European Data Centre Association's Technical Committee

Microgrid White Paper

A White Paper from the European Data Centre Association's Technical Committee

Is the microgrid the ideal solution for adaptive and reliable energy delivered as "software defined power" for next generation data centres?

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Executive summary

Traditionally, converging trends have had a tendency to benefit the technology industry. Take, for example, the way that digital transformation has driven up the demand for data throughout almost every form of industry, increasing sales and use of all forms of IT, from handheld and mobile devices to desktops, servers and beyond. Likewise, the impact of global population growth and a consequent effect driving demand for online services, from placing bets and watching sports to planning and booking travel to following educational courses.

These examples, together with many others, have increased the requirement for more and larger facilities to house online data processing and storage equipment – data centres. Facilities which have become essential to almost every conceivable every walk of modern life.

However, by virtue of the amount of IT they accommodate, data centres have become intensive energy users – a fact that has raised concerns in many quarters as the sector and its significant growth have come increasingly into the public eye. Today, many believe that people should be put ahead of machines including IT equipment in the queue for reliable access to electrical power.

At the same time, the climate emergency has forced the issue of sustainability to the top of the agenda, creating an inflection point for humankind to consider the way that enough power can be generated to satisfy all the demands associated with population and economic growth, without the carbon emissions associated with the traditional reliance on fossil fuels.

The challenges facing us at the beginning of the 21st Century mean that we need to think again about the ways in which power is generated, distributed and utilised. We can no longer look for small, incremental improvements but rather to create a sea change.

The purpose of this White Paper is therefore to start a conversation regarding microgrids. The document makes an assessment of where the data centre industry is, with a view to opening a debate about the feasibility of data centres joining with microgrids as a way to supplement utility grid power (either by load shedding, operating in island mode at times of peak demand, or by supplying excess generated power into the grid).

It asks the question, is this a desirable step which makes data centres (and microgrids) part of the solution to increased power requirements/ contested supplies/ and escalating costs – rather than part of the problem (i.e., simply an intensive energy consumer in competition with other users for costly capacity)? We also need to ask important questions like who's going to pay for the investment, and what, if any risks, does involvement with microgrids to supplement grid power pose for the clients of colocation and enterprise data centres?

Background

Over many years of practice, data centre designers and operators have optimised facilities to reliably support the power and cooling requirements of IT equipment. The industry has been effective in designing and deploying efficient data centre infrastructure systems for prescribed and static design points, optimised to meet traditional KPIs (CapEx, OpEx, footprint, reliability, scalability etc).

Power availability and capacity for data centres used to be 100% provided by Electrical Utility Infrastructure and combined – initially recommended by standards and best practices – with on-site back-up generation in order to maintain high reliability of services in the case of interruption to the utility power supply.

Over recent years the following trends have been highlighted:

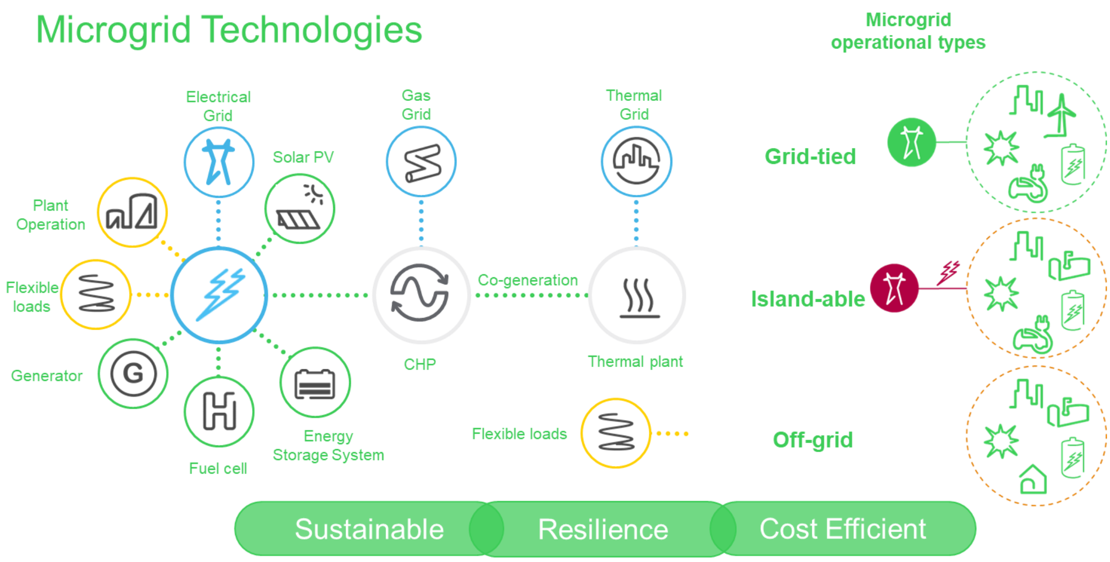
- Digital transformation has created constant demand to compute, store or exchange data, requiring additional new data centres and communication network infrastructure.
- The size of data centres is increasing in scale, moving from a typical 5MW to 20MW for large sites, with some Campus sites now reaching >300MW for hyperscale deployments.
- Ensuring full 24x7 "top down" capacity has become a challenge in some locations due to extensive power demand from all industry sectors, as well as the electrification and urbanisation of cities.
- In some cases, utility providers have installed "on site" power generation of x10MW to add local capacity to support new data centre construction.
- Most of the internet giants and some colocation companies are compensating for their Scope 2 energy carbon emissions through PPAs (Power Purchase Agreements), in turn making a contribution to the development of substantial renewable capacities (solar, wind, etc…).
- Alternative power generation technology or "green" fuels are under development, as well as other long term research projects into e.g., hydrogen, small modular reactors.

At the same time, microgrids have been deployed in various industries – by utilities or prosumers - to deliver renewable energy as complementary or alternative energy sources to the traditional utility power supply. Such projects were initially focused on small / medium sites of say, x100kWe, but more recently there has been a shift to larger capacity sites (e.g., solar or wind farms) reaching >100MW each.

Microgrid technology could, therefore, be a serious solution for data centres primary and back-up power generation capacity, able to meet high reliability and sustainability targets for today and tomorrow's business demand.

What is a microgrid?

A microgrid can be defined as; "A local electrical distribution network with **Distributed Energy Resources (DER):** generation, storage and flexible loads interconnected and coordinated by **intelligent management systems".**



A microgrid has three principal modes of operation/contracting:

1. **Grid-tied**: complementary power resources to classical utility production – hybrid system: grid + local – generally "on site" power generation operated by end-users or subcontracted to third parties.
2. **Island-able**: infrastructure that produces energy to perform in an autonomous manner – hybrid system: grid + local - operated and contracted by utilities / local utilities or third parties.
3. **Off grid:** power resources generated by alternative of utility sources - not connected to the grid - mostly operated and contracted by prosumers or third parties for local consumers.

From a consumer perspective the microgrid solution:

- Is mostly contracted with utilities or via third parties to utilities
- Offers alternative energy sources
- Changes energy distribution from a typical "top-down" paradigm to "bi-directional" flow, allowing new energy services and business models to be developed
- Is generally understood as powered by renewable or "green" energy, but can incorporate any kind of source such as (non-exhaustive):
  - Power generation or power back-up plant (diesel, gas, biofuel, H2… or a mix of energy)
  - Solar or wind farms, in some cases also hydropower… (green energy)
  - Fuel cell / hydrogen (knowing that >90% is produced today with carbonised energy)
  - Battery energy storage system (BESS) (energy stored is delivered as decarbonised energy)
  - New technology like small modular reactor (SMR) for next generation, modular nuclear power generation from ~20 to 80MW per unit (very close to decarbonised energy)

Sustainability targets

"Sustainable" data centres must – among others – measure carbon equivalent emissions from electrical power created by electricity produced, sourced or wasted based on the Greenhouse Gas (GHG) Protocol (or ISO 14064) which provides three categories to quantify energy source sustainability impacts:

- Scope 1 - Direct GHG emissions:
  All direct emissions within the operational control of an organisation.
- Scope 2 - Energy indirect GHG emissions:
  Indirect emissions generated from purchased electricity, heat, steam, or cooling.
- Scope 3 - Other indirect GHG emissions:
  All other indirect emissions from sources such as business travel, waste management, and the value chain.

For Scope 1 and Scope 2 emissions, the reduction objective is to achieve "net-zero" by the end of this decade through the use of renewable energy sources.

Scope 3 emission reductions are achieved through intelligent data centre design (architecture optimisation), quality of infrastructure sourced, footprint, weight, characteristics of raw material or components, transportation, packaging) as well as how the facility is operated and maintained (by implementing life cycle system efficiency, best practices, predictive maintenance, circularity, etc).

Problem statement

As applied over the last 25 years, "energy reliability performance" requirements have remained the same; to "**maintain power availability in any circumstances for continuity of services and be « fault tolerant ».**

Typically, this means "no single-point-of-failure" with "automatic real time reconfiguration and no interruption of IT services (after one failure)" reaching equivalent to 99.99% with 5 years frequency (at rack level) and continuous 80%+ capacity of IT nominal load according to standard (ISO 8528-1 for data centre continuous power).

By combining sustainability and reliability, the problem to solve can be summarised by the objective to have power available:

24x7 with 80%+ of IT power and Scope1+2=0

As a consequence, data centres – in common with the IT and telecommunication industry sectors – need the next generation of solutions to source, provide (directly or indirectly), distribute, store, manage and control the energy needed, aggregating various parameters that will reflect capacity, availability vs demand while achieving sustainability targets.

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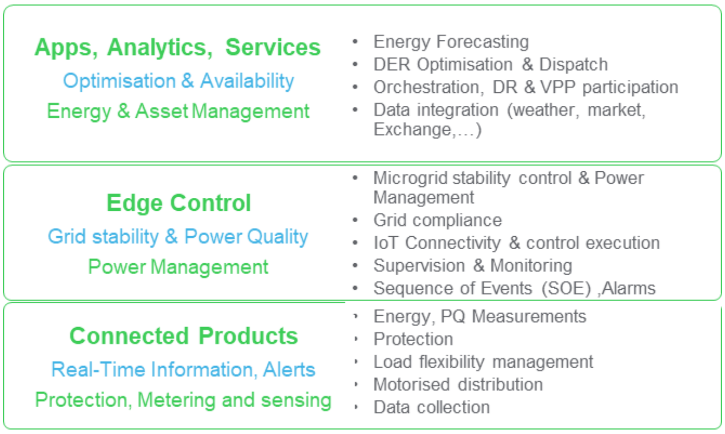
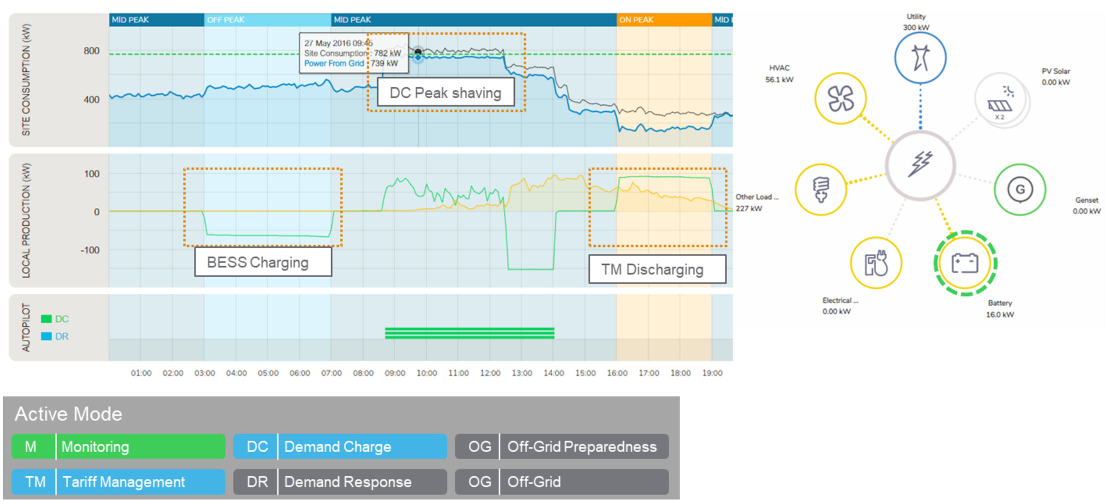
Can a microgrid provide "sustainable" energy?

Considering the production and electrical distribution from generation to the load, microgrid operational management is usually split as follows:

- Control availability of alternative parallel energy sources to secure continuity of power to the load with classical utility power which should include protection coordination, transfer sources, and reconfiguration to ensure the reliability and safety of the system.
- Optimise available energy comparing cost and capacity vs demand with forecasting, including predictive analytics to anticipate energy sourcing, developing a strategy according to energy market evolution.



Microgrid systems optimise the selection of energy while sources are activated to meet demand in real time. They also define the most appropriate times to optimise, e.g., charging battery systems (BESS charging), as well as discharging systems to mitigate tariff (TM – tariff management) or reduce demand (peak shaving), as illustrated in the diagram below.

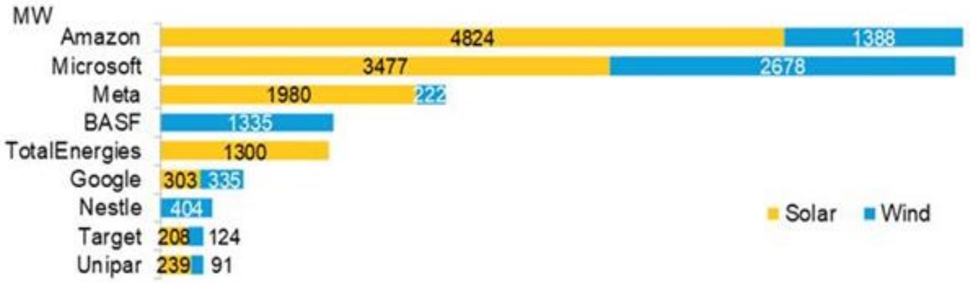


It is anticipated that the majority of microgrid infrastructure will be owned and operated by utilities or prosumers.

The proposal for data centres to operate using power generated from renewable sources is in part a response to sustainability pressures upon the sector to reduce its indirect Scope 2 emissions. The instruments used for this, power purchase agreements (PPAs), are concluded directly with power producers or their intermediaries and have helped propel the deployment of generation assets for greater renewable capacity in the energy market essentially managed by utilities.

Typically, internet giants claim that today (or in the near term), 100% of energy they purchase is from renewables under PPAs contracted directly with Utilities, prosumers or third parties/ brokers.

The following bar-chart lists "top corporate buyers of clean energy in 2021" in MW:

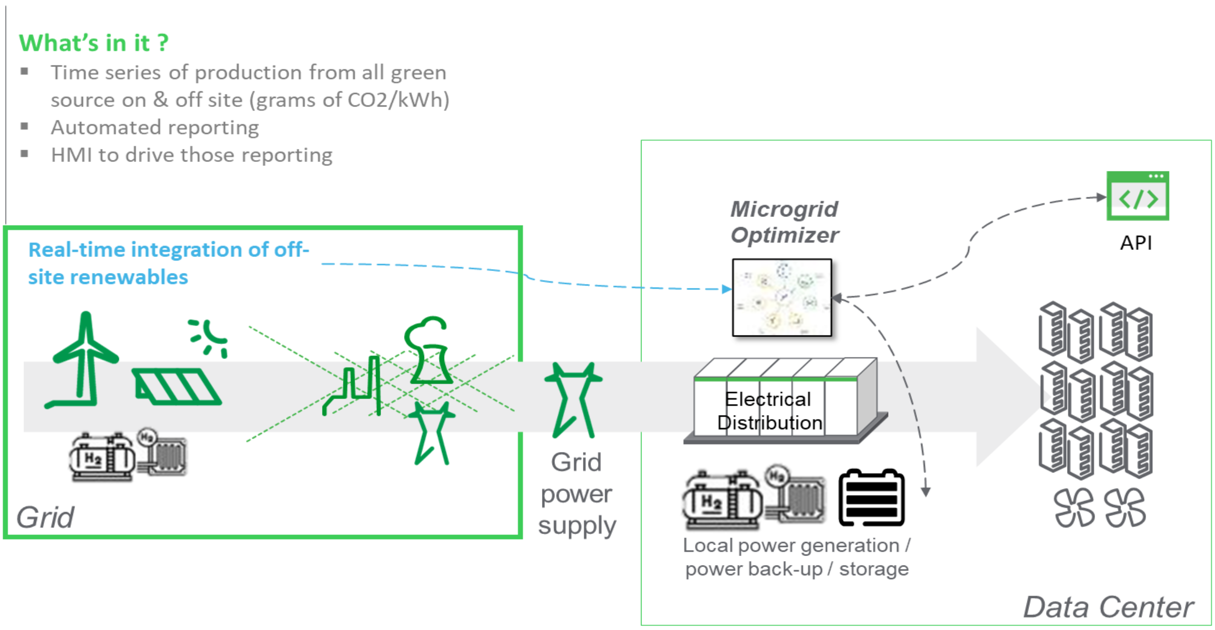


Source: BloombergNEF. Note: Onsite PPAs excluded. Data is based on publicly available information.

A PPA contract is considered as additional green power provided to the grid, but also as an "offset". In other words, it doesn't necessarily guarantee that the electricity supplied to the data centre site is composed of "green electrons," nor does it ensure that it consumes "net-zero carbon emission" electricity in real time.

For this reason, any microgrid requires an additional feature to track "energy CO2e" within its optimiser management system to assess the profile of energy coming from utilities or prosumers (or produced "on site") and ensure that energy distributed to the data centre fully meets a "net-zero" emission targets.

The next chart provides a high-level depiction of the principles of a next-generation microgrid optimiser system with the capability to provide the profile of energy supplied in real time to the data centre, allowing selection of the correct "net-zero" energy as an additional parameter to optimise operations together with cost and capacity.



How the microgrid must evolve to meet permanent power demand with full capacity and flexibility

Beyond political crisis and world complexity, and despite the massive investment in power generation, the energy market is evolving from its "historic simple top-down distribution with full and permanent capacity" to more of a "random capability to provide continuous energy" due to constant application changes and demand profiles.

Key data centre electrical requirements remain in place, and the "electrical distribution system must be able to:"

- Hand over Grid interruption and fast transfer to mitigate either electrical fault clearance time or time transfer - from x100µs to minutes (Class1) – as well as maintain power quality. Today mainly secured by UPS, ATS/STS or PSU in OCP
- Ensure back-up power in case of potential Grid interruption – from minutes up to hours even days – which has been so far generally performed by (diesel) standby power generators.

To develop "green" energy and more autonomy vs Grid, strategic design and engineering teams are exploring alternative energy sources such as the microgrid alongside:

- Energy storage (BESS) to store and provide secured energy, controlled directly by the data centre operator
- Back-up power generation using de-carbonised fuel (biogas, H2…)

- Renewable energy production (typically using a fuel cell system) to store and/or back-up energy with longer autonomy or runtime.
- Other local renewable energy sources (wind turbines, solar, hydro…) if the data centre site has the benefit of large space or appropriate environmental location.
- In the coming decade, energy production using the next generation of small modular (nuclear) reactors.

However, the availability of these solutions requires either more R&D (e.g., the development of large fuel cells, or new battery chemistries) or the assurance of an established and reliable supply chain allowing green fuel to be obtained in volume (e.g. H2) or the capability for massive deployment at scale and a reduction of cost vs. pilots - which means that designing data centre with progressive installation of those solutions - in parallel or sequentially replaced over time – is certainly a "must have".

Also, paralleling sources of energy for different loads in the context of a data centre application, demands a microgrid electrical system design that is able to (non-exhaustive):

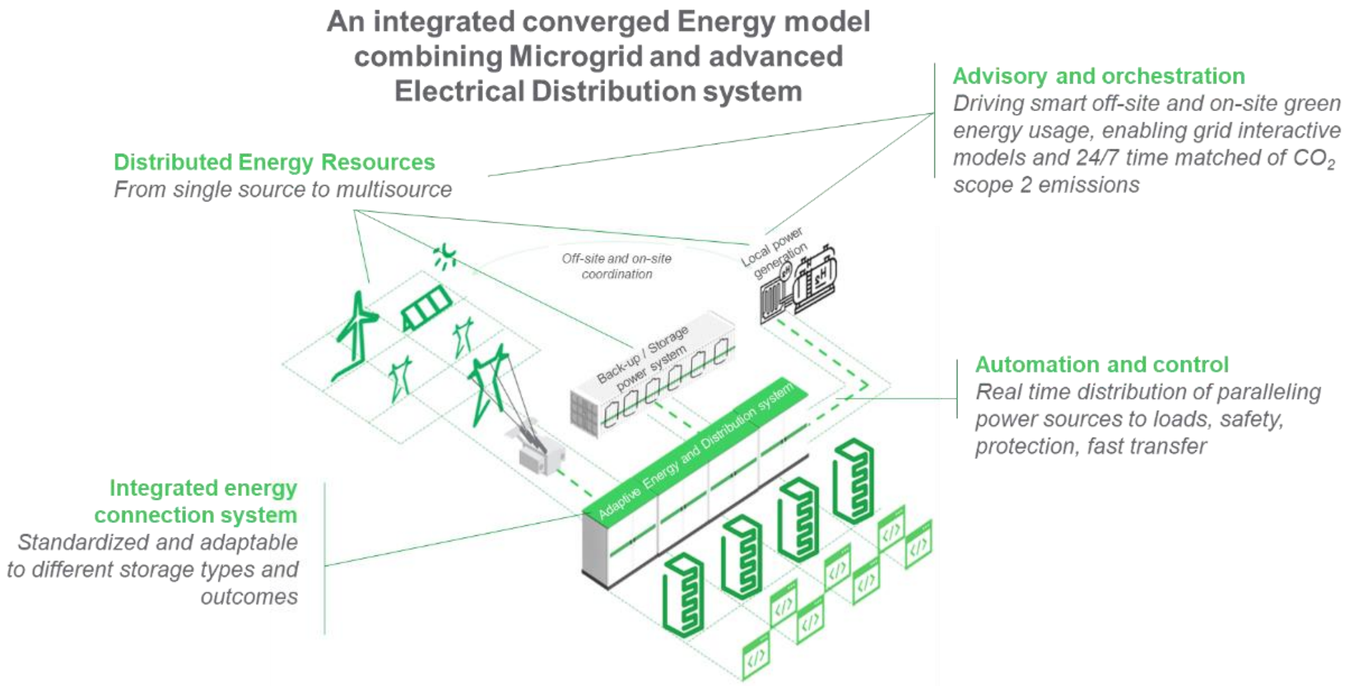
- Interconnect them – knowing that AC synchronisation is often a challenge when >2 sources.
- Combine "DERs" while providing real-time power for dynamic critical loads and distribute this capacity with "fast transfer" to meet Class 1 performance or equivalent.
- Provide real-time control energy dispatch optimisation as presented in the previous section.
- Coordinate protection and control for safety and reliable operation.
- Take into account complexity of size from large site (>10MVA) up to campus (>100MVA).
- Propose grid services with ROI controlling SLA risks

Solutions should have pre-defined scenario – or use cases – to size the different equipment for set levels of data centre autonomy – to be deployed according to business constraints, budget or project requirements in accordance with environmental conditions and related risks. As an example, the need to select which type and characteristics of grid services will be applicable according to business risks and expected ROI over a given lifetime.

Different to the classical microgrid sources provided, those for the data centre must be either "inside" the data centre and "outside" (issued by utilities or prosumers) in order to maintain the control of a given % of power. This approach is actually exactly the same as how data centres are operated and managed today, however the decision is no longer sequentially rolled out, but an aggregation of different constraints mastered to issue instantaneous results.

AI-style algorithms are already used in some existing microgrid systems to achieve this performance and fast deliver analysis and instruction to feed the SCADA system to distribute power vs demand according to capacity, timing, and scheduling.

The following diagram shows a high-level view of how electrical distribution infrastructure – as a low voltage power train - could be used to combine power management with a microgrid system to deliver an adaptive "software defined power system."



Use cases that can be implemented as key "benefits" (non-exhaustive)

- On-site prime power from utility cost optimised with expected capacity
- Real-time sustainability accounting and management - clean energy time-matching
- Optimised multi or new source data centre power backup: as "islanding" and source transfer capabilities
- Software defined power to optimise
    - Capacity
    - GHG emissions
    - Runtime
- Prosumer dispatch of DERs:
    - Frequency response
    - Tariff management
    - Peak shaving
    - Demand response
    - GHG optimisation

Conclusion

The microgrid is a solution that should support the data centre industry to be more sustainable "by design" while keeping the same performance regarding reliability and potential shortfall of power availability. It brings capacity to add flexible and parallel sources as well as secure renewable energy with optimisation features to meet business and cost constraints by enabling grid services to manage risks.

However, due to the data centre application specifics, size of sites and sustainability carbon emission tracking, some evolution of the standard microgrid offer is required to secure continuity of services and to meet the ultimate objective to reduce the use of "offsets" combining energy in real time transfer during operation including intelligent optimisation to "software-defined green power".

From the business perspective, microgrid solutions will have to accommodate the deployment and evolution of large (and more local) energy technology and manage risks while providing grid services to mitigate large investment.

Sources

Unless otherwise referenced, all diagrams, images and schematics are taken from the "Microgrid" and "Converged Energy" programs by Schneider Electric (SE).

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