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Kinematics Is Bringing Industrial-Grade Communications to Large-Scale Solar

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About This Paper

This paper is part of a series about technology, applications, and solutions for the utility scale solar tracker market. Written for the decision maker audience in the solar industry, these papers are intended to provide valuable insight to help you make informed technology and product decisions for your tracker implementations.

Power Plant Networking

We generally characterize large-scale solar as a singular entity, a power plant capable of delivering energy in bulk for storage in a battery bank or export to the grid. Each project typically has one point of interconnection with the electric transmission system. Whether producing 5 megawatts (MW) or 500 MW, however, projects increasingly depend on robust internal communications for security, reliability, and more. This paper will show that, as solar asset owners and operators contend with a growing need to enhance information technology (IT) infrastructure and manage risk, solar projects now function more like enterprise networks than ever before. The communication systems we use to share data between hundreds or even thousands of networked devices have become key drivers of plant performance and operational efficiency.

The challenges of seamless integration—including the ability to coordinate tracker movement and stow trackers due to the approach of extreme weather—can vary based on project site characteristics. Prime land with flat terrain once provided a level playing field for various communication systems. As the pipeline for development on prime land dries up and developers turn to land with undulation, hills, and ravines, constraints associated with the terrain can affect system performance. Asset owners and operators also must consider that systems without interoperable parts have limited abilities to modify or expand down the line. Be prepared for the need to make system upgrades in the years to come. Frequently, the loss of communication has been reported as the most common support ticket for solar tracker operations and maintenance (O&M).

Networking infrastructure is a long-term investment that reveals its true value after many years of performance. That is why it's important to identify tracker systems built on a flexible, future-proof platform. Look at the evolution of IEEE 802.15.4, the technical standard for low

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data-rate wireless networks.[1] While many devices in the commercial market operate according to the IEEE standard's 2011 edition, subsequent amendments greatly enhanced functionality in smart-grid applications, improving data rates and data accuracy and increasing the potential for longer-range communication. Systems locked in to the 2011 edition cannot easily leverage the recent advantages that have been introduced to the market, affecting project costs and scalability. With access to the latest networking principles, new equipment can start up with no manual configuration. Installation and commissioning can become as simple as syncing a smartphone to a laptop. Replacing a controller can be as easy as powering up the new device after removing the errant one.

Kinematics adopted Wi-SUN (Wireless Smart Utility Network) wireless mesh communications technology for our solar tracker actuation systems because we understood the importance of building upon a wireless networking ecosystem that would bring our clients the greatest reliability and flexibility.

Open Specifications, Flexible Architecture Are Essential

The functional differences between low-power, wide-area networking solutions stem from the origins of each technology and the problems they were created to solve. Let's start with Wi-Fi and LTE networks, known as star networks, because connected devices orbit around a central hub. Star networks make it easy to add and remove components without affecting the rest of the system. In a star network, data flows through the system's central core. The hub-and-spoke model makes it relatively easy to manage the network. But the end points do not talk to each other.

Mesh networks contrast with star networks in that connected devices share data with one another. Instead of relying on a central hub, mesh networks enable data hopping from point to point, along the most efficient path available. Mesh networks are considered self-forming and self-healing. If one end point stops working or is compromised, others pick up the slack with no interruption to the system. However, not all mesh networks are the same.

Networks can be developed around open specifications that are accessible to, and supported by, a robust group of vendors. Or they can operate within a proprietary ecosystem where one entity can exert outsized influence over suppliers. With flexible architecture, networks can alternate between mesh topology and star topology as needed based on conditions in the field. Or they can be designed for a limited set of unique applications, such as personal area networks serving indoor locations, generally under one roof.

What is Wi-SUN FAN?

Wi-SUN FAN is an open communications standard built on flexible architecture and

[1] https://icact.org/upload/2019/0503/20190503_finalpaper.pdf

supported by a global association of industry-leading manufacturers and services providers for utilities, smart cities, and the Internet of Things (IoT), known as the Wi-SUN Alliance. While monitoring and reporting on IoT technology trends over five years ending in 2022, Wi-SUN Alliance found that IoT enablement had emerged as a top IT priority. Key drivers of IoT adoption have shifted, showing that organizations are becoming more sophisticated in how they approach the technology. A growing consensus now believes industry-wide open standards for IoT deployment are very important. Organizations also demand systems with proven security. And most of all, organizations prefer reliability. "This demonstrates the mission-critical nature of many IoT deployments as adopters become more confident in the technology," Wi-SUN Alliance noted in a 2022 report.[2]

Wi-SUN communication systems use different operating profiles to enable seamless connectivity under some common smart-grid scenarios, such as networks for inside the home and out in the field. The Wi-SUN Field Area Network (FAN), providing interoperable, low-power wireless communications, derives many advantages from its flexible architecture and its use of an open specification. Chief among them are security, reliability, ease of deployment and operations, network performance, and scalability.

Security

The Wi-SUN Alliance has invested in enterprise-grade security measures that enable IoT customers' teams to protect the privacy of the data flowing across their infrastructure.

A key benefit of Wi-SUN FAN is its usage of public-key infrastructure (PKI), with each device containing a unique X509 identity certificate. Unlike most other IoT communication technologies which use pre-shared symmetric keys, Wi-SUN FAN's use of PKI, enables mutual authentication of devices and the network, preventing rogue devices access to the network. With network access granted, devices negotiate network keys using an adaptation of IEEE 802.11i. With keys established, device communication is secured using AES-128 encryption (long approved by U.S. government) Message encryption ensures that the data is both private and integrity checked (tamper proof).

Also important for security management is Wi-SUN FAN's adoption of IPv6, facilitating the use of standard enterprise network security tools. This enables customers to easily conduct intrusion detection, traffic shaping, network analysis, and penetration testing. It also allows customers to better mitigate denial-of-service (DOS) attacks, while giving them greater network visibility than their rivals.

Enterprise-grade security safeguards connected devices from techniques that white hat programmers have demonstrated to infiltrate smart home networks in controlled, and in some cases uncontrolled, environments. Wi-SUN FAN security methods include spread spectrum communication, sending data across different frequency bands to minimize risk of interference.

[2] https://wi-sun.org/iot-maturity-model/

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Reliability

Smart city and smart grid applications—including metering for electricity, gas, and water—depend on uninterrupted communications. Wi-SUN adoption, wth more than 100 million Wi-SUN capable devices awarded worldwide, reflects asset owners' and operators' confidence in Wi-SUN FAN as a long-term solution.[3] As the renewable energy market continues the transition from centralized generation to distributed generation, and we see ongoing growth in community-scale solar, the importance of networking reliability will only increase. Wi-SUN FAN addresses the need for reliability with a system architecture that enables data hopping and sub-GHz networking that eliminates interference from Bluetooth, Wi-Fi, and other technologies. Sub-GHz frequencies also improve data communication over sloping terrain. As with the telecommunications network, a wider coverage area means that the devices you rely on can stay connected across a larger territory. Increased network coverage also means you can deploy less equipment to serve your project's territorial needs.

Deployment and Operations

When networks expand from hundreds to thousands of devices, anything that complicates the process of adding or swapping out devices can undermine network viability. Nobody wants to take the time or spend the money to manually configure so much hardware. Wi-SUN FAN uses a self-forming function, so new equipment automatically recognizes the network upon startup, establishes a connection and configures itself to begin transmitting data.

Network Performance

Higher throughput provides quicker responsiveness and lower network latency for command-and-control applications. It also means that devices spend less time on the air, which equates to better power usage. Hardware in the Wi-SUN FAN can be designed for frequent low-latency communication, drawing less than 2 microamps when resting, around 8 milliamps (mA) when listening, and less than 14 mA when sending. Low latency enables on-demand commands, rather than waiting for devices to wake and receive and send messages.

Network Scalability

Networks must be able to scale in capacity and size. Higher bandwidth makes it easier to add more data-intensive applications in the future. Reliability improves as networks add more nodes. Support for standardization activities, including device testing and certification, comes from the Wi-SUN Alliance consortium with 300+ members in 46 countries, including Itron, Renesas, Silicon Labs, Landis + Gyr, and Cisco Systems. In recent years, Wi-SUN Alliance launched the first laboratory in the Americas, located in Brazil, that is authorized to test and certify products for Wi-SUN FAN. In 2023, Wi-SUN reported the availability of more than 80 Wi-SUN FAN-certified products and a total of around 300 Wi-SUN-certified products

[3] https://www.wi-sun.org/wp-content/uploads/WiSUN-Alliance-Comparing-IoT-Networks-2019-Nov-A4.pdf

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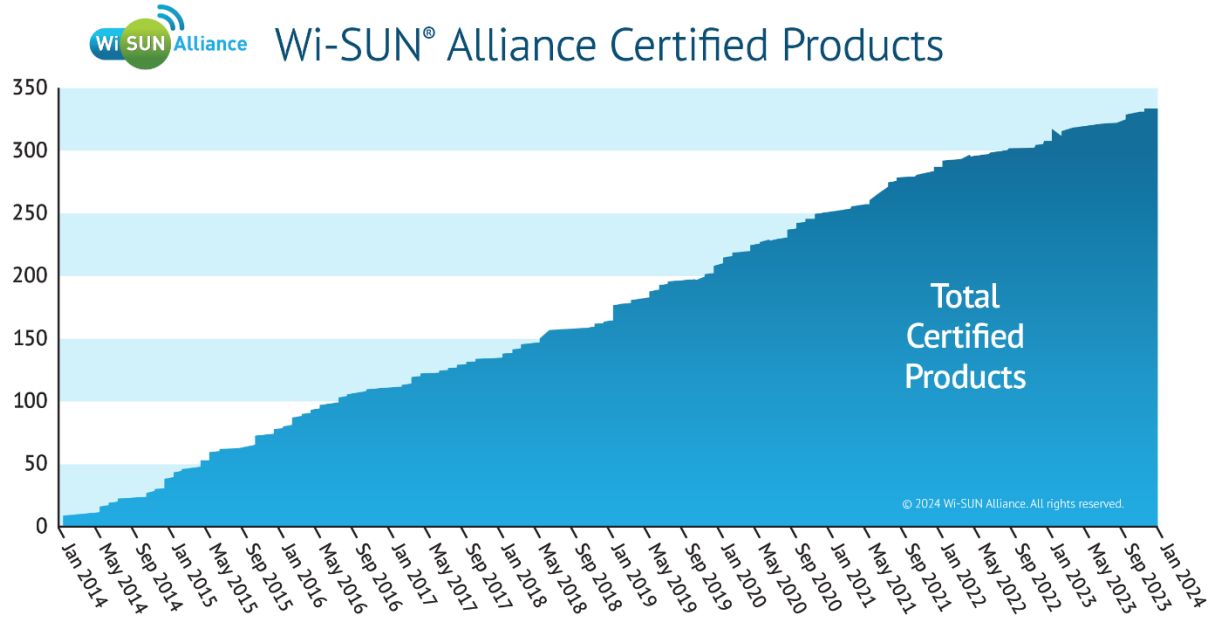

1 Total Wi-SUN-certified products have grown consistently since the certification process was introduced. Total certified products include Field Area Network (FAN) applications, Home Area Network (HAN) applications, and applications specific to utility metering in Japan. Source: Wi-SUN Alliance

Why Kinematics Chose Wi-SUN

Recent market developments have only solidified Kinematics's belief that Wi-SUN Alliance can best serve wireless communications for solar tracker actuators today and into the future. Anyone who was working in the solar industry in 2020 and 2021 has fresh memories of project cancellations, factory closures, and jobs lost due to COVID-era supply chain disruptions. A resilient supply chain depends upon a diverse vendor network. Wi-SUN Alliance, with a global ecosystem and promotion of multi-vendor interoperability, offers the greatest assurance of supply.

In 2023, the North American Electric Reliability Corporation (NERC), a regulatory authority that oversees grid security and reliability, moved to enhance compliance for large-scale solar. One step was to initiate voluntary reporting into the Generating Availability Data System (GADS), a database with operational details for more than 5,000 generating units in North America. Reporting into GADS is mandatory for conventional generating units with a capacity of 20 MW and above. This includes coal- and natural gas-fired power plants. In 2024, analysts expect that solar projects with 100 MW of capacity or more may be required to submit operational data to GADS. Projects with 20 MW or more might then face a reporting

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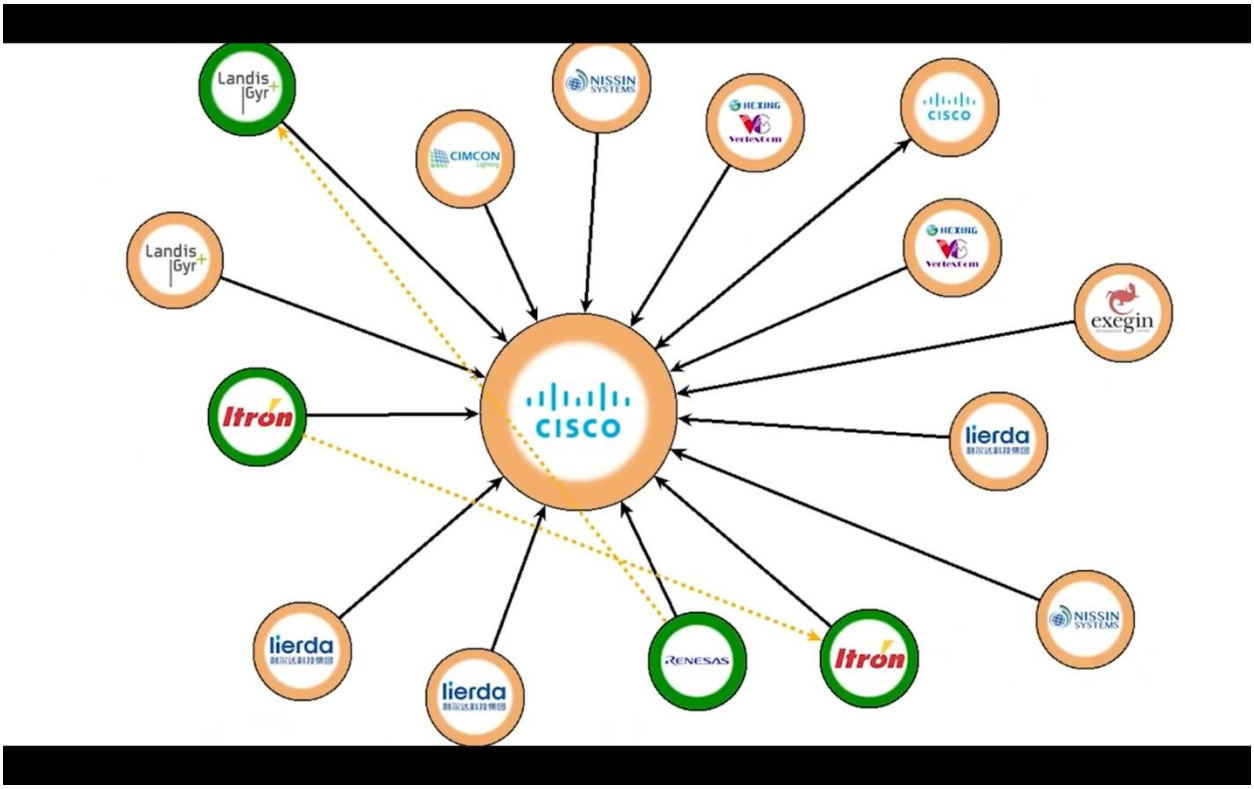
requirement as soon as 2025.[4] Expansion of NERC requirements will make it more important than ever to deploy enterprise-grade wireless communications now. Projects needing to make wholesale system changes down the road may be facing a significant new expense that cannot be offset by increased revenue.

Open standards unlock a level of collaboration that gets suppliers from vastly different industries—streetlighting, energy, building automation, and more—all pulling in the same direction to realize the vision of the smart city and the smart grid. In a community with open standards, participants have strong incentives to get involved. For starters, developers recognize a faster and smoother path to market when they can build systems on proven technology. There's also safety in numbers both for developers and users, knowing that open standards safeguard against vendor lock-in. The benefits snowball in a virtuous cycle. While you can't predict the future, you can mitigate the risk of stranded assets by investing in mature systems that many others are investing in too.



2 Wi-SUN Alliance certifies products based on compliance with an open standards-based communications profile and the ability to interoperate with other Wi-SUN-certified products. Source: Wi-SUN Alliance

If all the wireless communication systems in your experience have self-forming and self-

[4] https://radiangen.com/navigating-the-new-nerc-solar-gads-reporting-requirement/

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healing capabilities, it can be easy to take for granted how much time savings and value these systems provide. You have to glimpse into the past to appreciate today's technology. Talk to a network administrator servicing older platforms. Ask about the process of manually entering network addresses and the code writing required to configure new devices. Knowing how much the industry standard has evolved, you will see the parallel universes that we occupy, with some systems virtually frozen in time and others poised to scale.

Approaching Implementation

As an open specification, Wi-SUN FAN is accessible to anyone who can make use of it. Implementation, however, calls for wireless communications expertise and a thorough understanding of the test methods that products must go through to become Wi-SUN certified. Because the unique combination of skills and experience is limited, consider working with a team, like Kinematics, that has already put together the people and processes for Wi-SUN network deployment.

Use this paper as a guide to highlight the most important questions to ask as you evaluate Wi-SUN products, or any wireless network. How does your preferred system compare to other systems in terms of security, reliability, and ease of use? How many interoperable devices can join your network as a plug-and-play addition, and how many more devices are advancing through the product development pipeline? How does your system maneuver around obstructions, such as those that can be created by the land itself on complex terrain?

Contact Kinematics to talk with our wireless communications team about Wi-SUN and find out how our systems can support planning, installation, operations, and data collection for your solar projects. Visit us at *gokinematics.com*.