DIGITAL

Schneider Electric's Guide to Value-Driven Grid Data Management

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Executive Summary

Electric Distribution Utilities Face a Serious Data Management Challenge

The rapid proliferation of distributed energy resources (DER) poses many operational, planning, and business challenges for electric distribution utilities. The scale of this shift is even more significant than the transition to advanced metering infrastructure. Over the next five years, data generation will more than quadruple. Compared to other enterprises, distribution utilities face a unique data management challenge because of the large number and broad dispersal of its assets and customers.

A Value-Driven Approach to Grid Data Uncovers Many Business Values

To rise to this data management challenge, electric distribution utilities must not waste resources searching for a needle of "truth" in a data haystack. As distribution utilities become data operators in addition to grid operators, they need a foundational, stepwise, and practical approach to grid data management. Only then can their data management practices realize significant business value, including enhanced safety, cost efficiency, reliability, resilience, flexibility, sustainability, asset utilization, customer empowerment, cybersecurity, and affordability.

This Reference Guide Explains How

Logically organized according to distribution utility functions, the in-depth content within this guide systematically examines how "value-driven" grid data management practices enhance distribution utility planning, design, analysis, construction, operations, maintenance, training, and demand-side management.

You Can Explore the Use Cases Most Relevant to Your Business

What does this reference guide cover? Here is a sample of the nine grid data management use cases described within:

- **Distribution planning and simulation.** Planning and simulation tools can now encompass DER and electric vehicle data, analyze connection requests, and incorporate data from many sources (e.g., real-time control systems, smart meters, behind-the-meter, and distributed sensors) in associated network models and dynamic models across multiple time horizons.

- **Asset performance management.** Asset management tools and methods now use geospatial and operational data from more sources to help distribution utilities balance risks vs. costs, CapEx vs. OpEx, and short-term vs. mid-term asset repair/replace decisions.

- **DER management.** DER can accelerate decarbonization, enhance reliability and resilience, empower utility customers, support grid flexibility, expand utility services, and defer system upgrades. Yet its variable nature and unpredictability complicate utility planning, operations, asset management, and other functions. Learn about leading practices for distribution-transmission coordination, demand-side management, and microgrids, and see examples of optimal DER management.

- **Cybersecurity.** Cybersecurity and data privacy practices and compliance should pervade grid data management across the entire landscape – from the field to enterprise level, and from the grid to the grid edge.

Executive Summary

You Can Gain Insights into Better Grid Data Management

What will you learn? Here is short selection of key insights found within this reference guide:

- **Standards: The Hidden Heroes.** Compliance to standards is a crucial element of efficient grid data management. They leverage collaborative intelligence to enable interoperability, reduce resource needs, and facilitate integration of applications, as described in the use cases within.

- **The Digital Twin: A Cross-Cutting Tool.** Today's digital twins continue expanding beyond core applications. Soon, digital twins will provide value across all domains and zones, enabling better informed and faster decision making.

- **Advanced Analytics: The Next Step.** With grid data management as a foundation, emerging advanced analytics provide greater depth of analysis and bridge traditionally separate analyses into integrated use cases. Higher-fidelity data availability, siloed data consolidation into integrated databases, and artificial intelligence (AI)-based applications facilitate this evolution.

- **A Data-Backed Strategy: Data Governance.** While data assume a central role in business decision making, focus on embedding data management into business projects, instead of executing "data projects." Execution of utility business strategy should be backed by trusted, available, and sustainable data that are validated across data production chains.

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Introduction

The Opportunity

Grid data management practices and solutions are one way that electric distribution utilities can realize significant value, including enhancing safety, cost efficiency, reliability, resilience, flexibility, sustainability, asset utilization, customer empowerment, cybersecurity, and affordability.

For this reason, these practices can be called “value-driven” grid data management practices. Of equal importance, these practices can produce value across many distribution utility functions, including operations, maintenance, planning, design, analysis, construction, training, and customer engagement.

For distribution utilities, these data management practices, which include digital twins and advanced analytics, are part of the broader digital transformation process. However, holistically gathering, processing, validating, managing, governing, and effectively using data is challenging. For an average-sized utility, for example, the annual data volume generated is in the petabytes (million gigabytes) range, and is forecasted to double over the 2021-2024 period.[1] Due to the increasing power system complexity of most distribution utilities and other challenges, change is difficult, even when the benefits of digital transformation are clear.

Successful digital transformation and grid data management represent the dividing line between distribution utilities that generate value, and utilities that fail to realize this value for their organization, their customers, and society. Hence, a “digital division” has arisen between forward-looking distribution utilities that seek business and operational resilience for a strong future, versus cautious utilities that may incur significant risks through inaction.

Purposes of this Guide

The purposes of this guide are:

- To explain how electric distribution utilities can overcome a broad range of challenges with a strong foundation of value-based grid data management across their organizations
- To demonstrate via specific use cases how leading practices enable distribution utilities to apply a foundational, stepwise, and practical approach to grid data management
- To provide a comprehensive reference source for Schneider Electric customers and prospects seeking to gradually enhance grid data management practices in agile, consistent, scalable, secure, and cost-effective ways

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[1] IDC Research, “Address the Data Dilemma in Utilities,” IDC Analyst Brief, December 2020.

Scope of this Guide

This guide covers the broad array of data management challenges that distribution utilities face.

Although many examples of challenges, solutions, standards, and regulation in this guide are specific to North America, Europe, and Australia, the scope of this guide is global. Note that the guide focuses on the distribution grid, as well as loads, resources, standards, and regulation at the grid edge.

This document covers nine use cases, which Schneider Electric selected based on their relevance to data management, rapid evolution, and Schneider Electric expertise. The use cases are listed later in this section; this list is not intended to be comprehensive.

Utilities Face Multifaceted Data Disruption

Data are the lifeblood of the new digitalized distribution utility, the building block of grid data management, and the ultimate enabler of value.

These data come in many shapes and sizes, and originate from:

- Smart meters and various sensors
- Distributed energy resources, including renewables and electric vehicles (EVs), at the grid edge
- Network automation, including internet-of-things (IoT) devices, such as smart circuit breakers and smart transformers
- Substation automation and construction
- Asset condition monitoring
- Distribution grid analytics
- Vegetation management
- Customer engagement
- Energy forecasting and markets
- Geospatial information systems
- Archived time-series and other data
- Utility field personnel and engineers
- Many other sources

These sources are multiplying the amount of data that distribution utilities gather. At the same time, a growing ecosystem of stakeholders seeks to use these data, requiring efficient data exchange mechanisms. The data sharing ecosystem today includes distribution utilities, transmission system operators (TSOs) energy retailers, ISOs/RTOs, aggregators, regulatory agencies, and customers, and is expanding to include more players, such as energy markets or even data markets.

Overall Data Management Challenges

According to the former CEO of a large European distribution system operator, distribution utilities are rapidly becoming data operators in addition to asset managers and grid operators.

Compared with other businesses, the challenge of data management may be uniquely complex for distribution utilities because of the immense number and geographic dispersal of its assets and customers. However, the following generic data management issues cut across most industries and businesses:

- Management and storage of extremely large amounts of data
- Proliferation of electronic devices that can be uniquely identified
- Expanded use of the IP-based communications
- Availability of sufficient bandwidth to maintain connectivity
- Prioritization of data
- Minimization of data and connectivity losses
- Adaptation of existing infrastructure and business systems to handle the influx of data
- Assured cybersecurity and data privacy

The many functions within an electric distribution utility impose various data requirements, and therefore impose different grid data management challenges, across the data lifecycle (see the text box for definitions of various types of lifecycles).

"Lifecycles"

Data, assets, and models have lifecycles. In the context of the electric power industry and this guide:

- The **asset lifecycle** typically includes asset design, engineering, construction, implementation, operation, maintenance, upgrading, decommissioning, and disposal.
- The **data lifecycle** typically includes data generation, acquisition, storage/backup, and analytics and visualization.
- The **system model lifecycle** typically includes model specification, development, population with data, validation against the real-world, and ongoing refinement and enhancement.

In this context, the primary focus of this guide is **grid data lifecycle management**, as well as management of the models that use these data across the model's lifecycle. A secondary focus is use of data for asset management across the asset lifecycle. This guide discusses each of these in appropriate use cases.

Overall, utilities face the challenges of maintaining or improving the following:

- Data quality (accuracy, level of detail, and granularity)
- Data completeness and integrity
- Data latency (the need for up-to-date data)
- Data context (how data inter-relate)
- Data integration time
- Data accessibility
- Data relevance and usefulness to drive actions
- Data standardization (formats, protocols, etc.)
- Data scalability

Moreover, grid data needs vary across different time horizons. Real-time operations personnel have different data needs than operational planners or long-term planners.

One French grid operator estimates they spend 90% of their time understanding the meaning of the data, and 10% of the time actually using the data. This is not surprising, given the exponential increase in data flowing into utility databases. For example, consider the data explosion a single feature of the smart grid creates – the transition from traditional metering to the smart meter:

- With traditional metering, distribution utilities manually read and recorded one data point – kilowatt-hours (kwh) consumed – per month, for an annual total of 12 data points per customer.
- By comparison, a smart meter set for half-hour readings sends a utility 17,520 per year for a single customer.
- If the smart meter sends readings every 5 minutes, the annual total becomes 105,120 readings per customer.
- If smart meters also send the utility voltage, power factor, and other readings, a large utility may gather trillions of data points per year from smart meters.

Faced with a need for more and higher-fidelity data (i.e., more detailed, accurate data), as well as a blizzard of nearly unmanageable data, utilities are turning to various types of models to organize and interpret data. The text box defines the various types of models discussed in this guide.

“Models”

Models mean different things to different industries and people, and using a descriptive adjective with “model” is recommended. In the context of the electric power industry and this guide:

- A **physical model** is a three-dimensional representation of a real-world or proposed object, typically at a reduced scale, to help visualize complex structures.
- A **mathematical model**, which is a description of a system using mathematical concepts and language, can be used to analyze or forecast system behavior.
- A **software model** is a description of a physical model or mathematical model (or both) within a computer system.
- A **data model** is a description of the objects and their relationships within a software model. A data model provides the foundation for a description of the objects’ behavior in order to simulate or predict system operation.
- A (power system) **asset network model** is a static description of the current power system, including the topology of power system assets and how they are connected through feeders and lines, etc.
- A **dynamic model** (aka an operational network model) is a real-time description of the current power system using field data, such as currents, voltages, switchgear positions, etc.
- The **Common Information Model (CIM)** is an internationally-recognized protocol for specifying the characteristics of power system assets using a standard lexicon.
- A **digital twin** is a general term for any software/model that emulates the as-built or as-operated state of a real-world system.
- An **energy model** is more generalized and includes a broader array of relationships that affect the power system, (e.g., represents end users’ energy consumption or production).

This guide discusses each of these model types and their relevance to grid data management in appropriate use cases.

The Use Cases

The following set of use cases demonstrates the broad practicality and benefits of value-based grid data management.

The use cases reference applications within electric distribution utilities where grid data management can provide the greatest value. Some of these use cases consolidate utility functions due to their inter-related nature. For example, the DER Management use case consolidates functions related to the challenges, practices, and value associated with distribution and transmission coordination, distributed energy resource (DER) adoption, demand-side management, commercial/industrial buildings, and microgrids.

Each of these use cases is developed following the same logic:

- **Subject area overview**
- **Today's data management challenges,** objectives, and/or imperatives
- **Today's recommended practices** for value-driven grid data management
- **Value-producing business outcomes,** based primarily on Schneider Electric's "value pillars"
- **Schneider Electric solutions** to meet today's challenges

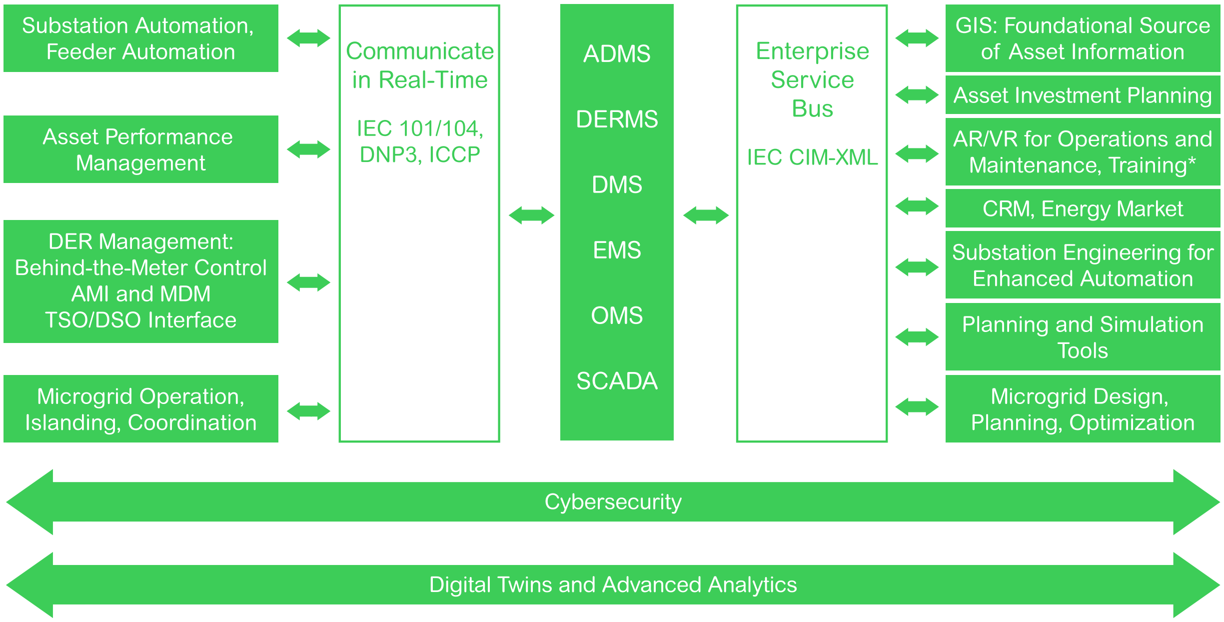
This guide covers the following nine use cases:

- Asset information management, network model management, and field work
- Distribution analysis and operations
- Planning and simulation
- Asset performance management and asset investment planning
- Substation automation, systems engineering and maintenance
- Augmented reality for system operations, maintenance, and personnel training
- DER management, including DSO-TSO coordination, a DER case study, demand-side management, and microgrids
- Smart metering
- Cybersecurity

Figure 1 shows how these use cases inter-relate in the broad definition of today's grid. Building on these nine use cases and extending grid data management to the near-term future, the digital twin merits special attention, because:

- Digital twins cut across and provide potential value across all nine of the use cases.
- Digital twins enable better informed, faster decision making using powerful simulators and analytics in a virtualized, software-defined environment.
- Digital twins provide a way to organize thinking on near-term enhancements to grid data management.
- Digital twins serve as a bridge to powerful families of advanced analytics that promise significant business benefits.

Hence, the end of this guide presents a section dedicated to digital twins and advanced analytics.



*Real-time applications are also developing in this area

Figure 1. How it all fits together: Value-Driven Grid Data Management

Value Pillars

A digitalized grid will support the goals of major industry value pillars, which can be summarized concisely as follows (see Figure 2):

- **Sustainability** minimizes environmental footprint
- **Resilience and reliability** mitigate power disruptions
- **Efficiency** ensures affordable energy
- **Flexibility** maximizes grid adaptability

This guide describes how the various use cases support these value pillars.

	Sustainability	Resilience and Reliability	Efficiency	Flexibility
Grids of the future pillars	Minimize environmental footprint	Build grid resilience	Ensure affordable energy	Enable smart investment and decarbonization
Enablers/ examples	• Remove greenhouse gases (SF_6 free) • Deploy sustainable products and circular economy practices • Reduce energy losses	• Ensure reliability • Withstand stressful forces of climate change • Mitigate cyber risks	• Increase operational efficiency • Optimize asset management • Improve grid edge planning and operations	• Optimize network planning • Enable DER integration
	Interoperable grid digital twins			

Figure 2. Schneider Electric grids of the future pillars and enablers/examples

Sustainability and Data Management

Of the four value pillars, sustainability is a ubiquitous goal and offers “cross-cutting” value: Any technology deployed to enhance resilience, efficiency, or flexibility must also consider sustainability.

- Sustainability impacts from enhanced **maintenance** via improved grid data management include:
    - Extending the lifetime of assets, which avoids manufacturing new devices
    - Reducing maintenance interventions, thus avoiding crew dispatches and emissions from truck rolls
    - Improving crisis management (resiliency), for example, via more efficient use of field technicians
- Sustainability impacts of **operating** the grid with advanced data management tools include:
    - Increasing energy efficiency
    - Reducing non-technical losses
    - Improving sector coupling (i.e., bridging traditionally separate analyses)
    - Optimizing use of grid-edge resources
- Sustainability impacts of improved grid **O&M coordination** via enhanced data management include:
    - Improved risk analysis, based in part on more precise information about asset health, affects traditional tradeoffs between O&M, enabling more comprehensive inclusion of green criteria to support sustainability
- Facilitating a more **flexible grid** via data management enhances sustainability by:
    - Easing the integration of renewable generation and EVs
    - Optimizing the ability of EVs to absorb more energy from renewables when they are available and to support grid services when needed (the V2G or vehicle-to-grid concept)
    - Obtaining a clear model of a distribution utility’s hosting capacity, as well as visibility into grid-edge activities
    - Optimizing addition of new DER and data-driven grid automation by considering lifecycle cost and sustainability

Organization of this Guide

This guide offers distribution utilities an overview of the current status and leading practices for grid data management.

The overall organization of the main body of this report is as follows:

- Standards and the Digital Transformation of Distribution Utilities
- The Use Cases (nine sections)
- Future Vision: Digital Twins, Analytics and More
- How to Deploy Data Management Practices
- Conclusions

About Schneider Electric

Schneider's purpose is to **empower all to make the most of our energy and resources, bridging progress and sustainability** for all. We call this **Life Is On**.

Our mission is to be your **digital partner for Sustainability and Efficiency**.

We drive digital transformation by integrating world-leading process and energy technologies, end-point to cloud connecting products, controls, software and services, across the entire lifecycle, enabling integrated company management, for homes, buildings, data centers, infrastructure and industries.

We are the **most local of global companies**. We are advocates of open standards and partnership ecosystems that are passionate about our shared **Meaningful Purpose, Inclusive and Empowered** values.

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Acronyms

Acronyms

ADMS	Advanced Distribution Management System
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
AI	artificial intelligence
AIP	asset investment planning
AKA	also known as
AMI	advanced metering infrastructure
API	application programming interface
APM	asset performance management
AR	augmented reality
ARES	alternative retail electricity supplier
AS	ancillary services
ARO	asset retirement obligation
AVL	automated vehicle location
BEM	building energy modeling
BIM	building information model
BRP	balance responsible party
BSDD	buildingSMART Data Dictionary
BTM	behind the meter
CAD	computer-aided design
CapEx	capital expenditure
C&I	commercial and industrial
CCA	community choice aggregator
CCPA	California Consumer Privacy Act
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
CfD	contract for difference
CIGRE	International Council on Large Electric Systems
CIM	Common Information Model
CIP	critical infrastructure protection
CIRED	International Conference on Electricity Distribution
CIS	customer information system
CMEP	California Metering Exchange Protocol
CMMS	computerized maintenance management system
CPUC	California Public Utilities Commission
CRM	customer relationship management
DCAM	Data Management Capacity Assessment Model
DER	distributed energy resources
DERMS	distributed energy resources management system
DG	distributed generation
DLC	direct load control
DMS	distribution management system
DNO	distribution network operator
DNMS	distribution network management system
DNP3	distributed network protocol 3
DNSP	distribution network service provider
DR	demand response
DRMS	demand response management system
DSM	demand-side management
DSO	distribution system operator
EaaS	energy-as-a-service
EAM	enterprise asset management
EAOA3D	EcoStruxure™ Augmented Operator Advisor 3D
ECSO	European Cyber Security Organization
EMA	Ecostruxure™ Microgrid Advisor
EMO	EcoStruxure™ Microgrid Operator
EMS	energy management system
ENTSO-E	European Network of Transmission System Operators for Electricity
EPAS	EcoStruxure™ Power Automation System
EPO	Energy Profiler Online
EPRI	Electric Power Research Institute
ERP	enterprise resource planning
ESO	electricity system operator
ETSI	European Telecommunications Standards Institute
ETL	extract, transform, load
EU	European Union
EV	electric vehicle
FAT	factory acceptance testing
FERC	Federal Energy Regulatory Commission (U.S.)
FiP	feed-in-premium
FLISR	fault location, isolation, and service restoration
GMDM	Grid Model Data Management
GDPR	General Data Protection Regulation
GEB	grid-interactive efficient buildings
GENCO	generation company
GIS	geographic Information system
GMS	grid management system
HES	head-end system
HMI	human-machine interface
HV	high voltage
ICCP	Inter-Control Center Communications Protocol
IDS	International Data Spaces

Acronyms

IEC	International Electrotechnical Committee
IED	intelligent electronic device
IEEE	Institute of Electrical and Electronics Engineers
IEM	internal energy market
IFC	Industry Foundation Classes
IIoT	industrial internet of things
IoT	internet of things
IPP	independent power producer
IRENA	International Renewable Energy Agency
ISO	independent system operator
IOS	International Organization for Standardization
IT	information technology
ITU	International Telecommunication Union
IVR	interactive voice response
KPI	key performance indicator
kW	kilowatt
kWh	kilowatt-hour
LSE	load serving entity
LV	low voltage
MDMS	meter data management system
ML	machine learning
MOC	meter operations center
MV	medium voltage
MWFM	mobile workforce management system
NEM	normalized electrical model, National Electricity Market (Australia)
NERC	North American Electric Reliability Corporation
NIST	National Institute of Standards and Testing
NRA	national regulatory authority
NWA	non-wire alternatives
O&M	operations and maintenance
OMS	outage management system
OpEx	operating expenditure
OSI	Open Systems Interconnection
OSMOSE	Optimal System Mix of Flexibility Solutions for European Electricity
OT	operations technology
PLC	programmable logic controller
PLM	product lifecycle management
PUC	public utility commission
PV	photovoltaics
PX	power exchange
QR-code	quick response code
R&D	research and development
RFQ	request for quotation
RIO	remote input-output
ROI	return on investment
RSC	regional solution center
RTO	regional transmission operator
RTU	remote terminal unit
SaaS	software-as-a-service
SAMU	stand-alone merging unit
SAPM	South Australia Produce Market
SAT	site acceptance testing
SCADA	supervisory control and data acquisition
SCL	substation configuration language
SDL	security development lifecycle
SDO	Standards Development Organization
SDx	software defined everything
SEEM	Southeast Energy Exchange Market
SEPA	Smart Electric Power Alliance
SGAM	Smart Grid Architecture Model
TC	technical committee
TCO	total cost of ownership
TNSP	transmission network service provider
TotEx	total expenditure (capital plus operating)
TOU	time-of-use
TSO	transmission system operator
UI/UX	user interface/user experience
V&V	verification and validation
VAR	volt-ampere reactive
VEE	validation, estimation, and editing
VPN	virtual private network
VPP	virtual power plant
VR	virtual reality
VVO	volt/var optimization
WFM	workforce management
WG	working group
WMS	workforce management system
XML	extensible markup language

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