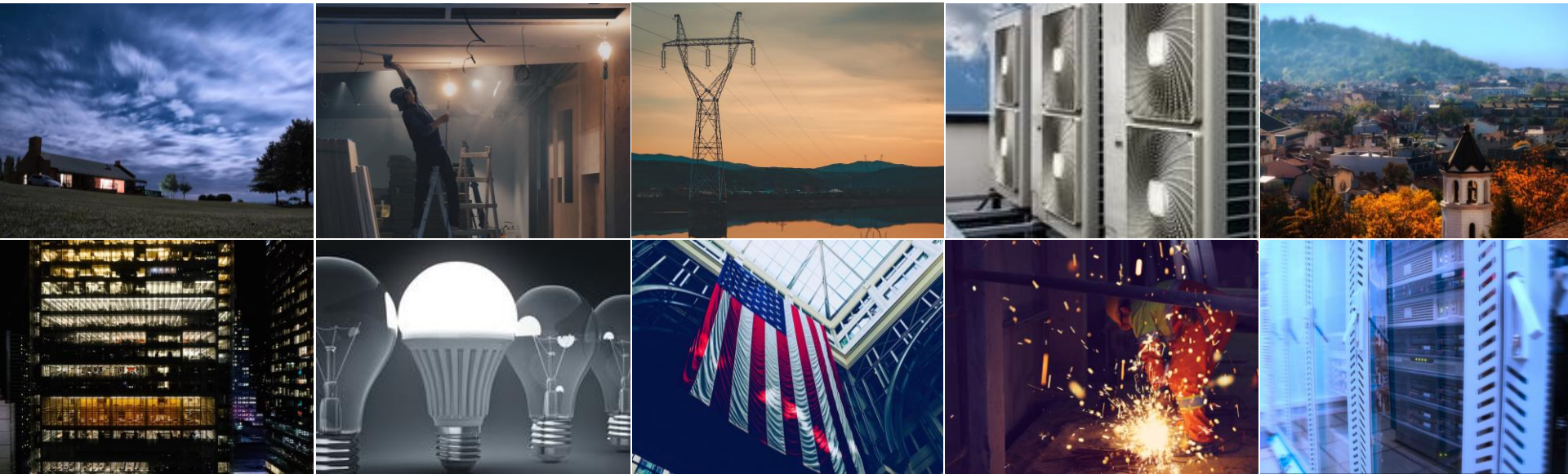
U.S. DEPARTMENT OF ENERGY

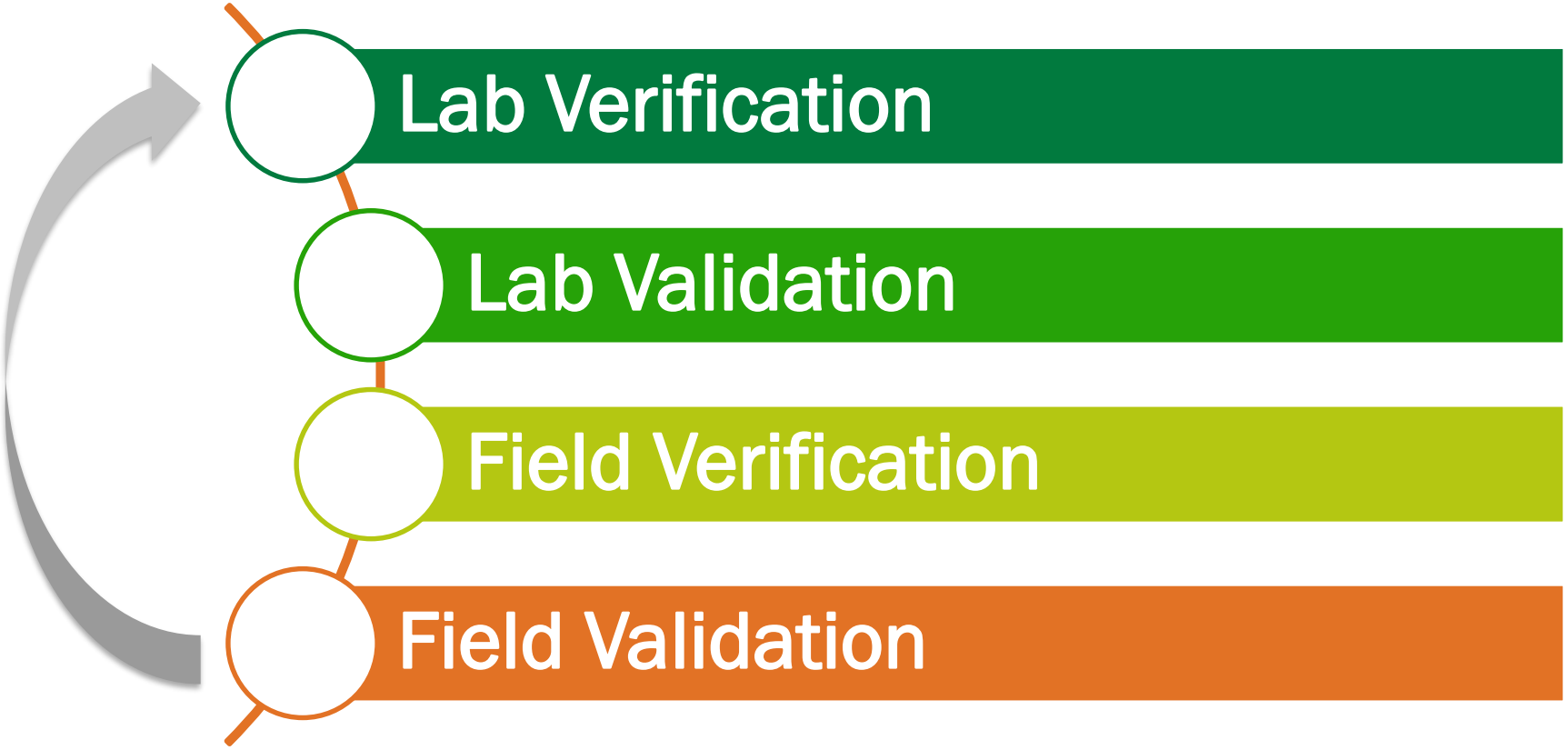
Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

# Does it work in the real world?

BTO's approach to field verification and validation of technologies

Peer Review April 15, 2019




Lab Verification
Lab Validation
Field Verification
Field Validation

# Objective

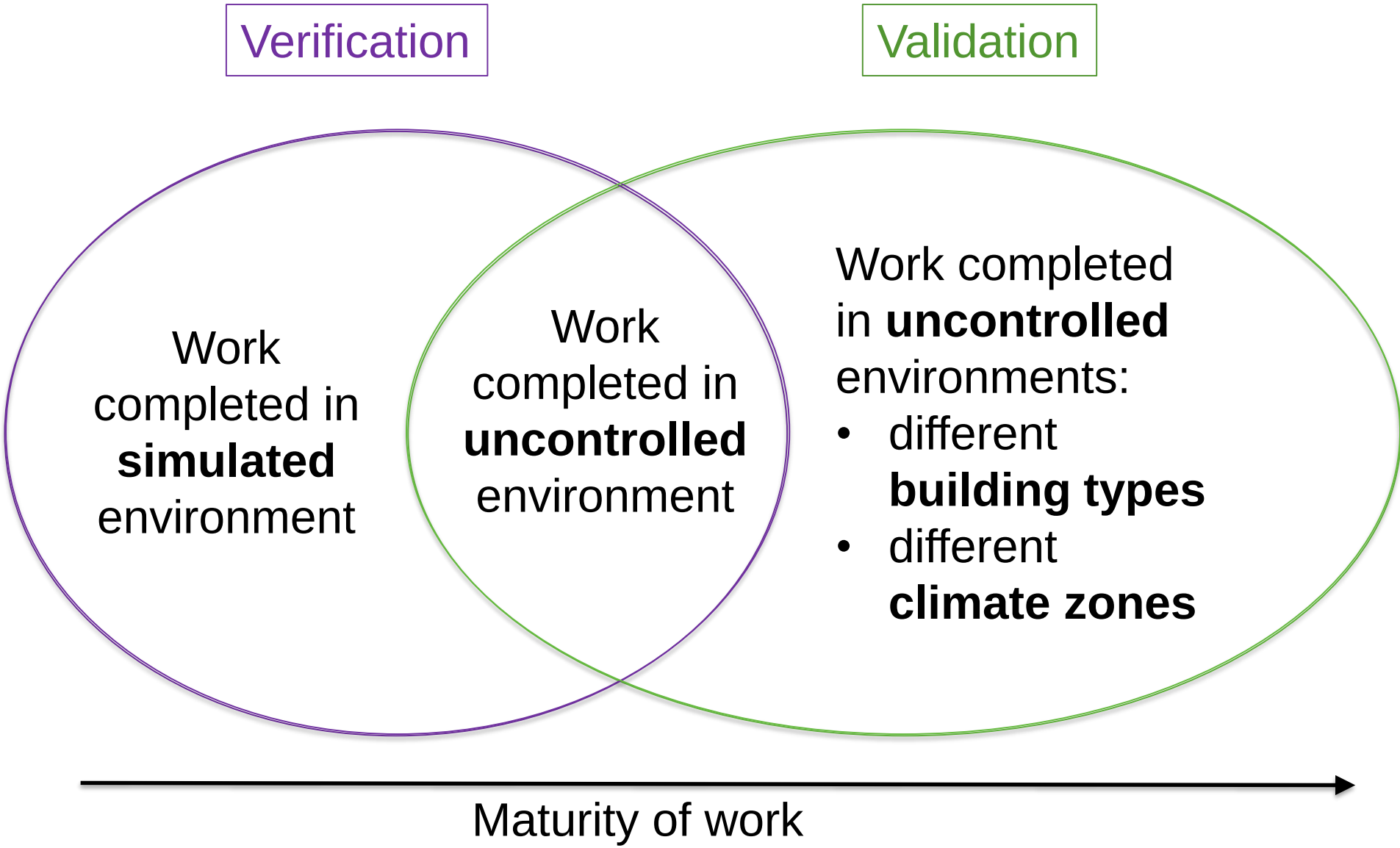
**Provide a framework for the verification and validation of energy efficiency, grid services, and non-energy variables**

- **Determine the scope and landscape of field verification & validation projects within BTO**
- **Determine best practices of field verification & validation projects**
  - Identify metrics
  - Document lessons learned
  - Demonstrate how to inform early stage research and development
- **Share with external BTO stakeholders to strengthen collaboration on field verification & validation**

# Approach

1. Determine a **definition** of field verification & validation to be applied to BTO projects
2. Determine **comprehensive list of BTO projects** currently funded that have a field verification or validation component
3. Identify the **maturity** of the projects, what **objectives and metrics** are used in each of these projects, and **outputs**.
4. Confirm determinations with technical managers and principal investigators.

# Definitions – maturity of work

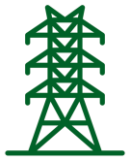


# Project objectives of field verification & validation work

- Validate pre-commercialized technology for research & development priorities
- Identify gaps in design and in-field performance
- Identify gaps in systems design and in-field performance
- Support method development data verification, collection, management, and analysis
- Provide third party validation
- Extend technologies to wider applications

# Aspects projects are verifying and validating

- Energy efficiency
- Energy storage
- Demand response capabilities
- Comfort
- Grid flexibility & renewables integration
- Affordability & cost effectiveness
- Ease of Operation & Maintenance
- Indoor air quality
- Service delivery
- Environmental



# Project outputs

- Data sets
- Accessible tools
- Final reports
- Transition to manufacturer
- Feedback to early stage R&D

# Expert panel

Karma

Teja

Michael

# Karma Sawyer, Ph.D. – Program manager of Emerging Technologies of BTO

- Oversees a diverse portfolio of R&D program areas to develop cost-effective, energy-efficient high-impact building technologies
- Partners with academia, national labs, small businesses, and industry in HVAC, windows and envelope, sensors and controls, SSL, building energy modeling & controls
- Joined ET team at BTO in 2013

# Teja Kuruganti, Ph.D. – Group Leader for Modeling and Simulation at Oak Ridge National Laboratory (ORNL)

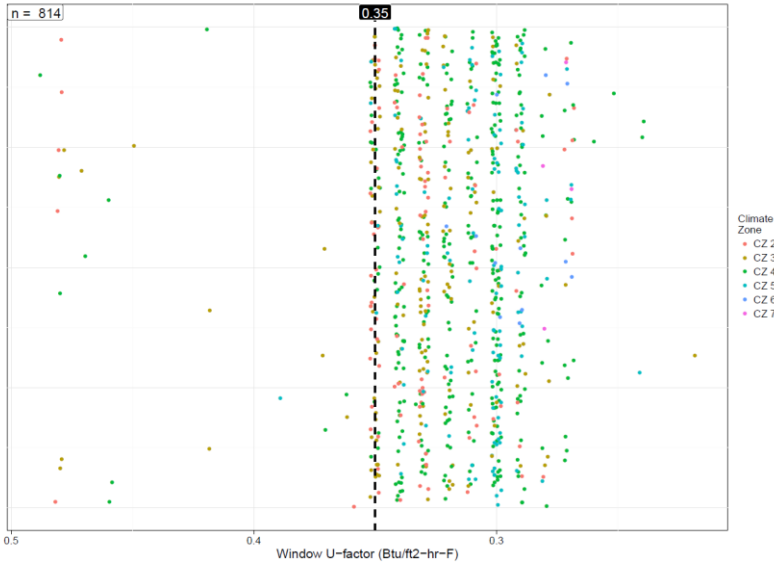
- Currently leads activities in developing novel sensors and controls for improving energy efficiency of buildings and novel techniques for enabling grid-integration and responsive building loads
- Joined ORNL in 2003 and has been working on field validation projects for the past 10 years

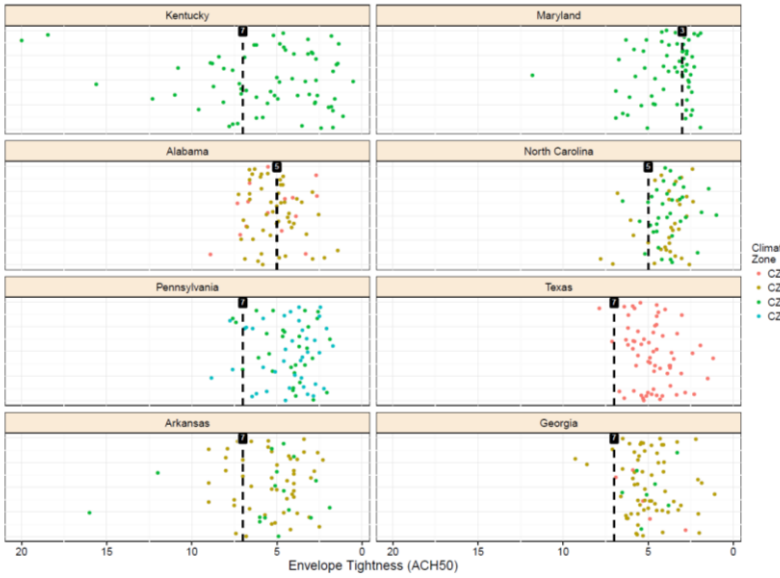
# Michael Deru, Ph.D. – Senior Research Engineer at National Renewable Energy Laboratory (NREL)

- Leads research within the Building Energy Science group
- Manages projects on development and validation of novel HVAC systems, building performance simulations, performance metrics for sustainability, source energy and emissions factors, water, and the US Life Cycle Inventory Database
- Joined NREL in 2000 and has been working on field validation projects for the past 18 years

# Codes Field Studies: Windows & Envelope (Karma)

- **Objective:** Maximize code-intended savings and provoke additional investments in energy code programs by:
- **M&V Approach**:
  - Results based on an energy metric and reported at the state level
  - Individual measures within new single-family homes
  - No personal data will be shared
  - Designed for statistically significant results at the state level
- **Trends Identified:**
  - Envelope tightness: similar range regardless of code requirement
  - Wall Insulation: typically meet lab R-values, but weak installation quality
  - Windows: almost all observations exceed requirements
- **R&D needs:**
  - Windows: performance driven by Energy Star
  - Envelope: installation is critically important, even for new construction



# Field Validation: Smart Neighborhood (Teja)

**Objective:** Evaluate building-to-grid integration with distributed energy resources and high performance connected homes at neighborhood-scale for optimizing cost, reliability, and environmental impact

**M&V Approach**:

- Alternating week on/off experiments for specific use case
- Extensive device-level submetering and data analysis platform/dashboard
- Models for generating data for additional validation

**Challenges:**

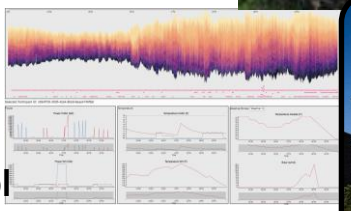
- Integration with device API – manufacturer updates, rate-limiting API calls
- Connectivity challenges – device manufacturer servers, home Wi-Fi
- Alert management to facilitate autonomous decision making

**Successes:**

- Deployment of neighborhood-scale control, automation, and data collection for transactive control between homes and microgrid
- Deployment of use cases to demonstrate the access to flexibility/virtual storage in residential buildings without customer impacts

**R&D needs:**

- Device discovery and auto-commissioning approaches for reducing integration costs
- Scalable device/agent-level authentication mechanisms
- Data-driven learning/forecast for energy consumption for use in control formulations



# Field Validation: Challenges and Rewards (Michael)

**Technology:** enVerid HLR indoor air scrubber
- Removes CO2, VOCs, formaldehyde, O3, PM

**M&V Approach:**
- Alternating weekly On-Off cycling of HLR
- Regression modeling of cooling/heating energy
- Whole building energy modeling for extended results
- Monitored IAQ and indoor T&RH

**Challenges:**
- Selecting buildings and characterizing air flows and balance
- Maintaining prescribed building operations for testing
- Data quality & uncooperative weather during FV


**Successes:**
- Feedback to enVerid and owners
- Learned the installation and operation challenges
- Validated energy savings and air cleaning

**R&D needs:**
- Improved ventilation control and air balancing
- Improved and lower cost IAQ sensors
- Improved sorbent effectiveness and life

# Expert panel

Karma

Teja

Michael