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U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

2021 PROJECT PEER REVIEW

U.S. DEPARTMENT OF ENERGY
WIND ENERGY TECHNOLOGIES OFFICE

Sandia National Laboratories

E10 - Hardening Wind Energy Systems from Cyber Threats

ESW&G – Grid Integration

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Jake Gentle - Idaho National Laboratory

August 3, 2021

INL Idaho National Laboratory

FY21 Peer Review - Project Overview

Project Summary:

- The team is investigating wind network hardening and security sensing and response technologies to provide wind site cyber resilience.
- These technologies and defense techniques will be shared broadly with the wind industry to harden communication systems to cyberattacks and detect adversary actions.
- To quantify differentiating benefit of different hardening technologies, the team is using a red teaming approach to demonstrate the significance of integrating these technologies in relevant wind site topologies within a cyber-physical co-simulation environment

Project Objectives 2019-2020:

- Create five topologies with a combination of hardening technologies.
- Design theoretical attack patterns and quantitative scoring methodologies for red team assessments.
- Survey commercial cybersecurity technologies that can be incorporated into wind systems.

Overall Project Objectives :

- Conduct adversary-based (red team) assessments of different defenses to score their effectiveness against different attack scenarios.
- Advise the wind industry of improvements to wind site security with the successful deployment of different cybersecurity technologies.

Project Start Year: FY20
Expected Completion Year: FY22
Total expected duration: 3 years

FY19 - FY20 Budget: $1M Total

Key Project Personnel:
Sandia: Jay Johnson (PI), Brian Wright
INL: Jake Gentle, Craig Rieger, Bev Novak, Tyler Phillips, Michael McCarty

Key DOE Personnel: Jian Fu (PM)

Project Impact

GOAL:

Recommend cybersecurity defenses for wind sites
using adversary-based assessments of virtualized wind site networks

Project Objectives

- FY19 - Build power system and networking co-simulation environment where cyber-attacks are reflected on the power simulation
- FY20 - Implement different cybersecurity defenses in the network emulation
- FY21 - Conduct adversary-based (red team) assessments of different defenses to score their effectiveness against different attacks

Outputs

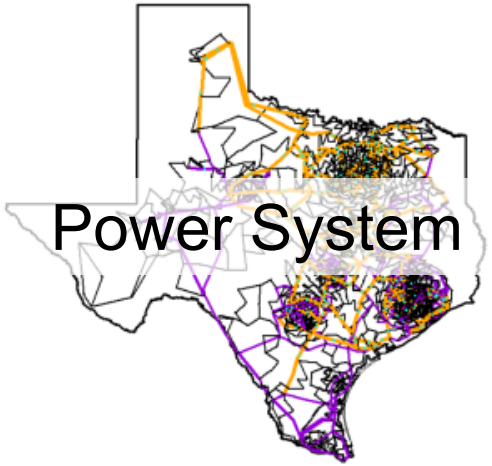
- Briefed Protect Our Power, Energy Systems Integration Group (ESIG) Operations and Maintenance (O&M) Users Group, Wind Cybersecurity Consortium
- Open-sourced baseline wind site networking topology for industry/researchers
- Cybersecurity survey of cyber hardening technologies
- Framework for representative, comprehensive technology benefit evaluation correlated to MITRE ATT&CK
- Quantitative cyber-physical scores for different hardening technologies/topologies

Impact

- Actionable, quantitative guidance for the wind industry on the best cybersecurity technologies to defend against local and remote wind site cyberattacks.

Program Performance – Scope and Execution

- FY20 milestone - Define co-simulation environment with networking components, virtualized wind site operation center, wind turbine components, and transmission power system.
  - Highly challenging, technical work to integrate a live, cyber-physical co-simulation environment that incorporates human inputs.
  - Reference architecture was created based on literature reviews and site interview.
  - Wind Turbine Generators (WTGs) are represented with Modbus Servers that include nameplate data, power system measurements, and control points.
  - The Power system Model is a well-studied 2000-bus Texas model that runs in PowerWorld Dynamic Studio.



ACTIVSg2000: 2000-bus synthetic grid running in PowerWorld

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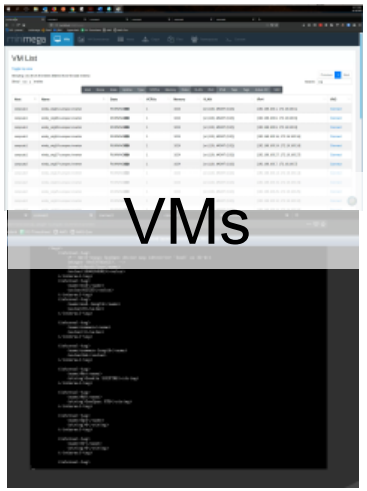

Virtual Machines including WTG Modbus Servers

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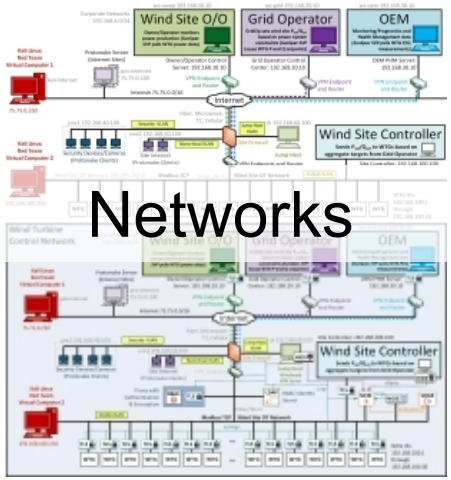

Virtualized Wind Site Networks

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Cyber-physical testbeds for scalable, repeatable and comprehensive red team assessments

Program Performance – Accomplishments & Progress

SCEPTRE Co-simulation

- Realistic communication networks and power system simulations in the SCEPTRE platform
- Used to conduct cybersecurity assessments on different wind plant network architectures and defenses

Initial Networking Design

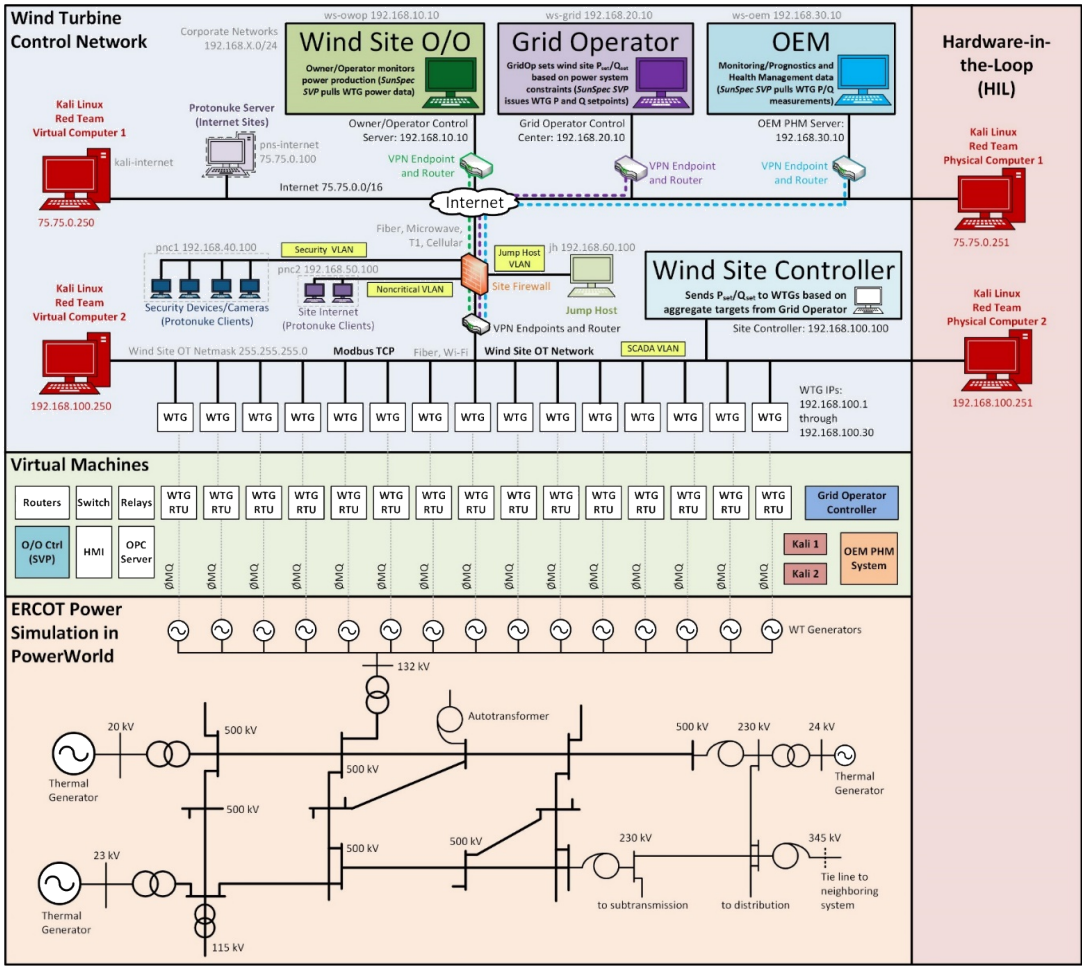
- Representative communications from Original Equipment Manufacturers (OEMs), Owner/Operators, and the utility/grid operator to wind site
- Wind Site segmentation using virtual local area networks (VLANs) with dedicated network for operational technology (OT) traffic

Wind Turbine Emulation

- Simplified Modbus Remote Terminal Unit (RTU) wind turbine controller includes active and reactive setpoints and power system measurements

Power Simulation

- Texas power simulation executed in PowerWorld to measure cyber-attack impact

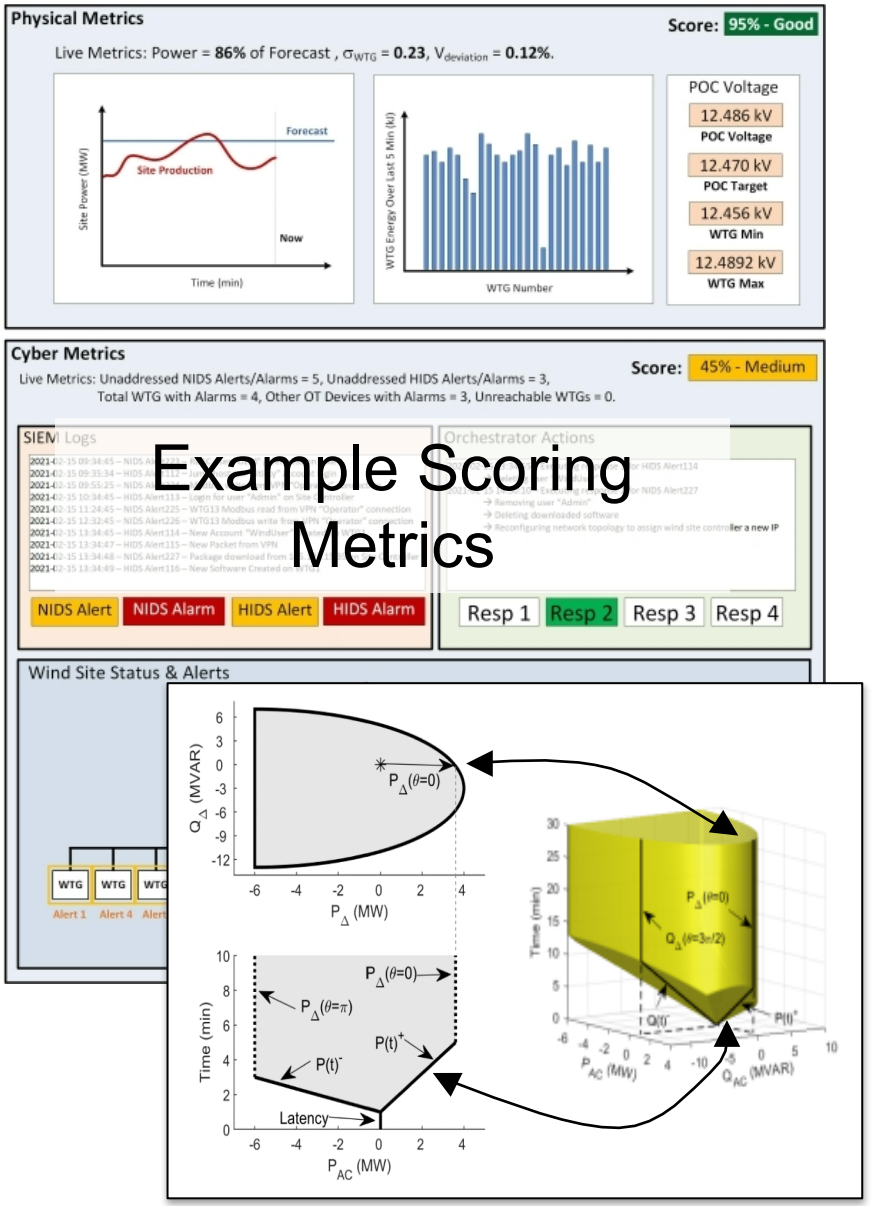


SCEPTRE scada-as-a-platform™

Program Performance – Accomplishments & Progress

- **Project Accomplishments**
  - Created virtualized wind site topologies with power system data, virtualized wind turbines, and live site controllers.
  - Integrated multiple hardening technologies into the co-simulation environment
  - Established cyber-physical scoring mechanisms based on the impact to the site network and power grid
  - Created local and remote cyberattack scenarios, correlated to MITRE ATT&CK

- **Copyrighted Open-Source Software**
  - Secure Wind Plant phēnix Topologies

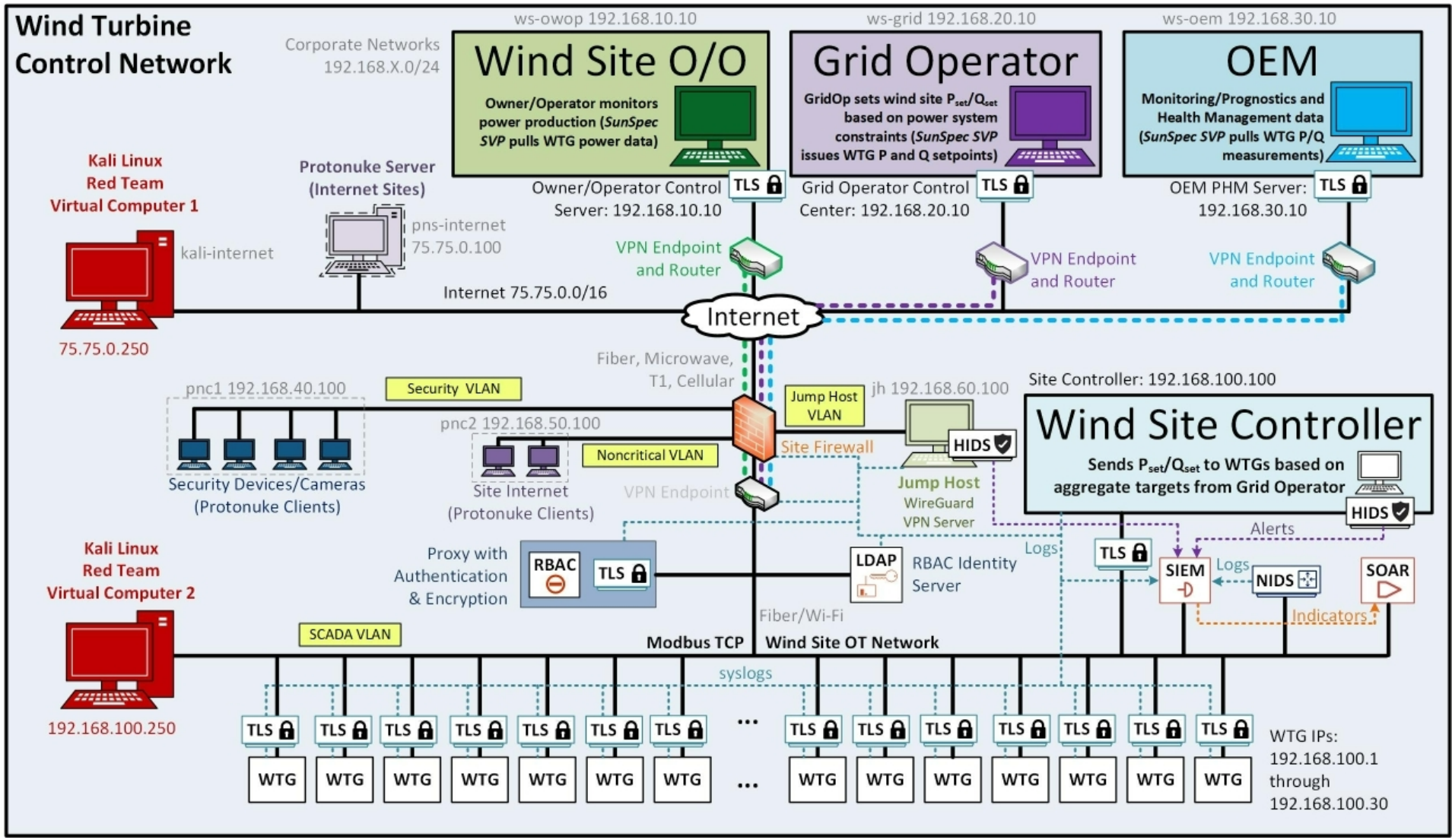


Program Performance – Upcoming Activities/Schedule

- In FY21, the team is deploying five topologies to demonstrate the spectrum of wind site security from baseline security to heavily fortified. Technologies include:
  - **OT Encryption**: encrypts traffic to the wind turbine network
  - **Role-based access control (RBAC)**: requires users to be authenticated/authorized before making changes to wind turbine setpoints.
  - **SIEM**: security information and event management (SIEM) system collects log data to alert admins of potentially malicious cyber activities
  - **NIDS**: network-based intrusion detection system (NIDS) uses deep-packet inspection to alert admins and/or SIEM system to anomalous network traffic.
  - **HIDS**: host-based intrusion detection system (HIDS) that alerts admins, SIEM, or SOAR system to changes to the server by monitoring logs, directories, files, and registries.
  - **SOAR**: Security Orchestration, Automation, and Response collects alerts and automates responses to threats.
- In FY22, the team will perform red team assessments on each of the topologies, score the results with cyber-physical metrics, and widely share these results.

	Encryption	RBAC	SIEM	NIDS	HIDS	SOAR
1						
2	X	X				
3			X	X		
4	X				X	X
5	X	X	X	X	X	X

Hardened Wind Site Topology



Program Performance – Upcoming Activities/Schedule

- FY20 - Developed Survey for cybersecurity vendors, renewables OEMs and Owners/Operators
- FY21 - Survey results received
- FY21 - Cybersecurity survey results will be share broadly.

Company	Solar	Wind	Electric Vehicles	Product name	Years on the market	HIDS Features										
						Protect from data egress	Attach external timing for log stamps	Support INDUSTRIAL CONTROL SYSTEM protocols	Detect new conversations	Decision support	Detects changes to firmware	Applicable to Purdue layers 0, 1, or 2	Monitor unauthorized access	Monitor changes in device	Other	Other, please explain
Alion	■	■	■	Big Data Platform (BDP)	8					■			■	■		
Dragos	■	■		Dragos	5			■		■		■		■		
Dragos	■	■		ProServices	5				■			■	■	■	■	Training, TTX, IRR, Penetration Testing, Arch Assessments, etc
Dragos	■	■		Threat Intelligence - WorldView	5				■	■		■				
Elastic			■	Elastic	9		■		■		■		■	■		
HP Inc	■	■	■	Computers, Printers 3D Printers	81								■		■	Micro Virtual Machine
Inzero Technologi	■	■	■	TRIPLiot	<1	■			■	■	■	■	■	■		
Itron Inc.	■		■	Smart grid	10+	■		■		■	■	■	■	■		
Mantis Networks	■	■	■	MantisNet CVF	1	■	■	■	■				■	■	■	Uniquely fingerprint authorized systems, detection of weak, or unsupported cryptographic traffic, introspection/analysis of any (TCP/IP) based industrial control system protocol
New Context	■	■		Threat Monitoring & Automated Response Platform	0		■	■	■	■	■	■	■	■		
Optiv Federal	■	■	■	Security Matters (ForeScout)	5+	■	■	■	■	■	■	■	■	■	■	Optiv resells & provides services for ForeScout (Security Matters), Microsoft (CyberX), Claroty, and other ICS products
PFP Cybersecurity			■	PxScan Analytics	5						■			■	■	supply chain security
PFP Cybersecurity			■	pMon 751	5						■			■	■	supply chain security
PFP Cybersecurity	■	■	■	PFP Monitor	1		■				■	■			■	Out of band monitoring. Air-gapped deployment.
R&K Cyber Solutions LLC	■	■	■	Heartbeat	<1				■	■	■	■	■	■		
R&K Cyber Solutions LLC	■	■	■	USB-ARM	<1	■				■		■	■			
R&K Cyber Solutions LLC	■	■	■	Beholder					■	■	■	■	■	■		
Templar Shield	■	■		Splunk	15	■	■	■	■	■	■	■	■	■		
Templar Shield	■	■		Tenable	10		■	■	■	■	■		■	■	■	Uses PLC protocols to detect and alert to control changes. continuous monitoring
Verve Industrial Protection	■	■		Verve Security Platform	5+			■	■		■	■	■	■	■	A combination of agent based, and then change management/non-agent based data acquisition
Waterleaf International	■			Cyberleaf	<1	■	■	■	■	■	■	■	■	■		
Waterleaf International LLC	■	■	■	Cyberleaf	1	■		■	■	■	■	■	■	■		

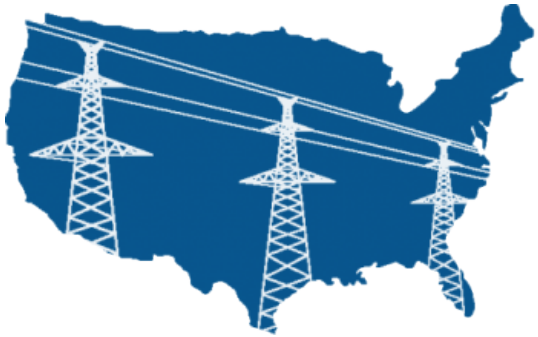
Example cybersecurity vendor survey results for HIDS providers.

- FY21 - SNL, INL, and NREL are working to assemble a small, invite-only workshop for wind cybersecurity to discuss many of the topics presented here.

Stakeholder Engagement & Information Sharing

- **Presentations**
  - J. Gentle, J. Johnson, “Cybersecurity for Wind Energy,” Protect Our Power - Best Practices in Utility Cybersecurity Conference, 27 Jan 2020.
  - J. Johnson, J. Gentle, “Hardening Wind Systems R&D Project,” ESIG O&M Spring 2020, 1 April 2020.
  - J. Johnson, J. Gentle, C. Rieger, “Hardening Wind Energy Systems from Cyber Threats – Project Briefing,” Wind Consortium Meeting, 7 April 2021.

ESIG
ENERGY SYSTEMS INTEGRATION GROUP



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