ARDEXA

ARDEXA UNIFIED CONTROL SOLUTION

REMOTE OPERATIONS AND CONTROL CENTRES

EXECUTIVE SUMMARY

Owners and operators of expansive and diverse renewable portfolios face a multitude of technical and business hurdles arising from the operation of diverse local SCADA (Supervisory Control and Data Acquisition), PPCs (Power Plant Controllers), PLCs (Programmable Logic Controllers) and RTUs (Remote Terminal Units) systems. Effectively tackling these challenges is of paramount importance and requires immediate attention. This is especially crucial in light of the need to rapidly expand renewable energy capacity, while hindered by current and anticipated labour constraints.

A “hub & node” architecture built with scalable and resilient cloud-native technology makes possible a purpose-built, unified control solution. This architecture uniquely enables rapid incorporation of heterogeneous plants and control systems, without the need to rip-and-replace existing control technology or standardise on a narrow set of SCADA vendors. Furthermore, the Ardexa unified control solution shifts control of data, plants, and assets to the portfolio owner, enabling and accelerating operational improvement. The hub & node, unified control architecture is secure by design and ensures compliance with cybersecurity standards and auditability.

PORTFOLIO LIFE CYCLE DRIVES SCADA DIVERSITY

There are multiple reasons for the variety of control systems found within present day renewable portfolios. In most cases, the controlling entity of each wind farm or PV plant changes over its life cycle from developer to EPC to one or more owner-operators. Following the initial commercial operation date, owner-operators effectively inherit the SCADA platforms implemented by the EPC.

Large renewable companies often grow their portfolios by acquiring operating assets, typically without consideration of seemingly secondary details like which SCADA system or PPC may be in use. And even in those cases where the original developer is the owner-operator, very often decisions about SCADA systems were made independently by the EPC. Rarely, if ever, is seamless integration into a unified control architecture among the criteria EPC companies use for selecting the SCADA system at a given plant. Wind portfolios typically operate turbines from various manufacturers due to the phased development of projects. The optimal choice of turbine vendor shifts over time, influenced by factors like supply chain disruptions or one manufacturer outperforming another in terms of levelized cost of electricity. Because PPC and SCADA systems are typically integrated into the solutions provided by turbine manufacturers, the development of large wind portfolios, or even individual wind farms, over the course of time leads to divergent control interfaces, resulting in increased complexity and operational inefficiencies.

The emergence of energy storage into existing solar or wind portfolios further complicates the control landscape. Existing SCADA platforms within operating plants are typically not capable of extending services to battery, hydrogen-based or pumped-hydro energy storage systems. The result is yet more diversity in SCADA systems across the portfolio.

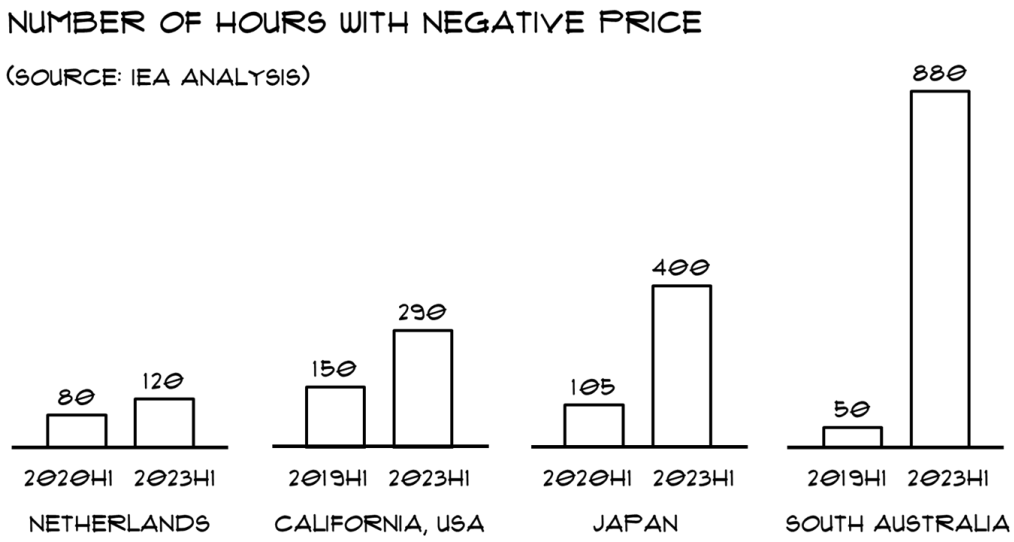
Geographic dispersity of energy assets is another prime driver of heterogenous SCADA solutions. There are no SCADA providers that can reliably support deployments in all countries and regions. EPCs tend to operate regionally and their relationships with SCADA vendors in their local markets also leads to geographic heterogeneity of control solutions.

BUSINESS IMPACTS DEMAND ACTION

Owners of extensive renewable portfolios are faced with the challenge of managing numerous divergent local plant SCADA systems, PPCs, and PLCs. This diversity in control systems significantly complicates the continuous operation of geographically dispersed plants. Tasks such as advanced production scheduling, live trading, grid curtailment actions, and initiating start/stop/reset commands for individual assets necessitate remote operations personnel to possess expertise in a wide range of control systems and HMI (Human-Machine Interfaces) systems. Furthermore, the requirement to remotely access local SCADA systems through discrete VPN connections adds another layer of complexity.

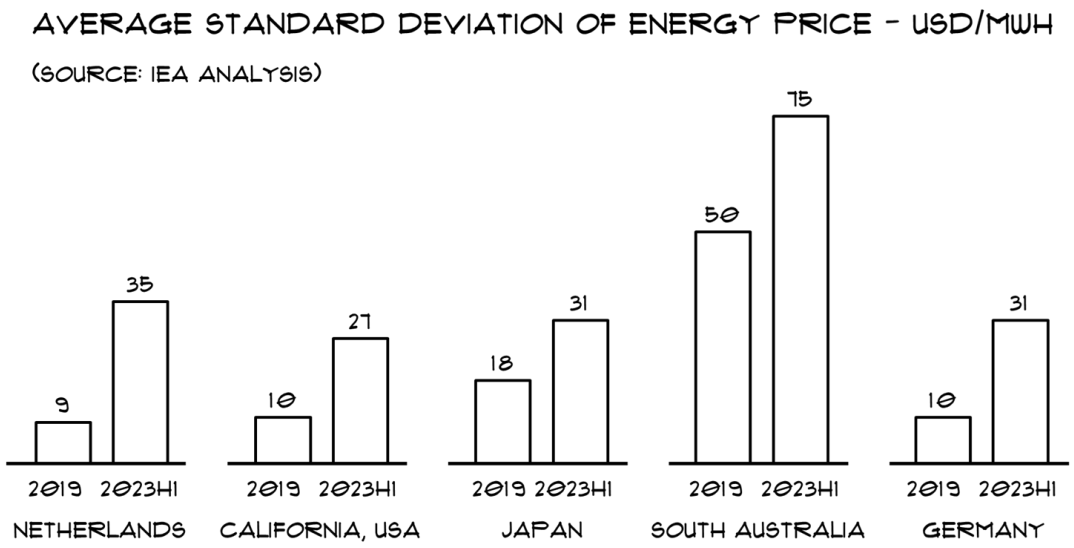
These diverse, intricate, and predominantly manual processes are highly inefficient and vulnerable to costly human errors. With thousands of manual curtailments carried out across a variety of SCADA systems, even small error rates can lead to substantial business repercussions, including negative pricing impacts and commercial penalties.

Curtailment of renewable energy, particularly solar, has been rapidly rising as renewables become a larger portion of utility scale electricity generation. Peak monthly curtailment in CAISO (California ISO) for example, doubled between 2021 and 2023. In the USA, grid operators such as ERCOT in Texas, projects that the percentage of curtailment will double between 2022 and 2035 to nearly 20% of solar capacity. The same story holds in Europe. This level of curtailment will lead to increasing adoption of energy storage deployments, in turn further increasing the complexity of remote power plant control.



ENERGY STORAGE BRINGS NEW COMPLEXITIES

This market dynamic is, of course, driving the investment in of energy storage systems. These storage projects will utilise hydro, battery and hydrogen technologies, and will lead to an increase in the number of control actions that will be executed by portfolio operators on a day-to-day basis.



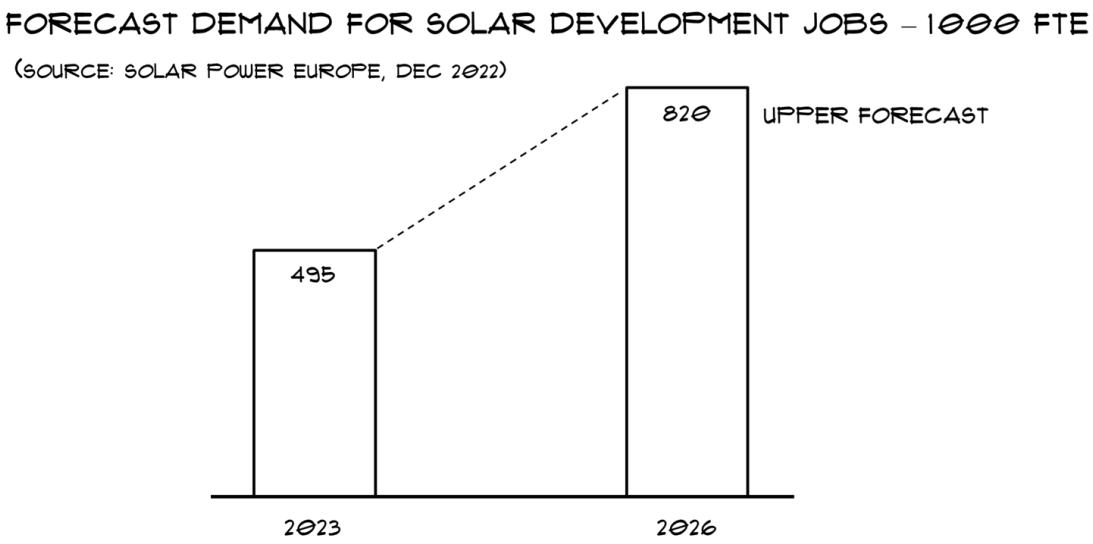
Over the course of time, producers will be looking to arbitrage price differentials on a continuous basis. The higher the price deviation is in any given market, the greater the opportunity for arbitration. The price arbitrage opportunity, within each market, is increasing across all major markets, leading to rapid evolution of market trading systems and the necessity for more flexible, efficient, and dynamic control systems to optimize revenue potential.

Central control rooms will have to send or relay production control signals to energy production assets, as well as storage assets. This interaction will be with an ever-growing universe of SCADA systems, many with low latency response requirements as the market and trading windows narrow.

LABOUR MARKET SHORTAGES

Up until now, renewable energy firms have managed the rising complexity of remote plant control by continually recruiting more SCADA and ROCC (Remote Operations and Control Centre) personnel. These ROCC teams typically interact with multiple plant SCADA systems to control remote plants. ROCC personnel must be trained on every system and keep up with all maintenance upgrades, while also handling a high diversity of cybersecurity protocols and standards. As a result, staffing tends to scale proportionally with the size of the portfolio.

Unfortunately, the available talent pool is insufficient to meet the soaring demand, leading to an escalation in labour costs and turnover of critical personnel. The projection is that access to skilled labour is going to worsen, with Europe alone forecasting a 100% increase in solar jobs over a 4-year period.

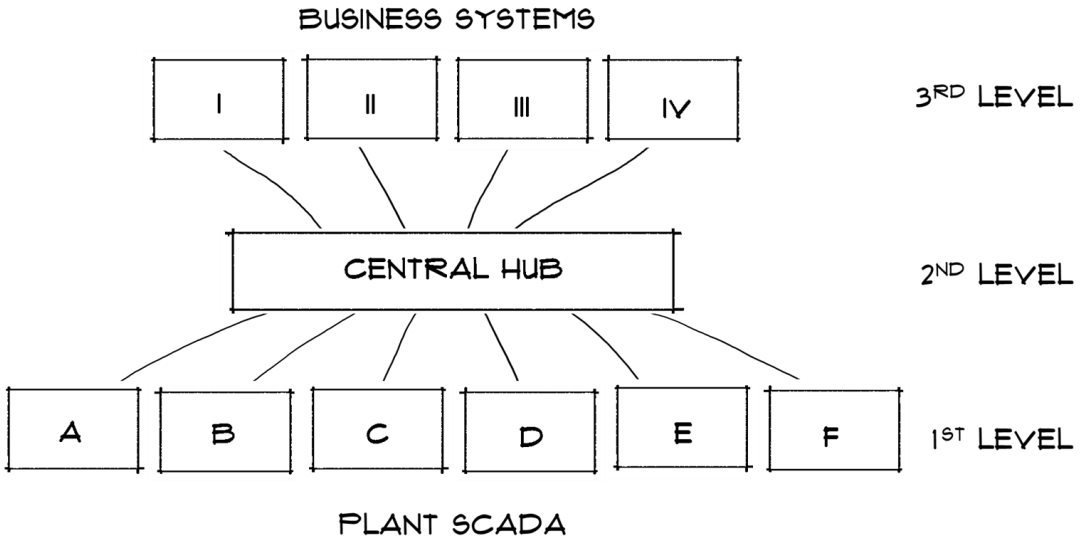


Simultaneously, the constrained labour market poses a significant impediment to the scaling of renewable energy power generation required to achieve vital net-zero targets. Greater investment in recruiting and employee retention programs will be insufficient to address the structural supply-demand imbalance.

DEMAND FOR UNIFIED CONTROL

Forward-thinking renewable energy companies are therefore directing their attention towards finding innovative solutions to overcome this labour challenge. Deploying a unified control architecture to connect plant OT systems helps overcome the reliance on highly specialised and difficult to source labour. An independent, portfolio-wide control plane can unify multiple plants seamlessly and facilitate process automation.

Efficiency is further gained by utilizing streamlined data collection methods that bypass bespoke control elements at each plant, as well as normalizing performance and state data locally at the plant level. Agility, flexibility, and independence from personnel with hard-to-find, vendor-specific skills are significantly enhanced by having an independent control plane. Ideally, this control plane is not tightly bound to monitoring or asset/performance management solutions. Instead, it is loosely coupled to such external business systems through RESTful APIs or streaming data connections.



UNIFIED CONTROL SOLUTION – BEST PRACTICES

- COORDINATE ALL COMMUNICATIONS FROM PLANT OT SYSTEMS TO BUSINESS SYSTEMS
- NORMALISE ALL PLANT OT DATA WITHOUT CHANGING PLANT SCADA SYSTEMS
- MANAGE CYBERSECURITY SYSTEMS (PKI, ACCESS, LOGS, SOFTWARE PATCHES, ETC.)
- DELIVER CONTROL SIGNALS TO PLANT IN A WIDE VARIETY OF INDUSTRIAL PROTOCOLS
- MOVE AND STORE ENORMOUS VOLUMES OF HIGH-FREQUENCY DATA EFFICIENTLY
- AUTOMATE ALERTING AND RESPONSE ACTIONS FROM PLANT OT DATA
- MAINTAIN SOFTWARE AND CONFIGURATIONS FOR HUB AND NODES
- MEET AND ADJUST TO CHANGING GRID, IT AND CYBERSECURITY REGULATIONS

LIMITATIONS OF SCADA FOR UNIFYING CONTROL

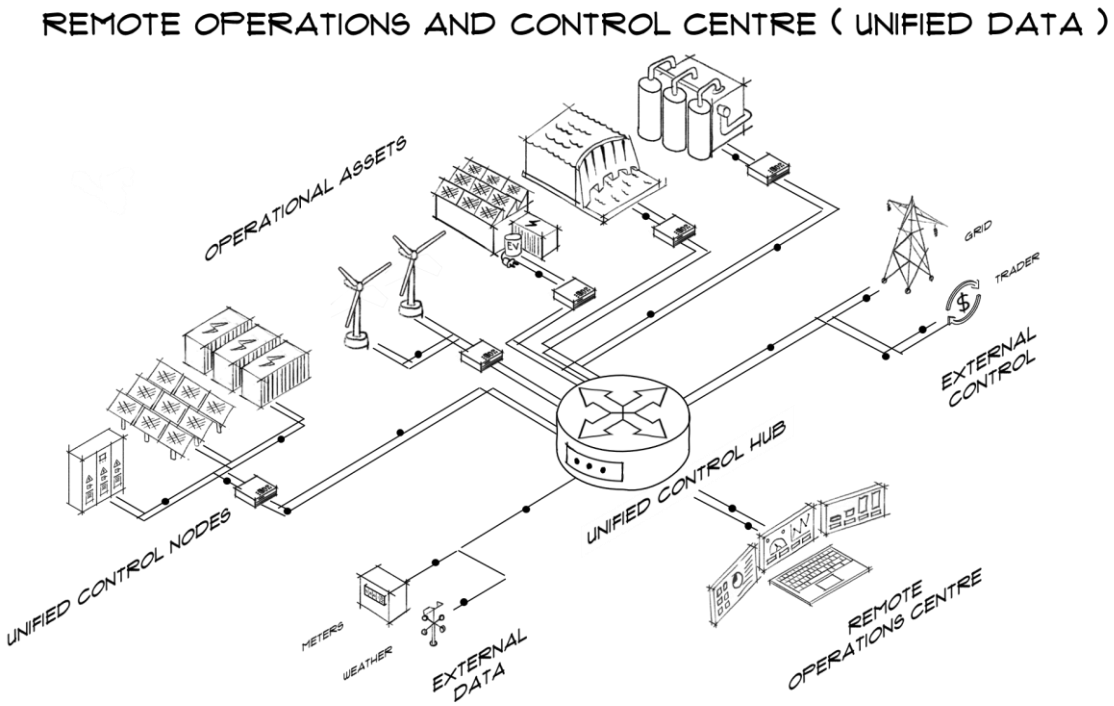
Under pressure to meet emerging requirements, plant SCADA system vendors are attempting to extend their solutions to multiple levels. However, there is tremendous inherent complexity to integrating disparate, closed and highly proprietary systems. Such strategies result in poor performing, highly inflexible architectures that do not deliver the best practice functions noted above and are costly to deploy and maintain. Another crucial consideration is the need for a central control hub function to be commercially independent from plant equipment manufacturers, plant SCADA providers and business systems. It's unrealistic to expect one proprietary SCADA provider to collaborate with another, competing SCADA provider to design and deliver a unified control solution. Without independence and trust, the central control hub can become very difficult to implement successfully.

It's a natural assumption that a central control hub would rely upon remote plant SCADA for collection of OT data. However, it has been proven that in most cases it is easier to collect data directly from equipment rather than from plant SCADA systems. Equipment such as inverters, trackers, turbines, weather sensors and the like, have predefined and documented data structures, making data collection & normalization repeatable and easily scalable across many plants. The same cannot be said of SCADA systems which generally have highly customised data collection interfaces.

The widespread use of ethernet based LANs at plants combined with proven cloud-native WAN technology, have made direct-from-source OT data collection the far more reliable option. Upgrades, patching, or downtime of SCADA systems affects the flow of all plant data to the central hub data system. SCADA systems are typically constrained in terms of the tags made available, as well as the frequency of collection, at the time the SCADA system is originally configured. Bypassing the SCADA therefore results in greatly enhanced reliability and flexibility.

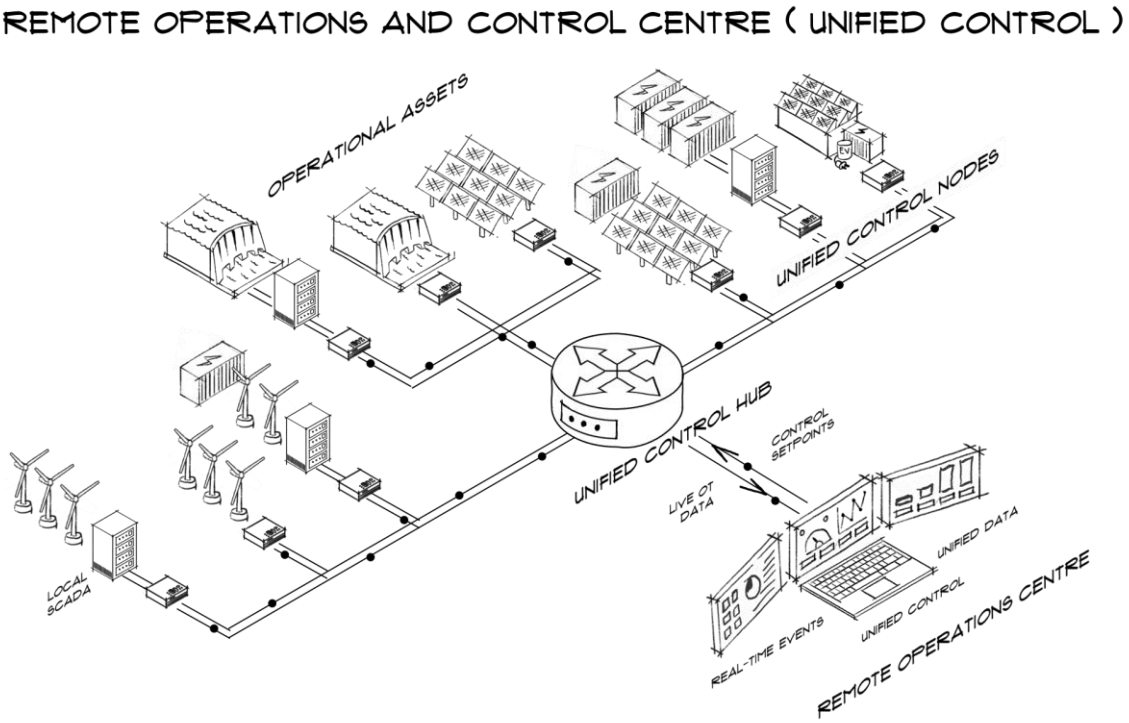
ARDEXA UNIFIED CONTROL SOLUTION

Large renewable energy companies are driven to establish a Unified Remote Operations & Control Centre by several compelling business factors. Firstly, it enables the harmonization of data from remote plants employing disparate SCADA and control systems. This consolidation fosters a cohesive and comprehensive overview of operations, facilitating data-driven decision-making, predictive maintenance, and optimization of resources.



Moreover, the Unified Remote Operations & Control Centre empowers personnel to seamlessly interface with a variety of plant control systems (SCADA, PPC, PLCs), eliminating the need for logging into multiple remote systems through VPN connections. This enhanced accessibility not only boosts operational agility but also strengthens cybersecurity by reducing potential vulnerabilities associated with numerous VPN connections.

Perhaps most importantly, the integration of unified data and control within the Unified Remote Operations & Control Centre paves the way for the automation of operations activities. This automation not only reduces the cost of energy production but also mitigates the costly impact of human errors. By minimizing human intervention in routine tasks and leveraging data-driven insights, large renewable energy companies can achieve greater efficiency, reliability, and cost-effectiveness in their operations. This, in turn, ultimately drives their long-term growth and profitability goals.



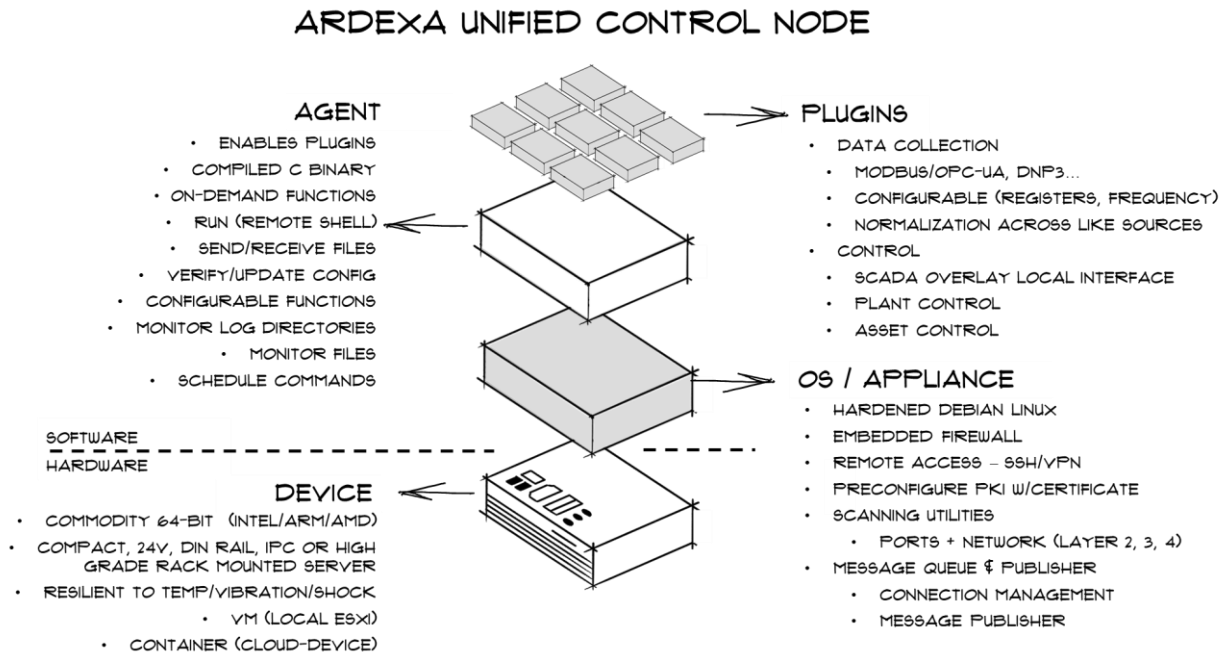
The leading enabling solution for unified plant and asset control is Ardexa's Digital Control Platform.

The Ardexa DCP is a seamlessly integrated system composed of edge-deployed Unified Control Nodes and a centralized Unified Control Hub, connected over a resilient, highly secure message broker. The asynchronous message broker is designed to guarantee that all source data collected and normalized at the edge is inserted into a unified OT data store in the Control Hub. Neither intermittent nor extended connectivity interruptions will result in gaps in OT data. The broker is also a foundational element of the DCP's secure-by-design architecture. All connections from the plant to the Unified Control Hub are outbound, and initiated from the remote facility, with access controlled by the DCP's public key infrastructure. All data and signals are encrypted and transmitted from each remote plant over a discrete message queue.

UNIFIED CONTROL NODES

The Ardexa Unified Control Node leverages an open, flexible, and robust software stack to unify data from diverse sources in real-time. Simultaneously, it streamlines remote plant and asset control, making it all possible through a range of industrial protocols.

Unified Control Nodes have access to a large library of prebuilt Ardexa Machine Plugins. Machine Plugins made available in the library can be selected and remotely deployed (and updated) from the Unified Control Hub. The experience is much like that of smart phones and their associated online app stores—find, download, install and run in minutes. There are two primary types of Plugins: Data Collection and Control.



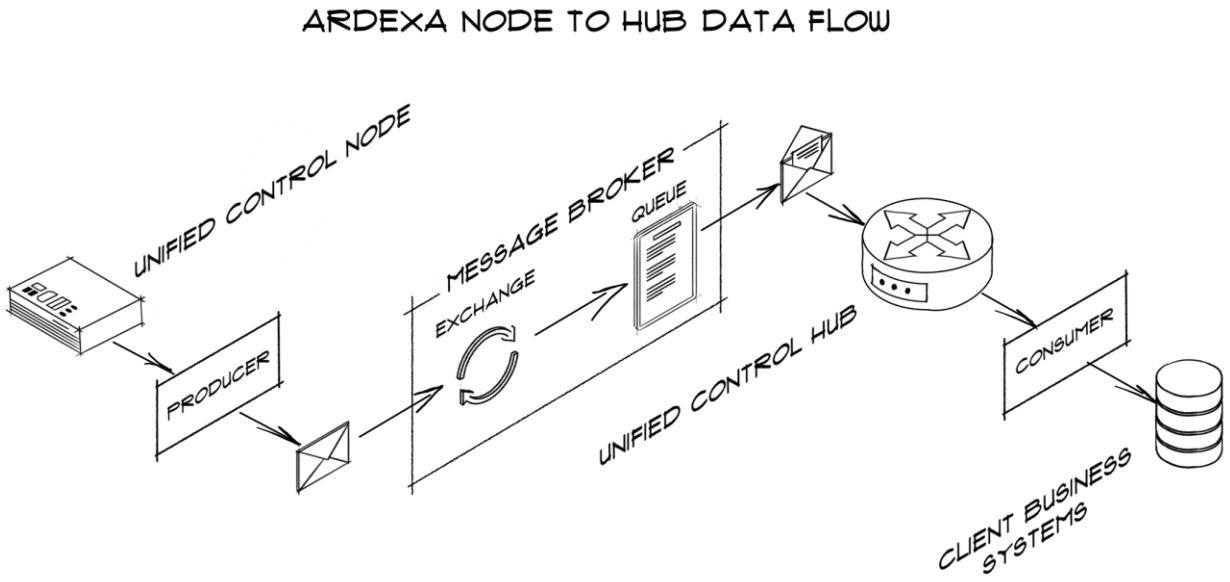
The Machine Plugin library contains hundreds of ready-made data collection Plugins. There are Plugins supporting numerous brands and models of inverters, turbines, weather stations, pyranometers, string combiner boxes, trackers, batteries, turbines, transformers, meters and more. For like data sources, such as all inverters, the Machine Plugin normalizes data across brands and models to a common-sense standard, including naming convention, format, and unit of measure. Every data collection Plugin is easily customizable by Ardexa users—providing control of which registers are collected, collection frequency, etc.

The flexibility, simplicity, and expansive capability of Ardexa Plugins is made possible by the software stack that makes up the underlying layers of the Unified Control Node stack.

The Agent is a compact, compiled binary that can efficiently execute a core set of functions that collectively enable the expansive set of capabilities found in both data collection and control Plugins. The fact that Plugins are simple to build, easy to deploy and easy to configure arises from the underlying capabilities of the Ardexa agent.

The Agent and its Plugins are hosted on a soft appliance that can be deployed on physical hardware or virtual machines at the local plant, or optionally on containers hosted within the Unified Control Hub, in the last case connected to the remote plant over an existing VPN.

The Unified Control Node soft appliance is made up of a hardened Debian Linux OS and a suite of networking and security applications, including: an embedded firewall, remote access (SSH/VPN) as well as the endpoint components of the Ardexa message broker which manages the connection to the Unified Control Hub. Typically, the Unified Control Node is configured for the customer by Ardexa and arrives at the plant with a digital certificate issued by the Public Key Infrastructure (PKI) built into the Ardexa Digital Control Platform.

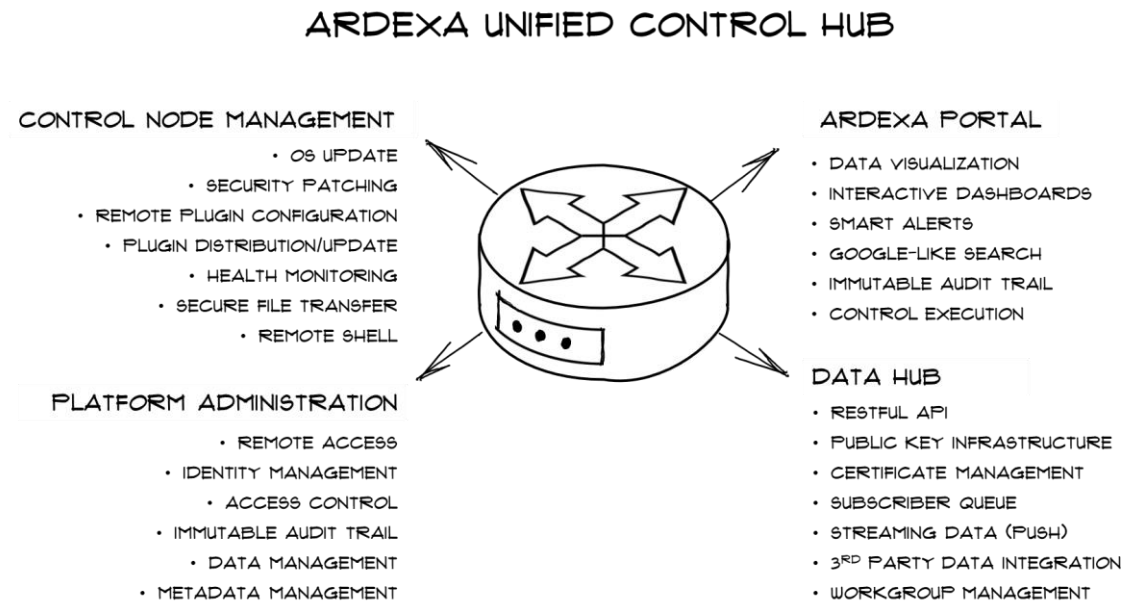


UNIFIED CONTROL HUB

Customizable Control Plugins are available in the Ardexa Plugin library which are designed to interface with 3rd party PPCs and PLCs at local plants. These are available in a broad range of industrial protocols, including Modbus, IEC 104, OPC UA, DNP3, PLC protocols, etc. Ardexa Control Plugins receive commands and schedules over an encrypted connection from the Unified Control Hub and translate them to the relevant command or setpoint which is delivered to the local plant control interface. Typical commands include start, stop, reset and setpoint change.

Managing active power and power factor setpoints via automated day-ahead schedules across many plants with heterogeneous PPCs is an illustrative example of Ardexa's SCADA Overlay solution. From the Unified Control Hub user interface, operators manage schedules for their entire portfolio simply and easily. Users can create schedules and apply them to the Unified Control Node at selected plants (or groupings of regional plants). If the Unified Control Node is offline, the schedule will automatically be transferred as soon as the Unified Control Node reconnects to the hub. The Control Plugin then processes the file and sends the setpoint change directly to the local PPC and an "applied" confirmation is sent back and is represented visually in the Unified Remote Operations & Control Centre.

Operators can leverage analyses, alerting, visualisation, and other tools in the Unified Control Hub to monitor the impact of control signals or detect exceptions automatically. The Unified Control Hub provides ROCC Operators with a single interface for executing curtailment and other plant and asset control functions as well as monitoring plant performance without making changes to local plant SCADA or PPCs.



The Control Hub provides an interface for centrally managing all Unified Control Nodes. Setting up configurations, updating software, monitoring cybersecurity logs, controlling access and many other functions are handled centrally with a very granular and strict rules. The operational efficiencies resulting from the streamlining and centralisation these functions are significant.

A PROVEN SOLUTION FOR TOMORROW

Rapidly scaling renewable energy production is vital to meeting the world's net-zero goals and mitigating the potentially devastating effects of climate change. The renewable energy industry's ability to meet that challenge, is thwarted in a material way by the finite pool of technically resources necessary to operate renewable energy portfolios. Unifying and streamlining remote operations and control while automating manual processes will be essential to overcoming these daunting challenges.

But inherent limitations of legacy SCADA technology complicate the owner-operator's ability to optimize their plants and portfolios. In fact, unifying control using traditional SCADA solutions creates additional demands on the very same limited resource pool, thereby increasing cost and delaying the implementation of a Unified Remote Operations and Control Centre.

Ardexa's Unified Control Solution, leveraging an open, highly extensible hub & node architecture, offers owner-operators a proven and cost-effective path to unifying control across widely distributed, heterogenous renewable energy portfolios.

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