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Cybersecurity for Distributed Wind: MIRACL Advisory Board Meeting 2022

October 2022

Megan Jordan Culler

Changing the World's Energy Future

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Cybersecurity for Distributed Wind

MIRACL Advisory Board Meeting 2022

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Idaho National Laboratory

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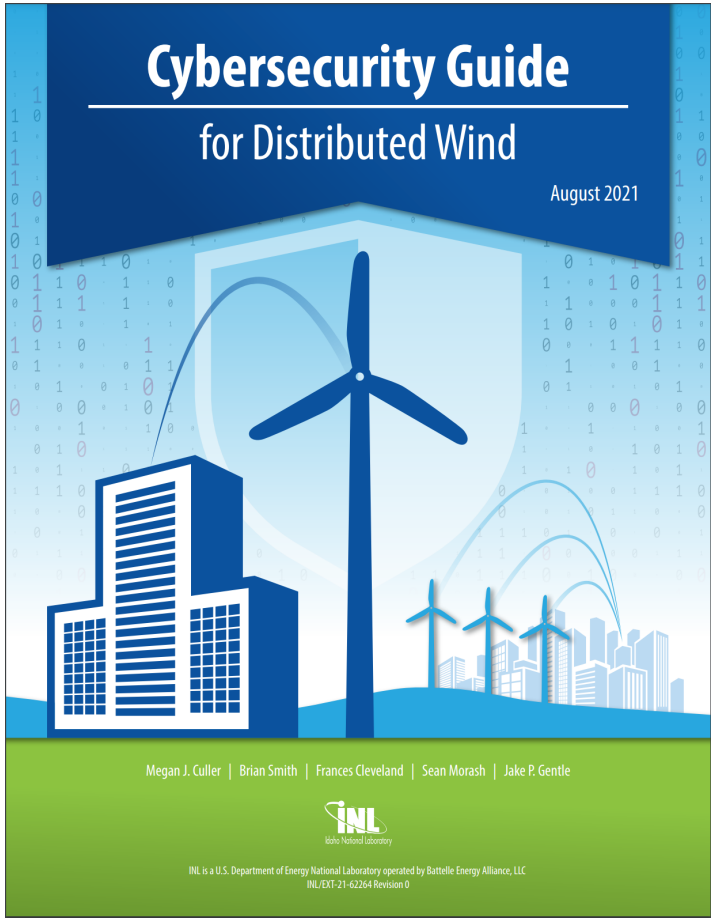
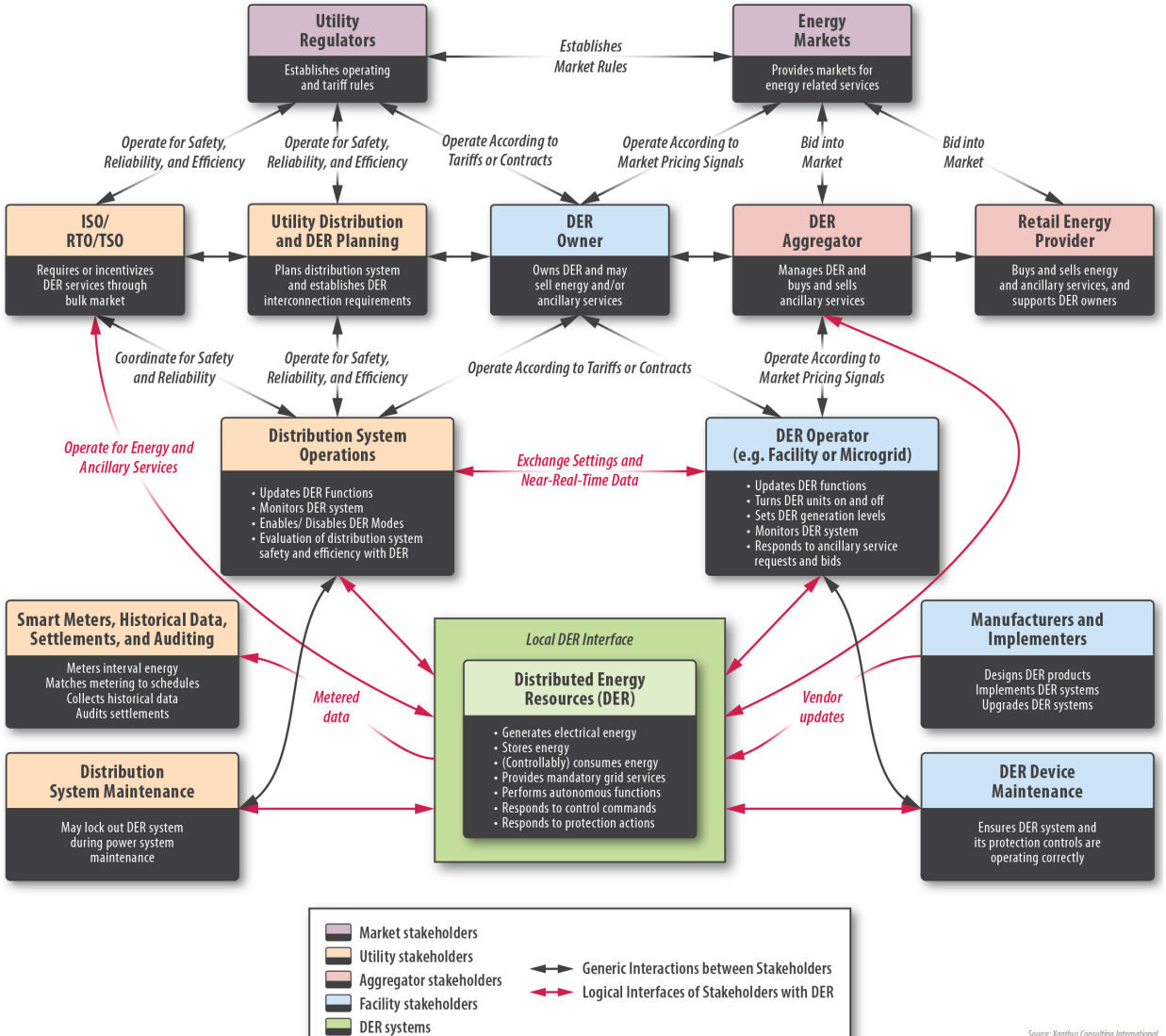
Cybersecurity Guide for Distributed Wind

- Establishing a common architecture
- Need for cybersecurity for distributed wind
- Challenges of securing distributed wind
- Cyber risk management architecture
- Recommendations & stakeholder roles

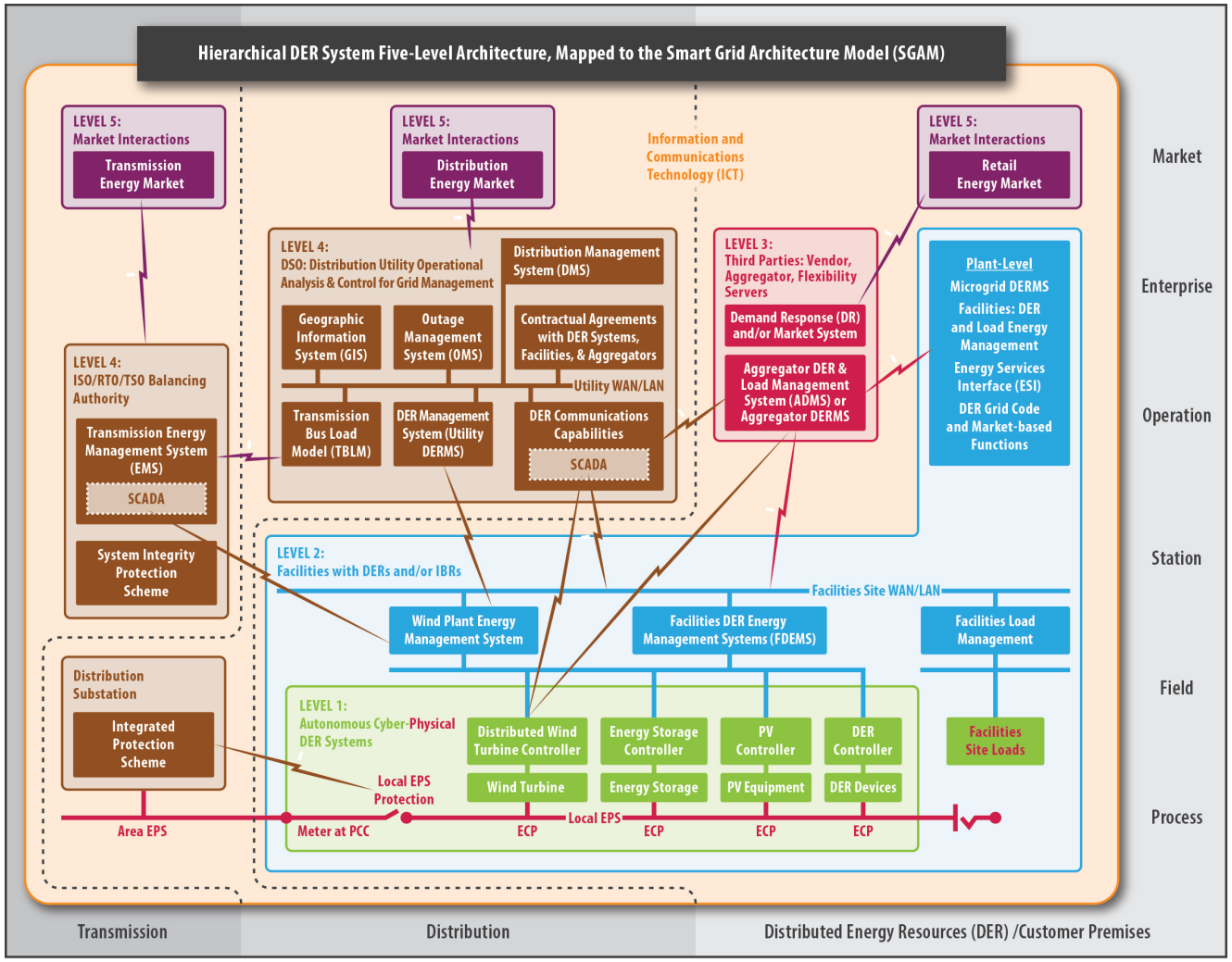


Distributed Wind Reference Architecture Stakeholders



- Who has a role in distributed wind cybersecurity?

Distributed Wind Reference Architecture
Overall Architecture

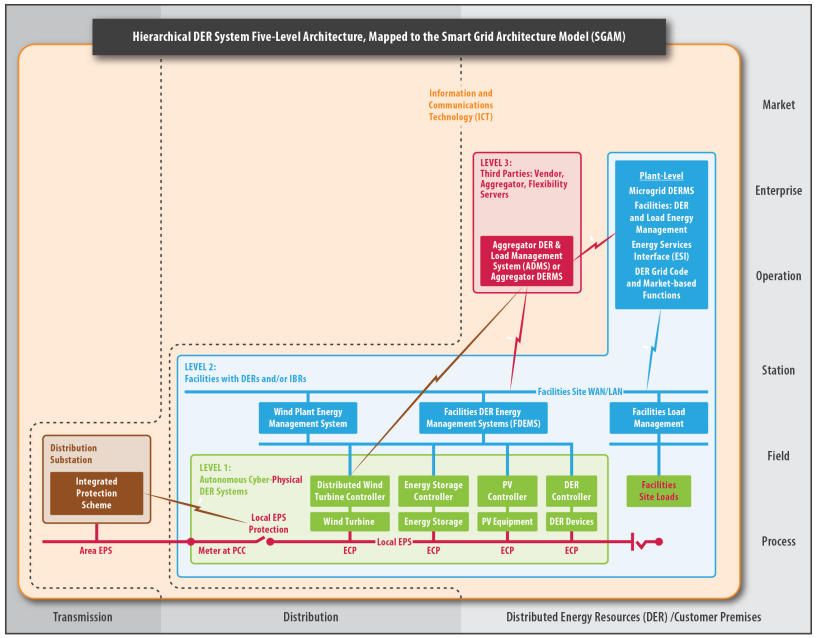


Source: Xanthus Consulting International
21-50152

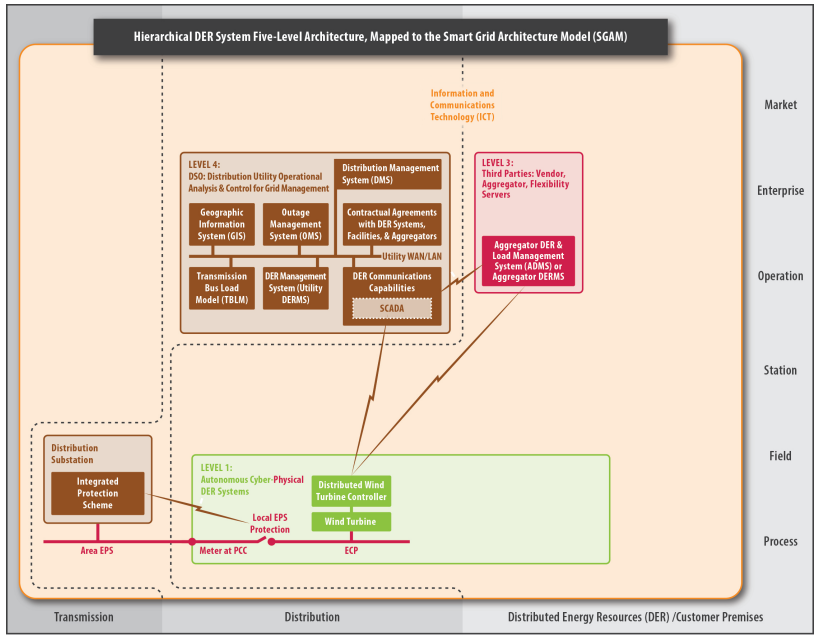
- What is the system that we are protecting?

Distributed Wind Reference Architecture
Customized Architectures

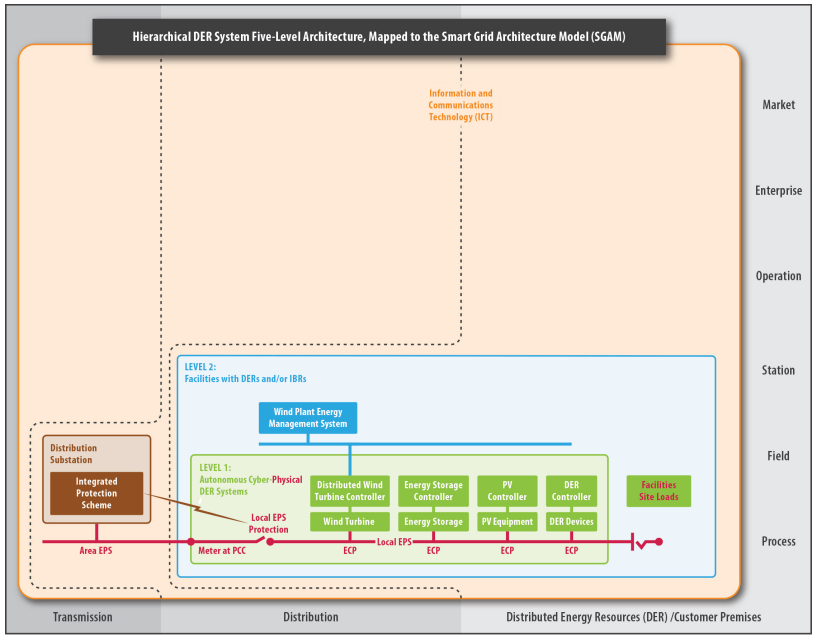
- How does this system change based on the configuration of assets?



Microgrid



Aggregator managed



Behind-the-meter

The Need for Distributed Wind cybersecurity

Academic Exercises in Exploiting Distributed Wind

- Attacks against SCADA system for unauthorized control
- Attacks targeting turbine damage, wind plant disruptions, substation disruption and damage
- Worms to propagate within a turbine or throughout a wind plant network
- Vulnerabilities in specific turbine systems
  - Cross-site request forgery to change default user password
  - HMI vulnerability providing access to credentials in plain text
- Vulnerabilities exploited to exceed turbine limits
- Pass false measurement data between turbines and SCADA using a man-in-the-middle attack

Zabetian-Hosseini, Asal, Ali Mehrizi-Sani, and Chen-Ching Liu. "*Cyberattack to Cyber-Physical Model of Wind Farm SCADA.*" Paper presented at the 44th Annual Conference of the IEEE Industrial Electronics Society, Washington, D.C., October 2018. DOI:10.1109/iecon.2018.8591200

Staggs, Jason, David Ferlemann, and Sujeet Shenoi. "Wind Farm Security: Attack Surface, Targets, Scenarios and Mitigation." *International Journal of Critical Infrastructure Protection* 17 (2017): 3-14. DOI:10.1016/j.ijcip.2017.03.001.

ICS-CERT. "*XZERES 442SR Wind Turbine Vulnerability.*" Last modified August 27, 2018. [Online]. https://ics¬cert.us-cert.gov/advisories/ICSA-15-076-01

Yan, Jie, Chen-Ching Liu, and Manimaran Govindarasu. "Cyber Intrusion of Wind Farm SCADA System and Its Impact Analysis."

Real-world Events

- 2014: Russian-linked hackers remotely accessed and manipulated wind turbines' automatic voltage regulator settings (limited reach)
- 2018: Technician downloaded malware by mistake on a laptop. Later, when plugged into wind plant, turbines stopped working one-by-one
- 2018: Workstations infected with cryptojacking malware, slowing down wind network
- March 2019: Firewall vulnerability led to DoS that disrupted view into solar and wind generation sites

https://www.mita-teknik.com/products-solutions/wind/wind-turbine-control/turbine-control/

Real World Events Cont.

- Nov. 19, 2021: Vestas hit by ransomware
- Feb. 24, 2022: Enercon wind turbines in Germany lose remote monitoring connection due to SATCOM attack
- March 31, 2022: Nordex Group, major wind turbine manufacturer, hit by Conti ransomware
- April 11, 2022: Deutsche Windtechnik, wind turbine maintenance company, hit by cyber attack

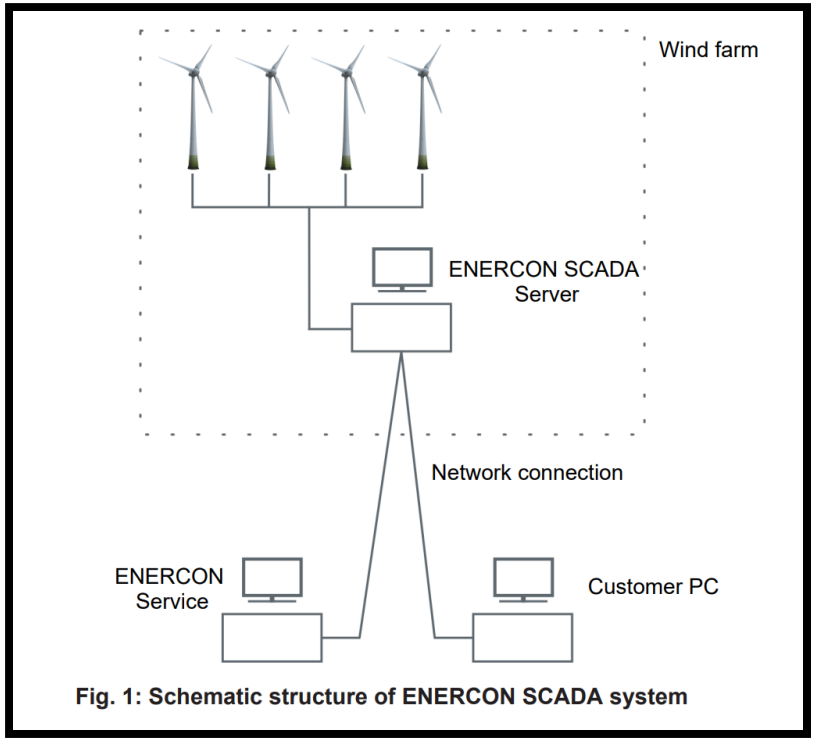


Fig. 1: Schematic structure of ENERCON SCADA system

Challenges to Securing Distributed Wind Systems

Risk Management Architecture

Risk = **Likelihood** x **Consequence**

Risk = **Threat** x **Vulnerability** x **Consequence**

Risk = **Threat - M_T** x **Vulnerability - M_V** x **Consequence - M_C**

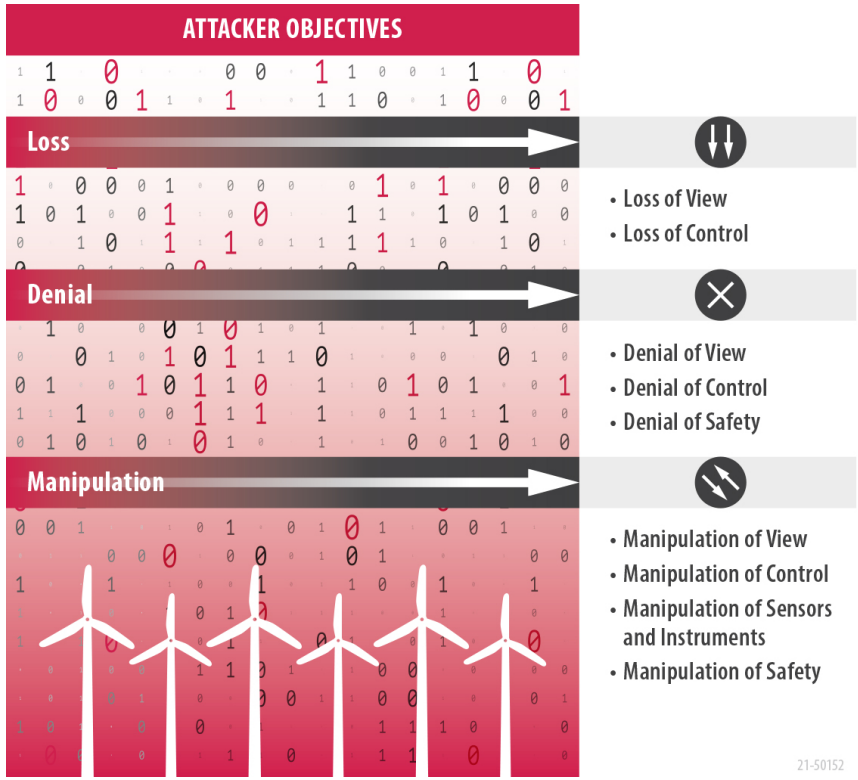
- Risk management comes from mitigating each element individually
- Cyber resilience measures can apply to any element

Risk Management Architecture: Threats

Threat = **Intent** x **Capability** x **Opportunity**

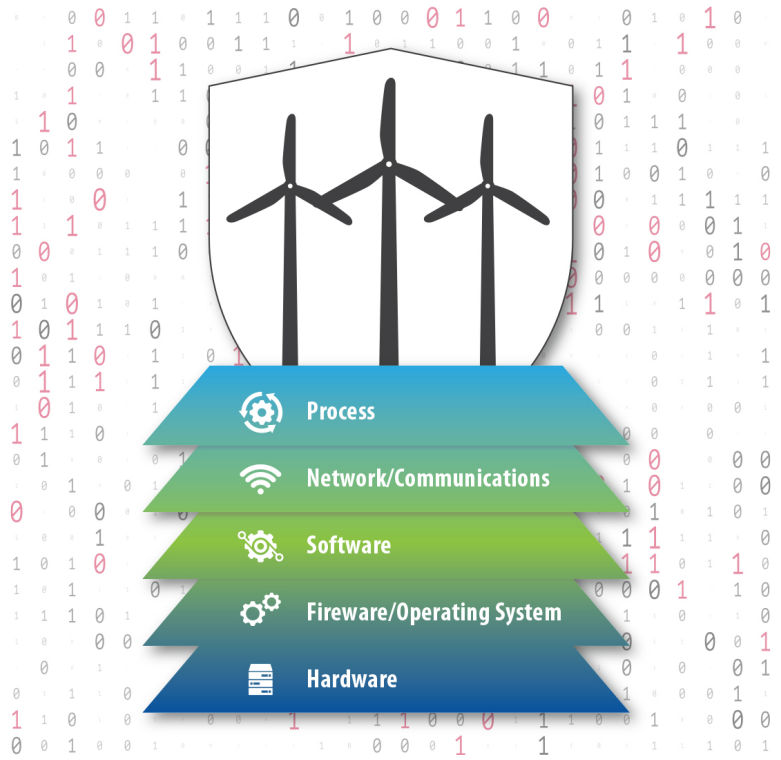
- **Intent:** may be intentional (driven by a particular objective) or unintentional
- **Capability:** skills and funding
- **Opportunity:** Access to a target

Capability	Example
Hacker	Spower Firewall DoS attacker
Insider	AWEA technician
Organized group	Russian cybercrime
Hostile nation-state or terrorist	Nation-state sponsored APT



Risk Management Architecture: Vulnerabilities

- **Vulnerability:** a weakness which can be exploited by an adversary to gain unauthorized access to or perform unauthorized actions on a system
- May be a flaw in either design or implementation
- Can occur at any layer of the system
- Distributed wind examples:
  - Worms propagating malicious commands through flat wind network
  - XZERES 442SR CSFR
  - NovaWind Turbine HMI vulnerability

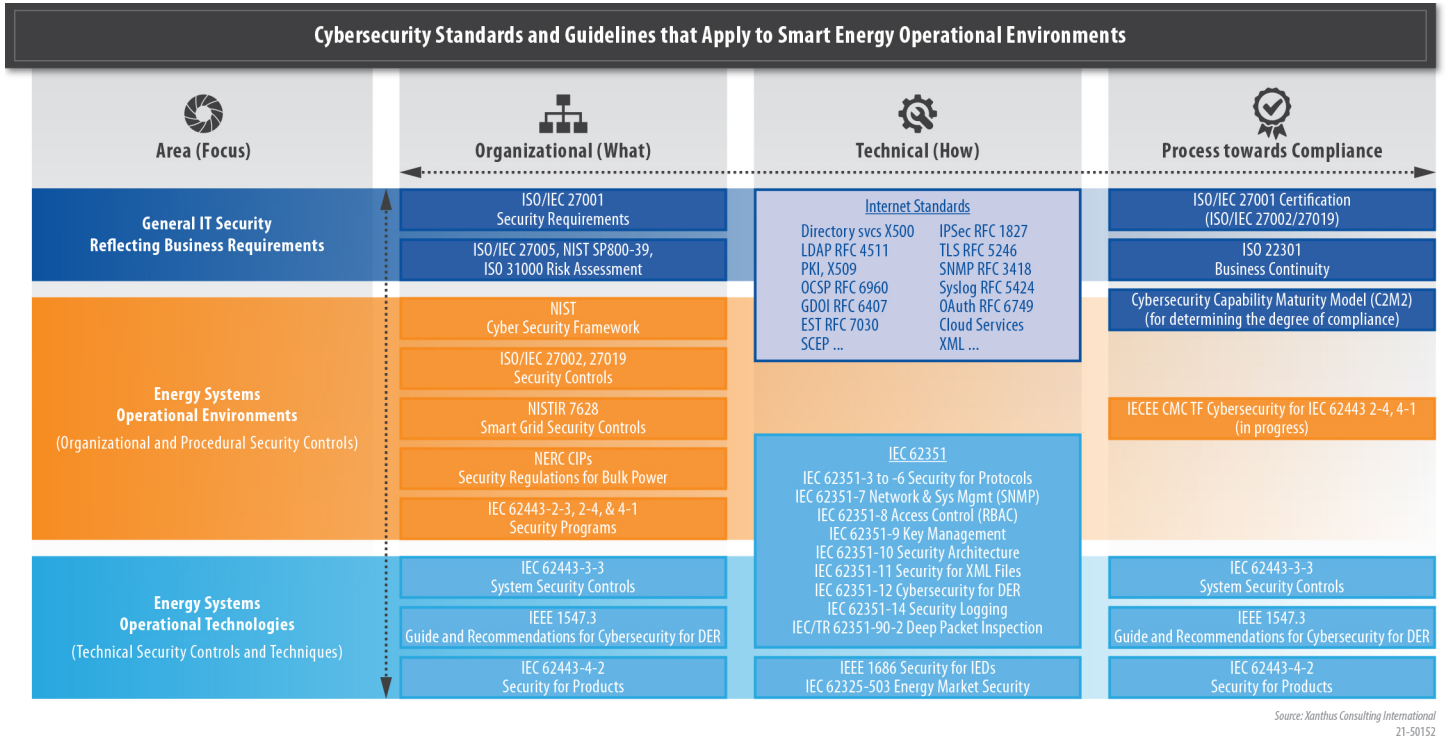


Risk Management Architecture: Consequences

POTENTIAL IMPACT BY STAKEHOLDER			
Event	**Utility (Non-Operator)**	**Operator (Facility/Aggregator/Utility)**	**Manufacturer, Integrator, or Installer**
Loss of View		• Loss of revenue	• Reduce reputation • Financial liability
Loss of Control	• Energy imbalance	• Propagated failures • Injury • Equipment damage	• Reduce reputation • Financial liability
Denial of View		• Improper operation	• Reduce reputation • Financial liability
Denial of Control		• Improper operation	• Reduce reputation • Financial liability
Denial of Safety	• Injury	• Injury	• Reduce reputation • Financial liability
Manipulation of View	• Improper control decision	• Improper control decision	• Reduce reputation • Financial liability
Manipulation of Control	• Additional energy resources • Injury	• Loss of reliable operation • Activation of critical load algorithm • Loss of required generation • Failure to meet contractual obligations	• Reduce reputation • Technical investigation • Financial liability
Manipulation of Sensors and Instruments	• Energy imbalance • Failure of regulatory compliance	• Improper operation • Severe mechanical damages • Loss of revenue resource • Increased operation and maintenance costs	• Reduce reputation • Increase after-sale expenses • Potential product call-back • Financial liability
Manipulation of Safety	• Extended restoration time • Failure of regulatory compliance	• Injury or death • Loss of intellectual property • Technical investigation	• Devalue brand name • Reduce market share • Decommission the product from the market • Financial liability

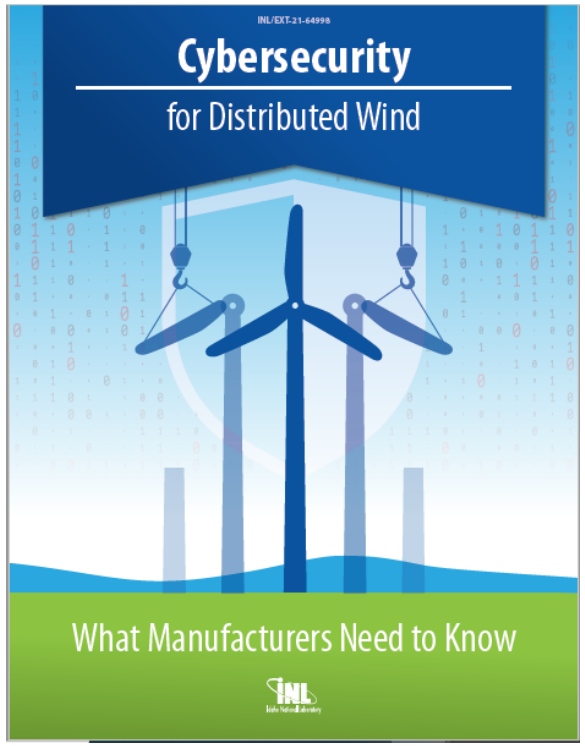
Mitigations: Cyber resilience by design

- Recommendations to align with IEEE 1547.3, Section 5
  - Risk assessment and management
  - Communication and network engineering
  - Access control
  - Security management
  - Coping with and recovering from security events
- Relevant standards

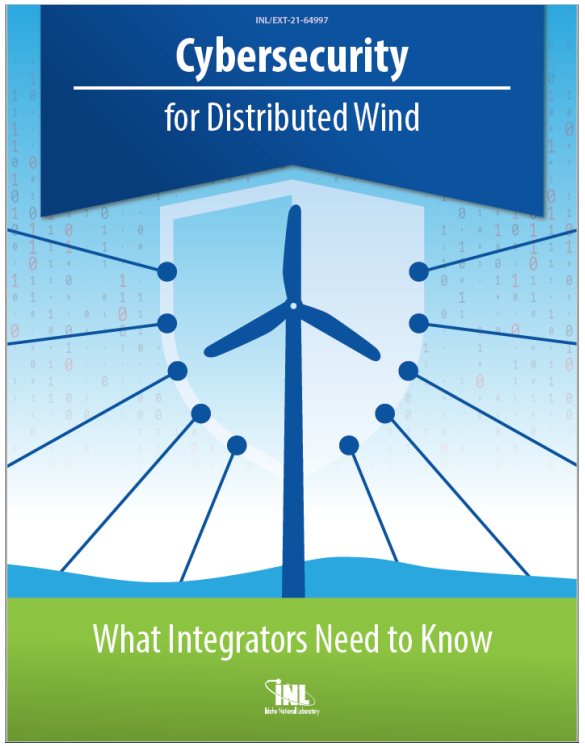


Mitigations: Cyber Resilience by Design

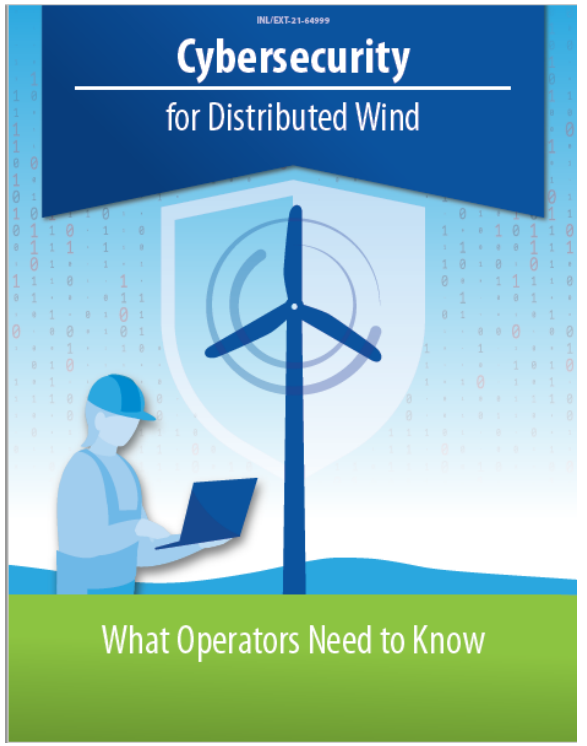
- Stakeholder roles and responsibilities



Manufacturers



Integrators



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