Renewable Energy— Offshore Wind

Cisco IoT 1.2 Solution Brief

January 2025

Cisco Validated Design

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Cisco Solution for Renewable Energy—Offshore Wind

Providing scalable and secure infrastructure enabling the global accelaration of offshore wind technology

As we move toward the future, many countries are accelerating the use of renewable energy and investing in grid scale renewable technologies such as:

- Onshore and offshore wind
- Solar photovoltaic farms
- Battery storage
- Emerging technologies such as wave and tidal power

Stakeholders are diverse and range from dedicated renewable energy companies to major oil and gas companies and traditional power utilities.

Reliable and secure connectivity is key for providing monitoring and control of these offshore and therefore remote assets. Without a reliable and secure communications infrastructure, management and control would be challenging.

From the offshore wind asset operator's viewpoint, the network needs to be easy to deploy, monitor, upgrade, and troubleshoot. The network design also needs to be standardized to enable easy specification and procurement at the early stages of a project. Avoiding both customized design and different architectures for each project should enable a speedier project delivery phase.

A standardized solution is required that provides the flexibility to meet these needs while facilitating a clear path forward as complexity and scale evolve (for example, larger wind farms, increased number of devices and applications, and increased reliability).

This solution brief provides an overview of the new Cisco validated solution to support offshore wind farms. This solution provides the following key benefits:

- **Flexible deployment options:** Support for simple to advanced solutions that cover various deployment options (scalable for small to large wind farms). A modular design that can adjust to the various sizes of wind farms that are deployed. Providing a flexible platform for the deployment of future services and applications.
- **Rugged and reliable network equipment:** Network equipment designed for harsh offshore environments where required. The ability for network equipment to operate in space-constrained locations and tough environmental conditions.
- **Simplified provisioning:** Automation and simple onboarding, monitoring, and management of remote networking assets with centralized monitoring and management of multiple wind farm networks.
- **Simplified operations:** Increased operational visibility, minimized outages, and faster remote issue resolution. Compliance of network device configurations (changes from a known baseline are flagged) and firmware with powerful analytics to provide deep visibility of the network assets.
- **Multi-level security:** End-to-end robust security capabilities to protect the infrastructure and associated services, monitor traffic flows, and provide control points for interfacing to third-party networks and equipment. Vulnerability information for discovered assets and asset reporting to aid regulatory compliance (for example, NIS 2 and NERC CIP).

Offshore Wind Farm Connectivity

Generally, offshore wind sites connect onshore in rural locations where access to backhaul technologies is limited. While offshore to onshore connectivity is served by fiber optic cable, the backhaul from the onshore location is more challenging and often relies on service provider network availability for services such as fiber, MPLS, metro ethernet, and so on.

Network Challenges

Multiple Operating Parties

The multiple parties involved within wind farm operations present challenges for network operation and access to required services. The parties could be as diverse as the wind farm operator staff, turbine network operation and maintenance engineers, substation engineers, and various supplier subcontractors.

All these parties require network access but have different needs for the accessed equipment or systems.

Environment

Wind farms are challenging environments for communication networks and many locations require environmentally hardened equipment, such as equipment with no fans and extended temperature ranges. Some locations provide controlled telecom rooms that allow for the use of typical enterprise equipment.

Remote and Distributed Locations

Renewable energy sites often are in areas that are underserved by traditional communications networks. A typical operator has multiple farms that are distributed regionally or even globally. Each operator has challenges with WAN connectivity to sites and connectivity within sites.

Offshore Locations

Offshore locations provide a unique set of safety challenges for maintenance personnel access. Challenges include weather, salt, spray, and access to offshore assets (for example, turbines and platforms).

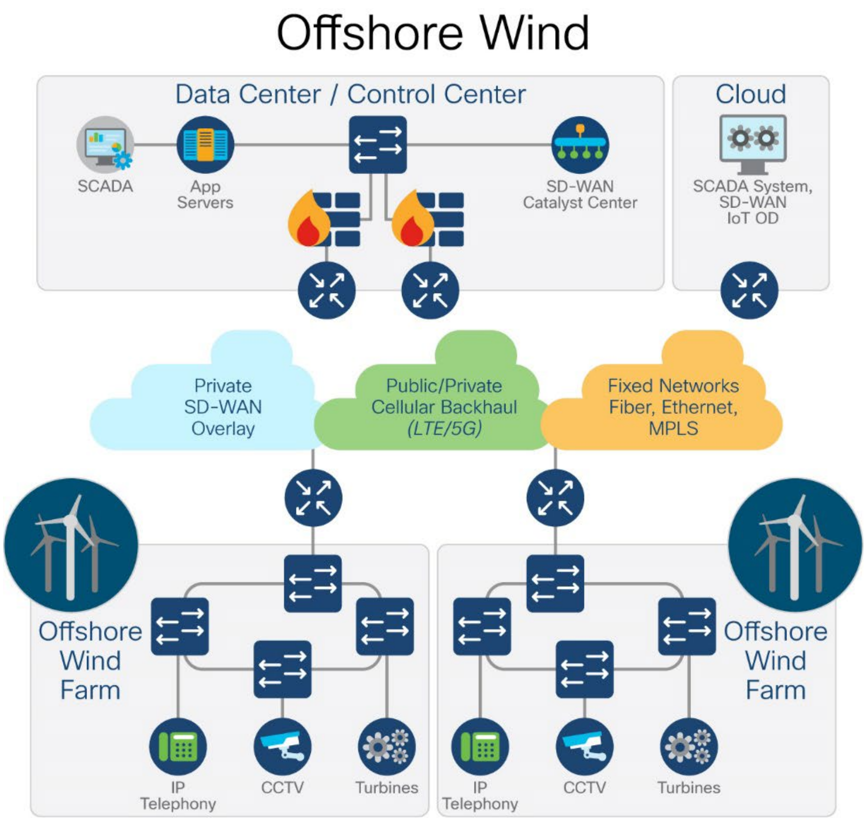
Onshore Locations

While not as challenging as offshore locations, onshore renewable energy sites normally are in remote areas where communication networks are not readily available.

Data/Control Centers

Every operator will have several data centers that serve the business. These data centers provide many of the services that are required to be accessed from the onshore and offshore wind farm locations. WAN connectivity from these data centers to each renewable energy site is required.

In general, sites for offshore wind farms need to employ highly-resilient communications.
Most sites require a completely resilient hardware design and architecture to mitigate failures. Typically, this requirement applies to offshore sites where access is difficult. Resiliency would be individual hardware resiliency (such as WAN routers, switching network topologies, and power supplies) and network design (use of resiliency features to provide redundant topologies across routers and switches). The goal is to eliminate any single point of failure.



Design Considerations

Applications:

- Turbine control & monitoring
- Power automation & control
- Corporate services (voice, video, data)
- Miscellaneous systems (environmental, wildlife monitoring, fire/smoke detection, weather systems, worker mobility/radio)

Components:

- Industrial & enterprise switching
- Routing for WAN
- Wind farm wide Wi-Fi (corporate & guest access)
- Management & automation with Catalyst Center
- Cyber Vision for ICS visibility

Most offshore wind farm sites participate in the local energy balancing market and are classified as critical power generation sites, which means that the grid can control them in times of over or under demand. These sites may require redundant communications connections, depending upon the business criticality, and may be subject to regulatory cybersecurity conditions (for example, NERC CIP in North America or NIS2 in the European Union).

Due to the remote site locations, redundant communications are usually provided via whatever alternative backhaul technology is available for the site. These technologies could be satellite, fiber, or microwave radio. Microwave radio is common when the primary link is always a challenge to implement because it is unrealistic to expect two diverse fiber or radio links to each onshore site.

Remote Access

Suppliers and operations staff should be able to access a wind farm remotely. Remote access must be provided securely with no separate dedicated “back door” or local connections.

Users who are authorized to access the network and what applications and operations users can access should be controlled and managed.

The use of bastion hosts or jump servers is recommended to restrict users to using only applications that an asset owner authorizes them to access.

External vendors and contractors and internal enterprise users should use the same method to access industrial assets within onshore and offshore networks.

External users should be authenticated using two-factor authentication via the existing enterprise remote access infrastructure to receive access to the bastion hosts only.

Bastion hosts or remote access servers can provide dedicated and isolated desktop devices with preloaded applications that can be used to control user access to permitted applications. This approach avoids an employee or contractor needing a laptop PC to access critical control networks directly.

Remote access should provide full logging and auditing capabilities.

Automation

There is a need for a cost-effective operational model, especially one that provides easier deployment, maintenance, troubleshooting, and improved stability and resiliency for wind farm operations.

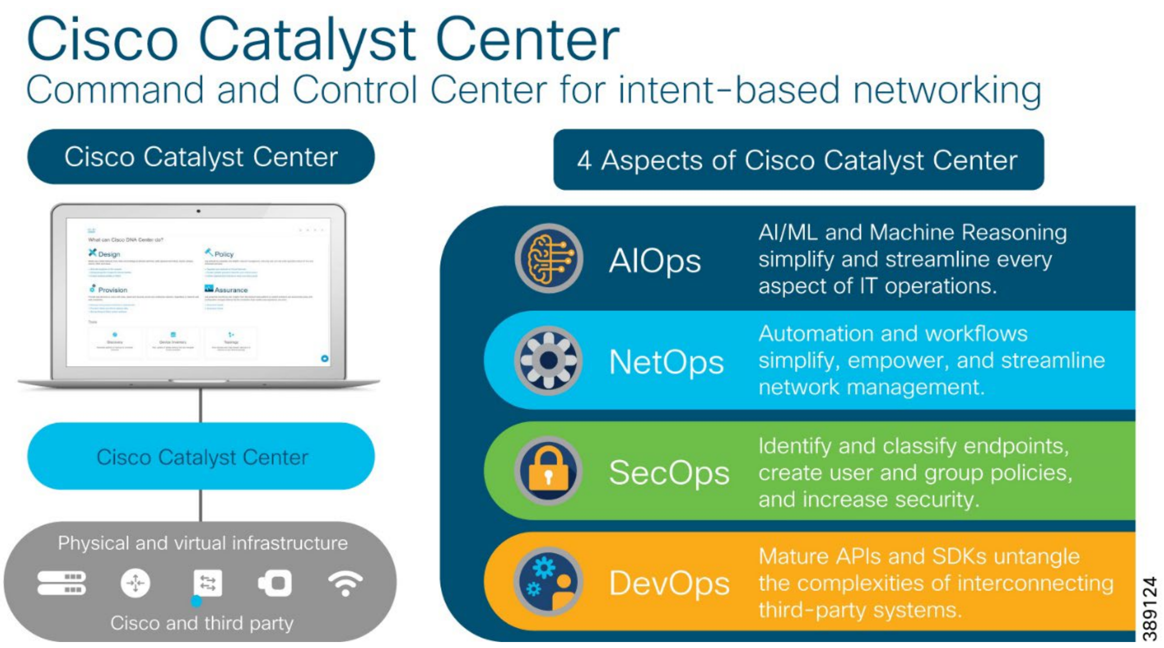
Traditionally, engineering a communications network is a manual task, with equipment configured by using a command line interface (CLI). With the rapid increase of facilities being built and the lack of skilled staff, automation becomes a major consideration for deploying and managing the lifecycle of any underlying WAN and wind farm networks.

The ability to eliminate costly deployment errors (especially those affecting offshore equipment, which require a higher cost to remedy) and create repeatable templated system configurations ease the burden of configuring these complex networks.

An offshore industrial ethernet infrastructure often is installed and maintained by personnel with minimal networking background. The results often are network configurations that are consistent when first brought into an operational mode but that drift with time, as network infrastructure is rarely if ever maintained or improved. Inconsistent configurations, disparate network device software images, and erratic security settings that effect system performance and security can result.

With increased cybersecurity risks, the increased need to provide end-to-end connectivity while maintaining the highest levels of availability results in a critical need to consistently deploy more sophisticated configurations and maintain them throughout the useful life of a network. Industrial automation systems rely on the consistent, repeatable, and maintainable deployment and operation of sensors, controllers, and other equipment. Why should this approach not apply to the network infrastructure?

Cisco Catalyst Center focuses on deploying and maintaining network infrastructure with automation, offering consistency, reduced effort, and reliance on simplified workflows for both IT and OT personnel. In many ways, Cisco Catalyst Center can be viewed as the “controller” for the network infrastructure.



Cisco Catalyst Center

Command and Control Center for intent-based networking

Cisco Catalyst Center

Cisco Catalyst Center

Physical and virtual infrastructure

Cisco and third party

4 Aspects of Cisco Catalyst Center

AIOps: AI/ML and Machine Reasoning simplify and streamline every aspect of IT operations.

NetOps: Automation and workflows simplify, empower, and streamline network management.

SecOps: Identify and classify endpoints, create user and group policies, and increase security.

DevOps: Mature APIs and SDKs untangle the complexities of interconnecting third-party systems.

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Cybersecurity

There is a need for a cost-effective operational model, especially one that provides easier deployment, maintenance, and troubleshooting, and improved stability and resiliency for wind farm operations.

Many wind farms increasingly form part of a country’s national critical infrastructure and as such should be protected.

Cybersecurity must be comprehensive and a fully integrated part of the overall network design. Any design should seek to minimize administrative overhead in cybersecurity deployment and operations.

The ability to identify all wind farm assets and their associated vulnerabilities, detect any new threats or anomalous behavior on the network, and monitor traffic on an ongoing basis greatly enhances the capability to minimize the cybersecurity overhead.

Improved security measures are necessary to become compliant with the North American Electric Reliability Corporation Critical Infrastructure Protection requirements (NERC CIP) or the European Union NIS2 requirements for wind farm assets that are the area of responsibility of those regulations.

The following fundamental principles must be adopted by the asset network operator to ensure secure systems:

- **Visibility of all devices in the wind farm plant networks**. Traditionally, enterprise devices such as laptops, mobile phones, printers, and scanners are identified by the enterprise management systems when these devices access the network. This visibility can be extended to all devices on a wind farm plant network.
- **Segmentation and zoning of the network**. Segmentation is a process of bounding the reachability of a device and zoning is defining a layer where all the members in that zone have identical security functions. Designing zones in a network is an organized method for managing device access within a zone and to control communication flows across zones. Segmenting devices further reduces the risk of an infection spreading if a device is subjected to malware.
- **Identification and restricted data flow**. All devices in a wind farm plant (operational network) and enterprise (IT-managed network) must be identified, authenticated, and authorized. The network must enforce a policy when users and Industrial Automation and Control System (IACS) assets attach to the network.

- **Network anomalies**. Any unusual behavior in network activity must be detected and examined to determine if the change is intended or due to a malfunction of a device. Detecting network anomalies as soon as possible gives plant operations the ability to remediate an abnormality in the network quickly, which can help reduce possible downtimes.
- **Malware detection and mitigation**. Unusual behavior by an infected device must be detected immediately, and the security tools should allow remediation actions for an infected device.
- **Traditional firewalls are not typically built for industrial environments**. There is a need for a firewall that can perform deep packet inspection on industrial protocols to identify anomalies in IACS traffic flows.
- **Hardening of the networking assets and infrastructure**. This critical consideration includes securing key management and control protocols, such as Simple Network Management Protocol (SNMP), using SSH rather than Telnet and implementing authentication for network protocols where it is available (for example BGP, HSRP, and so on).
- **Automation and control protocols**. It is important to monitor the IACS protocols for anomalies and abuse.
- **Adhering to security standards**. In the 1990s, the Purdue Reference Model and ISA 95 created a strong emphasis on architecture using segmented levels between various parts of a control system. This approach was further developed in ISA99 and IEC 62443, which brought focus to risk assessment and business processes. Any security risk assessment identifies which systems are defined as critical control systems, non-critical control systems, and non-control systems**.**

Why Cisco for Distributed Renewable Energy Networks

Cisco is a global leader in industrial networking and provides a wide range of products to address the offshore renewable energy market. By applying our secure and hardened industrial networking, IoT expertise, and experience working with industry leaders to address challenges existing in the industry, we have created innovative technology solutions that optimize and secure renewable energy assets. Our goal is to future-proof your investment by providing an evolution path from today's isolated deployments to secure, connected renewable energy deployments that support the energy needs of today and tomorrow.

Since the inception of IP networking, Cisco Validated Designs (CVDs) have been used to validate, architect, and configure industry best practices and technology solutions. CVDs start with solution use cases and architect the flow from the edge device to the application, validating the key Cisco and third-party components along the way. Each aspect of the architecture is thoroughly tested and documented with sample configurations, helping to simplify integration and de-risk implementations through proven solutions.

The goal is to ensure a deployment and a solution that is simple, fast, reliable, secure, and cost effective. Cisco developed renewable energy network solutions to specifically address the networking and security needs of renewable energy asset operators.

Offshore Wind Farm Use Cases

The communications options that are available at a given site greatly influence the outcomes and capabilities for any use case. The availability of dependable lower latency, high bandwidth connectivity (such as fiber, LTE/5G cellular, Wi-Fi) allows for more advanced network and data service options, while sites with bandwidth constrains may be limited to simpler use cases such as remote management and monitoring.

Key Use Cases

Corporate IT services: Providing corporate IT access (wired and wireless) to remote sites to enable worker mobility and access to key IT resources. Enabling worker efficiency and the ability to access services such as the corporate intranet, file sharing, and voice and video services.

Asset management and monitoring: Providing access for assets within a remote location for troubleshooting, statistics, or configuration. Typically used for accessing non-operational data.

Video surveillance and monitoring: Monitoring various areas is a critical capability for gaining awareness of activity around a wind farm. With video surveillance cameras, live video streams can be obtained on demand, viewed for immediate response, and stored for future review and assessment. Additional analytics can be deployed on a camera or on localized edge devices, making a camera or edge device a network sensor.

Camera use cases include safety such as fire detection and worker protection.

SCADA: Providing access to and from key operational devices within a remote location. Providing a secure connection to the control center for telemetry and operational data.

The types of devices that provide key operational data include but not limited to:

- Wind turbine monitoring and control (such as Performance monitoring)
- Fire detection and alarming
- HVAC
- Power systems protection and control
- Environmental and weather systems
- Wildlife detection and monitoring systems
- Lightning detection
- Marine systems (radar, radio)

These devices usually are key to operating a renewable energy site, providing both monitoring and control capabilities.

Secure remote access: Secure remote access should be provided to allow employees and external contractors to access relevant systems for monitoring, troubleshooting, and maintenance. Users should be restricted to access only assets and access type based on permissions that are configured with applications such as RDP, SSH, HTTP/S, VNC. This approach simplifies troubleshooting devices remotely, with the aim of reducing downtime and onsite visits.

Access control: Devices providing security related access to remote sites. Includes devices such as keypads, card readers, electronic locks, and sensors that detect open doors or hatches. Reporting data and events to the control center.

Meteorological & environmental sensors: Devices and sensors associated with monitoring weather, environmental conditions, and lightning detection, and specialized devices for specific regional use cases (for example, bird or bat monitors).

Radio systems: Tetra radio is the most prevalent offshore solution today for personnel communications. Private LTE is starting to be deployed in some offshore projects providing a more capable data solution. However, 5G networks are starting to appear and provide a platform for multiple use cases now and in the future: Mission Critical Push to Talk, Service Operations vessel connectivity, turbine SCADA network backup, drones for inspection and worker remote expert support (cameras, video glasses, and so on).

The Cisco Validated Design provides a high bandwidth and resilient architecture as a platform for all corporate and OT services today and in the future.

Offshore Wind Farm Cisco Validated Design

As digital technology is increasingly required to operate remote distributed energy resource locations, equipment must be installed with close attention paid to ease of operations, management, and security. Cisco Validated Designs are simple, scalable, and flexible. They focus on operational processes that are field-friendly and do not require a technical wizard. Our centralized network device management (Cisco Catalyst Center) and strong networking asset operation capabilities eliminate the need for manual asset tracking or inconsistencies in field deployment from one site to another. Integration with operations ensures that field technicians can easily deploy and manage devices without the need for IT support, while IT and OT teams have full visibility and control of the deployed equipment.

Additionally, Cisco provides various connectivity options, ranging from fiber to cellular or high-speed wireless where hardwired connections are not available.

Cisco has launched a complete validated design for offshore wind farms. This design focusses on an end-to-end architecture for the asset operator's network, including both onshore and offshore locations.

The Cisco Validated Design provides the capability to securely interface with third-party networks such as the turbine SCADA network, export cable system, and the substation protection and control network. Cisco security technologies such as Trustsec working with Cisco Catalyst Center and Identity Services Engine also allow centralized security policies to provide network segmentation.

The Validated Design provides a flexible network to allow additional services to be added as needed while maintaining segregation of traffic. This flexibility includes both wired ethernet switching and Wi-Fi networks, which are available at the OSS and turbines. Additionally, Cisco Ultra Reliable Wireless Backhaul radios are used for high bandwidth situations such as service operations vessel connectivity.

The Cisco Validated Design uses various Cisco platforms and technologies for automation, configuration, and monitoring, including Cisco Catalyst Center and switch features such as plug and play (PnP).

The Validated Design addresses the WAN handoff interface and new technologies such as Cisco SD-WAN for automating deployment of overlay networks across multiple underlying WAN technologies.

Finally, the Validated Design addresses innovation areas such as solutions for the service operation vessels (SOV), which provide high bandwidth connectivity for corporate workers and contractors when operating offshore.

The Validated design is built on the following functional blocks:

- Wind farm operator data center
- Wind farm wide area network (WAN)
- Onshore DMZ
- Onshore substation
- Offshore DMZ
- Offshore substation

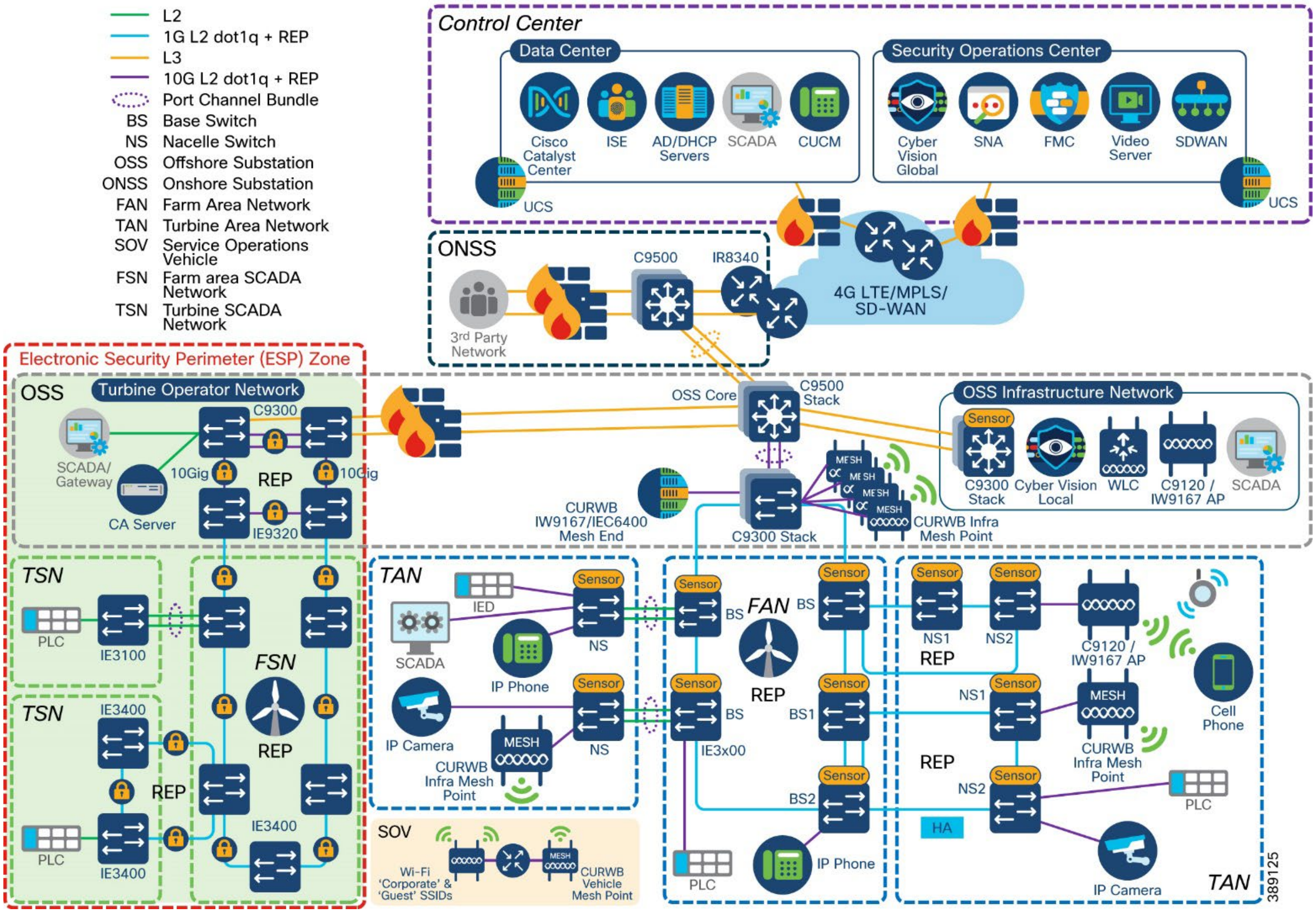
- Turbine control network (SCADA)
- Turbine power automation and control network
- Turbine plant IT network (for example, enterprise and plant services)
- Offshore service operations vessels (SOV)
- Operations and maintenance buildings (O&M)

The validated design allows customers or partners to select which parts are applicable to a certain project or deployment or utilize the complete end-to-end architectures.

For the current release, the following functional block is out of the scope of the detailed design. This functional block is covered by the Substation Automation validated design:

- Power automation, control and metering network:
  - Provided and validated by the power automation and control supplier.
  - Offshore and onshore provided substation equipment and turbine switchgear and IEDs.
  - Uses separate fibers (for onshore, offshore, and turbine networks) and a dedicated network based on IEC62439-3 PRP (Parallel Redundancy Protocol) and/or High-Availability Seamless Redundancy (HSR).

Wind Farm1.2 Solution Architecture



The turbine control and power automation networks are typically interfaced at the onshore or offshore DMZ locations. This approach allows traffic inspection and security rules to control the flow of traffic from these third-party managed systems to the asset operator's network.

The Cisco Validated Design provides several resilient and non-resilient topologies for the turbine network and resilient rings for connecting the turbines to an offshore substation aggregation point.

It is increasingly common to use rings within the turbines themselves (especially as the turbines get larger and systems generate more critical data), as well as for the connectivity between turbines (each physical string of turbines is connected via two pairs of fibers in a ring topology. Turbine rings aggregating at the offshore substation. The level of redundancy is down the individual customer or supplier specifications, but the Cisco Validated Design provides tested solutions for all high availability scenarios.

Distributed Energy Site Multi-Level Security

Wind Farm Security Key Points

- Build a dynamic inventory of all devices and their real time communication flows
- Segment communications within the onshore and offshore zones and the local DMZ
- Monitor and detect abnormal traffic behaviors
- Contain malware and other attacks

Any industrial infrastructure is at a constant cyber and physical security risk. As devices become connected, the attack surface increases. A secure architecture requires a multilayer approach that includes the physical security of offshore assets, securing network equipment ports, network segmentation, and application-level traffic security. Our solution integrates all layers of security to keep equipment, applications, and data secure.

Segmentation is the process of isolating certain traffic types from one another by using virtual networks (for example, VLAN and VRF). This approach provides an administrator with additional control for applying security or quality of service to that traffic. These actions often are referred to as macro segmentation.

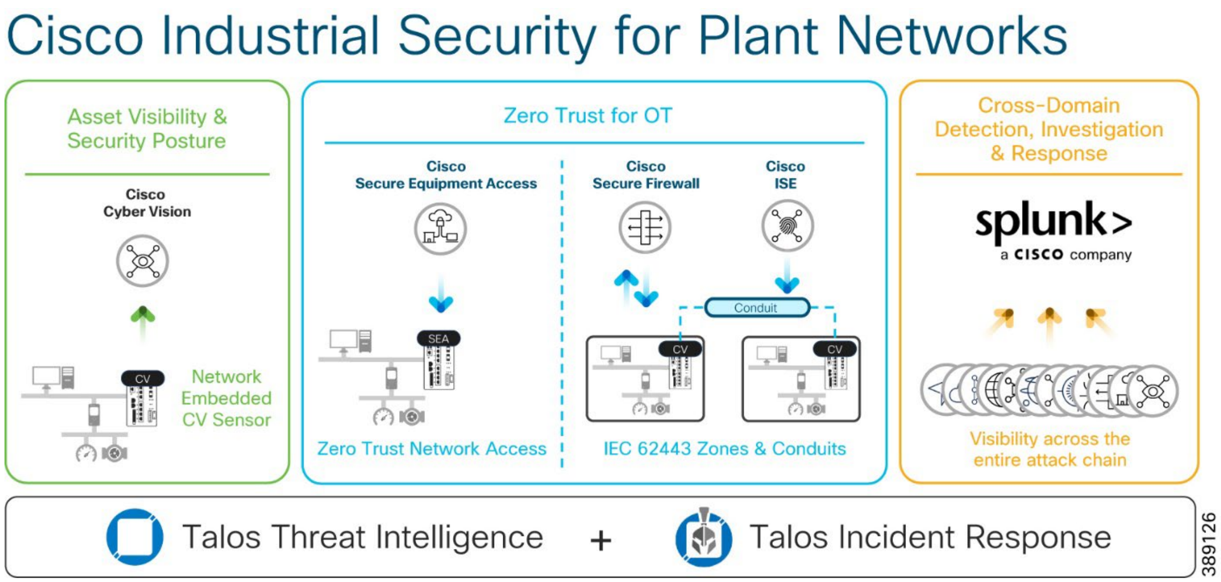
Micro segmentation provides another layer of segmentation to further isolate equipment on the same virtual network. The micro segmentation capabilities used with port level security ensure that only known devices are allowed on a network and that a specific policy is in place to control which devices and equipment can communicate with each other. In some cases, this control can be down to the protocol level.

Securing the perimeter ensures that all traffic entering or exiting onshore and offshore networks is controlled and inspected where required.

Validated design security control points include the following:

- DMZ at a datacenter
  - Normal enterprise security model for incoming WAN connectivity
  - Clustered firewalls for IDS/IPS
- DMZ at onshore substation
  - Redundant firewalls for IDS/IPS
  - Secure local perimeter for third-party network connections
  - Monitoring traffic flows for known threats
  - Blocking undesirable traffic
- DMZ at offshore substation
  - Redundant firewalls for IDS/IPS
  - Secure perimeter for third-party network connections
  - Monitoring traffic flows for known threats
  - NAT for third-party networks
  - Blocking undesirable traffic

The security design is built up as shown in the following figure. Each step adds value and provides a clear benefit to the overall security posture of a wind farm.


Cisco Industrial Security for Plant Networks
Asset Visibility & Security Posture
Cisco Cyber Vision
CV
Network Embedded CV Sensor
Zero Trust for OT
Cisco Secure Equipment Access
SEA
Zero Trust Network Access
Cisco Secure Firewall
Cisco ISE
Conduit
CV
CV
IEC 62443 Zones & Conduits
Cross-Domain Detection, Investigation & Response
splunk> a cisco company
Visibility across the entire attack chain
Talos Threat Intelligence
+
Talos Incident Response
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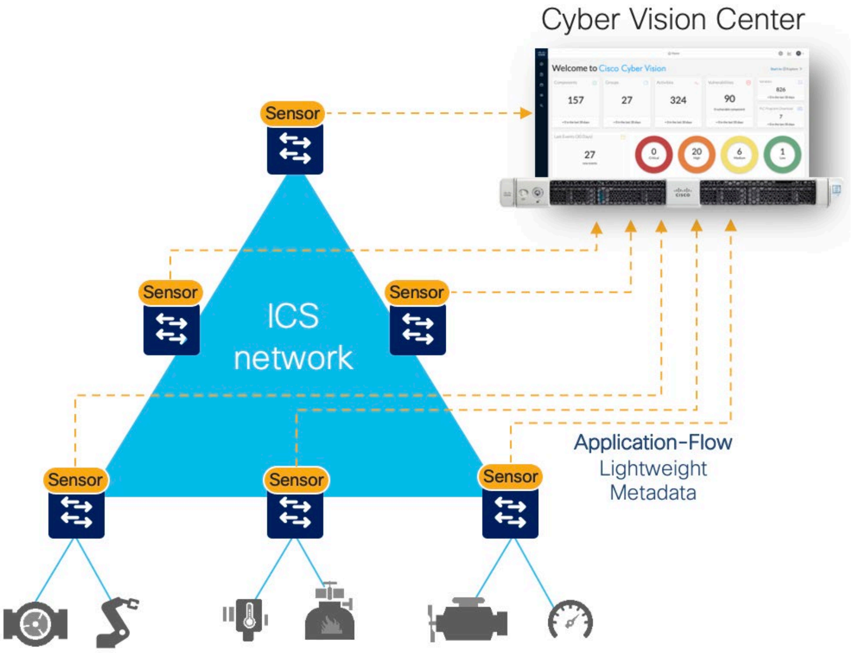
Cisco Catalyst Center, interfacing with Cisco Cyber Vision, and ISE can help secure your operations:

- Establish a security profile to manage industrial networks
- Create authentication and authorization policies in ISE
- Visualize connected industrial assets in Cisco Catalyst Center as discovered and profiled by Cisco Cyber Vision and grouped in ISE
- Monitor communications patterns between asset groups using NetFlow traffic and help define and validate access policies
- Create and manage cybersecurity segmentation policy (Trustsec and Scalable Group Tags (SGTs)) for a wind farm network
- Deploy policies with confidence and segment the network to restrict unnecessary access
- Allow use of other Cisco security applications such as Umbrella, Secure Network Analytics (Stealthwatch), and SecureX for further enterprise security integrations

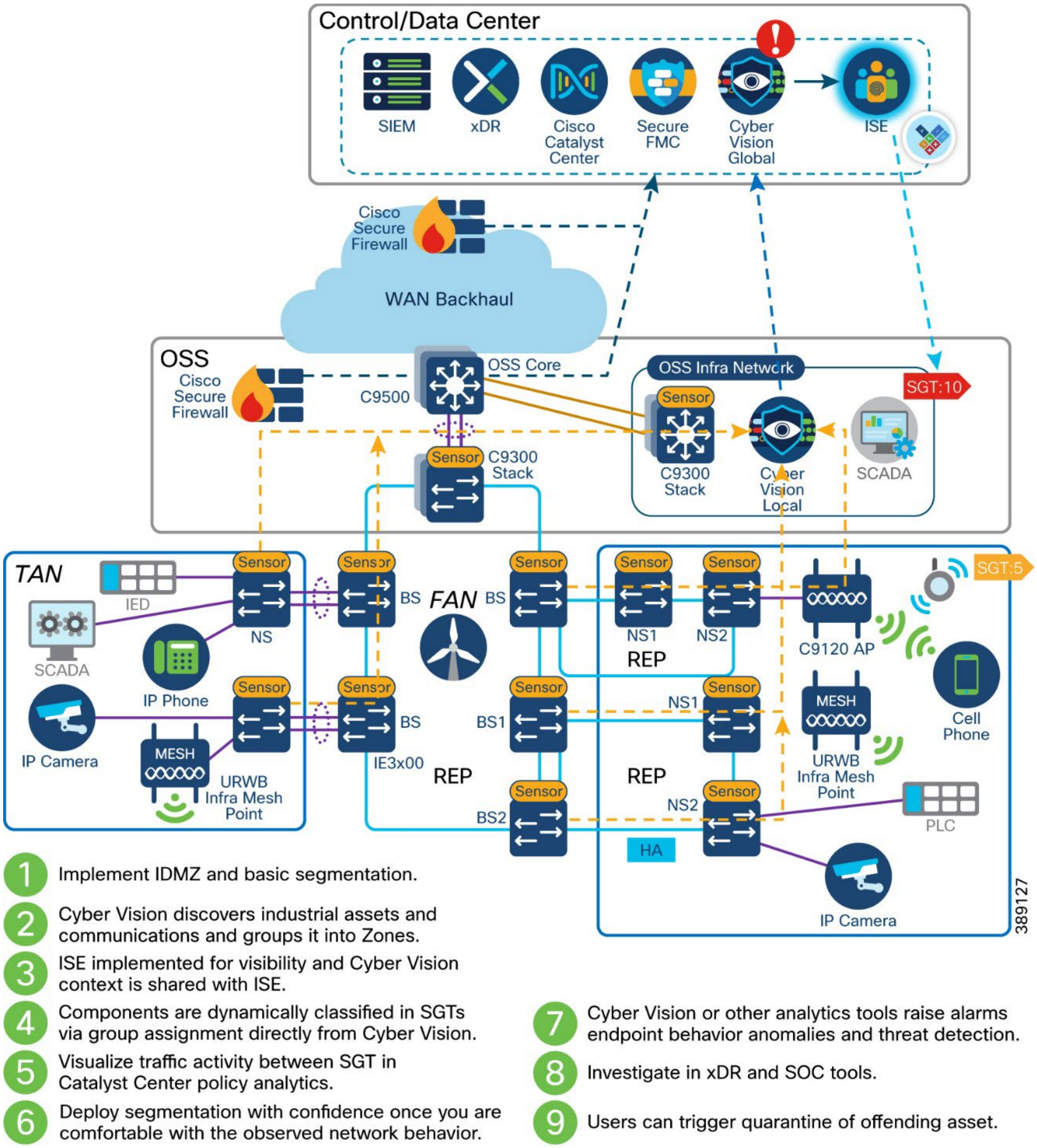
In industrial environments, network-based monitoring capabilities typically are deployed using switched port analyzer (SPAN) ports instead of in-line network taps that could create a communication point of failure. Cisco Cyber Vision provides a unique approach that uses sensors embedded into network equipment (switches, routers, and gateways) to collect packets that flow through the industrial infrastructure. Using a combination of passive and active discovery techniques, a sensor leverages advanced knowledge of industrial protocols to decode and analyze packet payloads through deep packet inspection (DPI). This approach lets Cyber Vision profile each endpoint, detail endpoint interactions with other endpoints and resources, and build an asset inventory.



Benefits of Cyber Vision include scalable real-time cyber security protection from external and internal threats, and include the following:

- **For network operations:** Ability to consistently apply security policy, deploy security updates, and protect against unwanted devices or applications on the network. Ongoing monitoring and analysis of network with automated anomalous network traffic detection and alerts and the ability to instantly quarantine suspect devices or applications.
- **For field operations:** Visibility to offshore networks, quickly deploy equipment without having to understand complex security deployments. Know that critical applications are available and operational at offshore locations.

The following diagram illustrates the use of Cyber Vision in a validated network architecture to enable the use of segmentation policies with Cisco Catalyst Center.



1. Implement IDMZ and basic segmentation.
2. Cyber Vision discovers industrial assets and communications and groups it into Zones.
3. ISE implemented for visibility and Cyber Vision context is shared with ISE.
4. Components are dynamically classified in SGTs via group assignment directly from Cyber Vision.
5. Visualize traffic activity between SGT in Catalyst Center policy analytics.
6. Deploy segmentation with confidence once you are comfortable with the observed network behavior.
7. Cyber Vision or other analytics tools raise alarms endpoint behavior anomalies and threat detection.
8. Investigate in xDR and SOC tools.
9. Users can trigger quarantine of offending asset.

Conclusion

The demands for robust and connected solutions with a simple to manage and operate network infrastructure are becoming essential to support renewable energy networks at scale. The Cisco Wind Farm solution provides the capability to address different deployment options while maintaining a single provisoning and management application with built in cycbersecurity.

Cisco Offshore Wind Farm Network Benefits

- Pre-validated, proven multiservice network for all your present and future goals
- Ruggedized network for robust and effective movement of data
- Automated service segmentation to simplify security policies
- Centralized security policy control
- Plug-and-play device deployment for simplicity and efficiency
- Automated uniform policy deployment for one redundant and resilient network
- Flexible network topologies and backhaul options for future services and growth opportunities

Resources

- Cisco Utility & Renewable Energy Validated Designs
- Cisco Industrial Routers & Gateways
- Cisco Industrial Switches