Business & Technology Surveillance

Elevating Co-op Analytics: The Case for a Data Lakehouse

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America's Electric Cooperatives

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ARTICLE SNAPSHOT

WHAT HAS CHANGED?

With the introduction of advanced metering infrastructure (AMI) and distributed energy resources (DER), electric cooperatives are generating more data than ever before. Historically, this data has lived in disconnected systems, each optimized for its own operational purpose but poorly suited to answering questions that span them. Meanwhile, the tools available to unify this data have matured: data lakehouse architecture now lets cooperatives combine the flexibility of a data lake with the structure and reliability of a data warehouse.

WHAT IS THE IMPACT ON ELECTRIC COOPERATIVES?

Without a unified data layer, co-ops are left stitching together insights manually. This slows decision-making, limits the ability to adopt artificial intelligence (AI) / machine learning (ML) and advanced analytics, and puts cooperatives at a disadvantage compared to utilities that have already modernized their data infrastructure. The cost isn't just inefficiency. It's slower response times, missed grid insights, and reduced readiness for what's coming next in the industry.

WHAT DO ELECTRIC CO-OPS NEED TO KNOW OR DO ABOUT IT?

Cooperatives do not need to modernize everything at once. Starting small, with one well-defined question and the few systems needed to answer it, lets a co-op show the value of unified analytics up front, then build from there. Aligning information technology (IT), operations, and engineering early matters as much as the technology itself.

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Summary

Electric cooperatives are sitting on an enormous and often untapped data asset. Through their advanced metering infrastructure (AMI), outage management systems (OMS), geographic information systems (GIS), supervisory control and data acquisition (SCADA) systems, and customer information systems (CIS), co-ops generate data that is crucial to how they operate, plan, and serve their members. Yet NRECA's Co-op Technology Survey found that only 20% of co-ops had any analytics or business intelligence (BI) tools in place, and most had minimal integration between these core systems.

This report draws on four NRECA publications, responses to NRECA technology surveys, and discussions with cooperatives to frame the problem, map the opportunity, and outline the architecture needed for co-ops to gain more from their data. The report's central argument is that the value of co-op data is realized not by having the systems that generate it, but by connecting them. That means building continuous data pipelines into a data lakehouse and applying analytics tools that generate insights across system boundaries.

A data lakehouse is a unified architecture that combines the flexibility of a data lake with the structure and reliability of a data warehouse.

One of the clearest use cases for a data lakehouse is the Advanced Distribution Management System (ADMS), which unifies SCADA, OMS, the distribution management system (DMS), and the distributed energy resource management system (DERMS) into a single operational platform. ADMS depends on real-time telemetry to manage a grid increasingly shaped by distributed energy resources (DER) and electric vehicles (EVs), but it is only as effective as the data feeding it. A data lakehouse doesn't replace ADMS's operational role, but complements it. It gives co-ops the historical depth and cross-system analytics that ADMS alone isn't built to provide, and it helps keep the data models ADMS depends on accurate and current. But ADMS is one use case among many. This same foundation supports load forecasting, predictive maintenance, rate design, and member service analytics.

Why This Matters Now

Artificial intelligence (AI) is often discussed as the next major opportunity for co-ops, but adoption is still in the early stages. NRECA's Co-op Technology Survey found that just 2% of co-ops had adopted AI. This is largely a matter of timing. Practical AI tools for utilities are new, and most co-ops are still working out where they fit. When co-ops are ready though, AI will only be as good as the data it is given. Predictive models for things such as transformer failure and load forecasting require integrated, historical, cross-system data.

A data lakehouse is built to supply that data. In plain terms, it is a central store for a co-op's operational data. It keeps a raw copy of everything that flows in from source systems, so the data can be reprocessed later to answer questions no one has thought of yet. On top of that raw layer sits a governed, structured layer that BI tools and analysts can query reliably. Section 4 of this report explains why this combination suits co-ops. Cooperatives that adopt a lakehouse now are not just solving today's BI reporting needs, they are also building the historical record AI will need as it matures.

This urgency isn't limited to AI. As co-ops increasingly rely on data to guide decisions, from grid planning to member services, demand for new analytics use cases is growing faster than most co-ops' current architecture can support. Every new use case has to be built on the same fragile, point-to-point integrations described in Section 4, so the gap between what co-ops want to do with their data and what their systems can deliver keeps widening. With a data lakehouse, co-ops are able to meet their current analytics requirements, while also positioning themselves to support future use cases as historical data accumulates.

Section 1: The Current State of Cooperative Technology

NRECA's Co-op Technology Survey captured responses from 196 distribution co-ops, providing a detailed snapshot of technology adoption across the membership. The survey showed that co-ops had invested significantly in core operational technologies, but those technologies largely operated in isolation from one another.

Technology Adoption Rates

The most widely deployed data collection platforms were operational and customer-facing systems. As Figure 1 shows, AMI led adoption at 81%, reflecting co-ops' early leadership approach in smart metering, significantly higher than the broader utility industry average of 63%. Customer Information Systems (CIS) followed at 77%, with the National Information Solutions Cooperative (NISC) serving as the vendor for two-thirds of those deployments.

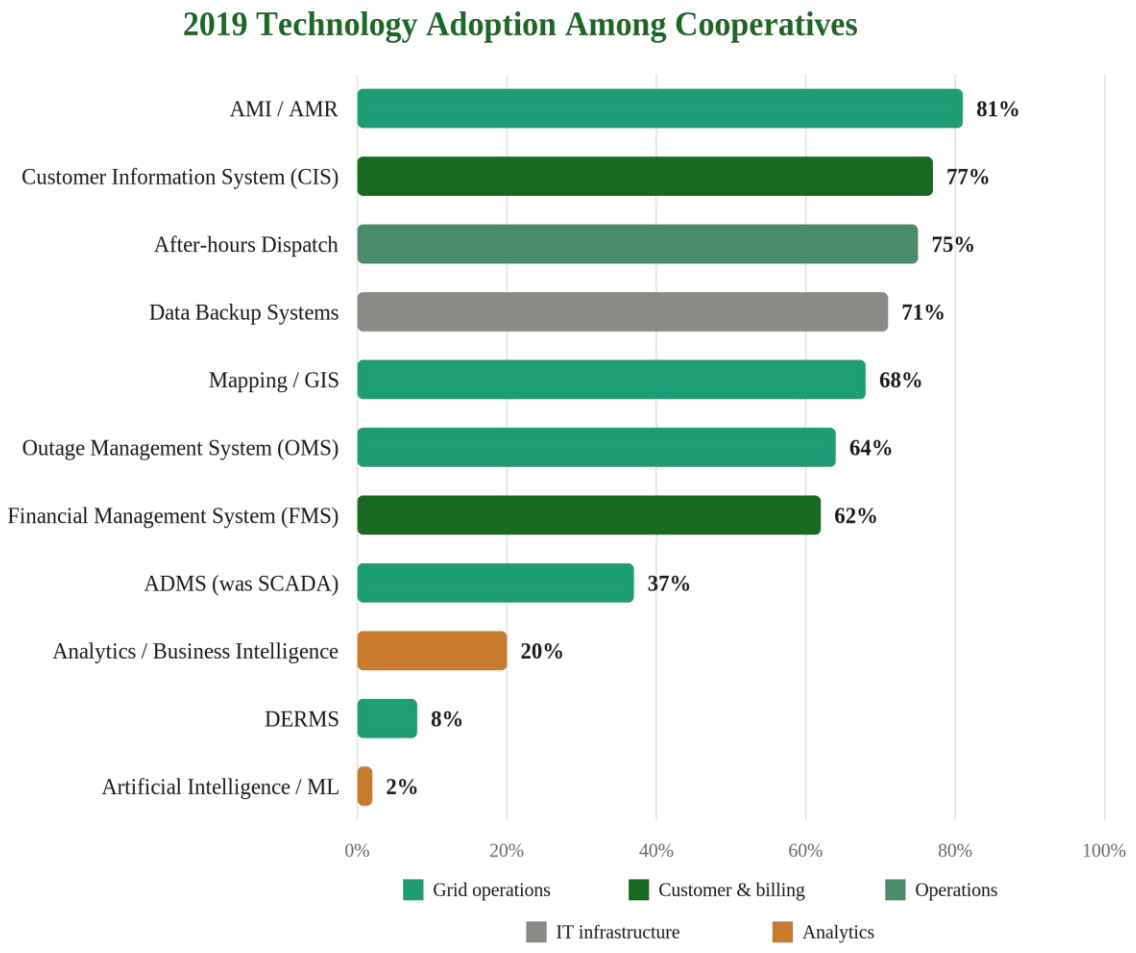


Figure 1: Technology Adoption Rates by Category

Source: NRECA 2019 Co-op Technology Survey

The Silo Problem

Despite high adoption of individual systems, the survey found that integration between systems was limited. This is the core structural barrier to realizing data value. Each system holds valuable data, but that data cannot be combined for cross-system analytics. New, integrated systems like ADMS can only be stitched together at this stage through fragile connections, not a genuine, shared foundation.

Looking specifically at ADMS, the system that most depends on data from multiple sources, NRECA's surveys found that:

- Only 33% of co-ops have any integration between their ADMS and OMS, according to NRECA's Co-op Technology Survey.
- Only 21% had any integration between ADMS and GIS, according to NRECA's Co-op Technology Survey.
- Zero co-ops had integrated SCADA with DERMS, according to the 2023 ADMS report.

Why This Matters

ADMS cannot function at its full capability without data from AMI, GIS, OMS, and engineering analysis systems. Low integration rates mean co-ops with an ADMS installed are still not capturing its full value. Integrated, these systems give an ADMS a current feeder model, faster fault location, and visibility into DER. The same limit applies to any use case that spans systems from load forecasting to member analytics.

Co-op Conversation

One cooperative summed up the challenge plainly: data classification is a constant struggle, and pulling meter data management (MDM) data out of vendor databases is notoriously hard. For now, its focus isn't a full overhaul; it's simply getting data centralized and usable.

Section 2: ADMS as a Data Lakehouse Use Case

ADMS is one of the most data-intensive use cases for a data lakehouse, and one many co-ops are working toward. The August 2023 NRECA report, *An Evolution into ADMS for a Changing Landscape*, provides a detailed examination of what ADMS is, where co-ops stand in their adoption, and what it takes to build toward it. The report draws on a survey of 65 co-ops ranging from under 1,000 to over 126,000 meters, as well as interviews with four major ADMS vendors. Its central finding, that accurate, integrated data models matter more to ADMS success than vendor selection, is why it is a major focus in this section.

What is ADMS?

ADMS is best understood as an evolution of distribution automation technology rather than an entirely new system. At its foundation is SCADA, which has been used for decades to monitor and control substation and feeder equipment. ADMS builds on this foundation by adding three major layers: OMS, DMS, and DERMS, as summarized in Table 1.

Table 1: Components of an ADMS

DATA SYSTEM	DESCRIPTION
SCADA	Supervisory Control and Data Acquisition: provides one-line diagrams, alarm management, real-time telemetry, historian records, and remote control of substation and feeder equipment. Deployed at 80% of surveyed co-ops.
OMS	Outage Management System: identifies outage locations, notifies members of status, and coordinates crew restoration activities. Deployed at 64% of surveyed co-ops, often as a standalone system not integrated with SCADA.
DMS	Distribution Management System: adds feeder-level visibility and control including FLISR (fault location, isolation, and service restoration), Volt/VAR optimization, solar generation estimation, and switch order management.
DERMS	Distributed Energy Resource Management System: manages the complex interaction of behind-the-meter resources including solar, storage, and EVs as a portfolio. Deployed at only 8% of surveyed co-ops, none with SCADA integration.

Source: An Evolution into ADMS for a Changing Landscape, NRECA, August 2023

Within an ADMS, each layer adds a capability the last one lacked. SCADA monitors and controls substation and feeder equipment in real time, but its visibility ends at the devices it is connected to. Problems beyond those devices often go unseen until members call in or meters report them. OMS identifies where an outage occurred and coordinates crew response, though that response is still manual. DMS automates that response, using FLISR to isolate faults and reroute power, and Volt/VAR optimization to keep voltage in range without operator intervention. DERMS extends visibility to resources the co-op doesn't own, managing rooftop solar, batteries, and EV charging as a portfolio, rather than an unpredictable variable. Each layer moves the co-op away from reacting to grid conditions and toward anticipating them.

Why Co-ops Are Moving Toward ADMS

The August 2023 report identified three primary drivers pushing co-ops toward ADMS adoption, all of which fundamentally require better data integration across systems:

- **Distributed Generation**

  Residential, commercial, and utility-scale solar and storage deployments are increasing on co-op systems. These resources add variability to power flow and create hidden sources of generation that SCADA alone cannot see. Seeing them requires combining SCADA data with AMI, GIS, and interconnection records.

- **Transportation Electrification**

  Members increasingly expect reliability that supports EV charging, and EV loads are causing rapid, unpredictable changes to load profiles. Managing them requires near-real-time data from chargers and meters, which many co-ops today receive only in batch downloads.

- **Demand for DMS Capabilities**

  DMS allows co-ops to automate restoration, optimize voltage, and anticipate problems, but only if the underlying data models are accurate and current. Without DMS, co-ops can only react to grid conditions once they occur.

Survey respondents identified their top ADMS priorities as restoration speed improvement, system visibility for DER and EV locations, DER management for demand response, and VOLT/VAR optimization.

Each of these drivers is, at its core, a data problem. Seeing DER, managing EV load, and running DMS functions all depend on combining SCADA, AMI, GIS, and interconnection data that sits in separate systems today. This is where a data lakehouse enables ADMS deployment. It reconciles that data in one governed place, keeps the feeder models ADMS relies on current, and stores the history needed to validate them. A co-op that builds the data foundation first can deploy ADMS faster and get more from it once it is live.

The Data Model Challenge

For co-ops building toward ADMS, the challenge is knowing where to start and how to build in a way that delivers value at every step. As identified by the 2023 report, the most critical step toward ADMS is not selecting a vendor but building and maintaining accurate data models. The report identifies a hierarchy of DMS feeder model types that can be implemented one after another, where each enables progressively more capability, starting from the simplest operator-only model up to a full power flow model representing system connectivity, inputs, outputs, and dynamics. Figure 2 shows this hierarchy.

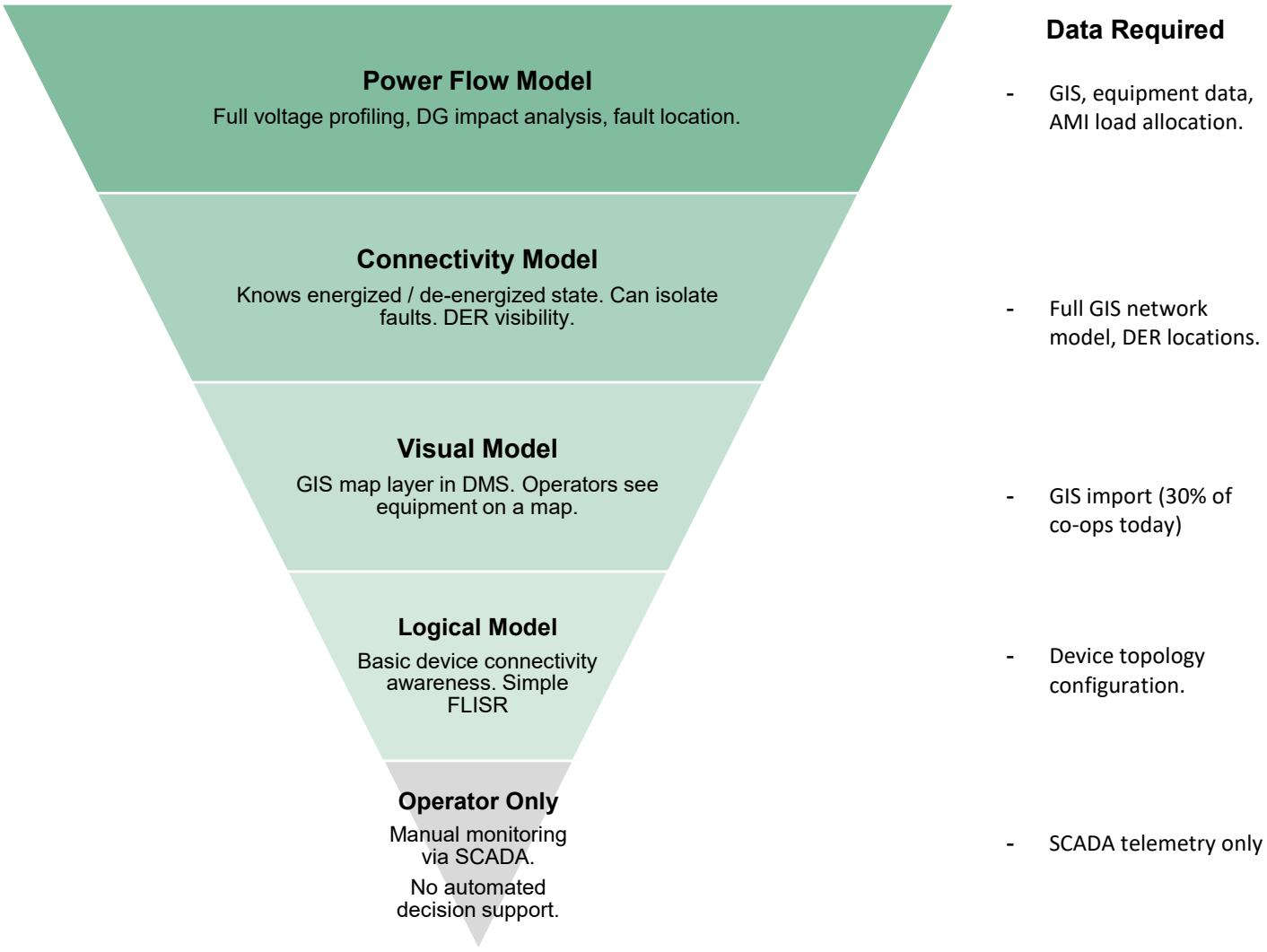


Figure 2: DMS Feeder Model Complexity Hierarchy

Source: An Evolution into ADMS for a Changing Landscape, NRECA August 2023

This hierarchy shows that ADMS capability depends on how much integrated data sits underneath it. Achieving a robust power flow model – where FLISR, Volt/VAR optimization, and DER visibility deliver real value – requires GIS, equipment data, and AMI to be reconciled together. In the 2023 survey, most co-ops with ADMS platforms installed were still working toward this tier, which suggests that the system's full value remains untapped. The more complete a co-op's data model becomes, the more of ADMS's value can be realized. However, ADMS is only one way to put co-op data to work, which is why the next section looks at the value of that data more broadly.

Co-op Conversation

A cooperative in Colorado found itself tracking meter inventory across three separate databases. Each was technically correct on its own terms, but each updated on its own schedule for its own purpose. The problem wasn't accuracy. It was consistency. Inventory statuses did not match across the three systems, and there was no single source of truth to work from.

Section 3: The Value of Cooperative Data

The November 2022 NRECA report, *The Value of Cooperative Data*, makes a compelling case that co-ops are systematically undervaluing and under-protecting one of their most significant assets, the data their systems generate every day. As that set of data grows, so do the privacy and security obligations that come with it, which is one more reason to manage it centrally under consistent governance rules.

The report finds that co-op data holds substantial value that most co-ops are not yet capturing. ADMS is one concrete path to realizing that value, but the report's use case map shows the opportunity extends well beyond any single system, into nearly every part of a co-op's operations. The table below maps key use cases by their potential value to the co-op network.

Table 2: Limited Sample of Data Use Cases, Value vs. Feasibility

Highest-Value Use Cases	Mid-Value Use Cases	Emerging-Value Use Cases
• Grid operations & predictive maintenance • Load management program design • Co-op & member demand charge management • Advanced load forecasting	• DERMS implementation & optimization • Building audits & benchmarking • Rate design studies • Fraud & theft detection • DER project siting & sizing • Data quality support	• Electrification opportunity identification • Community supply program enrollment • Driver telematics & safety • Inter-co-op crisis response

Source: NRECA Report, *The Value of Cooperative Data*, November 2022

The report places grid operations and predictive maintenance, load management, demand charge management, and advanced load forecasting in its highest-value tier. What these use cases share is that none can be accomplished from a single system's data. Load forecasting, for example, draws on AMI, weather, and historical grid data simultaneously. Realizing this opportunity means not just building new capability, but recognizing value co-ops may already hold.

Co-op Conversation

A cooperative built a dashboard that flags high usage before members see their bill. By comparing recent usage against a control group and against weather, it flags anything more than two standard deviations from expected usage. As a result, staff can reach out proactively instead of waiting for a complaint call.

Section 4: The Data Lakehouse and Continuous Pipeline Architecture

The silo problem described in Section 1 and the data model requirements described in Section 2 both point toward a common solution: a data lakehouse that aggregates data from all source systems through continuous pipelines. It reduces the need for complex point-to-point integrations built for analytics and reporting, and it feeds the data models ADMS depends on, while ADMS keeps its own real-time operational connections. This architecture is consistent with NRECA's Data Strategy Planning Service framework, which calls for a holistic, integrated view across six domains: Consumer Service, Asset Utilization, Distribution Grid, Metering, Process Performance, and Financial. Co-ops can use that service, offered through NRECA's Consulting Services group, to plan this kind of architecture.

Why a Data Lakehouse?

Prior sections in this report establish that co-op data is valuable, and that obtaining that value through ADMS and analytics both depend on integrating it across systems. This raises an architectural question: what kind of centralized system should sit at the hub of that integration? Modern data platforms generally follow one of three patterns: the data lake, the data warehouse, and the data lakehouse. The differences between them matter directly for how a co-op would use the resulting system for BI reporting, analytics, and systems such as ADMS.

- **Data Warehouse:** Imposes structure before data is stored, making it fast and reliable for BI tools, but requires deciding a data model upfront.
- **Data Lake:** Stores data in its raw form and defers structure until it is queried, preserving flexibility but offering little support for reliable BI reporting on its own.
- **Data Lakehouse:** Combines both: a governed, structured layer for BI performance, sitting on top of a raw layer retained for long-term reprocessing.

Table 3: Comparison of Data Systems

Type of Data System	Storage as Raw Data	Applied Data Model
Data Warehouse	No	Yes
Data Lake	Yes	No
Data Lakehouse	Yes	Yes

This trade-off is not abstract for a co-op, and resource constraints make it sharper still. Building two separate systems, one warehouse for BI reporting and one lake for raw data flexibility, is far more resource-intensive than a co-op needs to take on. A warehouse alone would meet the immediate BI need. However, committing to a data model upfront comes at a cost: later use cases, like advanced load forecasting and demand charge management, depend on reconciling data in ways not fully known in advance, which would require restructuring. AI sharpens this point, with adoption still in the early

stages, few can say today which models they will run in five years or what data those models will need. A lake alone avoids that rework, but it leaves a co-op without reliable BI reporting. It also does nothing to move a co-op closer to the power flow model described in Section 2, which still requires GIS, equipment, and AMI data to be reconciled.

A lakehouse is the less resource-intensive option. It meets both needs from a single build: the governed layer supports BI today, while the raw layer underneath avoids the cost of re-architecting later. That doesn't make it free. A lakehouse still requires data engineering skills, ongoing governance, and storage and cloud costs, which is why it makes sense to start small.

How This Addresses the Silo Problem

Currently, co-ops manage a complex web of direct integrations between systems. Each integration is a custom connection that must be built, maintained, secured, and updated whenever either connected system changes. MultiSpeak®, an industry standard for exchanging data between utility software applications, has become the dominant standard for many of these integrations, but GIS integration remains largely file-based, and DERMS has essentially no standard integration approach.

A data lakehouse replaces much of this web with a hub-and-spoke architecture. Each system connects once to the lakehouse, which becomes the single source of truth for analytics, and analytics applications draw from the lakehouse directly rather than from individual source systems. When a source system changes, only its connection to the lakehouse needs updating. Real-time operational links, such as those between SCADA, OMS, and ADMS, remain in place. The lakehouse replaces only the point-to-point connections built for reporting and analysis.

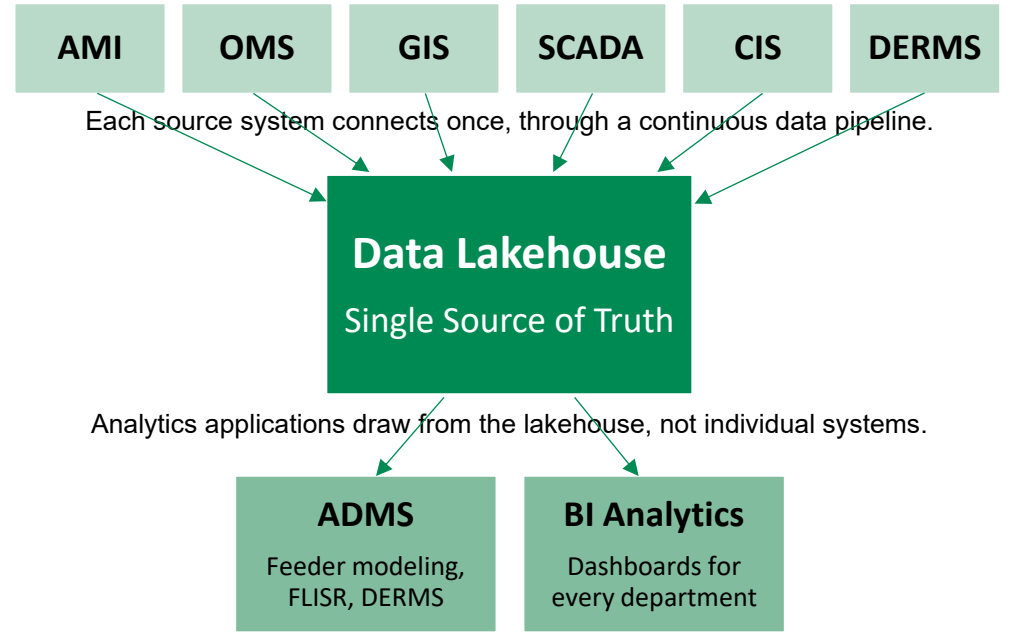


Figure 3: Hub-and-Spoke Data Lakehouse Architecture

Why Pipelines are the Foundation

The core data problem facing co-ops today is not that data does not exist. It is that the data exists in too many places, in too many formats, managed by too many vendors, with too little connectivity between them. As Section 1 showed, co-ops had invested heavily in individual systems, but integration between them remained shallow. Many of the connections that do exist rely on periodic file exports or manual data entry, as illustrated by the Co-op Conversation excerpts throughout this report. Both approaches to data capture can be inconsistent and cannot support the real-time, cross-system intelligence that modern grid operations require.

Continuous data pipelines change this equation. Rather than waiting for systems to exchange data on their own schedules through their own protocols, continuous pipelines actively pull data from each source system and load it into the lakehouse. As a result, the lakehouse becomes a living, current representation of the co-op's entire operational environment, not just a snapshot from yesterday's file export. It becomes a continuously updated picture that reflects grid conditions, member activity, asset status, and financial performance as they stand.

Pipelines are not usually a one-time build. Operationally, they need monitoring that catches fails or late loads, data quality checks, and a process for updating connections when vendors upgrade source systems. Organizationally, they need a named owner for each pipeline, data engineering skills in house or through a partner, and leaderships that budgets for upkeep as an ongoing cost rather than a one-time project.

For operational use cases like ADMS, this matters because the most valuable capabilities, including feeder modeling, load flow analysis, fault location, Volt/VAR optimization, and DER visibility, depend on accurate data models built from multiple source systems. Without pipelines bringing that data together in a dependable, timely, and consistent way, those models fall out of date and ADMS works from incomplete information. The 2023 NRECA ADMS survey found that only 17% of co-ops had brought GIS into SCADA even for basic visualization, and none had integrated SCADA with DERMS. Both figures reflect the same fragmentation that a unified data platform is meant to address.

How Data Pipelines Can Enhance Analytics

The value of continuous data pipelines extends well beyond simply moving data from individual systems to a central location. The integration built into the pipeline layer allows for analytical capabilities that did not exist before and cannot be replicated by an individual source system working alone. There are two specific ways in which this happens:

- **Cross-System Correlation Becomes Possible**

  Each individual platform can only answer questions about its own data. OMS can speak to how many outages occurred on a feeder last year. Asset management can speak to the age and condition of the transformer on that feeder. SCADA and its historians can speak to the voltage profile on that feeder. AMI can speak to the load growth pattern on that feeder over the past several years. But none of these systems can answer the question that actually matters for grid planning: *Given the combination of asset age, load growth, voltage stress, and outage history,*

how likely is an asset to fail in the next 12 months, and what does that failure cost compared to proactive replacement today? That answer requires information from all four datasets simultaneously, and it can only be answered when those datasets are combined in a unified data platform through continuous data pipelines.

- **Historical Depth Accumulates and Compounds, Enabling Prediction**

  Individual source systems are typically designed to support current operations, not long-term historical analysis. SCADA historians store operational data, but often have limited retention periods or storage constraints. OMS systems are optimized for managing active outages, not querying five years of outage patterns. AMI systems can store interval data, but querying across the full meter population over multiple years directly from the MDM system is often impractical.

  Unlike the individual source systems, the data lakehouse is designed for long-term retention at scale. The records each pipeline delivers accumulate over time, building a historical depth that individual systems cannot match. When combined with the real-time data flowing continuously from operational pipelines, this historical depth is what enables the most valuable analytical capabilities a co-op can build.

Real-time data alone shows what is happening on the grid right now. Historical data alone shows what has happened in the past. Together, they help predict what is likely to happen next. This predictive capability is where most of the value identified in the research lies. Three examples show how:

- **Monitor Transformer Health**

  A voltage reading from a substation transformer means relatively little on its own. Combined with three years of historical voltage readings from the same transformer, seasonal load profiles, recent maintenance records, and weather data, it becomes a data point in a predictive model that can identify early signs of degradation before a failure occurs.

- **Defect Theft**

  A spike in AMI tamper alerts on a particular feeder means relatively little on its own. Combined with billing anomalies from CIS and historical theft patterns from prior investigations, it becomes a signal that triggers a fraud investigation workflow.

- **Keep Feeder Models Accurate**

  A sudden change in load profile on a feeder means relatively little on its own. Combined with interconnection or DERMS data showing that new behind-the-meter solar came online that morning, it confirms that the DMS feeder model needs to be updated to account for the new generation.

This combination of real-time signal and historical context is what moves a co-op from knowing what is happening on the grid to anticipating what comes next. The longer a lakehouse accumulates data, the

more powerful this predictive capability becomes, which makes pipeline infrastructure a compounding asset rather than a fixed cost.

Co-op Conversation

One North Carolina cooperative used to export data from its vendor's database just to generate a report, with no guarantee the data was standardized once in the co-op's possession. A cloud-based data warehouse gave the co-op a single, trusted source of truth that is far more accessible than pulling from its vendor directly.

Section 5: Improving BI & Analytics Accessibility

Business intelligence tools turn data into dashboards and reports that non-technical staff can use. When a BI tool connects directly to the lakehouse, it can draw on cross-system data to produce dashboards for every organizational function. NRECA's Co-op Technology Survey found that among the 20% of co-ops with BI tools installed, usage was concentrated in Engineering (85%) and IT (80%), with significantly lower uptake in Finance, Operations, and Member Services. This concentration likely reflects who can reach the data. Those departments sit closest to the technical systems generating it and are staffed by the people most able to navigate multiple source systems by hand. A lakehouse changes this by giving every department access to integrated, current data without requiring technical expertise in the individual source systems underneath it. Access stays secure because the lakehouse's governance layer enforces role-based permissions and standard data definitions centrally, rather than department by department.

A lakehouse architecture also reflects how BI tools were intended to be used. A BI tool is designed to sit on top of the source systems it reports on and make their data usable to non-technical staff, not to replace those systems. That promise breaks down when the underlying data is still siloed, since a dashboard is only as integrated as the data feeding it. Connecting a BI tool to a lakehouse, rather than to individual source systems one at a time, is what allows that promise to hold.

Using a lakehouse to supply BI tools also keeps like tasks together: the data and its management tooling live in the lakehouse, while analysis and visualization live in the BI tool. The BI tool queries the lakehouse's governed, structured layer directly, without requiring data to be moved, duplicated, or separately maintained. When data stays siloed, it follows a separate set of rules for each source system; unifying those rules on one platform improves both security and ease of management. The same pipelines that feed ADMS data models and predictive analytics also feed the dashboards every department depends on.

Co-op Conversation

One co-op said its biggest lesson was that a data warehouse alone isn't enough. Staff need clearly defined uses for it, not just access to data and tools, and the people using it need to be trained to use it well. Preparing users, the co-op found, matters as much as building the platform.

Conclusion

Electric cooperatives regularly create a wealth of valuable data. Systems such as AMI, OMS, GIS, SCADA, and CIS each generate data that is useful to multiple business areas, and NRECA's survey data shows that most co-ops have already invested heavily in them. All too often, however, these systems lack the integration that could provide much deeper insights. That gap leaves real value unrealized and keeps ADMS and other cross-system tools from delivering their full potential. By integrating data across platforms and departments, co-ops can build on a strong, shared foundation rather than a fragile, hard-to-maintain network of point-to-point connections.

With a single investment, a data lakehouse built on continuous data pipelines integrates a co-op's data without forcing a choice between reliable BI reporting today and the raw data flexibility that predictive analytics will require tomorrow. Co-ops that begin building this foundation now are better positioned to move from knowing what is happening on their grid to anticipating it. The same foundation is what AI and advanced analytics will depend on as they mature: the integrated, historical data a lakehouse accumulates. That progression, and the value it unlocks, starts with the important first step of deciding to treat integrated data as core infrastructure.

Source Documents

This research synopsis draws directly from four NRECA publications. All statistics, valuations, adoption rates, and vendor data referenced in this document originate from these sources.

- **NRECA 2019 Co-op Technology Survey**

  Market Research Services, NRECA · June 2019

  196 distribution cooperatives surveyed on adoption of 29 technologies, vendor usage, integration levels, and planned investments. Primary source for all technology adoption statistics, integration matrices, and vendor market share data used in Sections 1 and 5.

- **The Value of Cooperative Data**

  Emma Stewart (former NRECA Chief Scientist), David Pinney (Principal, Analytical Tools & Software Products), ADL Ventures · November 2022

  Research report on the commercial value of co-op data assets, pricing methods, use case mapping, and data privacy frameworks. Product of the NRECA Analytics, Resiliency and Reliability Workgroup. Primary source for all data valuation figures in Section 3.

- **An Evolution into ADMS for a Changing Landscape**

  Jim Weikert, Vice President of Utility Automation & Communications, Power System Engineering · August 2023

  Technical survey and analysis of ADMS architecture, DMS model complexity, vendor landscape, and co-op migration pathways. Based on surveys of 65 cooperatives and interviews with Minsait ACS, OSI, Survalent, and Schneider Electric. Primary source for Section 2.

- **Data Strategy Planning Service — Service Profile Sheet**

  NRECA Business and Technology Strategies · September 2020

  One-page service framework describing NRECA's data strategy consulting service. Establishes the five-deliverable planning framework and the six organizational domain areas (Consumer Service, Asset Utilization, Distribution Grid, Metering, Process Performance, Financial) referenced in the data strategy maturity discussion.

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