Preparing electric utilities for the energy transition

Insights from the Clean Electrification Maturity Model
Learn how IBM can help your energy company become more resilient, reliable, and sustainable through a clean electrification strategy. We work with leading corporations and organizations that are driving toward net-zero carbon emissions, increased electrification, and a cleaner planet through advanced technologies and data-driven insights. Let us help you develop new ways to power through the challenges ahead. Visit us at ibm.com/industries/energy

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The most mature electric utilities are evolving for the energy transition and have organization-wide strategies for innovation and modernization in place.

Utilities are modernizing for decarbonization, but progress is slow.

A maturity assessment of the clean electrification capabilities of transmission and distribution utilities found that the most mature enterprises have an organization-wide vision and strategy to modernize and innovate, and are well underway in transforming cultures and operations. However, the average maturity of clean electrification capabilities is low, reflecting meaningful opportunities for advancement.

Technology and grid operations represent significant challenges.

The most mature utilities prioritize IT/OT architecture initiatives and 100% of them have an enterprise IT architecture in place. They are 2.8 times more likely to align IT/OT architecture roadmaps, and 95% of the most mature utilities prioritize development of distributed energy resources (DER). However, the maturity gap between more mature and less mature organizations in grid operations and technology is small, pointing to the need for the entire industry to develop faster in these key domains.

Data analytics differentiate the most mature utilities across operational domains.

The most mature utilities have deployed more advanced data analytic capabilities and are 2.7 times more likely to use real-time analytics. By using AI enablement of asset and inventory forecasting, they have opened up a large gap between themselves and their less mature counterparts, being 5.7 times more likely to implement this transformational technology.
Clean electrification: Powering up decarbonization efforts

In 2023, the global effort to decarbonize will reach two tipping points. For the first time, investments in solar power generation will exceed spending on oil production.¹ And with wind and solar now generating over 12% of global electricity, 2023 is projected to be the year when emissions related to power generation starts to decline.²

Clean electrification—using electricity generated from low-carbon sources instead of fossil fuels—is a crucial element of global decarbonization for the electric utility and industrial sectors.

This progress is good news for the electric power industry and for sustainability efforts everywhere. However, as utilities increase clean electricity generation, they are also under escalating pressure to reduce emissions by 45% by 2030 as called for by the Paris Agreement.³ At the same time, the electric power industry must make multi-trillion-dollar investments in grid improvements to meet the growing global demand for electricity.

Based on these challenges, customers, investors, governments, communities, and other stakeholders have big questions for electric utilities: What are they doing to build a resilient and sustainable energy future? How are they applying new technologies and innovating to transform operations? And how do they compare with peer electric utilities—what are they learning from others to increase their capabilities?

The Clean Electrification Maturity Model (CEMM) was developed specifically for electric utilities to answer these big questions. It is the first comprehensive tool that enables electric utility executives to measure their performance across a broad spectrum of capabilities, get a clear picture of where they need to get better, (or “visualize where they need to improve”) set priorities for transformation, and track progress along the way.

With the CEMM, electric utilities now have a proven, objective tool that addresses a broad set of capabilities driving clean electrification across the enterprise. The CEMM also serves as a compass that points to the leaders—the electric utilities with the highest maturity levels in the capabilities that will power a more sustainable energy future.
The Clean Electrification Maturity Model: A roadmap to guide electric utility modernization

Based on 14 years of research and input from electric utility experts around the world, the CEMM was created by IBM and the American Productivity & Quality Center (APQC), a nonprofit organization that provides open standards benchmarks. Designed as a multidimensional, dynamic self-assessment tool, the CEMM maps eight high-level domains that reflect the top strategic imperatives facing utilities and cross-checks up to 200 operational capabilities listed under each domain (see Figure 1).

**FIGURE 1**

**The Clean Electrification Maturity Model**
The eight domains and the operational capabilities under each domain

<table>
<thead>
<tr>
<th>Strategy and Leadership</th>
<th>Organization and Culture</th>
<th>Technology</th>
<th>Sustainability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business vision</td>
<td>Operating model and change management</td>
<td>Information strategy and innovation</td>
<td>Environmental strategy and goals</td>
</tr>
<tr>
<td>Regulatory and stakeholder management</td>
<td>Employee experience</td>
<td>Architecture and security</td>
<td>Public health and safety</td>
</tr>
<tr>
<td>Modeling and planning</td>
<td>Knowledge management and talent</td>
<td>Project delivery and ecosystems</td>
<td>Decarbonization and net zero</td>
</tr>
<tr>
<td>Financial and risk management</td>
<td>Health and safety</td>
<td>Data and analytics strategy</td>
<td>Community engagement</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Grid Operations</th>
<th>Work and Asset Management</th>
<th>Market Innovation</th>
<th>Customer Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faults and outage management</td>
<td>Engineering and project portfolio management</td>
<td>Research and innovation</td>
<td>Prospect</td>
</tr>
<tr>
<td>System operations and reliability</td>
<td>Asset management</td>
<td>New energy ecosystems</td>
<td>Acquire</td>
</tr>
<tr>
<td>Operational efficiency</td>
<td>Work management</td>
<td>New services and revenue streams</td>
<td>Service</td>
</tr>
<tr>
<td>Microgrids and DER</td>
<td>Externalities</td>
<td>Energy markets balancing</td>
<td>Retain</td>
</tr>
</tbody>
</table>
Utilities can go (or dive) as deep into the CEMM assessment matrix as they want. Participants select options that describe how they address each capability. The maturity model uses these inputs to rank each domain according to a range of maturity designations that start at the lower end with Evaluating, Developing, and Implementing and rise to the higher levels of Living and Leading (see Figure 2).

By comparing their own levels of maturity to other organizations, electric utilities discover where the maturity gaps exist. After opportunities for improvement are identified within the CEMM framework, electric utilities can target specific capabilities for improvement. And by boosting maturity levels in these focus areas, electric utilities can achieve performance and sustainability goals in the areas where they matter most.

**FIGURE 2**

**Five levels of self-assessed maturity**
The CEMM calculates maturity scores from Level 1 to 5 based on how utilities respond to questions in each domain

- **Leading**
  Breaks new ground and advancing the state of practice

- **Living**
  Implementation is tuned to increase organizational performance

- **Implementing**
  Deployment is integrated across the organization

- **Developing**
  Implementing modernization focus across the enterprise

- **Evaluating**
  Taking the first implementation steps
The first global CEMM survey revealed significant opportunities for improvement

In 2022, 90 transmission and distribution (T&D) electric power utilities participated in the first global CEMM survey. These utilities represent a cross section of organizational sizes and structures and operate in 26 countries (see “Study approach and methodology” on page 22).

Based on the survey results, the IBM Institute for Business Value (IBM IBV) calculated maturity scores for individual organizations and an overall maturity score for all respondents. The CEMM shows that overall maturity level for T&D utilities is low. With an average maturity score lower than Developing (Level 2 out of 5), there is considerable headroom for improvement (see Figure 3). However, maturity scores reported by organizations in the top 25% show that some utilities have made substantial progress in transforming their operations.

How did the most mature utilities get that way? What are leaders doing that other utilities can emulate? Where are they carving out the biggest leads? And why does improving capabilities in high priority domains make a difference?

By focusing on significant gaps between high-maturity electric utilities and others—areas where leaders are often two or three times further ahead—this report highlights some of the biggest opportunities for improvement. T&D utilities starting at the lower end of the maturity spectrum can see where more mature peers invest their time and effort, assess their path to improvement, and make plans to improve their own results.
FIGURE 3

Range of clean electrification maturity scores of T&D electric utilities

<table>
<thead>
<tr>
<th>Category</th>
<th>Average maturity</th>
<th>Most mature 25%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategy and Leadership</td>
<td>1.6</td>
<td>2.2</td>
</tr>
<tr>
<td>Organization and Culture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sustainability</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grid Operations</td>
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</tr>
<tr>
<td>Customer Experience</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Market Innovation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: IBV Clean Electrification Maturity Model Benchmark Study, 2023. (n=105, T&D = 90)
Due to challenges related to climate change, extreme weather, energy transition, shifting customer needs, and a changing workforce, a large electric utility experienced significant power outages. After a performance review, operators concluded that disruptions would continue unless they took significant mitigation actions.

Using the CEMM as a framework for its enterprise-wide assessment, the organization launched a transformation project. The organization realized it had operational issues because it lacked comparative global maturity in the training and skilling, work management, and automation capabilities that could handle increased decision-making complexity.

For each domain, the organization developed aspirational targets for the next five years, as well as goals for a 10-year strategy. Each capability statement from the CEMM provided a “how to” set of actions to achieve specific maturity targets. This information continues to inform comparisons, help develop improvement objectives, and prioritize investments to improve capabilities.
In the Sustainability domain, 100% of the stakeholders at mature utilities are engaged to develop new products, services, and future programs.
Using the CEMM data to gain a perspective on performance

Looking at the CEMM data to compare maturity levels between electric utilities is a useful exercise, but this data can also be used to show that when a utility performs better in key capabilities, this performance edge also delivers other operational advantages.

For example, advanced analysis can predict if the operations of a T&D electric utility are more sustainable and reliable than those of their peers according to the specific capabilities they have implemented. These utilities are defined as those delivering more than 20% of their electricity from renewable sources. They also, on average, perform in the top 25% for the key operational metrics of System Average Interruption Duration Index (SAIDI) and System Average Interruption Frequency Index (SAIFI).

The capabilities they have implemented match those of the most mature utilities and have the following themes:

- Deploying advanced digital capabilities to enhance operational performance and improve customer engagement and support
- Managing risk and responding to regulations with a collaborative, inclusive approach
- Focusing on mobility and informing, securing, and empowering the field workforce
- Investing in research and innovation that encourages adopting and integrating distributed energy resources (DERs) and operating DER programs at scale
- Providing customers with green energy alternatives and more personalized service
- Proactively managing and maintaining physical assets with advanced analytics and rigorous processes.
Strategy and leadership

The strategy and leadership domain of the CEMM assesses the extent to which utilities establish a strong vision, communicate clearly with the market, and drive toward defined goals. All of the most mature utilities have established an organization-wide vision and strategy, compared to only 57% of the rest of participants. This supports the conclusion that leaders who align the entire organization toward transformation accelerate change through advanced capabilities.

Mature utilities also understand that engaging with communities and managing stakeholder expectations is an important expression of leadership. That’s why they engage with stakeholders on legislation and regulation at a rate 2.8 times higher than their less-mature peers.

Finally, 95% of the top-tier utilities use new tariffs to pay for their transformation efforts—a rate 2.4 times higher than others (see graphic). Funding modernization shows how leading utilities recognize the importance of securing necessary levels of community support to achieve long-term goals.

<table>
<thead>
<tr>
<th>Top three strategy and leadership capabilities more prevalent at mature electric utilities</th>
<th>Most mature 25%</th>
<th>All other respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adapting tariffs to fund and sustain transformation.</td>
<td>95%</td>
<td>40%</td>
</tr>
<tr>
<td>Proactively engage stakeholders on legislation and regulation.</td>
<td>86%*</td>
<td>31%*</td>
</tr>
<tr>
<td>Organization-wide vision and strategy for innovation and modernization exists.</td>
<td>100%</td>
<td>57%</td>
</tr>
</tbody>
</table>

* n< 20 results should be considered directional
The organization and culture domain of the CEMM assesses employee skills and working environments. The most mature organizations have established cross-functional working approaches to increase engagement. In fact, 95% of advanced utilities use agile, cross-functional teams to address business initiatives—a rate that is more than two times higher than less-mature organizations.

Leading electric utilities are committed to providing their workforce with more advanced digital tools—top performers use real-time dashboards at a rate 4.1 times higher than others.

Another important success factor: 95% of mature utilities use real-time analytics to assess safety risks for both employees and communities (see graphic). These organizations leverage real-time sensor data and predictive analytics to support worker and public safety.

### Top three organization and culture capabilities more prevalent at mature electric utilities

<table>
<thead>
<tr>
<th>Capability</th>
<th>Most mature 25%</th>
<th>All other respondents</th>
<th>Percentage</th>
<th>Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real-time analytics utilized to minimize safety risk for employees, customers, and society.</td>
<td>95%</td>
<td>31%</td>
<td>95%</td>
<td>3.1x more</td>
</tr>
<tr>
<td>Dashboards contain predictive real-time metrics.</td>
<td>73%*</td>
<td>18%*</td>
<td>73%*</td>
<td>4.1x more</td>
</tr>
<tr>
<td>Agile and adaptive cross-functional teams are engaged to drive transformation and change.</td>
<td>95%</td>
<td>46%</td>
<td>95%</td>
<td>2.1x more</td>
</tr>
</tbody>
</table>

*n< 20 results should be considered directional
Sustainability

The sustainability domain of the CEMM includes initiatives that support the expansion of clean electrification. To this end, leading utilities are 100% committed to engaging stakeholders on sustainability-related services and practices.

Recognizing the power of working together, these organizations team up with stakeholders 2.5 times more and with partner ecosystems twice as often to advance sustainable operations. When compared to others, leading utilities are also 3.4 times more likely to define, develop, or acquire the skills that are necessary to achieve their sustainability goals (see graphic).

Top three sustainability capabilities more prevalent at mature electric utilities

- Stakeholders are engaged to develop new products, services, and future programs. 100% 2.5x more
- Sustainability skill sets have been defined and developed or acquired specialized. 82%* 3.4x more
- Proactively engage across partner ecosystem to achieve higher sustainability standards and goals. 100% 2.0x more

Most mature 25%
All other respondents

*n< 20 results should be considered directional
The CEMM technology domain focuses on a digital foundation that supports AI, the Internet of Things (IoT), blockchain, and automation in a secure, flexible, hybrid cloud environment. In the top quartile of maturity, 100% of utilities have enterprise architectures that enable visibility, security, and data integration across the enterprise to enable valuable insights (see graphic).

Additionally, 91% of mature electric utilities align their IT/OT enterprise architecture and roadmaps with ecosystem partners, compared with only 32% of their peers.

For cybersecurity, the most mature electric utilities are 2.9 times more likely to automate security solutions that are active across environments. These tools reduce operational risks and help limit or avoid the financial and catastrophic reputational impacts of data breaches. The global average cost of a data breach in 2023 was $4.45 million, and the average savings for organizations that use security AI and automation extensively is $1.76 million compared to organizations that don’t.4

| Top three technology capabilities more prevalent at mature electric utilities |
| IT/OT enterprise architecture and roadmaps align with ecosystem partner roadmaps. | 91% | 2.8x more |
| Automated cyber security methods are active across all environments. | 86%* | 2.9x more |
| Enterprise architecture in place to guide technology selection and implementation. | 100% | 2.3x more |

*< 20 results should be considered directional
Grid operations

The grid operations domain of the CEMM is at the heart of what electric utilities do. Bringing more clean electricity onto the power grid is key to increasing sustainable energy production. However, renewable energy sources are widely distributed and difficult to integrate with grids that have been built around central power stations.

More mature utilities have a head start with advanced capabilities around microgrid and DER. The share of renewable energy from solar, wind, hydro, and biomass, already at a 28.7% share in 2021, continues to increase. With microgrids, renewable DER improves grid resilience and energy efficiency.

Electric utilities are major players in integrating microgrids. Sophisticated capabilities and integration of Distributed Energy Resource Management Systems (DERMS) and Advanced Distribution Management Systems (ADMS) are key enablers. Compared to 26% of other electric utilities, 95% of mature electric utilities have implemented ADMS and DERMS to manage DER and microgrids (see graphic).

Automated bidding capabilities for market pricing platforms are also used by more of the most mature organizations. Sophisticated algorithms provide optimized decision-making insights based on real-time information about markets, pricing, available capacities, and transmission constraints.

Top three grid operations capabilities more prevalent at mature electric utilities

<table>
<thead>
<tr>
<th>Capability</th>
<th>Most mature 25%</th>
<th>All other respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>DER and microgrid offerings</td>
<td>95%</td>
<td>18%</td>
</tr>
<tr>
<td>ADMS and DERMS systems include functionality to manage DER and micro grids</td>
<td>95%</td>
<td>26%*</td>
</tr>
<tr>
<td>Automated bids generated from a real-time market pricing platform that analyzes generation and load</td>
<td>95%</td>
<td>36%</td>
</tr>
</tbody>
</table>

*< 20 results should be considered directional
Work and asset management

The work and asset management domain of the CEMM focuses on some of the core competencies of utilities, including operating efficiency, maintaining physical assets, and fostering the safety of people and the grid.

Most participants have digital capabilities that support work and asset management. However, a wide gap exists in monitoring asset conditions with digital connectivity and predictive analytics. Only 22% of less mature utilities have this capability, as opposed to 82% of the most mature organizations, which use these capabilities at a 3.7 times higher rate.

5.7 times more of the mature utilities use AI and machine learning (ML) to optimize planning, forecasting, asset scheduling, and inventory management. Analytics help predict breakdowns, identify wear and tear, and enable preventive measures to be taken before problems get worse.

Where crews conduct field work, mature organizations are 3.4 times more likely to provide mobility solutions equipped with advanced capabilities, such as AI-powered apps. Advanced mobile support enables these workers to perform their jobs more efficiently and get real-time help for complex issues (see graphic).

<table>
<thead>
<tr>
<th>Capability Description</th>
<th>Less mature (22%)</th>
<th>Most mature (82%)</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asset condition monitoring incorporate digital connectivity and predictive analytics.</td>
<td>22%</td>
<td>82%</td>
<td>3.7x more</td>
</tr>
<tr>
<td>Mobility solutions are enabled by cognitive expert systems.</td>
<td>24%*</td>
<td>82%</td>
<td>3.4x more</td>
</tr>
<tr>
<td>AI &amp; ML enable optimization of design, forecasting, scheduling, assets, and inventory.</td>
<td>12%</td>
<td>68%</td>
<td>5.7x more</td>
</tr>
</tbody>
</table>

* n< 20 results should be considered directional
Market innovation

The market innovation domain of the CEMM assesses how electric utilities adapt to changing market conditions, evolve business models, and develop new services to meet customer needs. On average, 3.3 times more of the most mature utilities prioritize research in energy balancing and trading. Improved trading systems enable more liquid markets and lower energy prices for customers.

To enhance grid management and resilience, 86% of mature T&D utilities recognize that research and innovation in e-mobility services are crucial to advance electric vehicles and related infrastructure, versus 28% of others (see graphic). These utilities are accelerating the integration of EVs into smart grids to help balance supply and demand.

Finally, 3.3 times more of leading utilities are exploring dynamic energy transactions by using energy tokens for peer-to-peer energy trading. By enabling consumers to participate in grid flexibility services, electric utilities can increase customer engagement and satisfaction while boosting overall energy efficiency.

Top three market innovation capabilities more prevalent at mature electric utilities

- **Research and innovation for energy balancing and physical trading at the distribution level.**
  - **86%***
  - 26%*

- **Research and innovation for e-mobility services are conducted.**
  - **86%***
  - 28%*

- **Dynamic energy transactions are enabled through energy tokenization.**
  - **77%**
  - 23%

*nc 20 results should be considered directional

3.3x more

3.1x more

3.3x more

Most mature 25%

All other respondents
The customer experience (CX) domain of the CEMM assesses how utilities deliver personalized service and provide customer satisfaction. On average, nearly four times more of the top 25% electric utilities apply data, analytics, and platform capabilities in three important ways to support customer engagement (see graphic).

The most mature electric utilities are digitizing customer service at a higher rate—86% provide self-service capabilities compared with only 18% of others. And four times more of the mature participants have fully implemented CX platforms to streamline services, improve engagement, and leverage data analytics.

Finally, all of the high performers recognize that personalized experiences increase customer satisfaction. While leaders use analytics for personalized service, more than half of the others do not. Providing personalized energy reports and advice helps customers understand energy consumption and find ways to reduce energy usage during peak periods to cut costs.

**Top three customer experience capabilities more prevalent at mature electric utilities**

<table>
<thead>
<tr>
<th>Customer self-service capabilities for management of products and service resolution are provided.</th>
<th>86%*</th>
<th>4.8x more</th>
</tr>
</thead>
<tbody>
<tr>
<td>18%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consolidated customer experience platforms have been established.</td>
<td>86%*</td>
<td>4.1x more</td>
</tr>
<tr>
<td>21%*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analytics are used to personalize customer experience.</td>
<td>100%</td>
<td>2.6x more</td>
</tr>
<tr>
<td>39%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*< 20 results should be considered directional
Mature electric utilities are 5.7 times more likely than less mature organizations to use AI and ML to enable optimization of design, forecasting, scheduling, assets, and inventory.
Action guide: Take the next steps to clean electrification

Here are four steps any electric utility company can take now to increase its maturity and make progress on the clean electrification journey.

01 Find out where your organization falls on the clean electrification maturity spectrum (CEMM).

Use the CEMM tool to determine the maturity of your capabilities, based on industry benchmarks. Make this an enterprise-wide initiative that includes professionals across different business areas. Once you know your starting point, you can develop a strategic roadmap to achieve your objectives.

02 Set maturity targets in priority domains and track your progress.

Once you have completed the assessment, use it to establish maturity targets in domains with the most impact. Provide longer-term projects with sufficient resources and budgets. For many electric utilities, a focus on modernizing grid operations and implementing digital technologies can yield the most significant results.

03 Start with two or three quick-win projects.

This will enable you to demonstrate success quickly and encourage stakeholders to move on to larger-scale, company-wide projects with strategic impact.

04 Drive clean electrification initiatives at all levels of your organization.

Supervise clean electrification initiatives across the enterprise to coordinate and track results. Markers of improved capabilities can include better financial performance, enhanced customer service, greater operational flexibility, strengthened cybersecurity, and more sustainable operations.
Understand where your electric utility is on the path to clean electrification and more sustainable operations.
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Study approach and methodology

The IBM Institute of Business Value and APQC surveyed 105 electric power utilities that participate in the generation, transmission, distribution, and retail segments from 26 countries. The utilities assessed their level of maturity using the APQC Clean Electrification Maturity Model (CEMM) online assessment tool. Respondents told us how they performed on key performance indicators and answered questions to enable assessment of the maturity of their capabilities across the eight CEMM domains which include Strategy and Leadership, Organization and Culture, Technology, Sustainability, Grid Operations, Work and Asset Management, Customer Experience, and Market Innovation. Responses for 15 organizations that do not participate in the transmission and distribution segments were excluded from the analysis of this report.

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Benchmark Insights feature insights for executives on important business and related technology topics. They are based on analysis of performance data and other benchmarking measures. For more information, contact the IBM Institute for Business Value at global.benchmarking@us.ibm.com.

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Notes and sources


