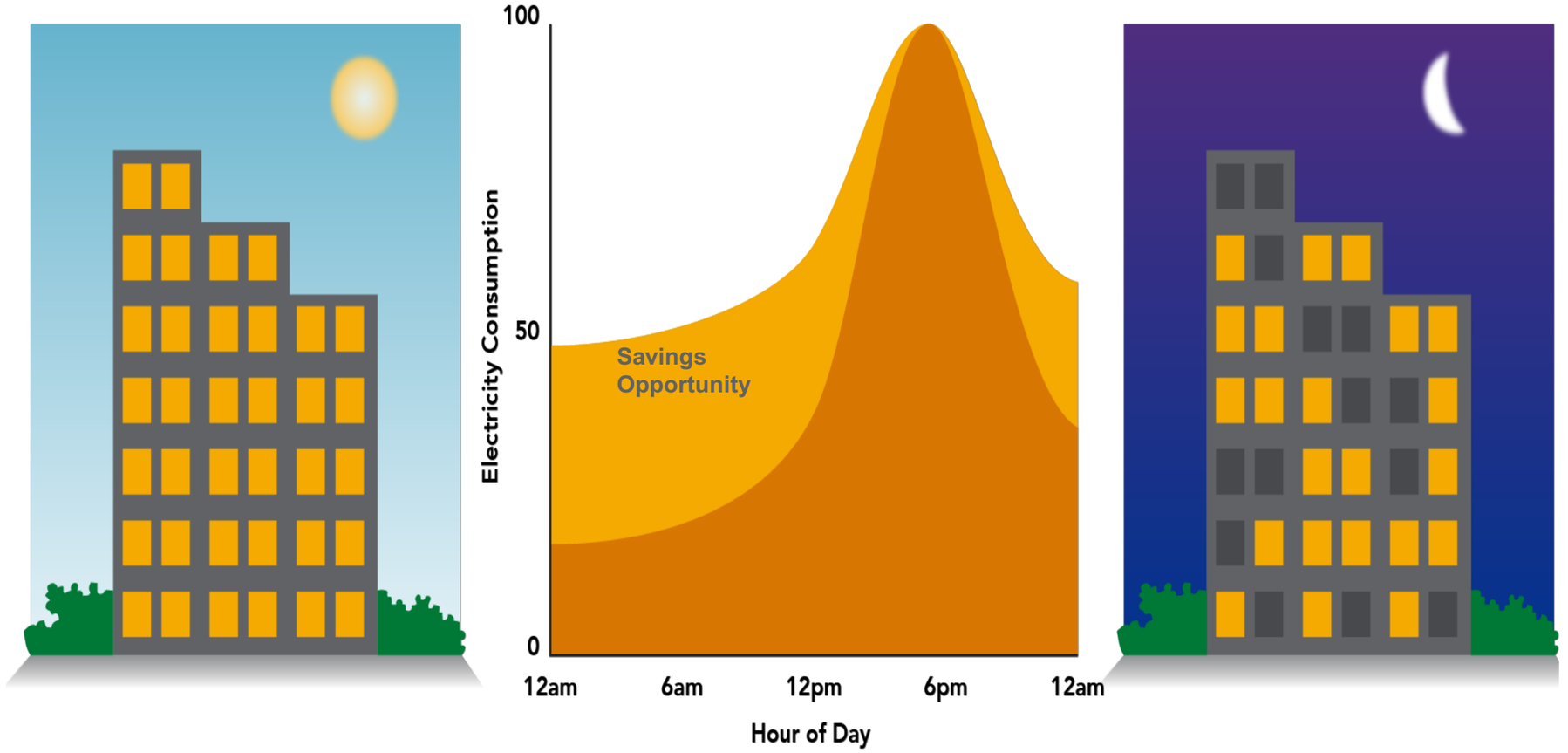
Smart Buildings are Always Self-Aware

Self-aware buildings learn occupant's needs, respond to changing weather conditions and automatically make changes to the HVAC and lighting systems to maximize energy efficiency



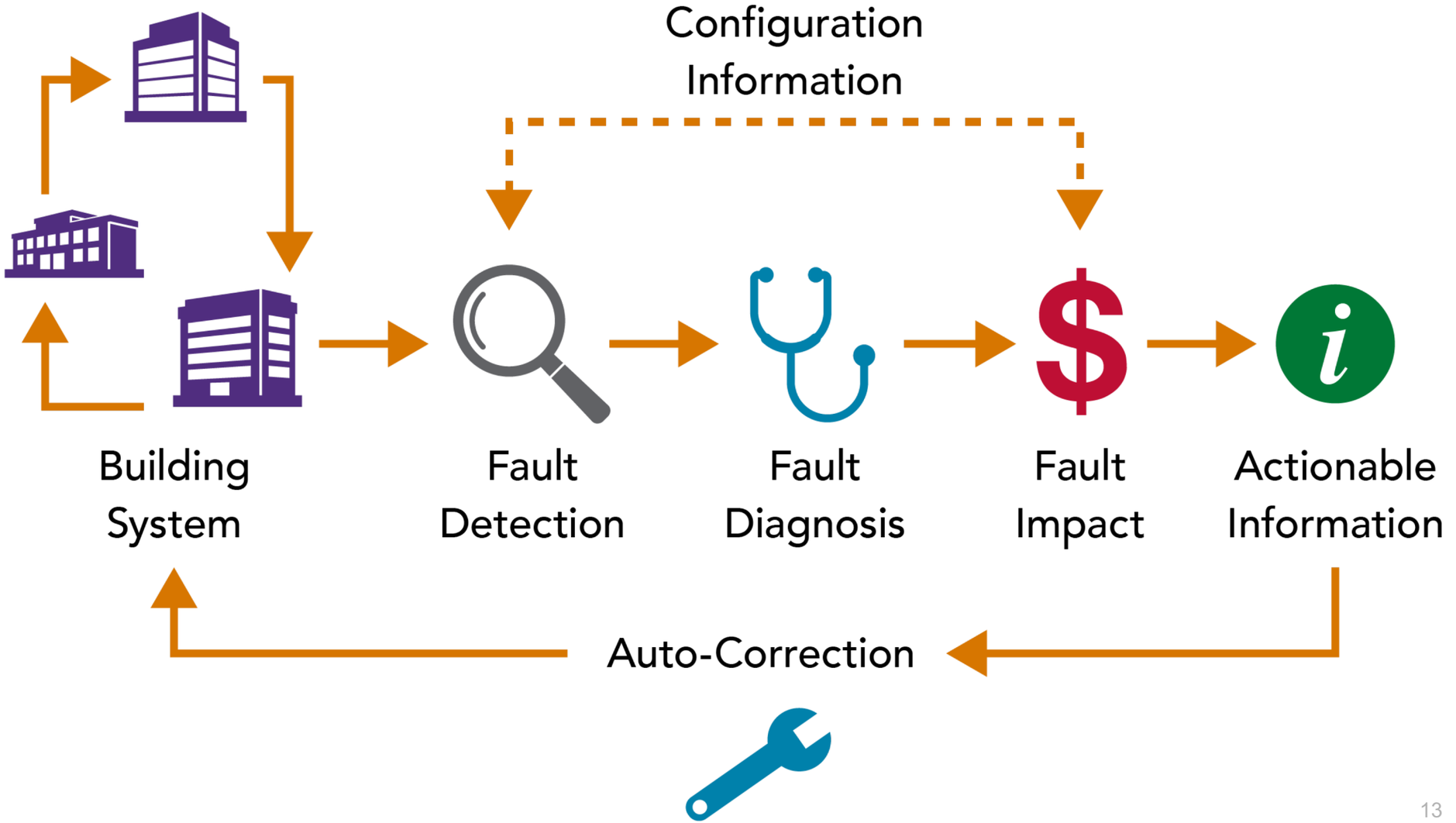
Another Example of Self-Aware Smart Building

Buildings that detect lack of activity in spaces and automatically adjust lighting and HVAC systems to dedicate less resources to these spaces



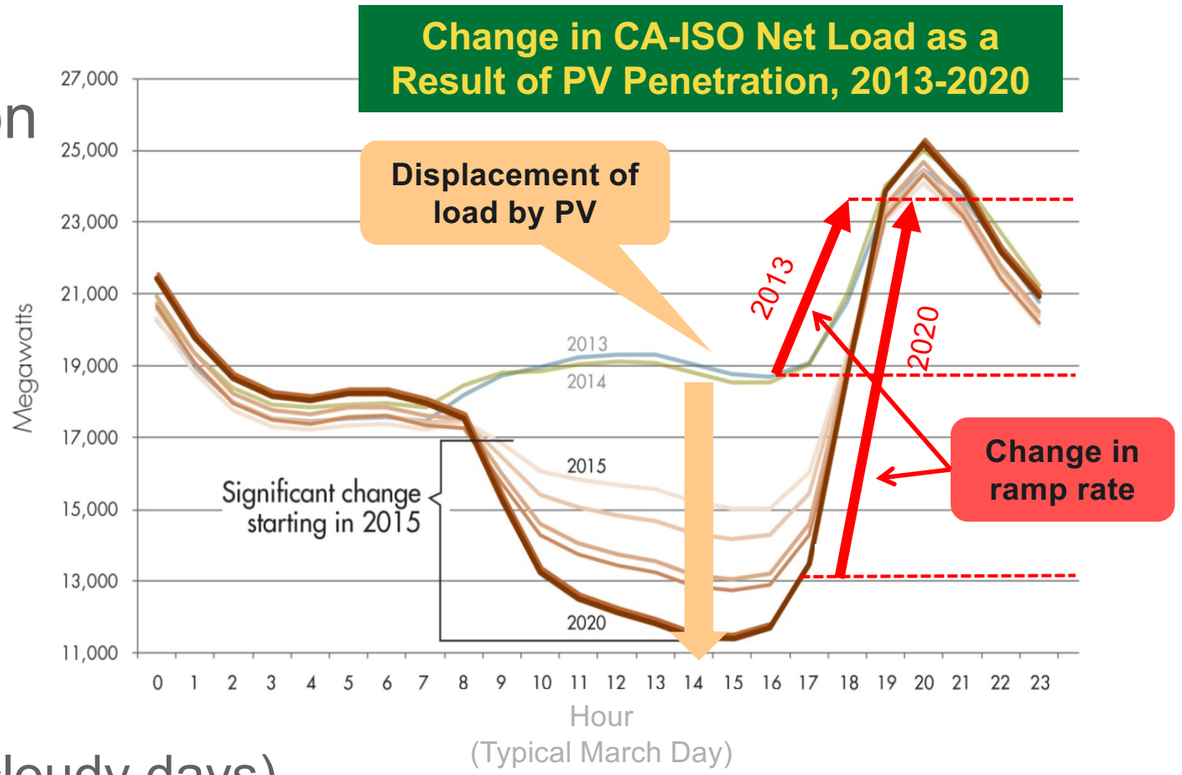
Smart Buildings Continuously Self-Diagnose, Self-Commission and Self-Heal

Continuously operating building systems at peak efficiency

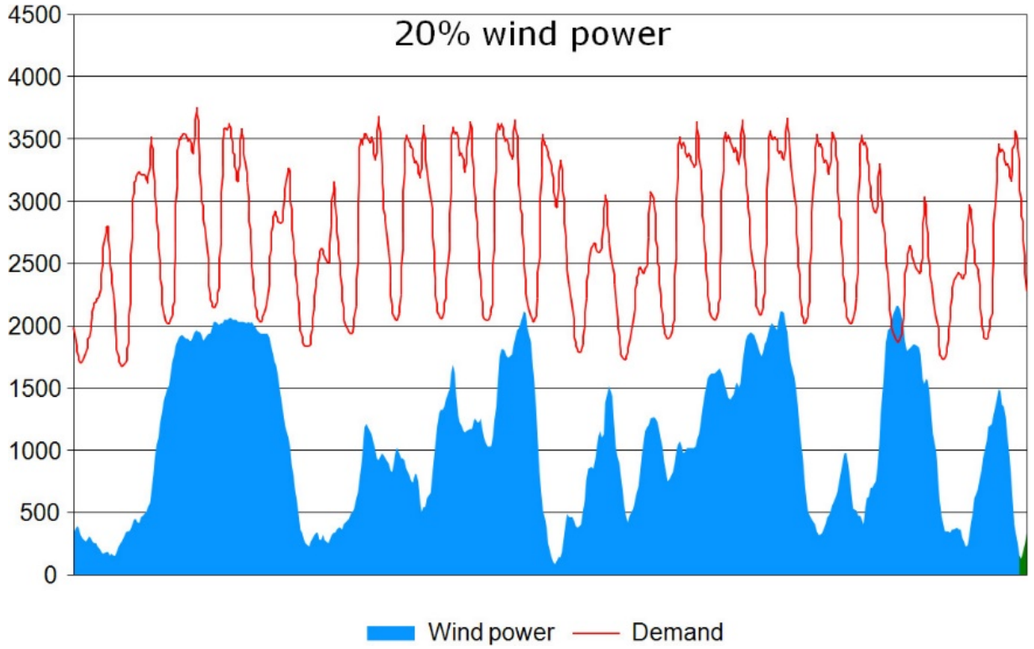


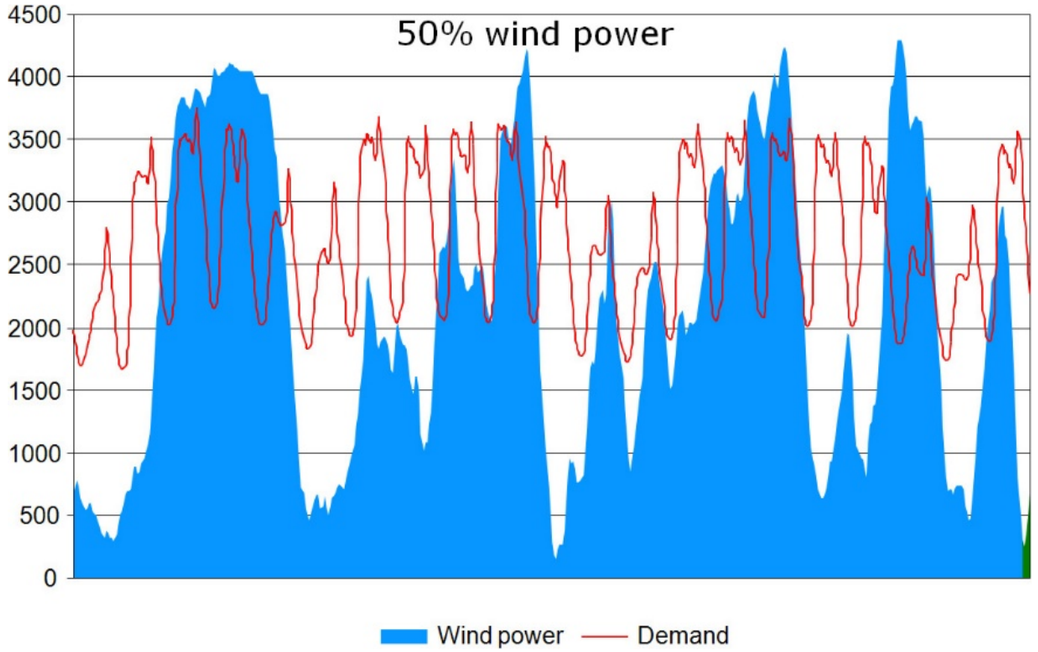
Smart Buildings can help Mitigate Solar PV Penetration

- Rapid photovoltaic (PV) penetration increasingly displaces mid-day loads over time
- Challenges presented by PV penetration become barriers under business-as-usual operations
  - Ramp rate (load change) at end of day expected to double
  - Rapid swings complicate dispatch – a hazard for reliability
  - Increase costs for more reserve power plants
  - Rapid distribution system voltage swings from fluctuations in output (intermittently cloudy days) must be managed



Smart Buildings can also help Mitigate Wind Penetration





- The situation in western Denmark in 2008: Wind generation is 20% of power required to meeting the total demand. Wind power exceeds demand about 200 hours/yr

- The expected situation of the whole of Denmark in 2025: wind power production could meet 50% of total demand. Wind power could exceed demand for about 1,000 hours/yr

Soruce: Kok, K. 2013. "The PowerMatcher Smart Coordination for the Smart Electricity Grid. Ph.D. Published by TNO, The Netherlands
Cover design by Jos Rietstap SIKS Dissertation Series No. 2013-17.

Pacific Northwest
NATIONAL LABORATORY

Closing Remarks

- “Smarter” buildings will result in persistent building operations, significant energy savings and improved occupant comfort
- Most buildings are not ”smart,” but they could be
- To make buildings smarter, investment/infrastructure is needed
- Leveraging multiple value streams will help to make investments in infrastructure cost-effective
- Smart buildings can mitigate unintended, negative consequences from the effects from high penetration of renewable generation
- Integrating buildings systems with electricity grid can benefit both the grid as well as building owners/operators
- Although there are a number of efforts to develop applications to improve building energy-efficiency, including increased hosting capacity of renewables and increased grid reliability, more work is needed to close the gap

Pacific Northwest
NATIONAL LABORATORY

Thank you