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A practical guide for migrating electrical architectures to the New Energy Landscape

White Paper

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Executive summary

The need for operational resilience and low carbon emissions are driving demand for new electrification solutions at all levels. Across our “always-on” world, businesses lacking the proper backup power and transfer switch architecture risk power outages that can result in immediate production losses, high restart costs, and reduced operational efficiency. Businesses are also under pressure to trim energy consumption and decarbonize. In this New Energy Landscape, powered by the Electricity 4.0 convergence of electric and digital, electrical system equipment manufacturers, utilities, and consumers must work together to devise solutions. This paper analyzes the trends driving businesses and consumers towards adopting new electrification architectures and presents options for how engineers can best navigate the transition.

Introduction

The world maintains a seemingly insatiable energy demand. According to Statista, by 2050 total energy consumption will increase 43% compared to the year 2000. Over that same period, however, renewable energy consumption is projected to increase by a factor of almost 6x. This increase is encouraging as scientists warn that to avoid disastrous (and costly) climate change events, the world will need to get to net zero by 2050.

After decades of operating in "business as usual" mode, our current energy generation, delivery, and consumption systems are radically changing. Those transitions include aggressive decarbonization and migration to both electrification and digitization.

Electricity is the most efficient energy and best vector for decarbonization. It is virtually 100% efficient at end-use with current uses today. By 2050, the share of electricity in everything we do will triple to 60-70% of the final energy mix, with wind and solar supplying nearly two-thirds of the world's electricity demand. Consequently, the energy system will inevitably switch to electrification over the coming decades to power infrastructure, buildings, homes, industry, and mobility.

Digitization, on the other hand, makes the invisible visible, enabling efficiency and eliminating waste. When connecting the physical world to digital technology, such as metering and monitoring, stakeholders can see how electricity is consumed in real-time. Accompanying apps, analytics, and software further enable data to drive more energy efficiency while lowering carbon emissions.

The much-needed transition from fossil fuels is rapidly underway.

Power grids will also transform, enabling data-driven, smart management of power networks that will address the growing demand for clean electricity and account for the increasing supply of decentralized renewable generation (such as the rolling out of new generators that support networks using eco-friendly/renewable fuels). As the power supply gets more resilient, the amount of waste from electrical transmission and distribution losses will decrease.

On a tactical level, multiple drivers are accelerating the trend toward what we now call the New Energy Landscape, which is powered by Electricity 4.0 – the convergence of electric and digital. These include:

- **A universal acceptance of sustainability commitments** – For government, business, and society, sustainability has emerged as a top priority. For example, many organizations have established environmental, social, and governance (ESG) departments, often headed by a Chief Sustainability Officer (CSO). Their core responsibility is to establish carbon reduction targets and precise dates for when decarbonization is to be achieved.

  Governments are also pushing the sustainability agenda by implementing a wide range of policy interventions and investing billions of dollars to support electrification and the transformation of industrial systems. Many citizens are embracing new technologies such as hybrid and electric vehicles (EVs), residential solar systems, and generators that integrate with renewable power generation systems to reduce the burning of fossil fuels and to decrease energy-related bills. To achieve these collective decarbonization goals, governments, businesses, and individuals are adopting cleaner, renewable energy sources on the energy supply side while transitioning their power consumption to more efficient electrified loads on the demand side.

- **Demand-side efficiency** – As electrification takes hold, energy consumers in the transportation and building sectors will transform from using gas furnaces and water heaters, to energy-efficient EVs, electric heat pumps, and high-efficiency generators. Across industries, the use of hydrogen, carbon capture, and electricity storage will increase. To effectively manage such diverse energy management strategies and technologies, the flexibility of on-site systems will be key. Factors that enhance flexibility include attention to the design of energy-related process flows and the introduction of new applications that integrate HVAC and EV, energy storage, and back-up generator systems. The full toolkit of supply-side decarbonization, process electrification, and demand-side efficiency at scale and speed will be required to achieve global decarbonization goals.

- **Rise in available funding, lowering of new technology costs** – The United States recently passed the trillion-dollar Infrastructure Investment and Inflation Reduction Act offering a once-in-a-generation investment to help retool, repower, repurpose, or replace energy infrastructures. In addition to federal initiatives, state and local rebates also play an essential role in accelerating decarbonization. In addition, financial incentives, available through the local power utilities, play an indispensable role in helping building owners migrate to smarter buildings. In some cases, the cost of modernizing new systems can be reduced by up to 30% through grants or incentives.

  On the technology front, the cost of many electrification system components, such as lithium-ion batteries for energy storage, is plummeting, making it much more affordable for organizations to invest in clean energy.

- **Development of new eco-friendly building codes and standards** – States across the nation are modernizing their building codes to enable the construction of more sustainable buildings. For example, California's Title 24 is designed to reduce wasteful and unnecessary energy consumption in newly constructed and existing buildings. In Title 24, solar panels, battery energy storage systems (BESS), and smart thermostats are required in all new commercial building applications or additions. The use of programmable thermostat settings helps minimize energy consumption, for example automatically turning down the heat or air conditioning at certain times of the day or when fewer people are in the building on weekends. Codes and standards are also being updated to reflect changes in digital electricity for feeding expanded EV networks, and for the protection and safety of microgrids and the generator systems that support them.

Critical advantages of New Energy Landscape approaches

A tipping point has now been reached due to the severe consequences of climate change. Regulators, utilities, and energy consumers agree, for many reasons, that current energy networks require new approaches to reduce environmental impact, improve efficiency, and control costs while providing a high degree of power resilience.

What is this New Energy Landscape, and how should businesses plan to navigate this new energy terrain? **Table 1** illustrates five key differences between the traditional and the evolving New Energy Landscape.

Table 1

The New Energy Landscape influences energy generation, delivery, and consumption at all levels.

	Traditional Landscape	New Energy Landscape
Power sources	Primarily two sources: fossil fuel-based utility and backup generator power	Multiple renewable sources, including solar, wind, fuel cell, and BESS, supplemented with modern backup generator and switching systems.
Power loads	Alternating Current (AC) based	Mostly Direct Current (DC) based* (requires inverters to merge into the AC network)
Characteristics	Unidirectional power flows. Switching from utility to generator typically only occurs during outages	Grid becomes bidirectional with both AC and DC power flows linking upstream and downstream, with backup generation to boost resilience.
Hierarchy	Utility is primary	Utility and distributed energy resources (DERs) work together as primary.
Mission	Resilience	Resilience and economic optimization (more sustainable, more efficient – including lower cost, faster installation, etc.)

* The global DC power supplies market is forecasted to grow at a CAGR of 4.3% from 2022 to 2032, according to a new report by Future Market Insights. The market is driven by the increasing demand for renewable energy, the need for efficient power management, and the growing adoption of smart grid technologies.

Migrating to the New Energy Landscape introduces fundamental changes to how we generate, distribute, and consume power. For example, many new electrical loads come with embedded electronics that make them "smarter." Many electronic devices today are digital by default (or software defined). What were once 'boxes' are now 'smart, connected boxes' that, combined with software and services, empower users with complete visibility of their energy usage.

In some cases, supervisory systems no longer need to exercise control over these devices – they can act autonomously. Consider the example of EV chargers. These devices can sense the number of cars they are servicing and their load demand when the vehicles plug in. If many cars are plugging in simultaneously, embedded controls regulate the charge rate to avoid system overload. For example, for a rental car fleet owner charging can be minimized when utility rates are at peak to lower overall operational costs.

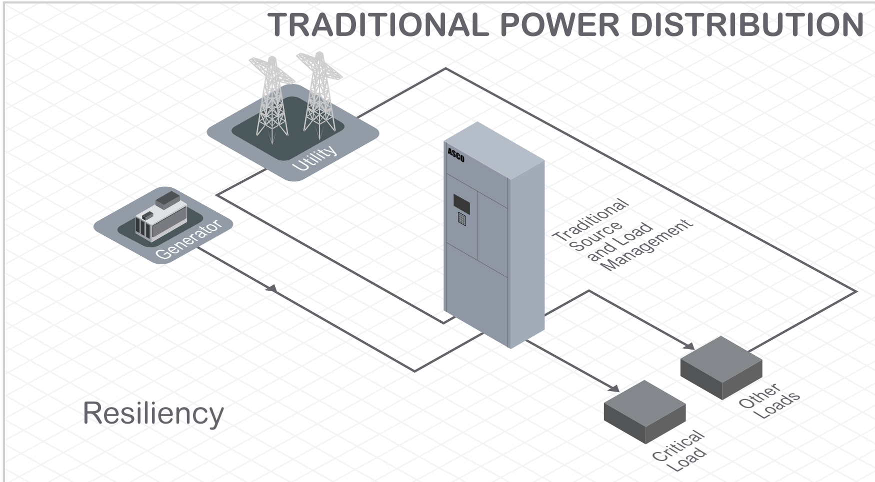

Figure 1
The traditional approach relies on two energy sources: the utility and generators.

Technologies impacted through migration to the New Energy Landscape include EVs, BESS and other backup power systems such as generators, power conversion systems, and LED lighting, among others. A typical New Energy Landscape trend is the increased presence of DC power within commercial building environments. As a result, DC solution gaps will be exposed in standard electrical infrastructure architectures. As the DC subsystems develop and merge with established electrical networks, devices such as DC breakers and DC disconnects will be required to support the new generation architectures in commercial buildings.

Control systems will involve more power conversion devices such as inverters (which accomplish the DC-to-AC conversion). Further downstream in the network, smart loads such as EV chargers will also drive increased demand for DC power and conversion of DC-to-AC power.

For example, in California net metering has been popular for several years. Net metering consists of a system of solar panels or other renewable energy generators connected to a public-utility power grid with any surplus power transferring onto the grid, allowing customers to offset the cost of power drawn from the utility.

Due to a recent policy shift, the remuneration for selling power back to the grid (exported power) is now decreasing. As a result, Californians are incented to adopt batteries with their solar installations if they want to achieve a reasonable return on investment. California represents roughly 50% of the nation's residential solar market. With the introduction of battery storage as an essential element of the solar solution, a self-consumption model is established that saves electricity when costs are low for use when prices are high.

How engineering departments can navigate the transition

For engineers looking for ways to navigate the migration to a New Energy Landscape, new-generation solutions should emphasize the simple, safe, and reliable adoption of sustainability. Tactical solutions and strategic architectures should address these three critical priorities:

1. **Simplicity** – Operational resilience is at risk when systems grow too complex. By starting with basic and straightforward smart systems, initial upfront investment costs are low, and a solid base is built to expand gradually. For example, in an electrical infrastructure the existing physical wiring can be used to drive more resilient source management (think split bus panels for bolstering redundancy). As demands on the system grow, purpose-built offers designed, integrated, and tested in a factory can be delivered as a system instead of assembling disparate pieces and parts on-site. Pre-assembled vertical integration in the factory adequately sizes and links fundamental electrical devices such as smart meters, protection relays, busbars, and breakers, saving time usually spent cabling, integrating, and coordinating. This form of simplification not only helps bolster resilience but also enables faster design and installation cycle times. By embracing tested, validated, and documented architectures, users and engineers simplify their transition to a lower-carbon electrified work environment, increasing productivity and lowering costs.
2. **Price performance** – Building a resilient electrical infrastructure environment need not necessarily generate high expenses. However, care must be taken at the design stage to implement a successful transition to workplace electrification. It is rare for an enterprise to abruptly switch from a pure diesel to a pure PV plus storage environment. Most transitions involve a hybrid approach that can access both electricity sources. Regardless, whenever a solar/BESS solution is implemented to reduce the use of CO_2 -emitting generators (when the solar/BESS solution is introduced and utilized instead of a generator), a robust isolation strategy for that BESS must first be established. Similar to the degree of resilience designed into a typical Automatic Transfer Switch (ATS) with generator configuration, the same rigor should be applied when creating a robust isolation architecture for solar solutions.
3. **Code compliance** – As the New Energy Landscape steadily reinvents how energy is generated, delivered, and consumed, electrical codes and standards are changing quickly to adapt. In many cases, technology changes are implemented faster than the codes. In such an environment, the design engineers must be engaged as closely as possible with standards bodies and their technology partners. Close collaboration will help when interpreting changes for long-term planning purposes and understanding what best practices to pursue to maintain highly resilient solutions.

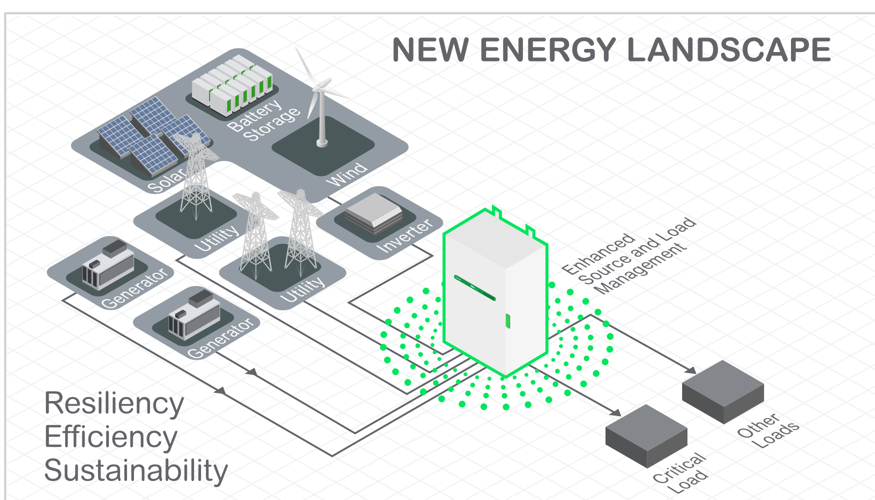

Figure 2

The New Energy Landscape approach involves multiple renewable resources.

Conclusion

We stand at a pivotal moment in time. The global need for reliable power has never been greater, and how we deliver that energy has never been more fragile. Success depends upon a sustainable balance of power generation and consumption that lowers costs while maximizing resilience. The choices we make now will be the choices that bring the world a common-sense energy approach enabled by collaboration and innovation.

We now know where the new energy journey is taking us: through changing business models and renewable energy, smart grids, and prosumers (individuals and businesses that consume and produce energy), to business owners' electric bills. New technologies enable the further development of New Energy Landscape initiatives by allowing improved operational planning, better management of grid assets and workforce. They also enable energy providers and consumers to respond quickly to marketplace pricing actions and demands.

As prosumers get more involved in the power and distribution process, utilities can realize cost savings by enabling more flexibility and faster response. Operating in such a manner implies tight interfaces between the centralized smart grids and distributed power sources, enabling communication in both directions.

Although investments in these new technologies may increase short-term capital costs, long-term advantages will include lower operating costs, reduced energy waste, and more integrated and flexible networks.