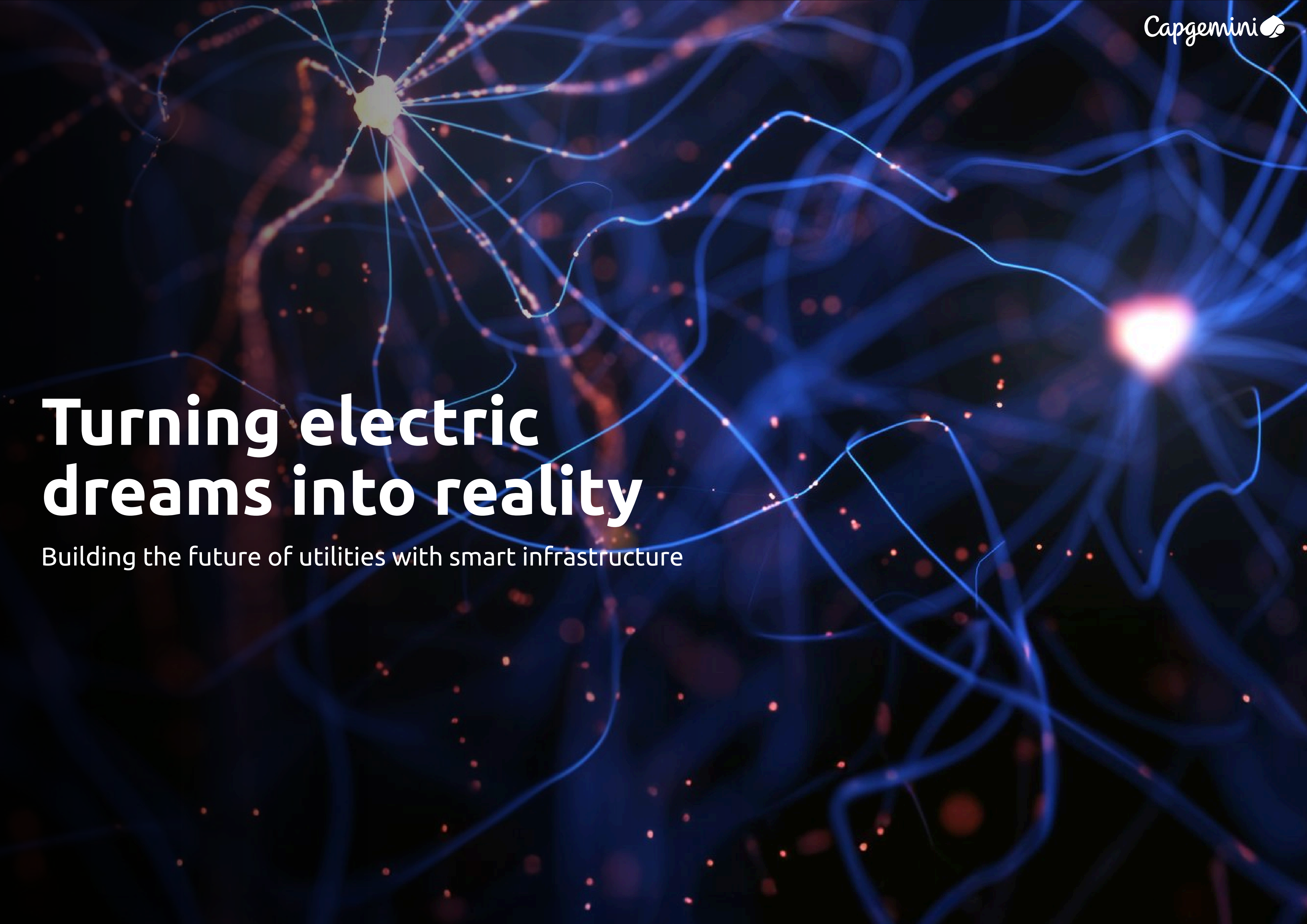


Capgemini

Turning electric dreams into reality

Building the future of utilities with smart infrastructure

Introduction

Around 20% of electricity grids worldwide will need to be replaced by 2030.[1] Many of the grids in use today underperform for one simple reason: they were initially designed for specific purposes and then modified for other uses.

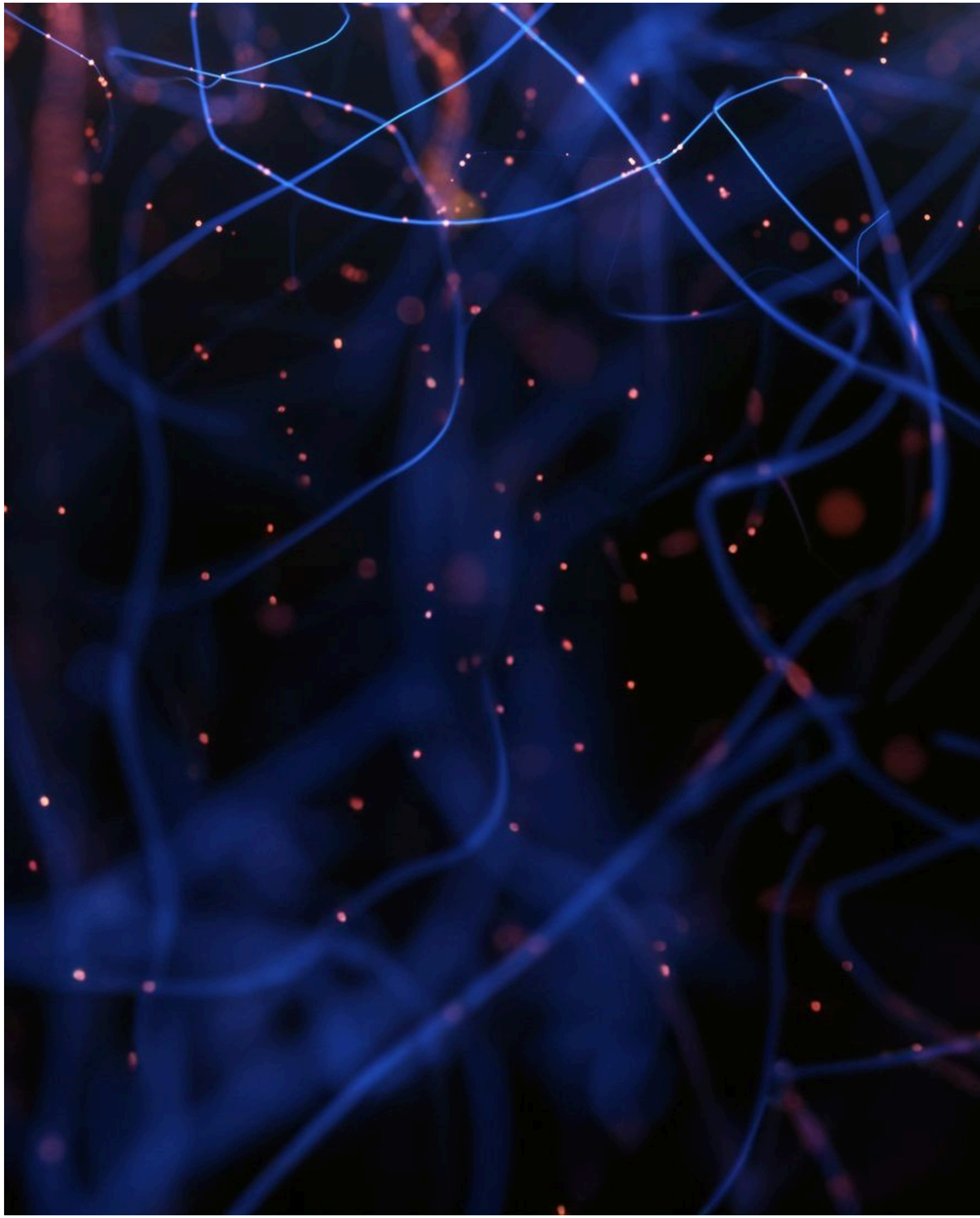
Historically, utilities deployed physical assets and operated them for decades. But, to ensure resilience for the future, modern electricity grids must embrace digital transformation and leverage data through smart infrastructure.

This means building smart grids and software platforms, and managing software as part of asset lifecycles that will now be much shorter.

At the same time, the push for increased sustainability and decarbonized energy has brought about a need for energy providers to make a radical change. Energy-related greenhouse gas (GHG) emissions contribute to over 73% of all emissions globally.[2]

The technological shift needed to reach these objectives requires the deployment at scale of smart infrastructure.

While navigating the move toward a more sustainable and resilient future, utility providers can use smart infrastructure to become more efficient, more agile, and more secure, while providing new services to their customers.



Decentralized distribution grids open up new possibilities

Modern networks rely on software platforms to facilitate decentralized distribution. The fact that production and storage assets can be disconnected from the grid offers **greater flexibility and adaptability in energy management.**

Through smart infrastructure, energy can now be produced in a hybrid way or across various territories through decentralized distribution networks. Where distribution networks were once strictly one way, decentralized distribution grids work both ways, with end users being able to act as 'prosumers' and produce energy to use themselves or inject onto the grid. Storage solutions, which were once almost non-existent, are now widely available.

[1] Electricity security in tomorrow's power systems, IEA, 2020

[2] Climate Watch, Historical GHG emissions

Key market changes

Utilities need to rethink and realign their operations, based on current trends affecting the energy sector, including:

The diversity of assets

Utility providers must consider how to effectively manage the **wide range of new asset types** that are now available on the grid. These include:

- distributed energy sources (such as solar, wind, and hydrogen)
- electric vehicles (chargers and mobile batteries)
- methane (generation and storage)
- batteries (generation and storage)
- heat pumps

An increase in the number of assets

As well as a greater number of asset types, there is also an increase in the assets themselves. Previously, when a substation transformed energy via a switchgear, the number of assets used was around 1,000. Nowadays, an EV battery used for grid management can reach **millions of assets**. Utilities can only efficiently deploy these assets on a huge scale with smart infrastructure.

Mobility

Over 16 million electric vehicles are expected to be sold worldwide in 2027.[3] And utilities need to adapt to how these vehicles consume energy. Providing energy to vehicles on-the-move presents its own set of unique challenges in terms of where the vehicles are heading and how much energy they will need.

Smart infrastructure provides a platform on which data can be monitored and exchanged in real time, leading to **a faster and more accurate balancing** of the grid. A greater number of **variable assets** also need to be taken into account, such as consumption forecasts and vehicle energy storage.

New types of services

The increased use of renewable energy has also led to new services. These include **energy-as-a-service** for electric vehicles and the **optimization of flexibility and demand/response,** which is associated with storage that is delivered by new stakeholders.

The increasing number of stakeholders

Regulators and the utilities themselves are no longer the only stakeholders in the management of the grid. Aggregators, virtual power plant providers, renewables operators, consumers as prosumers, and public network microgrids (such as hospitals) can all participate in grid management.

How smart infrastructure overcomes these challenges

To support the changes in assets, services, and stakeholders, we require a highly distributed management system that allows:

- stronger network resilience
- more efficiency in how energy is delivered
- optimized network design with increased performance and improved flexibility
- shorter deployment times at scale
- strengthened cybersecurity within new network architecture

By using multiple levels of nodes, the management system can work toward these objectives. Each of the nodes will require a certain amount of automation and decision-making capabilities. To manage the complexity of network topology, market, and technical rules, nodes will need to use ML/AI/rule-based algorithms and also possess a high level of OT/IT integration. Node configuration will inevitably change over time to align with the state of the distribution grid, as well as its topology evolution.

IoT solutions and edge technology are required to meet utilities' need to make real-time decisions. Sensors and 'attractors' on the grid gather data to inform these decisions. But it is also necessary to have compute capabilities on the edge, as the type of decisions that utilities make cannot always be managed centrally.

To ensure the smooth running of the smart infrastructure, a common software platform must be developed that allows stakeholders to exchange data in an intelligent, automated way.

Data-led solutions

The effective management of decentralized grids is largely dependent on accurate data collection and analysis. For example, leveraging vast amounts of data – including weather patterns, auction outcomes, flexibility connections, and DER (distributed energy resources) profiles – to derive valuable insights and optimize grid operations. Robust interoperable architecture lets operators effectively manage data throughout the entire grid lifecycle, ensuring the smooth integration of diverse data layers.

Data-driven grids aggregate all the data from various streams to obtain value from it. AI and ML solutions can be used to analyze the data for predictive maintenance, localized substation management, and risk-based asset planning.

Connected assets play an important role in smart infrastructure

Taking data from connected assets also allows real-time grid health monitoring and management. This means **better outage detection** and **improved grid balancing.**

Connected assets provide data that is used to create **demand/response models based on consumption patterns**. By adapting to real-time data, smart infrastructures can **optimize energy consumption** in a way that favors **renewable energy.**

Shorter lifecycles

Smart infrastructure adapts to meet trends in demand and keep up with technological advances. This level of flexibility means that its development/deployment cycles are significantly shortened, and the assets used in smart infrastructures must be replaced more quickly than the assets previously used by utilities.

Advanced metering infrastructures, for example, have been in place for over a decade and a new generation of smart meters is emerging. California and the Nordics, who deployed their first smart meters in 2010, have already begun to update their smart metering systems.

Grid operations need to be restructured

Ecosystems can be built around the grid. This includes smart substations and new software, like distributed energy resource management systems (DERMS), that address renewable energy and allow interaction with aggregators and virtual power plant suppliers.

Besides improving the efficiency of predictive maintenance, optimizing assets is crucial, as they now consist of software, as well as copper.

Distribution grids will become fully distributed eventually, and ubiquitous telecommunication technology (UTT) must decide whether to add more power lines or adopt a more agile – and innovative – approach to managing the current grid, to avoid installing more copper in the field.

Advanced asset management

Smart infrastructure – and its use of real-time data – allows utilities to improve their distribution grids through strategic planning, which includes risk management, particularly for new hazards stemming from climate change, such as wildfires and flooding.

In the event of a natural disaster, it is crucial to determine how energy can still be distributed to the location where it previously flowed.

This illustrates how asset management has evolved from simply purchasing and installing transformers to addressing a broader range of considerations.

The impact of regulators

Utilities operate under the supervision of regulators who define the direction in which energy providers must proceed. In order for utilities to continue to evolve, regulatory bodies should also adapt their regulations to fit changes within the energy sector.

Areas in need of reform

The distribution system operator (DSO) market currently focuses on hardware assets. The recognition of **software as a valuable asset** in the DSO market is needed to ensure a smooth transition to widespread smart infrastructure for utilities – and increased sustainability.

Furthermore, transmission and distribution (T&D) operators need more room to innovate. To achieve this, the energy market structure must be modernized to allow for greater aggregation and flexibility.

In addition, the boundary between transmission system operators (TSOs) and DSOs should be reviewed, with both entities taking responsibility for **demand/response forecasting and supervision.**

To support these changes, T&D operators must be responsible for capacity markets and new services, including demand response, storage, and capacity management, on top of their traditional roles in energy transmission and distribution.

Properly executing the transition to smart infrastructure

The journey toward building smart infrastructure is a long and complex one. This is why it is essential to have a strategic partner who can provide a comprehensive range of services to address the coordination of the entire ecosystem. Having different partners for different areas of the process can cause coordination issues, which can lead to delays in the process and potential cybersecurity issues.

Capgemini is an experienced partner that offers a full scope of services including consulting, project management, software integration, and engineering. Whether dealing with embedded software design for a smart substation, or the electronics that are needed to perform input-output functions within the substation, managing the legacy systems is essential. Replacing everything at once is not practical, so we need to be able to cope with the old standards while introducing new hardware. We provide a model that can manage all legacy assets to be replaced, depending on the roadmap and their value.

At Capgemini, we understand the complexities involved in building smart infrastructure and have the expertise to provide tailored solutions that meet the specific requirements of your smart infrastructure goals, efficiently and effectively.

Contacts

Frédéric Dabe

Head of Energy & Utility Center of Excellence
– Capgemini Engineering
frederic.dabe@capgemini.com

Fabrice Robert

Chief Technical Officer for Smart Utilities
– Capgemini Engineering
fabrice.robert@capgemini.com

Connect on LinkedIn with Capgemini Engineering