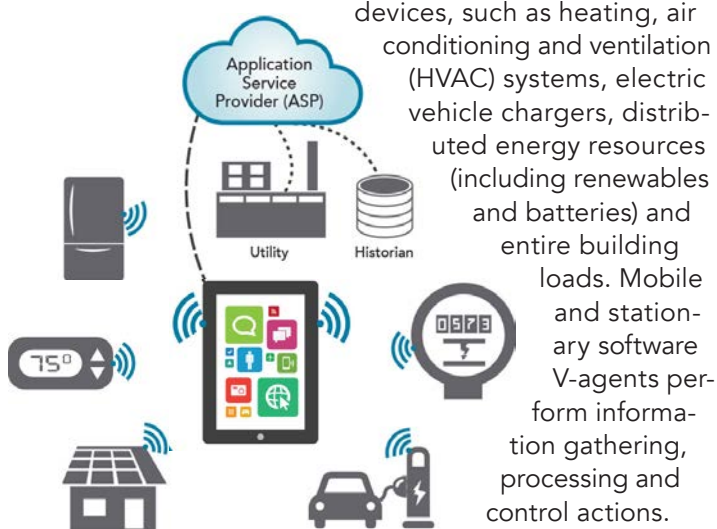


## A Technology for Efficient Buildings and Integration of Distributed Energy Resources with the Grid

VOLTTRON™, developed at Pacific Northwest National Laboratory, is a distributed control and sensing software platform. Used in concert with special applications known as V-agents, the groundbreaking technology analyzes and converts growing data streams from today's buildings to actionable information that improves building operations, manages energy consumption and enables true integration of buildings with the electric grid. VOLTTRON™ independently and securely manages a wide range of



### VOLTTRON™'s 3 Key Benefits:

**Cost-effective** – Open source software (free to users) and can be hosted on inexpensive computing resources

**Scalable** – Can be used in one building or a fleet of buildings

**Interoperable** – Enables interaction/connection with various systems and subsystems, in and out of the energy sector

### VOLTTRON™'s 3 Primary Use Areas:

**Building Efficiency** – To help control building energy system performance

**Building-Grid Integration** – To support “beyond demand response” approach and integration of distributed energy resources into the grid

**Transactive Control** – To support a scalable, distributed control mechanism for transacting information about systems, loads, and constraints to deliver user specified services

## VOLTTRON™ TIMELINE

» VOLTTRON™ developed (September 2012)

### 2014

» Deployed in DOE Transactive Network Project with participation from Lawrence Berkeley and Oak Ridge national laboratories (March)

» Released as open source software (April)

» Adopted by Virginia Tech as platform for BEMOSS™, a small commercial building operating system (Spring)

» First DOE-sponsored VOLTTRON™ user forum (July)

» Release of Version 2.0 (September)

### 2015

» Second DOE-sponsored VOLTTRON™ user forum (July)

» Release of Version 3.0 (September)

» Deployed by the National Renewable Energy Laboratory (NREL) in its Energy Systems Integration Facility (December)

### 2016

» Release of BEMOSS™ V2.0 (March)

» Deployed by Transformative Wave in Northwest buildings (Spring)

» Applied in DOE Clean Energy & Transactive Campus project (Spring)

» Deployed by Intellimation in D.C. buildings (Spring)

» Used in DOE BIRD-IP program (Spring)

» Incorporated in Portland State University graduate course (Spring)

» Applied in 10 DOE grid modernization projects (Summer)

» Used in DOE Connected Buildings Challenge (Summer)

» Third DOE-sponsored VOLTTRON™ user forum (August)

» Release of Version 4.0 (September)

## VOLTRON™: MORE THAN A DOZEN USABILITY ADVANTAGES

- » Open, flexible and modular software platform
- » Easy application development
- » Object-oriented, modern software development environment
- » Language agnostic
- » Low CPU, memory and storage requirements
- » Built-in weather service that retrieves info from any location
- » Cybersecurity features

### Supports:

- » ZeroMQ distributed messaging
- » MODBUS and BACnet protocols
- » Both Intel and non-Intel CPUs
- » Collection of non-energy-related data (comfort, financial, etc.)
- » Platform services such as messaging, mobility and application support
- » Flexible Historian framework (enables use of preferred storage solution)
- » Many other protocols

## COUNTING ON SECURITY

VOLTRON™ was designed with cybersecurity in mind, including features such as memory protection, resource constraints and guarantees, authentication, authorization, and trust. For applications that require software to “move” between platforms, VOLTRON™ supports secure application transport, including code, configuration and collected data.



VOLTRON™ is available to the public for download. Visit <https://github.com/VOLTRON/voltron> to learn more. Redistribution and use of VOLTRON™ in source and binary forms are permitted in accordance with VOLTRON™ Terms listed on GitHub.

An “Office Hours” users group has been formed to periodically discuss the technology and new developments. For general information about VOLTRON™ and/or the users group schedule, contact [voltron@pnnl.gov](mailto:voltron@pnnl.gov).

Web page: <http://transactionalnetwork.pnnl.gov>

## VOLTRON™ + APPLICATIONS = SOLUTIONS

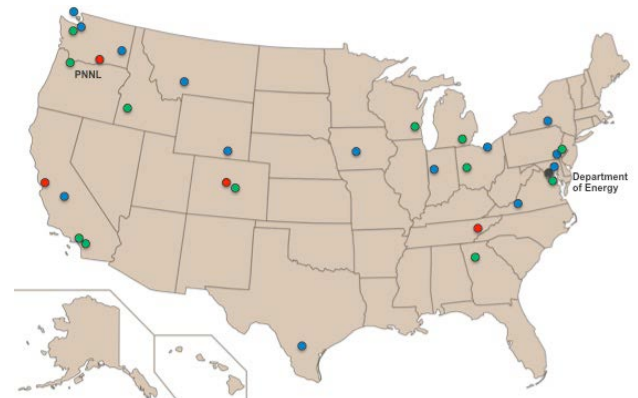
Key applications developed by PNNL and others to date:

- » Automated Fault Detection and Diagnostic V-Agent (for air-handling units or rooftop units)
- » Autonomous Control of Rooftop Units
- » Demand Response V-Agent (dynamic electric pricing)
- » Supermarket Refrigeration
- » Renewable Energy Integration
- » Lighting Diagnostic
- » Automated Continuous Commissioning V-Agents for Air-Handling Units
- » Measurement and Verification
- » Smart Monitoring and Diagnostic System
- » Intelligent Load Control V-Agent



## COAST-TO-COAST USE AND DEVELOPMENT

VOLTRON™ developers are building a community of public and private sector users to apply the technology and help drive improvements. Two national laboratories—NREL and Oak Ridge—are among those that have provided key development contributions.



### VOLTRON™ Downloads

- National Laboratories
- Universities
- Private Sector Orgs

## VOLTRON™ IN THE MARKETPLACE

Developers and planned products/services:

- » **Virginia Tech (BEMOSS™)**—Small commercial and residential control application
- » **Transformative Wave**—Small building services
- » **Intellimation**—Commercial office building services

