



# Wireless Valve Position Indication Sensor System

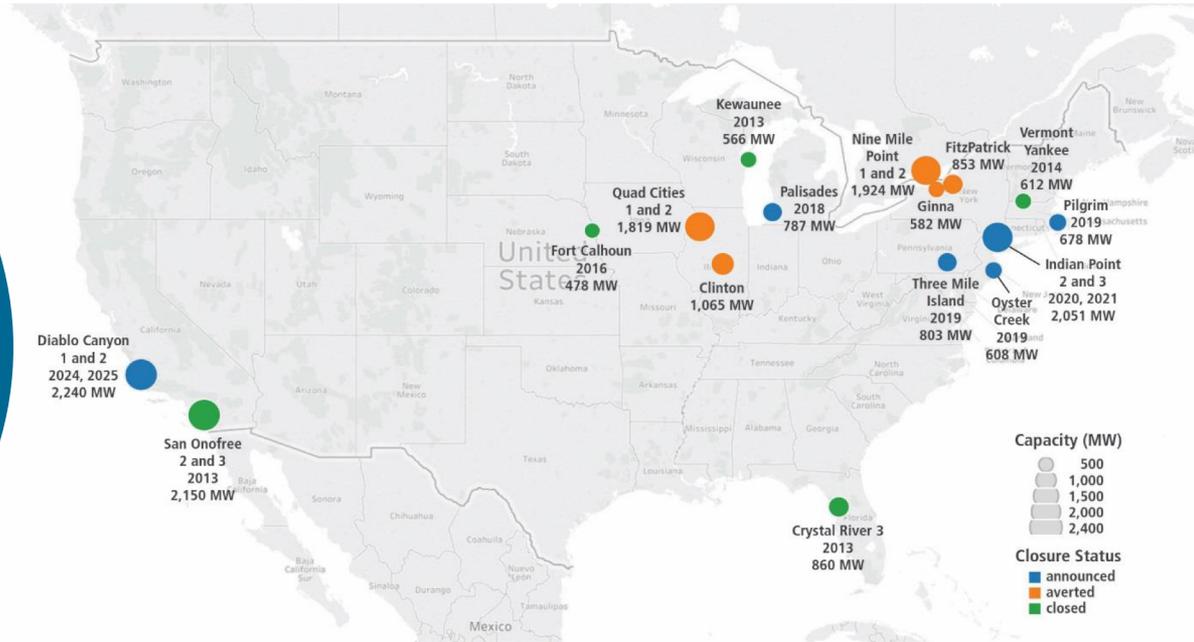
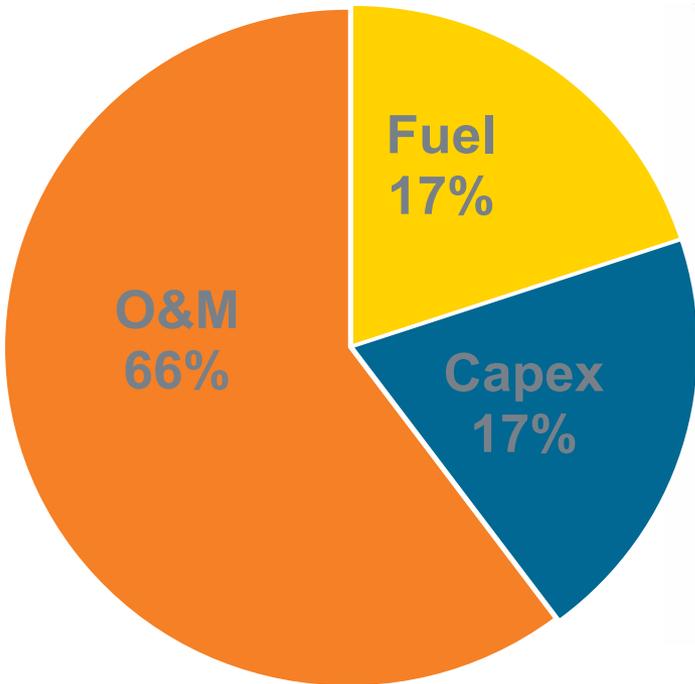
Advanced Sensors and Instrumentation  
Annual Webinar

October 31 – November 1, 2018

Vivek Agarwal  
Idaho National Laboratory

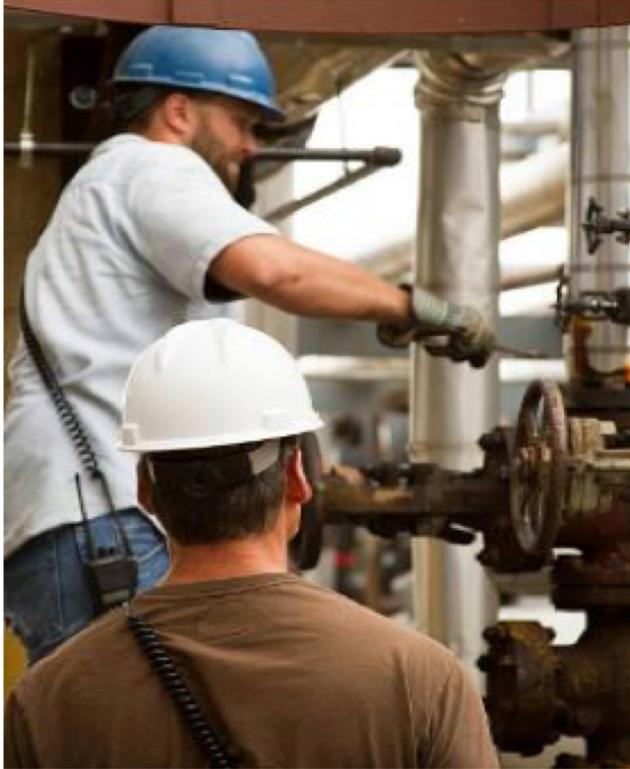
# Motivation

## Economic Challenges Causing Early Closure of Nuclear Power Plants



# Motivation

150-200 manual valves per reactor plant



# Existing Valve Position Indication Technologies

## Analog Technologies



Limit Switches



Shaft Encoder



Proximity Readers

Digital Technologies	Recertification & Valve Disassembly	All Manual Valve Types	Radiation Tolerant	Communication Protocol	Continuous VPI	EMI/RFI Certification
Emerson	Yes	No	No	Wireless HART	No	No
ELTAV	Yes	No	No	IEEE 802.15.4	No	No
Honeywell	Yes	No	No	Proprietary	No	No
Westlock	Yes	No	No	IEEE 802.15.4	No	No

# Research Opportunities

- Research, design, development, demonstration, and deployment associated with sensor system life cycle (i.e., Technology Readiness Level ,TRL, 1-9)
- Wireless valve position indication sensor system requirements
  - Avoid valve disassembly to install sensor system and recertification process
  - Miniaturized design
  - Meets electromagnetic interference and radio-frequency interference guidance
  - Meets plant and regulatory cyber guidance
  - Low power consuming
  - Radiation lifetime expectancy
  - Wireless communication over most industrial protocols (IEEE 802.11, Zigbee, Bluetooth, and LTE)
  - High quality of service of the wireless communication
  - Light weight and seismic qualified
  - Easy to install, un-install, and low maintenance
  - Ability to leverage power harvesting technologies in future to address battery lifetime expectancy concerns

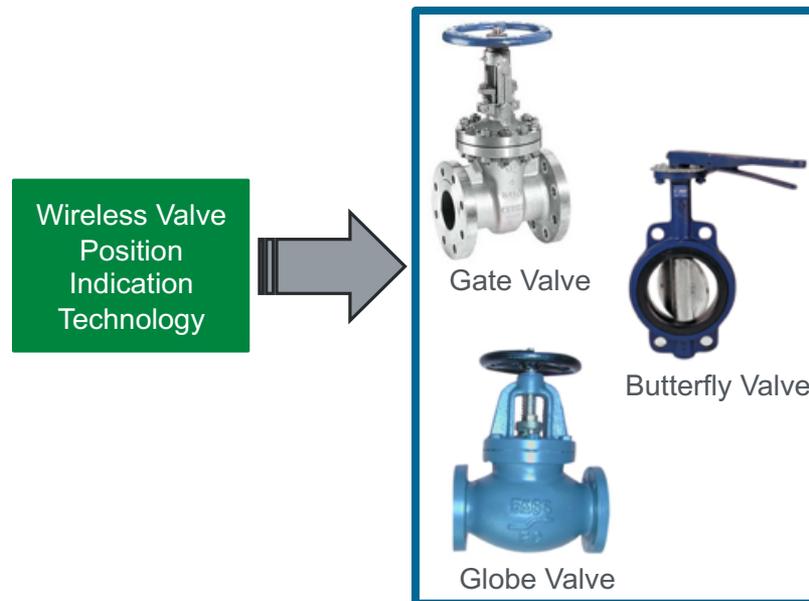
# Project Overview

## Project Goal

Automate manually performed concurrent or independent manual valve position verification in nuclear plants

## Project Objectives

- Research, design, develop, and demonstrated a wireless valve position indication (VPI) sensor system for manual valve types
- Deploy the wireless VPI sensor system in nuclear plants and other power industries

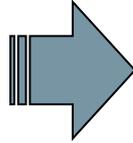
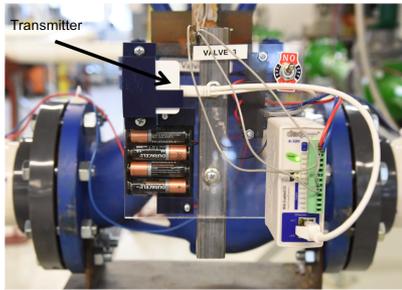


# Project Team

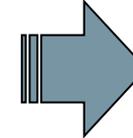
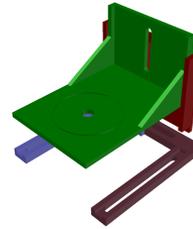
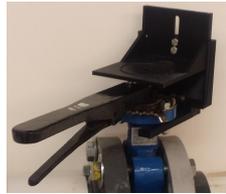
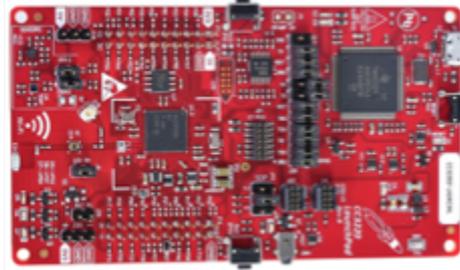
- **INL Team**
  - Vivek Agarwal – Principal Investigator
  - John W. Buttles
  - Ahmad Y. Al Rashdan
- **Idaho State University (ISU): Energy Systems Technology & Education Center (ESTEC)**
  - Ryan Pitcher
  - Jeremy Perschon
- **Analysis and Measurement Services (AMS) Corporation**
  - Chad Kiger

# Project Schedule

## Fiscal Year 2015: TRL 3

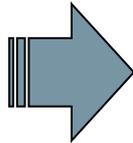
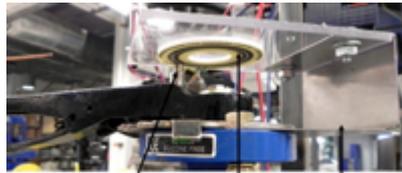


## Fiscal Years 2017-2018: TRL 6



## Fiscal Year 2019-2020: TRL 8

DOE Office of Technology  
Transition Funded Topic 2  
Project

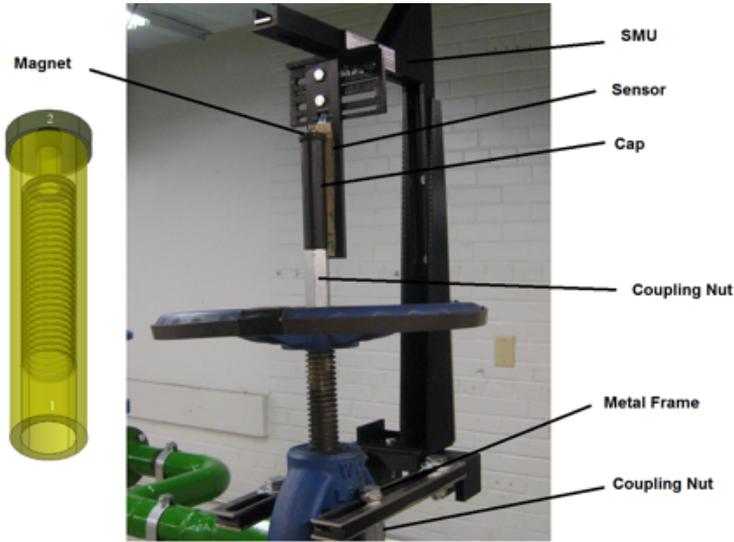
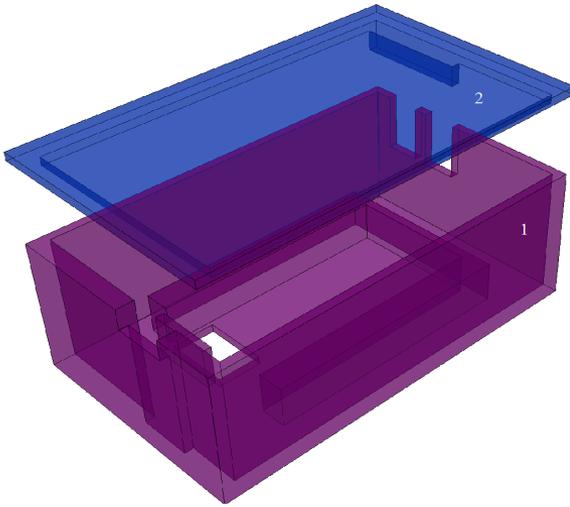


- No EMI/RFI evaluation
- High Power Consumption
- Low quality of service

- EMI/RFI evaluation
- Low Power Consumption
- High quality of service

# Wireless Valve Position Indication Sensor System

## Sensor Mounting Unit Design and Development



# Features of INL's Wireless VPI Sensor System

Digital Technologies	Recertification & Valve Disassembly	All Manual Valve Types	Radiation Tolerant	Communication Protocol	Continuous VPI	EMI/RFI Certification
INL Wireless VPI	No (Not Required)	Yes	Yes*	Securely Supports Most Wireless Communication	Yes	Yes
Emerson	Yes	No	No	Wireless HART	No	No
ELTAV	Yes	No	No	IEEE 802.15.4	No	No
Honeywell	Yes	No	No	Proprietary	No	No
Westlock	Yes	No	No	IEEE 802.15.4	No	No

\* Final design and product will be radiation tolerant

# Accomplishments

- **Milestones Achieved**
  - Prototype was evaluated for electromagnetic interference and radio frequency interference
  - An adjustable (X, Y, and Z directions) and reconfigurable universal sensor mounting units (SMUs) were design and 3-D printed in plastic
  - Quality of service and reliability of wireless communication was evaluated. Low packet and low latency was achieved.
  - The prototype was tested and demonstrated on an experimental flow-loop with nine manual valves (4 rising stem gate valves, 3 quarter-turn butterfly valves, and 2 rising handle globe valves)
- **U.S Utility Patent Application # 15/851,442 Filed on 12/21/17**
- **The technology won the second place at the DOE Laboratory-wide National Laboratory Accelerator Pitch Event in San Ramon, CA on 11/30/17**
- **Completed a Technical Report on the project on 03/30/18**

# Technology Impact: Value Proposition

## O&M Cost



**10%** reduction in O&M costs

At least **50%** reduction of manual valve position verification **labor**

**Reduction** in radiation zone manual valve verification

## Reduce Downtime



At least **\$1M/day** savings during a **plant outage**

**3 to 5 years** extension of **valve calibration cycle**

**Health monitoring** of manual valves

## Efficiency Gain



**Value-based** maintenance

**Digital** verification

**Remote Monitoring** of manual valves

## Reduce Risk



**Reduction** in radiation exposure

**Reduction** of other **occupational hazards** and **regulatory risks**

## Human Errors



**90%** reduction in human errors

# Technology Impact: Commercialization

- INL do plan to commercialize wireless VPI sensor system
  - Identify potential licensee
  - Enter into an license transfer exercise in consultation with INL Technology Deployment



# Summary and Path Forward

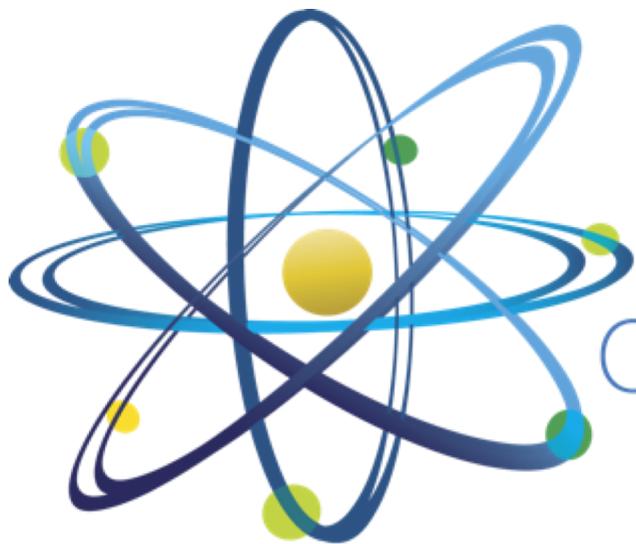
- The research, development, and demonstration performed to date has allowed the technology to achieve TRL 6.
- A patent application is filed
- The technology will provide access to data that was otherwise not available or laborious to gather
- Automate a manually performed activity using a technology-based solution
- Enhance productivity and reduce cost
- Enables existing light water reactor fleet long-term economical operation without compromising on safety
  
- As part of path forward, wireless VPI sensor system needs to be enhanced to TRL 8 prior to commercialization
- INL team will be working with Exelon owned plants

# Questions

For additional details, Please feel free to contact

Vivek Agarwal, ([vivek.agarwal@inl.gov](mailto:vivek.agarwal@inl.gov))

John W. Buttles, ([john.buttles@inl.gov](mailto:john.buttles@inl.gov))



Clean. **Reliable. Nuclear.**