Utility 4.0

Utility 4.0 represents a transformative paradigm that leverages advanced technologies, digitalization, and intelligent systems to revolutionize the way energy companies operate in the renewable energy landscape. It heralds an era of enhanced efficiency, reliability, and sustainability, empowering renewable energy companies to navigate the complexities of a rapidly evolving energy ecosystem.

Technology Considerations

When considering the technology architecture of Utility 4.0, several key aspects come into play. Utility 4.0 emphasizes the integration of advanced technologies to enable digital transformation and optimize utility operations.

- Internet of Things (IoT)
- Data Management
- Advanced Analytics & AI
- Cloud Computing and Edge
- Communication Networks
- Cybersecurity
- Integration
- Interoperability

In This Issue

Embracing Utility 4.0 in the Renewable Energy Industry

By Tim Hardwick

Embracing Utility 4.0 in the Renewable Energy Industry.

In the face of escalating global energy demands and the urgent need to combat climate change, the renewable energy sector has emerged as a beacon of hope. With its remarkable potential to harness clean, sustainable power from natural resources, renewable energy has become a cornerstone of the transition towards a low-carbon economy. However, the successful integration and efficient management of renewable energy sources require innovative approaches that go beyond traditional utility systems. This is where Utility 4.0 steps in.

Utility 4.0 represents a transformative paradigm that leverages advanced technologies, digitalization, and intelligent systems to revolutionize the way energy companies operate in the renewable energy landscape. It heralds an era of enhanced efficiency, reliability, and sustainability, empowering renewable energy companies to navigate the complexities of a rapidly evolving energy ecosystem.

The renewable energy landscape is evolving at a rapid pace, presenting both opportunities and challenges for companies in the sector. To navigate this complex terrain and achieve their sustainability goals, organizations require a comprehensive and well-designed architecture that can integrate various components and technologies seamlessly.

While no single architecture framework is tailor-made for renewable energy, integrating multiple frameworks can provide a holistic approach that addresses the unique requirements of the industry.

In this edition of Tech Times, we delve into the world of Utility 4.0, exploring its key components and highlighting its significance for renewable energy companies. We will uncover how this next generation of utility systems is reshaping the industry, propelling it towards greater adoption of renewable energy sources and enabling a more sustainable future.

We also take a look at the process of integrating architecture frameworks to create a cohesive and meaningful architecture for renewable energy companies. We explore the key building blocks, industry standards, and frameworks that contribute to a holistic architecture. By blending methodologies such as TOGAF, OSGP, IIR, NIST CPS Framework, IEC 61850, the Zachman Framework, and other relevant guidelines, organizations can establish a foundation that aligns with best practices and caters to their specific needs.

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Distributed Energy Resources (DER)

DER refers to decentralized small-scale power generation units located near the point of consumption. DER is a key component of Utility 4.0, which incorporates advanced digital technologies, automation, and data analytics. DER enables a shift towards a resilient, efficient, and sustainable energy system.

It promotes decentralized generation, reducing the need for long-distance transmission and enhancing grid reliability.

DER primarily consists of renewable energy sources, facilitating greater integration of clean energy into the grid.

It focuses on energy efficiency and demand-side management, capturing waste heat and optimizing overall system efficiency.

DER empowers consumers to become prosumers by generating their own power and participating in grid activities.

Utility 4.0 leverages advanced technologies for monitoring and managing DER systems, optimizing energy dispatch and grid stability.

DER enhances grid flexibility, resilience, and the ability to respond to fluctuations in demand and supply.

In summary, DER in Utility 4.0 transforms the traditional utility model by promoting decentralization, renewable energy integration, energy efficiency, and customer empowerment, leading to a resilient, efficient, and sustainable energy ecosystem.

Utility 4.0 Components

Utility 4.0 refers to the next generation of utility systems that leverage advanced technologies and digital transformation to enhance efficiency, reliability, and sustainability.

Utility 4.0 refers to the next generation of utility systems that leverage advanced technologies and digital transformation to enhance efficiency, reliability, and sustainability. While there may be different interpretations and variations of Utility 4.0, here are some key components typically associated with it:

- **Smart Grid:** Utility 4.0 involves the integration of a smart grid infrastructure, which uses advanced sensing, communication, and control technologies to optimize the generation, distribution, and consumption of electricity. Smart grids enable real-time monitoring, automation, and two-way communication between utilities and customers.

- **Distributed Energy Resources (DERs):** Utility 4.0 incorporates a greater adoption of distributed energy resources, such as solar panels, wind turbines, energy storage systems, competitive electricity transmission and electricity interconnectors. These resources allow for decentralized energy generation, load balancing, and flexibility in the grid.

- **Internet of Things (IoT):** IoT devices play a crucial role in Utility 4.0 by enabling connectivity and data exchange between various components of the utility system. Sensors, meters, and other IoT devices collect real-time data on energy consumption, grid performance, and equipment condition, allowing for better decision-making and predictive maintenance.

- **Advanced Analytics and Artificial Intelligence (AI):** Utility 4.0 relies on advanced analytics and AI techniques to process vast amounts of data collected from different sources. AI algorithms can analyse data patterns, predict energy demand, optimize grid operations, and identify anomalies or potential failures, enabling more efficient and proactive management of the utility system.

- **Cybersecurity:** As utility systems become more digitized and interconnected, robust cybersecurity measures become essential to protect against potential cyber threats and ensure the integrity and reliability of the grid. Utility 4.0 emphasizes the implementation of strong security protocols, encryption, and monitoring systems to safeguard critical infrastructure.

- **Customer Empowerment:** Utility 4.0 aims to empower customers by providing them with real-time data on their energy consumption, personalized energy management tools, and options for demand response. Customers can make informed decisions, optimize their energy usage, and actively participate in demand-side management programs.

- **Electrification and Decarbonization:** Utility 4.0 promotes the electrification of various sectors, including transportation and heating, as a means to reduce greenhouse gas emissions. By integrating renewable energy sources and supporting decarbonization efforts, utility systems contribute to sustainability goals and a cleaner energy future.

These components highlight the key features of Utility 4.0, focusing on digitalization, connectivity, automation, and sustainability to drive the transformation of traditional utility systems into more intelligent, efficient, and responsive entities.

Technology Architecture

The technology architecture of Utility 4.0 is focused on leveraging IoT, data management, advanced analytics, AI, communication networks, cloud computing, edge computing, cybersecurity, and integration to enable the digital transformation of utility companies.

These technologies work together to optimize operations, enhance decision-making, improve efficiency, and deliver value to both the utility providers and their customers.

- Internet of Things (IoT)
- Data Management
- Advanced Analytics & AI
- Cloud Computing and Edge
- Communication Networks
- Cybersecurity
- Integration
- Interoperability

Key Technology Considerations

When considering the technology architecture of Utility 4.0, several key aspects come into play. Utility 4.0 emphasizes the integration of advanced technologies to enable digital transformation and optimize utility operations. Here's an overview of how technology architecture is involved in Utility 4.0:

- **Internet of Things (IoT):** IoT plays a significant role in Utility 4.0. It involves the deployment of sensors, smart devices, and meters across the utility infrastructure. These devices collect and transmit data in real-time, enabling utilities to monitor and control various aspects of their operations, including energy generation, distribution, consumption, and equipment performance.

- **Data Management:** Utility 4.0 relies on robust data management systems to handle the vast amount of data generated by IoT devices and other sources. This includes data storage, processing, and analytics capabilities to derive actionable insights from the data. Technologies like big data platforms, data lakes, data warehouses, and data analytics tools are employed to analyse and utilize the data effectively.

- **Advanced Analytics and Artificial Intelligence (AI):** Utility 4.0 leverages advanced analytics and AI techniques to extract valuable insights from the data collected. Predictive analytics models can be developed to forecast energy demand, optimize asset maintenance, detect anomalies, and identify patterns for better decision-making. AI technologies, such as machine learning and deep learning algorithms, enable the automation of processes and the development of intelligent systems.

- **Communication Networks:** Robust and secure communication networks are essential for Utility 4.0. These networks facilitate the seamless exchange of data between devices, systems, and stakeholders. Technologies such as wireless communication protocols, fibre optics, and cellular networks are utilized to ensure reliable and efficient data transmission across the utility infrastructure.

- **Cloud Computing and Edge Computing:** Cloud computing and edge computing technologies play crucial roles in the architecture of Utility 4.0. Cloud platforms enable scalable storage, processing, and analysis of utility data, offering flexibility and cost efficiency. Edge computing brings computing capabilities closer to the data source, reducing latency and enabling real-time processing at the edge of the network. This is particularly useful for time-sensitive applications, such as grid optimization and asset monitoring.

- **Cybersecurity:** With increased connectivity and digitalization, robust cybersecurity measures are vital for Utility 4.0. Technologies like firewalls, intrusion detection systems, encryption protocols, and access controls are employed to protect utility systems and data from cyber threats. Additionally, techniques like anomaly detection, threat intelligence, and security analytics are utilized to proactively identify and mitigate security risks.

- **Integration and Interoperability**: Utility 4.0 requires seamless integration and interoperability among various systems, devices, and stakeholders. Service-oriented architectures (SOA), application programming interfaces (APIs), and data standards (e.g., CIM, IEC 61850) facilitate the interoperability and integration of different technologies and applications within the utility ecosystem.

The Open Smart Grid Protocol (OSGP)

OSGP is a framework that provides a standardized and interoperable approach to designing and implementing smart grid systems.

OSGP is a family of specifications published by the European Telecommunications Standards Institute (ETSI). OSGP, ETSI TS 104 001, is a relatively new but widely used specification for smart meter and smart grid devices, with over 5 million OSGP based smart meters and devices deployed worldwide.

OSGP is a very efficient data representation and interchange protocol that delivers high effective throughput on narrowband Power Line Communications (PLC) and other links.
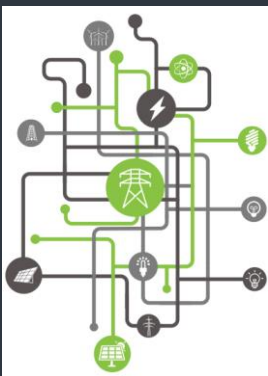
Architecture Framework for Renewable Energy

While there isn't a standardized architecture framework specifically tailored for creating a holistic architecture for renewable energy, several existing frameworks and standards can be adapted to develop a comprehensive architecture. Here are a few commonly used frameworks that can guide the creation of a holistic architecture for renewable energy:

- **NIST Framework for Cyber-Physical Systems (CPS):** The National Institute of Standards and Technology (NIST) provides a framework for designing secure and interoperable CPS, which can be applied to renewable energy systems. It addresses aspects such as system architecture, interoperability, cybersecurity, and data management.
- **IEC 61850:** This international standard focuses on the communication and interoperability of power utility automation systems. It provides guidelines for the design and integration of various components, including renewable energy sources, into the utility grid, ensuring seamless communication and control.
- **The Open Smart Grid Protocol (OSGP):** OSGP is a family of specifications published by the European Telecommunications Standards Institute (ETSI). OSGP, ETSI TS 104 001, is a relatively new but widely used specification for smart meter and smart grid devices.
- **Industrial Internet Reference Architecture (IIRA):** The Industrial Internet Consortium's (IIC) IIRA provides a comprehensive framework for designing and implementing industrial Internet of Things (IIoT) systems. It can be adapted to incorporate renewable energy technologies and optimize the integration of renewable sources within the energy ecosystem.
- **Zachman Framework:** The Zachman Framework, often used for enterprise architecture, can be applied to develop a holistic architecture for renewable energy. It provides a structured approach to identify and organize architectural artifacts, addressing various perspectives such as business, information, technology, and more.
- **TOGAF (The Open Group Architecture Framework)** is a widely used framework for enterprise architecture. It provides a comprehensive approach to designing, planning, implementing, and managing an enterprise's information technology architecture. The framework was developed by The Open Group, a consortium of organizations involved in the IT industry. TOGAF consists of a set of best practices, methodologies, and guidelines that help organizations align their business objectives with their IT strategy. It offers a structured approach to creating and maintaining enterprise architectures, enabling organizations to achieve consistency, efficiency, and interoperability in their IT systems.

What is a Reference Architecture?

A reference architecture provides guidance for the development of system, solution and application architectures. It provides common and consistent definitions for the system of interest, its decompositions and design patterns, and a common vocabulary with which to discuss the specification of implementations and compare options.

A reference architecture also provides a common framework around which more detailed discussions can centre. By staying at a higher level of abstraction, it enables the identification and comprehension of the most important issues and patterns across its applications in many different use cases. By avoiding specifics, a reference architecture allows subsequent designs to follow the reference architecture without the encumbrance of unnecessary and arbitrary restrictions.

The Industrial Internet Reference Architecture (IIRA)

The IIRA is a standards-based open architecture for IIoT systems. The IIRA maximizes its value by having broad industry applicability to drive interoperability, to map applicable technologies, and to guide technology and standard development.

IIRA enables seamless integration of industrial components, emphasizes security measures, supports scalability and adaptability, facilitates data analytics, and promotes collaboration among industry stakeholders.

Architectural Considerations

When designing a holistic architecture for renewable energy, it is essential to consider factors like system interoperability, scalability, cybersecurity, data management, and stakeholder requirements. Adapting and combining elements from relevant frameworks can provide a foundation for creating a comprehensive architecture that aligns with the specific needs of renewable energy systems and promotes the integration of diverse technologies and stakeholders.

It is important to note that the choice of framework or architecture should be tailored to the specific context, requirements, and standards relevant to the renewable energy project or organization. While frameworks like TOGAF, NIST CPS Framework, IEC 61850, and the Zachman Framework can provide valuable guidance, they are not exclusively designed for renewable energy. These frameworks offer general principles, methodologies, and best practices that can be applied to various industries, including renewable energy.

Given the unique aspects and evolving nature of the renewable energy sector, organizations often customize and adapt existing frameworks to address the specific requirements and challenges of renewable energy systems. This customization may involve incorporating aspects such as renewable energy generation, grid integration, energy storage, demand response, and sustainability considerations. Additionally, some countries and organizations have developed their own guidelines, frameworks, and standards that focus on renewable energy system integration and architecture. These resources are typically tailored to specific regional or organizational contexts.

Therefore, while there isn't a dedicated architecture framework exclusively for renewable energy, organizations working in this field can draw upon existing frameworks, standards, and industry-specific guidelines to develop a holistic architecture that meets their specific needs and aligns with best practices in the renewable energy sector. IT systems.

The TOGAF Standard, 10th Edition is a significant structural change to support the separation of universal concepts, stable best practice, and thought leadership.

This version of the standard makes adoption of stable best practice and emerging ideas easier.

Combining universal concepts, stable best practice guidance, and emerging ideas is how you develop and use the best Enterprise Architecture.

Any organization undertaking the development of an Enterprise Architecture to guide change and improvement will benefit from use of the TOGAF Standard.

It provides stable best practice to develop, maintain, and use an Enterprise Architecture.

Enterprise Architecture & TOGAF

The Open Group Architectural Framework (TOGAF®) is a methodology and framework for Enterprise Architecture, aimed at enhancing business efficiency. By utilizing TOGAF®, businesses can establish their objectives and align them with architectural goals related to enterprise software development. For over 25 years, TOGAF® has served as a common language for enterprise architects (EAs) to devise IT development strategies. Its inception in 1995 aimed to facilitate structured collaboration between enterprises and enterprise architects, enabling effective coordination of cross-departmental projects to meet crucial business objectives. Primarily, TOGAF® strives to achieve the following key business requirements, as outlined by the Open Group Architectural Forum:

- Ensuring a shared language among all stakeholders.
- Standardizing open methods for enterprise architecture to avoid reliance on proprietary solutions.
- Saving time, money, and resources while maximizing their utilization.
- Demonstrating tangible return on investment (ROI).

To enforce systematic and repeatable implementation of the above objectives, organizations can follow the TOGAF® Architectural Development Method (ADM), a customizable process that manages the requirements of large-scale IT modernization initiatives across various stages.

In 2022, The Open Group introduced the 10th Edition of the TOGAF Standard, superseding the previous 9.2 Edition. This update aims to enhance the ease of adoption and implementation of TOGAF's best practices. The 10th Edition offers improved efficiency, simpler navigation, and increased accessibility, making the framework more user-friendly for organizations.

When applied to renewable energy systems, TOGAF can assist in developing an architecture that incorporates renewable energy sources, optimizes energy management, and aligns with business objectives. It aids in defining the necessary architectural viewpoints, establishing interoperability, and addressing various aspects such as security, scalability, and data management.

Moreover, TOGAF can facilitate the integration of renewable energy systems into existing enterprise architectures, ensuring seamless connectivity and compatibility with other organizational systems and processes. It supports the identification and management of stakeholders, risks, and dependencies, enabling a holistic approach to architecture development. By leveraging TOGAF as a framework, renewable energy companies can benefit from a standardized and proven methodology for architecting their systems. It provides a structured approach to tackle the complexities of renewable energy integration and ensures alignment with industry best practices and standards.

The Origins of the Pace Layered Architecture

In looking at how other industries deal with the problem of variable rates of change in complex systems, Gartner came across the concept of pace layers as developed by Stewart Brand in his book, "How Buildings Learn" (1994).

He was addressing the challenge of designing a building that would have a long and useful life, be resilient to change, and be able to accommodate the needs of various owners and occupants. His technique was to identify a series of layers, ranging from the building site, which never changes, to the "stuff," such as chairs, lamps and pictures, that might move around on a daily or weekly basis.

In between are layers, like the building structure, which could last 100 years; the skin or exterior surface, which might be redone every 20 years; and the services, such as plumbing; heating, ventilation and air-conditioning (HVAC) or electrical wiring, which are often replaced or updated in seven to 15 years.

These architectural layers have very different paces of change, but they must be designed to work together for the building to function effectively.

Gartner believed that the same idea of pace layers could be used to build a business application strategy that delivers a faster response and a better ROI, without sacrificing integration, integrity and/or governance.

Pace Layered Architecture

The Pace Layered Architecture (PLA) adds significant value when designing and managing complex systems, including those related to renewable energy. PLA, developed by Gartner, is an architectural approach that recognizes the varying rates of change in different components of a system and provides a framework for managing those changes effectively. In the context of renewable energy, the PLA can offer several benefits:

- **Agility and Flexibility:** Renewable energy systems are subject to rapid technological advancements, policy changes, and market dynamics. The PLA allows organizations to segment their architecture into different layers based on the pace of change. This segmentation enables them to respond swiftly to evolving requirements, leveraging more agile components while ensuring stability in core systems.

- **Innovation and Experimentation:** The PLA encourages innovation by allowing organizations to introduce new technologies, pilot projects, and experimental solutions in the fast-changing layers without disrupting the stability of critical components. This flexibility supports the exploration of emerging renewable energy technologies and their integration into the architecture.

- **Scalability and Modularity:** Renewable energy systems often require scalability to accommodate increasing energy generation, storage, and distribution capacities. The PLA facilitates scalability by separating the architecture into layers, enabling the modular growth of individual components without affecting the overall system's stability.

- **Risk Management:** With the PLA, risk management becomes more effective. By differentiating the layers, organizations can focus risk mitigation efforts on critical and stable components while experimenting with new technologies and approaches in the faster-changing layers. This approach minimizes the impact of potential failures or disruptions on the entire system.

- **Integration and Interoperability:** Renewable energy systems involve the integration of diverse components, technologies, and stakeholders. The PLA provides a structure for integrating and managing different layers with varying dependencies, ensuring interoperability and seamless interaction between components.

- **Futureproofing:** The PLA supports futureproofing of renewable energy systems by accommodating changes in technology, regulations, and business models. Organizations can update or replace components in the faster-changing layers without compromising the stability and longevity of the underlying infrastructure.

By adopting the PLA, organizations in the renewable energy sector can achieve a balance between innovation and stability, agility and reliability, and adaptability and scalability. It enables them to effectively navigate the complexities of the renewable energy landscape, promote sustainable growth, and stay ahead in an evolving industry.

Integrating Architecture Frameworks

Identify Relevant Frameworks

- TOGAF
- IIRA
- OSGP
- NIST CPS Framework
- IEC 61850
- Zachman Framework

Define Architecture Objectives

Conduct Gap Analysis

Customise & Align Frameworks

Establish Integration Patterns

Establish Governance Mechanism

Communicate & Train

Continuously Evolve & Improve

Integrating Architecture Frameworks

Integrating multiple architecture frameworks to make sense in a renewable energy company requires a thoughtful approach and customization to fit the specific needs and context of the organization. Here are some steps to help guide the integration process:

- **Identify Relevant Frameworks:** Assess the architecture frameworks available and identify the ones that align most closely with the goals and requirements of the renewable energy company. Consider frameworks such as TOGAF, IIRA, OSGP, NIST CPS Framework, IEC 61850, and Zachman Framework, as well as any industry-specific guidelines or standards that may be applicable.

- **Define Architecture Objectives:** Clearly define the objectives of the architecture integration effort within the renewable energy company. Identify the key focus areas, challenges, and goals that need to be addressed. This will help determine the specific aspects and components from each framework that need to be integrated.

- **Conduct Gap Analysis:** Perform a gap analysis to identify areas where the selected frameworks overlap or complement each other. Determine how the different frameworks can be combined to cover the necessary architectural aspects of the renewable energy company. This analysis will highlight areas where customization or alignment is required.

- **Customize and Align Frameworks:** Customize the frameworks and align them to the renewable energy company's specific requirements. This may involve adapting terminology, modifying processes, and integrating relevant components from each framework to create a cohesive and comprehensive architecture.

- **Establish Integration Patterns:** Define integration patterns or guidelines that outline how the different frameworks will work together. Establish principles for harmonizing terminology, integrating processes, and ensuring consistency across the architecture. This will provide a roadmap for integrating the frameworks and maintaining a unified approach.

- **Establish Governance Mechanisms:** Implement governance mechanisms to oversee the integration and ensure ongoing alignment. This can involve establishing an architecture review board or committee responsible for validating architecture decisions, addressing conflicts, and ensuring adherence to the integrated framework.

Continuously Evolve and Improve

- Encourage feedback.
- Monitor effectiveness.
- Make adjustments.
- Continuously evaluate.
- Continuously improve.
- Ensure relevance.
- Ensure alignment.

- **Communicate and Train:** Communicate the integrated architecture framework to relevant stakeholders within the renewable energy company. Conduct training sessions to educate employees and teams about the framework's purpose, components, and how to apply it in their respective roles. Foster a shared understanding and ownership of the integrated architecture.

- **Continuously Evolve and Improve:** Architecture integration is an iterative process. Encourage feedback, monitor the effectiveness of the integrated framework, and make necessary adjustments based on lessons learned and evolving industry trends. Continuously evaluate and improve the integration to ensure it remains relevant and aligned with the renewable energy company's objectives.

Remember, the integration of architecture frameworks is not a one-size-fits-all approach. It requires careful consideration of the organization's specific needs and the frameworks available. Adaptation, customization, and ongoing refinement are key to creating an integrated architecture framework that makes sense and adds value to the renewable energy company's operations and goals.

Holistic Architecture Frameworks

Holistic architecture framework empowers renewable energy companies to overcome challenges and seize opportunities.

By combining the strengths of multiple frameworks and tailoring them to their specific needs, organizations can navigate the complexities of the renewable energy landscape, accelerate their sustainability objectives, and lead the transition to a renewable-powered future.

By embracing this approach, organizations can forge a sustainable path, optimize resource utilization, and contribute to a greener and cleaner future.

Conclusion

As renewable energy companies navigate the complexities of the industry, the integration of architecture frameworks emerges as a crucial endeavor for achieving a holistic and effective approach. While no single framework exclusively caters to renewable energy, organizations can leverage a combination of established frameworks, such as TOGAF, NIST CPS Framework, IEC 61850, OSGP, and Zachman Framework, to develop a tailored architecture that aligns with their unique requirements.

By integrating these frameworks, renewable energy companies can unlock numerous benefits. They gain agility and flexibility to adapt to evolving technologies and market dynamics, fostering innovation while maintaining stability in core systems. Scalability and modularity enable seamless expansion as renewable energy generation and storage capacities grow. The integration also enhances risk management by isolating experimentation layers, minimizing potential disruptions, and optimizing system performance.

The integration process entails identifying areas of overlap, conducting a gap analysis, customizing the frameworks, and establishing integration patterns. Through clear communication, training, and ongoing governance, organizations can ensure a shared understanding and consistent application of the integrated architecture. The iterative nature of this process allows for continuous improvement and adaptation as the renewable energy landscape evolves.

Ultimately, a holistic architecture framework empowers renewable energy companies to overcome challenges and seize opportunities. It facilitates seamless integration of diverse technologies, promotes interoperability, and future-proofs their operations. By embracing this approach, organizations can forge a sustainable path, optimize resource utilization, and contribute to a greener and cleaner future.

In conclusion, the integration of architecture frameworks serves as a valuable tool for renewable energy companies seeking to design a comprehensive and effective architecture. By combining the strengths of multiple frameworks and tailoring them to their specific needs, organizations can navigate the complexities of the renewable energy landscape, accelerate their sustainability objectives, and lead the transition to a renewable-powered future.

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