Meeting Power Grid Challenges with New Computing Technologies

ARC White Paper
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A key for utilities to meet increasingly complex needs while maintaining uncompromisingly strong security and operational stability is to focus on proven data management and to optimize integration capabilities. These approaches are detailed in this white paper. They represent the best way for utilities to meet new requirements reliably and flexibly, and to transform data into a strategic asset by unlocking its true value. Industry leaders in utilities can now leverage capabilities which have enabled decades of secure solution delivery in banking, telco, and other industries.

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Executive Overview

The rapid advancement of computing technology is having a profound impact on electric grid operations, one where the right approach to IT technologies and frameworks will empower IT and OT teams to work better together. Red Hat has a foundational commitment to open design principles, one which has driven the success of its broad and deep product and service portfolio of application orchestration, edge computing, and open-source solutions.

Linux-based operating systems are arguably the most popular choice for servers in the utility industry. They are known for their stability, security, and flexibility, making them well-suited for mission-critical applications. The open-source nature of Linux allows for customization and adaptation to specific utility needs, and it fosters a strong community of developers and users who contribute to its development and support.

While the mission-critical domains of Red Hat's work has, by its very nature, led to less trade press coverage or fanfare than one would find for a typical major software supplier's closed source proprietary software solution, Red Hat has, for the last two decades, played a key role in the enhanced evolution of a vibrant product ecosystem of developers, partners, and end users in the electric utility industry. Red Hat has long been recognized as a leader in finance, telco, and other industries, and the company is well positioned to become a global leader in the utility industry's computing evolution.

This white paper delves into how Red Hat's enterprise-grade open-source solutions are ideally positioned to help transform the electric grid landscape, with a focus on highly secure capabilities in support of operational excellence, as well as value-driven key collaborations, technological advancements, and strategic partnerships.

In comparison to more standardized enterprise IT solutions, there are unique challenges associated with the highly specialized OT systems used by electric utilities, especially in the face of the much more complex operational demands now being placed upon them. The utility industry's use of Linux-based operating systems is ubiquitous. Such systems are arguably the most popular choice for servers. They are enabling grid operators to address tidal waves of data and meet ever-more complex computational demands. To meet these challenges, a key role is increasingly being played by platforms such as Red Hat Enterprise Linux (RHEL) which enable rapid, robust

application development and AI integration, while also ensuring grid infrastructure meets stringent security requirements.

Red Hat's Real-Time Operating Systems (RTOS) capabilities within Red Hat Enterprise Linux enable complex tasks to be completed within specific time constraints where timing is critical. CPU time and other resources are allocated so that real-time tasks are given their needed higher priority over regular tasks which can be critical to grid protection and substation operations.

Fundamentally, open solutions enable IT and OT teams to work better together and focus on what each does best, by ensuring ongoing realization of the long-standing benefits of avoiding custom "one-off" solutions. Red Hat has always maintained its foundational commitment to open-source design principles. These principles drive benefits that are being magnified for IT and OT domains, by ongoing massive increases in computing power.

Inherently, Red Hat's enterprise-grade open-source platforms reflect design practices and a cultural foundation where operational robustness and security are built in. In contrast to publicly available open-source software, the enterprise-grade open-source solutions covered in this white paper provide unsurpassed reliability in support of mission-critical workflows. In the utility industry, Red Hat's design philosophy leads to better end user adoption of the solution's capabilities, amplifying the advantages of an enterprise-grade approach that includes Red Hat's demonstrable reliability, security, and support features.

Data Tsunami: Utilities Ride the Wave of Transformation

Electric utilities are on a digital transformation path which has been put into high gear with the accelerating collection of data and new data analytics and operational software tools associated with increasing use of AI technologies.

Utilities are using new computing capabilities to increase reliability, reduce outage times, and plan for new sources of intermittent renewable generation and changing load profiles. In this context, RHEL's reliability, security, and long-term support make it a valuable operating system for substation environments.

- RHEL hosting capabilities for SCADA systems are well proven for industrial processes and have applications for monitoring and control of substation equipment.

- Some protection and control relays run embedded Linux operating systems, and RHEL provides a compatible environment.
- For many years, RHEL has been used to collect and store data from substation devices.
- RHEL also runs communication gateways that connect substations to control centers.

Using RHEL can help standardize the operating system environment across substations, simplifying management and maintenance. RHEL supports virtualization and containerization technologies, which can be used to consolidate workloads and improve resource utilization in substations.

The electric grid is evolving with new distributed energy resources, data centers, electric vehicles, heat pumps, microgrids, controllable loads, and new market signals. This new data will increasingly be used by utilities to manipulate both generation and loads to ensure the grid is stable and producing power at the lowest cost.

Utilities are using the technologies described in this white paper to integrate new and existing IT and OT applications, develop cloud-native applications, and automate, secure, and manage increasingly complex environments. Open-source software, edge solutions, and the other developments described below illustrate these key trends.

The largest new source of grid power comes from wind, solar and batteries. These intermittent sources are often behind the meter (not measured by utilities) and are highly weather-dependent.

Accurate prediction of generation and load forecasts requires integration of micro-climate data into predictive models which are built by constantly improving AI software.

Contextualizing ever more ubiquitous data from a new generation of substations, and customer loads, is another key driver in this evolution of data analytics software.

To ensure the electric grid is more reliable and resilient in the face of these complexities, utilities continue to improve their utilization of more advanced

network and asset models, digital twins, and data from diverse sources, with more sophisticated software solutions, platforms, and data flows.

The Digital Economy is valued at more than $2.6 trillion in the U.S., making up more than 10% of U.S. GDP and has been growing at more than 2.5 times the rate of GDP growth.
(Source: U.S. Bureau of Economic Analysis)

It has become increasingly important for utilities to be flexible with their computing platforms. As a result, it comes as no surprise that the optimal stewardship of critical grid infrastructure is evolving in many beneficial ways, e.g., via increased use of digital twins, advanced analytics, real time data, and more rapid agile development capabilities for software solutions, and related platforms that are all percolating up to the forefront of the value being delivered.

From the perspective of grid operations, Red Hat's product portfolio for compute infrastructure Enterprise Linux (RHEL) solution set provides an open, enterprise-ready platform with the requisite flexibility to adapt to the evolving array of software and mission-critical capabilities, from the edge to the enterprise, as we will now see in detail.

Red Hat's Interaction with Leading Grid Technology Platforms

Red Hat collaborates with major players in the electric grid sector to enhance interoperability and innovation. These collaborations enable seamless integration of various grid components, facilitating real-time data processing and operational efficiency.

ABB's Edgenius platform, which is built on Red Hat OpenShift and Red Hat Device Edge, provides a comprehensive edge platform for industrial software applications. This allows for greater flexibility and scalability in deploying ABB's solutions closer to the source of data in grid and industrial settings.

Hitachi Vantara's Lumada platform benefits from Red Hat's expertise in data management and analytics. Red Hat's OpenShift Data Foundation and AMQ solutions enable Lumada to handle vast amounts of grid data efficiently, providing actionable insights for grid optimization.

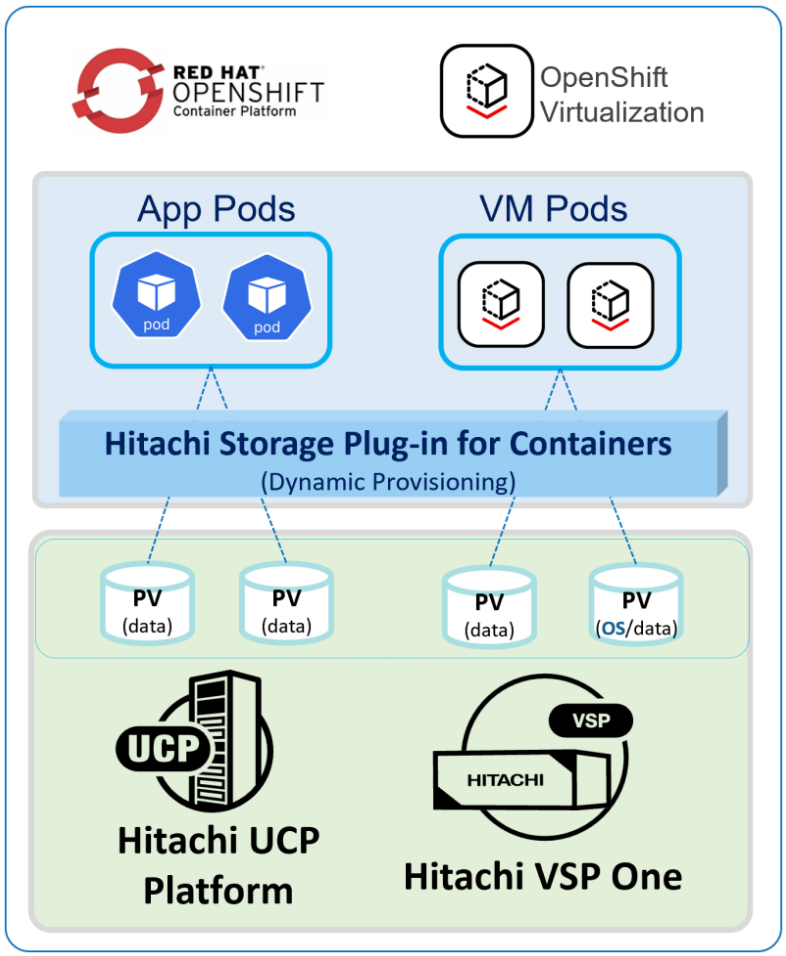
Red Hat OpenShift Container Platform (OCP) with the OpenShift Virtualization feature enabled, has been deployed on the Hitachi Unified Compute Platform as shown below.

Red Hat offers comprehensive open, enterprise ready platforms for grid automation through various technologies that support communications, messaging, and security.

RHEL is a stable, secure, and high-performance operating system that can serve as the foundation for mission-critical solutions. OpenShift is an application development platform that allows acceleration of development and streamlined deployment, which in turn allows for flexibility developing utility applications.

Foundation for Grid Automation and Operations

Hitachi and Red Hat Platform



Most grid asset management software applications are not real-time and, therefore, can operate on cloud servers. Related applications include Asset Performance Management (APM), Plant Asset Management (PAM), Enterprise Asset Management (EAM), Field Service Management (FSM), Asset Integrity Management (AIM), Training, and long-term forecasting.

Grid control centers use a wide range of OT software applications that operate on a variety of platforms. This software includes applications to support EMS, ADMS, GIS, DERMS, OMS, SCADA, WAMS, and the utility power markets.

In addition, there is a big advantage for control centers to move to a common platform where workloads can have shared compute.

Red Hat supports the Linux virtualization of grid controls. For example, phasor measurement units (PMUs) which require high speed real time operating systems, can be deployed on embedded Linux distributions. To mitigate hardware and software dependencies, these could also be run in real-time virtual machines (RT VMs) with a future option to migrate to Red Hat Enterprise Linux (RHEL) for its broader benefits.

Kernel-based Virtual Machines (KVM) additionally collect high speed data about voltage and phase and in combination with KVM provides functionality as a hypervisor for virtual workloads.

Security and Compliance

Security and compliance are paramount in grid operations. Red Hat provides comprehensive "baked in" security solutions to ensure the integrity and reliability of grid systems that collect data from a wide range of devices, with various communications protocols.

Cluster Security for Kubernetes

Red Hat offers advanced security features for Kubernetes clusters, ensuring that grid applications are protected from threats. This includes vulnerability management, access controls, and runtime protection.

Linux Security

Red Hat's enterprise Linux solutions provide robust security features, including system hardening, secure boot, and compliance auditing. This ensures that grid systems meet stringent security and regulatory requirements.

Data Management and Analytics

Effective data management and analytics are essential for optimizing grid operations. Red Hat provides powerful solutions for managing and analyzing grid data, including:

OpenShift Data Foundation

Red Hat's OpenShift Data Foundation offers a scalable and secure platform for managing grid data. It provides data storage, backup, and recovery capabilities, ensuring data availability and integrity.

Table of Utility OT Applications

OT Grid System	Red Hat Capabilities
EMS (Energy Management)	Red Hat's solutions enhance EMS by providing real-time data processing capabilities and improving system reliability. OpenShift and Ansible Automation Platform enable seamless integration and automation of EMS components.
ADMS (Advanced Distribution Management Systems)	Red Hat's enterprise-grade open-source solutions support ADMS modernization by offering an edge computing management platform and framework with robust security features and capabilities for delivering software across scalable IT infrastructures. This ensures efficient distribution grid management and enhances grid resilience.
GIS (Geospatial Information Systems	RHEL is certified to work with leading GIS software platforms like Esri ArcGIS, providing compatibility and support for essential geospatial tools. The Ansible Automation Platform automates various GIS tasks, such as provisioning infrastructure, deploying applications, and managing configurations.
Dynamic market pricing (e.g., LMP or Local Marginal Price of power)	Red Hat AMQ is a high-performance messaging platform that handles the massive amounts of real-time data generated in electricity markets. This includes LMP data, grid conditions, and DER availability. AMQ provides efficient streaming of this data to applications that perform price forecasting, optimization, and automated trading
WAMS (Wide Area Management Systems)	OpenShift Container Platform (OCP) provides a foundation for Network Function Virtualization (NFV), allowing network functions to be virtualized and deployed on standard servers instead of proprietary hardware. This brings flexibility, scalability, and cost-efficiency to WAM systems.
DERMS (Distributed Energy Resource Management)	OpenShift is a container platform that allows utilities and DER aggregators to deploy and manage DERMS applications in a cloud-native environment. This provides flexibility, scalability, and portability for DERMS solutions, enabling them to adapt to changing grid conditions and DER deployments. . In addition, DERMS provide an example of an OT application where Red Hat can enable an abstraction layer whereby deployment and management can be done consistently while allowing portability from substations to data centers and even to the public cloud. I.e., the OT applications can be run wherever they best fit into the end user's operating model, adapting to changing grid conditions and DER deployment priorities.
OMS (Outage Management Systems)	Ansible has automation capabilities ideally suited for better outage reporting, crew dispatch, and communications via reduction in manual effort, and improvement in the speed and accuracy of outage response. Red Hat AMQ is a messaging platform that handles the high volume of real-time data generated during outages, such as sensor data from the grid and customer calls.
SCADA (Supervisory Control and Data Acquisition)	Red Hat's OpenShift Container Platform (OCP) can be used as a base for SCADA systems which enables utilities to securely connect and manage diverse SCADA systems for improved analytics and compliance of these critical remote monitoring, control, and data gathering capabilities across critical grid infrastructure.

AMQ

Red Hat AMQ enables high-performance messaging and data integration, facilitating real-time data processing and analysis. This enhances the ability to derive actionable insights from grid data, improving operational efficiency.

Partnerships and Collaboration

Red Hat's ongoing expansion into the electric grid sector being accelerated by way of strategic partnerships and collaborations with leading industry players:

- Red Hat works with Dell, Advantech, Welotec, and others to provide secure and scalable computing solutions with certified Red Hat software operating on their devices. This collaboration enhances reliability and efficiency for substations and grid control centers.
- The vPAC Alliance, which includes Red Hat, focuses on developing and promoting open standards for grid automation and modernization. This partnership drives innovation and ensures interoperability across grid systems.
- Red Hat's collaboration with LF Energy SEAPATH aims to enhance computational availability. This open source collaborative project ensures that grid systems are both reliable and secure.

Recommendations

Based on ARC research and analysis, we recommend the following actions for owner-operators:

- Computing equipment in substations and grid control centers should be taken care of with the same rigor as computing infrastructure in data centers today. Since reliability and security are paramount in both cases, great care should be taken to select the software architecture.
- Standardize all computing infrastructure across environments by choosing enterprise-ready solutions, certified partners and flexible solutions that can adapt to the future computing needs of utilities.
- Align with industry standards and activities such as those from vPAC and SEAPATH.
- Connect with Red Hat to learn more. (Link)

Conclusion

Red Hat's enterprise-grade open-source solutions can provide great value to the evolution of computing technology for electric grids. Through strategic partnerships and technological innovations, Red Hat is driving grid automation, modernization, and efficiency. This white paper has highlighted the key areas where Red Hat supports the transformation of electric grid operations.

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Acronym Reference:

ALM	Asset Lifecycle Management
ADMS	Advanced Distribution Management System
AI	Artificial Intelligence
AIM	Asset Integrity Management
AMI	Advanced Metering Infrastructure
AMQ	Advanced Message Queuing
APM	Asset Performance Management
DCS	Distributed Control System
DERMS	Distributed Energy Resource Management System
EAM	Enterprise Asset Management
EMS	Energy Management System
FSM	Field Service Management
GIS	Geographic Information System
GridOS	Grid Operating System
IED	Intelligent Electronic Device
IoT	Internet of Things
NFV	Network Functions Virtualization
OMS	Outage Management System
PAM	Plant Asset Management
PLC	Programmable Logic Controller / Power Line Communication
RHEL	Red Hat Enterprise Linux
SCADA	Supervisory Control and Data Acquisition
vPAC	virtual Protection and Control
WAMS	Wide Area Monitoring System

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