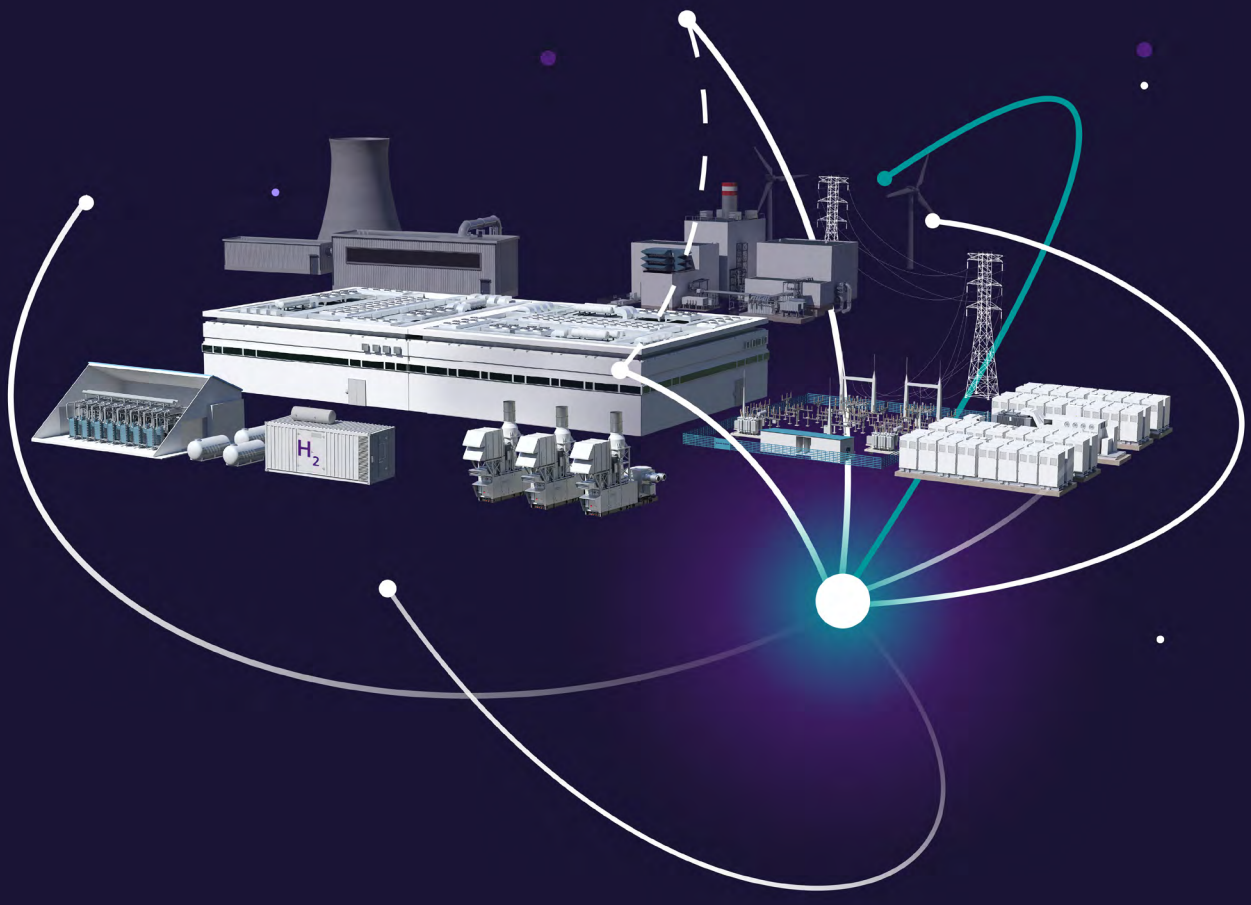
The horizon ahead

The future of European data centers



SIEMENS energy

Introduction

One of the emerging stories of the 21st century is that of data centers, and their astonishing success.

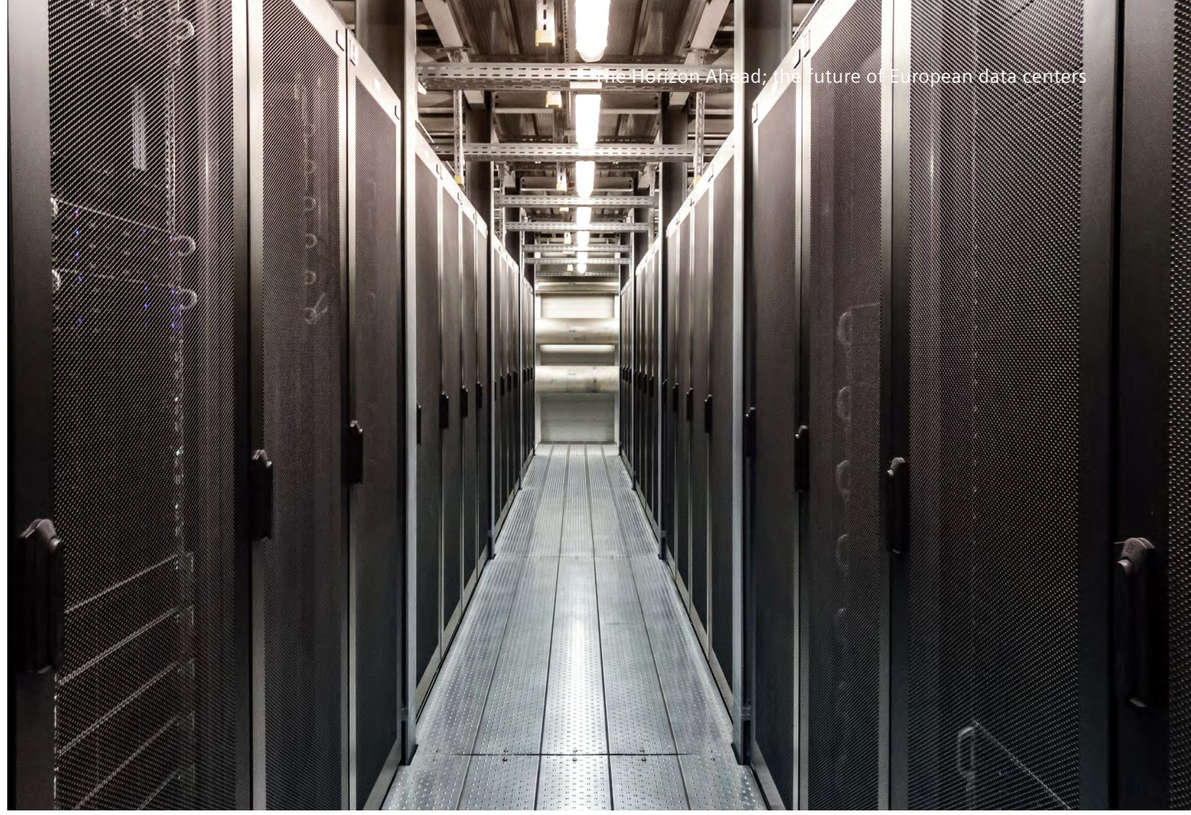
They permeate every area of life, clearly mapping to each layer of Maslow's Hierarchy of Needs; sourcing our physiological needs, providing our safety needs, all the way up to fulfilling our esteem and self-actualization needs, each through the services they enable.

Some data center-enabled businesses are household names; Ring, Uber, ChatGPT, Facebook and Netflix are among the most recognizable brands. However, the public gives little thought to how their services run, so long as they do run. Uptime is everything. For data centers, the five 9s of 99.999% availability is the holy grail. For data consumers, minor outages assume disproportionate importance in people's lives.

To extract data centers from our lives would be unthinkable, such is society's reliance upon their services. They are considered so important that in September 2024, the UK recognized data centers as being Critical National Infrastructure (CNI). This means data centers will receive greater government support in preventing and recovering from incidents like cyber attacks, power outages, or environmental disasters. Although not as far-reaching as the UK's CNI accreditation, the EU's NIS2 Directive categorises data centers as "essential" infrastructure and therefore subject to rigorous cybersecurity and operational resilience measures EU-wide.

To extract data centers from our lives would be unthinkable, such is society's reliance upon their services.

The Horizon Ahead; the future of European data centers



Corridors of power; a customer data center set-up

The impact of data centers is far-reaching, moving beyond simply storing, processing, and delivering data and applications. They have simultaneously made what we have faster to access, of better quality, with increased choice. This has made society ambitious and expectant of more.

Products offered to consumers that are centered around the provision of data are changing and improving with increasing pace; consumers are now even able to use the offerings to make their own products.

These innovations and increasing adoption curve are creating a widening gap between the speed of change of what is made available to consumers, and the normal business cycles of supporting infrastructure. Industry and business are also heavily reliant upon this infrastructure and, in particular, it being updated to keep it fit-for-purpose. Thus, data centers are faced with twin challenges; 1. achieving speed to market, and 2. securing the on-going resource for competitive operation.

Operators must overcome these challenges, while competing for resources and energy against other data centers and other grid-power intensive industries.

For data consumers relatively minor outages assume disproportionate importance in people's lives.

A changing geopolitical environment demonstrates that old certainties can no longer be relied upon, and new market entrants – disruptors – can appear without fanfare and yet create seismic impacts.

This white paper will discuss the complexity, risk and dynamic market situations that can only properly be addressed by comprehensive energy value chain expertise.

Speed to market – the urgency of now

The economic concept of First Mover Advantage (FMA) has long been acknowledged and understood; the first entrant into a market has distinct and on-going advantages of market share, brand recognition, brand loyalty and so on.

For data centers, FMA is more than a welcome advantage – it can be the pivotal factor in determining success or failure.

Data centers face challenges on at least four fronts

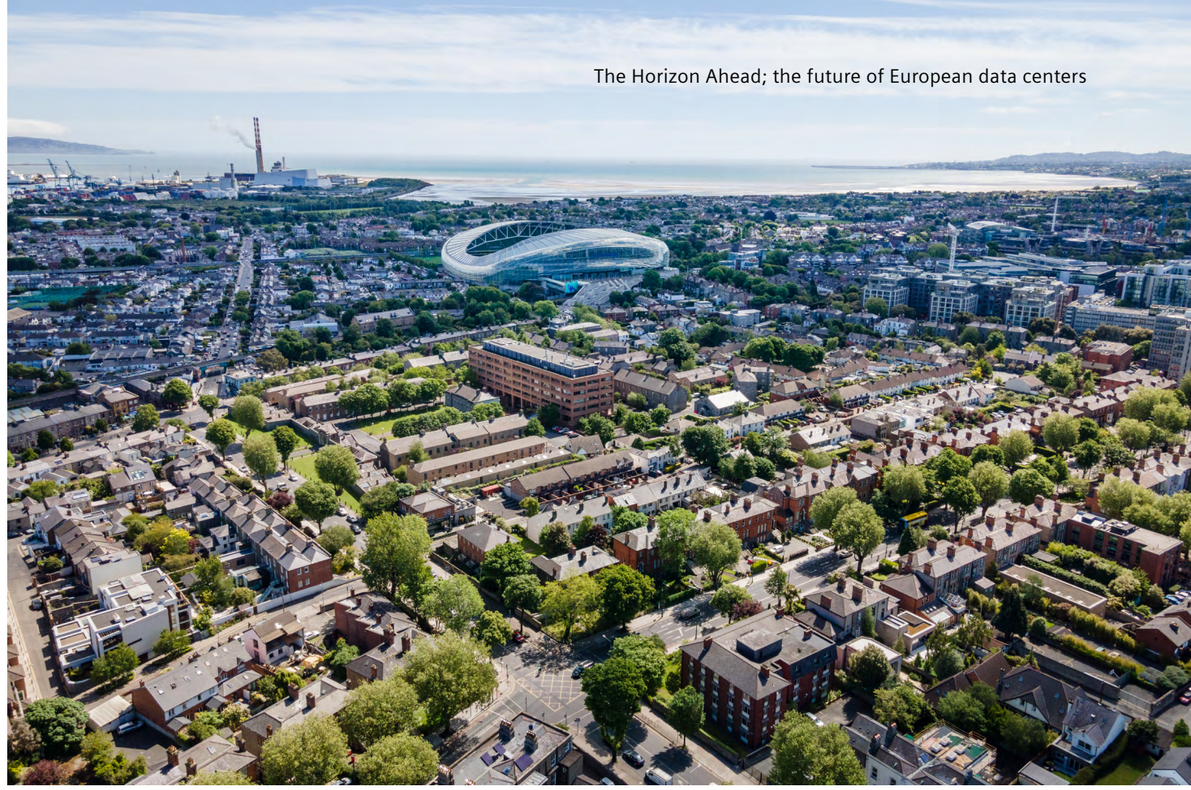
01 First, they **face competition** in their own data center type (Co-locator, Enterprise, Cloud or AI data center, see p.12 for definitions)

02 Second, they must work with grid infrastructure that can only distribute and deliver **finite capacity.**

03 Next, they must navigate **localization issues**, ranging from availability and the proximity of grid connection, to planning consents and to increasingly stringent environmental legislation.

04 Furthermore, they must also **compete with every other power-intensive industry located nearby.**

The Horizon Ahead; the future of European data centers



Urban data centers face unique challenges, but offer unique opportunities

It is not just the case that data centers benefit from the advantage of being first, it may be that the mover advantage is singular; that prospective second entrants to the market are shut out altogether. In August 2024, construction of a data center was unable to proceed because of a planning ruling[1] by South Dublin County Council, in the Republic of Ireland. The rejection was based solely on concerns for grid capacity that another data center would cause.

Most data center startups are looking at a maximum period of 24 months from conception to operation. Achieving such a tight timeframe is typically only possible with a grid connection; even extending connections to the nearest local grid can make a 24 month turnaround unfeasible.

Within such a timeframe, the commercial landscape can change almost beyond recognition. This can be a major positive factor – large organisations with extensive R&D programmes – totalling $1bn annually for Siemens Energy – may roll out new products or processes within any two-year period, from which customers may benefit. However, often this goes unseen by the customer. Advances in installation processes or Condition-based service interventions are examples where manufacturers 'over-deliver' to the customer's benefit, without it being either in a contract or obvious to outsiders.

Data center startups are looking at a maximum period of 24 months from conception to operation. Achieving such a tight timeframe is typically only possible with a grid connection.

1 https://www.rte.ie/news/business/2024/0827/1466894-permission-for-google-data-centre-denied

The shipping forecast

Of course change is not limited to upside opportunities, even seemingly trivial occurrences can have far-reaching negative impacts.

In March 2021, the 224,000 ton Ever Given cargo vessel was beached across the Suez Canal for six days. During this period, it is estimated that this single 400m-long blockage disrupted 12% of all global trade, costing around $9Bn per day. These direct impacts were matched and even exceeded by trailing impacts through knock-on effects, disruption to Just In Time (JIT) manufacturing and spoilage.



Ever Given risk mitigation its proper consideration?

Among the most heavily affected by the Ever Given incident were companies that had single-source procurement or that were over-exposed in a single market. Companies importing to a single-country market were forced to balance the opportunity cost of choosing to await the clearance of the blockage, over the cost of re-routing cargo via the Cape of Good Hope.

These highly infrequent but potentially catastrophic events are at the pinnacle of the hierarchy of risk, but all risk factors require consideration in industries as dynamic as data centers. To give all risks equal consideration – from a farmer's tractor demolishing a power pylon to a disruption to the supply chain serving the EU – Siemens Energy uses a proprietary probability-based tool, the Data Center Energy System Configurator. Through the Configurator's use, risk mitigation for example an Uninterruptible Power Supply – if that is the appropriate mitigation for the circumstance – can be built into a project's design parameters.



Data center operations – ideally up and running inside 24 months

Highly infrequent but potentially catastrophic events are at the pinnacle of the hierarchy of risk, but all risk factors require consideration in industries as dynamic as data centers.

While unforeseen circumstances will always occur to a degree, legislative or policy changes are rarely by accident. Typically, nominees or opposition parties make plain their policy intentions on a given subject some way in advance of an election. This risk/opportunity can be analysed and either mitigated or embraced depending upon the position, and the resources available to the organisation. The same holds true for the EU; traditionally the Commission announces intention, followed by a period of consultation and refinement, and then legislation is enacted.

It is reasonable to expect that data center operators are familiar with legislative proposals regarding data and its handling by data centers. However, it is arguably not reasonable to also expect data center operators to be fully conversant with other time-consuming policy changes.

This includes – but is not an exhaustive list of – amendments to planning regulations, emissions and environmental laws that are incoming, or any of the other overlapping policy considerations that could, and would, disrupt a 24 month – half an election cycle – period to get to market.

Market insights

Market insight is the great unsung hero for industries such as data centers; tracking industry trends rather than following them is important for success in any market, but especially useful in a trading bloc such as the EU.

Trading blocs are inherently less volatile than single countries because of the consensus that must be achieved between member states for progress to be made. Single countries can enact radical reforms to policy and industries whenever there is sufficient electoral mandate, whether these are advisable or not.

To follow a trend is inherently risky in complex and dynamic markets, yet is something that a significant proportion of most industries is prepared to do. Tracking trends is prudent, particularly in trading blocs where a currency or a system of legislation is common to all, but implementation and local economic conditions vary.

With scrutiny falling upon data centers for their energy consumption, and therefore their carbon footprint, measures to limit the growth of the emissions from data centers in line with their growth, are underway. In Europe, the EU is implementing a program of progressive thresholds for the environmental standards relating to the elimination of SF6 from grid infrastructure. This man-made gas, used for insulating switchgear, has a Global Warming Potential (GWP) 23,000 times higher than CO_2. Eliminating it from grid-connected data centers' operations would be the single highest contributor to a data center's Scope 2 emissions.

But harmonization of standards is not equal to standardization; while Siemens Energy has a whole portfolio of products to eliminate the use of SF6; tracking the trend of implementation in different European countries gives valuable insight into the pace at which individual nations undertake this. To comply with the deadline for complete elimination in 2032, this insight can be turned into a workable timeline that balances operational continuity with legal compliance.

Only through this comprehensive analysis and market insight can a multi-product partner design in flexibility and legal compliance for the future, while retaining the momentum of speed to market.

A design for life

Another trend, that could be replicated in other nations, is the Republic of Ireland's Commission for Regulation of Utilities's (CRU) proposed requirement for data centers to match their own provision of energy generation with the total demand that the data center puts upon the national grid. The demand on the Irish grid from data centers has grown exponentially, leaping from just 5% of total national demand in 2015, to 21% in 2023.

In the longer term, given Ireland's ambition to be a "technology-rich, innovative economy", this growth would clearly be unsustainable for public-sector infrastructure to maintain.

The proposed legislation requires that new data centers connecting to the grid comply with two stipulations: that they provide equivalent generating or storage capacity, and that this capacity of either type is onsite or in the local proximity.

The impact of these stipulations is felt immediately by co-locating data centers - generating or storage capacity takes up footprint that would otherwise be saleable to customers. The design obligations to provide for the proposed CRU requirements adds in a layer of complexity of both solution and supplier. Not all suppliers are able to offer a comprehensive portfolio of generation and backup products. In Ireland, the grid infrastructure and connections also make it probable that a data center, with its allied generating capacity, would have to be located in an urban or suburban environment. However, the population density of these areas would rule out generating capacity derived from carbon-heavy fuels. Again, to futureproof a potential design, gas turbines that are already dual-fuel/hydrogen ready might be the most viable option, among other suitable technologies. Although legislation from the CRU is yet to be enacted, the sector is already being regulated to a degree through planning laws; if you do not meet the stipulations, consent to build will be withheld.

The design obligations to provide for the proposed CRU requirements adds in a layer of complexity of both solution and supplier.

In other European states, such as the UK, local regulation requires that capacity-market backup generation is tested periodically throughout each year. Diesel generators typically expel significant emissions upon start up, making compliance with Scope 1 emissions problematic for many organizations. Only smart design, coupled with market insight and comprehensive product ranges, can overcome these issues, while not delaying operational availability.

Becoming generative

The era of the relationship between a grid-power supplier and their customers being one to all – where there is a one-way feed from the supplier to customers is, for all but domestic customers, essentially over.

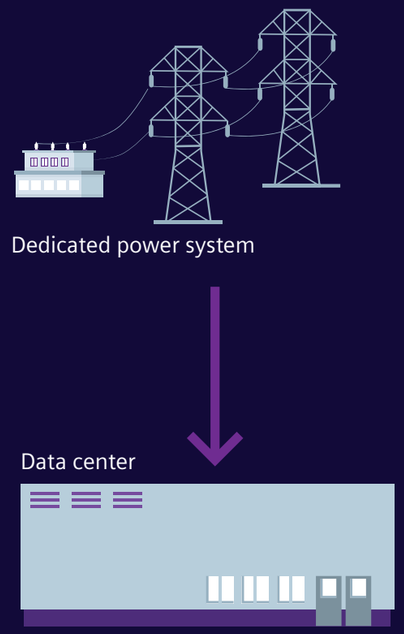
One-to-many

Utilities and other third parties developing microgrids for the delivery of dedicated power to data centers within a common location, often in conjunction with the integration of renewables into this particular energy mix.

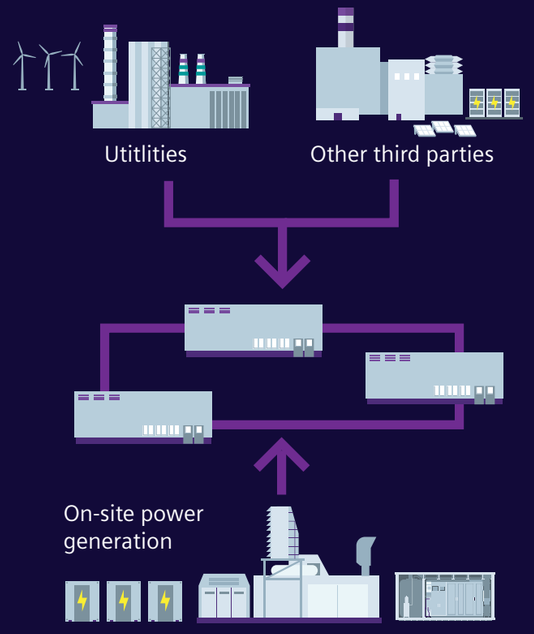


One-to-one

A dedicated power system is created solely to support a data center's operations.



Many-to-many



Even without legislative requirement, as in the case of Ireland, **two further power-supplier to power-consumer (S2C) relationships have evolved.**

The first, '1 to many' involves utilities and other third parties developing microgrids for the delivery of dedicated power to data centers and other power-intensive industries within a common location, often in conjunction with the integration of renewables into this particular energy mix.

The second new S2C relationship is '1 to 1', where a dedicated power system is created solely to support a data center's operations. This is likely to become the prevailing option for data centers, but with the possibility for that relationship to evolve into a 1 to many.

While most data center operators will be focused upon issues of ensuring uptime, smoothing demand peaks and legal compliance, where an operator has designed in dedicated power, there is the possibility that at some points there is an excess of power for the needs of the data center. Indeed this possibility of being able to reduce demand even at peak hours is recognized in Germany's Energiewende strategy and operators able successfully to reduce this demand are compensated for doing so.

Just can’t get enough

The journey from being at the mercy of the grid to having either the capability to be independent of it, or a contributor to it is known as the Prosumer (PROducer conSUMER) journey.

Current forecasts predict that by the end of 2026, global power consumption by data centers will be equal to the total power consumption of Japan – itself not without considerable power-heavy industry. In countries which have actively courted data center business, power consumption by data centers created there has risen on average by 400% over the last decade. The prosumer journey is likely to be one that all data centers must plan for, whether they are existing, or projected.

Every data center on the prosumer journey will have a different mix of requirements or priorities, dependent upon their individual circumstance.

Enterprise

Businesses that want to completely own their data. They will likely be on-site or custom built data centers. Think Banks wanting to ensure that they, and only they, are using these servers.



Co-locator

Business that don’t have a need to own their own servers. Instead they rent rack space in a pre-existing data center.



Cloud

Rental of servers but cloud based. You aren’t necessarily using a specific server as per the other examples but using what resources are available.



AI

AI Data centers offer high capacity for specialised, complex requirements.



The Horizon Ahead; the future of European data centers

With the right partner data centers can provide social utility as well as providing their data services

For some, the mid-to long-term provision will be through the installation of a gas turbine with the option to convert this in the future to a combined cycle gas turbine (CCGT). With this comes substantial efficiency and environmental gains. Other data centers will be best served by a Battery Energy Storage System (BESS), taking advantage of its compact dimensions to enhance grid stability and support peak-load management. At the same time utilizing its predictive analytics and machine learning algorithms gives the potential to forecast energy demand patterns for optimization purposes.

The enabling technologies supporting the prosumer journey change and evolve frequently, but the value that they bring remains a constant. By entering onto this journey, data centers build themselves ‘futureproofing’. This could, for example, be against excessive grid demand from competition, against environmental and related legislative change, or against deficiencies in peaking or backup power provision. These are the ‘essential values’ of futureproofing, however there are also some appealing incidental values that the prosumer proposition brings.

By its nature, power requirement for a data center is not always linear – there will be peaks and troughs. At points, power produced for a data center will outstrip demand and create an excess. With a grid connection and appropriate power management, being a prosumer opens up the possibility of selling this excess back to the grid and creating a secondary income stream.

Furthermore, with the right partner, data centers can provide social utility as well as providing their data services; another trend gaining traction that Siemens Energy is tracking is the harnessing of the excess heat that data centers and power generation inevitably creates, for use in the community in which the data center sits. For example, in Devon in the UK, Exmouth Leisure Centre is being heated with excess heat from a data center that is adjacent to it. A start-up, Deep Green, has announced plans for a further 100-150 identical projects and has attracted £200m of backing from UK domestic energy giant, Octopus.

This social utility may not be purely altruistic; if planning decisions for data centers follow the path that consents for wind power plants have taken, the non-monetary value derived by the community of having a data center could be a decisive factor in getting the go-ahead, or not.

Conclusion

The world continues to change and the pace of that change accelerates as more technology is made available to society.

However, although the services being made available to the ordinary consumer have changed unrecognizably in the last decade, the fundamentals of power provision to the technology industries has not. Since the Industrial Revolution, sufficient capacity for demand, appropriate allocation of supply, and a high level of continuity of supply have been the cornerstone of a successful operation. The thirst for energy to power industry then is no different from that need now.

Greater access to, and deployment of however, technology – both for consumers and organisations – brings with it greater competition than ever before. No area of society is immune from the increased pressures that are a consequence of this greater competition; governmental and local policy issues must reflect it, and all industries must compete for access to finite resources.

Given that resources available are finite, speed to market is the defining characteristic of a successful data center. However much and however frequently the technology within the data center changes, being first in establishing a data center is critical. Grid access, backup power contingency, uptime levels and policy changes are all factors that can contribute to, or detract from, a data center's success; but speed to market can mitigate many of the worst effects of these.

As this white paper has demonstrated, achieving speed to market is beset with resource issues, potential legislative changes, logistics considerations and so on that make following a project's critical path all the more complex, but all the more important.

Only by having a comprehensive energy value chain, from consulting through manufacturing and installation, all the way to risk management and government affairs can the complexities of the sector be identified, addressed and actively managed.

The Horizon Ahead; the future of European data centers

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There is an issue of availability and security of power supply. Uninterrupted power is not a new requirement; industry has faced this challenge before in sectors such as Oil and Gas, and – particularly in the public consciousness – hospitals. Though the technology has changed, markets have emerged, some markets have disappeared, and the scale of operations and consumption have grown beyond what could have been imagined in the days long gone, the customers' energy issues requiring resolution remain universal. Siemens Energy provided the solutions then, and will continue to provide solutions into the future.



Glossary

AI – an Artificial Intelligence data center

BESS – Battery Energy Storage Systems, a proprietary Siemens Energy back-up energy and grid stabilizing product

CCGT – Closed Cycle Gas Turbine; a gas turbine with a second stage to the combustion of gases, delivering improved efficiency of generation output

Cloud – a cloud-based data center solution

Co-locator – a data center comprised of more than one user, renting space and capacity

CRU – the Commission for Regulation of Utilities in the Republic of Ireland, a regulatory body

Enterprise – a data center devoted to serving one organization only

ESTATCOMM – a proprietary Siemens Energy technology for grid stabilisation

First Mover Advantage (FMA) – a phenomenon first observed in marketing, where the first entrant to a market get significant, and on-going, advantage

GWP (Global Warming Potential) – a measure of how much potential damage to the climate a substance would do, if treated incorrectly

Prosumer – a portmanteau word from PROducer / ConSUMER; in this context, an organization that moves from merely consuming power fed to it from a third party, to a producer of power and even a potential exporter of surplus power generated

R&D – Research and Development

SF6 – Sulphur Hexafluoride; an inorganic compound with dielectric properties making it useful as an insulator through which current will not pass

S2C – the (power) Supplier to (power) Consumer relationships

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