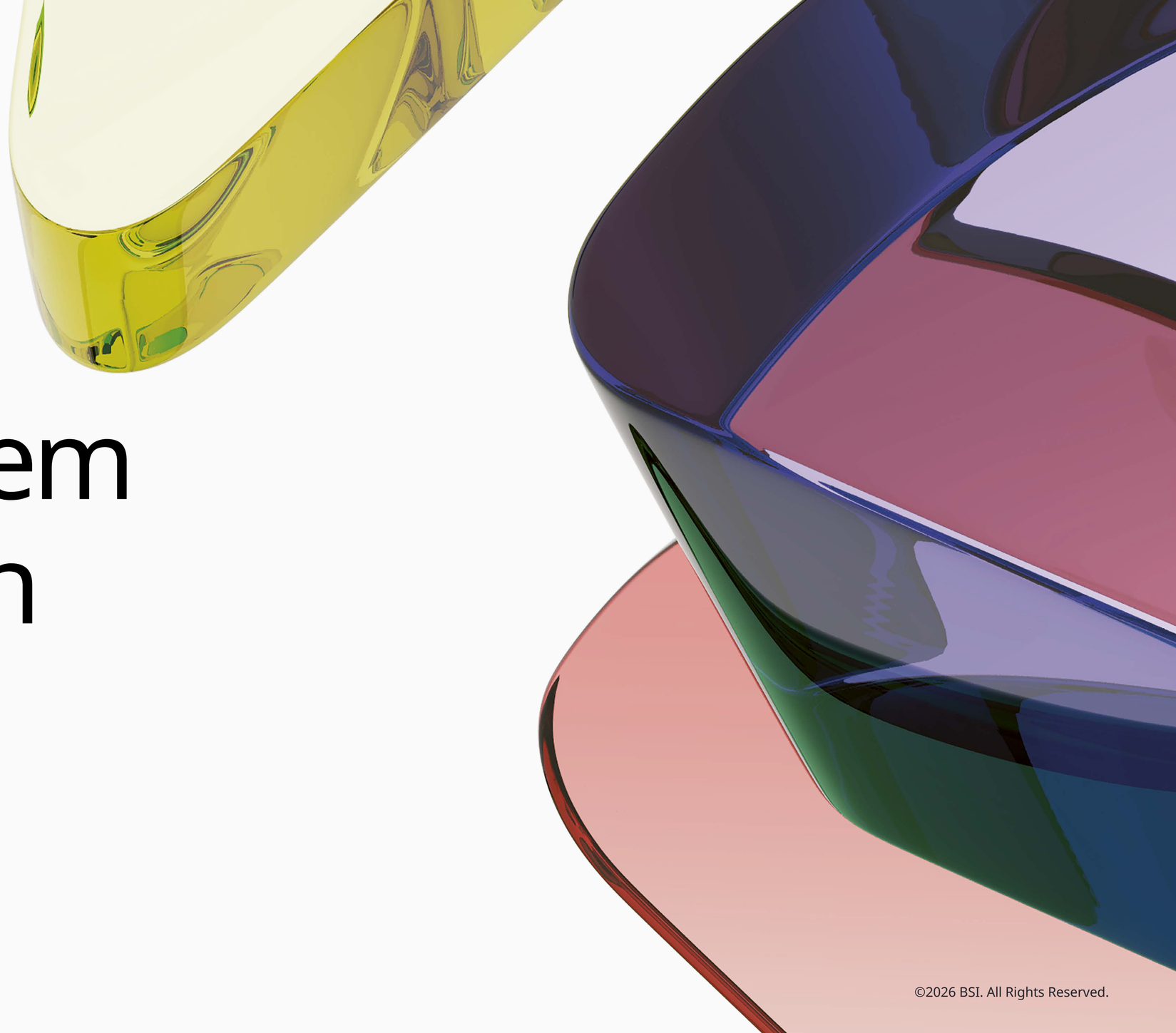
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Energy System Digitalization Report



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Contents

3 **Introduction**

5 **Digitalization – A global picture**

6 **The driving forces behind digitalization**

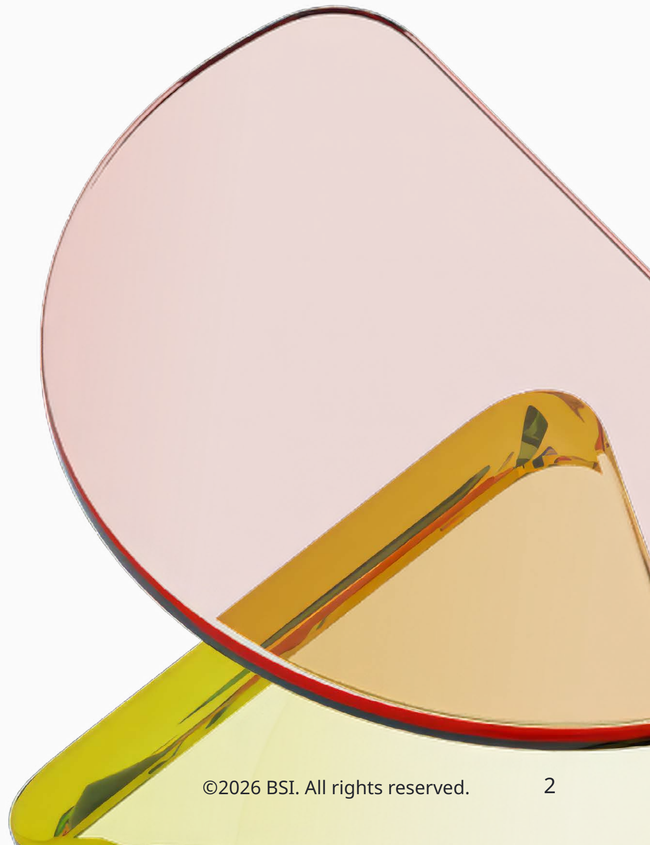
8 **Digital energy system components**

11 **Role of digital twins and the Common Information Model (CIM)**

17 **The role of standards in energy digitalization**

21 **International use cases of energy technology**

26 **Conclusion**



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Introduction

The energy sector globally is rapidly evolving through digitalization, driven by significant technological advancements and robust investments in digital tools. Global investment in the energy transition hit an all-time high of $2.3 trillion in 2023, representing a 8% rise compared to the previous year[1] - underscoring the sector's rapid shift towards smarter, more connected systems. This surge highlights the growing expenditures on digital technologies across multiple areas, such as renewable energy, energy storage and smart grids.[1]

Energy system digitalization refers to the integration of digital technologies into the energy sector. This includes the deployment of smart grids, Internet of Things (IoT) devices, advanced analytics, artificial intelligence (AI), and blockchain technologies.

These tools facilitate processes essential for the future grid including real-time monitoring, predictive maintenance, load balancing, and decentralized energy production and distribution systems. By embedding intelligence into the fabric of energy infrastructure, digitalization enhances the precision, flexibility and responsiveness of energy systems.

Global investment in the energy transition hit an all-time high of $1.8 trillion.



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Digital technologies are increasingly essential for optimizing global energy systems. By 2025, the emphasis remains on implementing smart grids, which are key to integrating renewable energy sources, improving grid reliability and enabling real-time energy management. This enhanced efficiency and flexibility is essential if global energy systems are to integrate new renewable resources to meet the COP28 targets of tripling renewable energy capacity and doubling energy efficiency by 2030.[2]

Further emphasizing investment in digitalization, over 1.06 billion smart meters were installed globally, and this number continued to climb, contributing towards a significant shift in modernizing utility distribution networks. IoT-based smart electricity meters have achieved significant adoption with a penetration rate of 43% globally. This penetration rate is expected to increase to 54% by the end of 2030.[3]



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Digitalization - A global picture

Different regions are embracing digitalization at different speeds. For example, Europe and North America are at the forefront of smart grid investments, whereas emerging markets in Asia and Africa are progressively implementing digital solutions to enhance energy distribution management and facilitate the integration of renewable energy sources.[4]

Smart meter installations have reached an impressive milestone in the UK, with over 41million units in place, representing over 71% of UK households.[5]

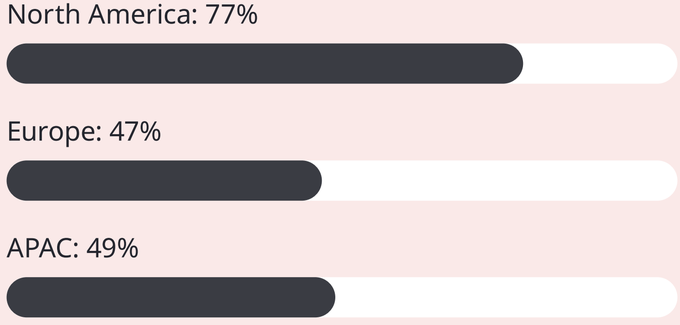
Over 11 billion devices were already connected to automated controls and sensors across the world within the energy sector in 2022, this number could reach more than 25 billion in 2030.[6] Efforts to modernize electricity grids began in Italy and the US in the late 2000s and gained momentum, leading to widespread national rollouts across the EU and APAC regions after 2010. Regulatory policies, bolstered by financial incentives from regional or national governments, have played a key role in this expansion. These policies have motivated utilities to upgrade from mechanical meters to smart meters, driving the modernization of grid infrastructure. North America stands out as the leader in market maturity for smart electricity meters with a 77% penetration rate, followed by APAC and Europe with a penetration rate of 49% and 47% respectively.[7]

43%
global smart meter penetration rate.

11 billion
connected energy devices (automated controls + sensors) in 2022.

£1.8 trillion
invested in the global energy transition (a 17% year-on-year increase from 2022 to 2023).

Smart electricity meter adoption by region



Source: IoT Analytics

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The driving forces behind digitalization

The rapid digitalization of energy systems is being driven by global sustainability goals, regulatory demands, and advances in connected technologies. However, realizing these benefits safely and efficiently requires internationally recognized standards that ensure interoperability, cybersecurity, and consistent quality across borders. BSI, as the UK's National Standards Body and a global leader in developing and publishing standards, can be your partner in supporting this transition.

Several factors underpin the surge in energy system digitalization:

Climate change and sustainability goals

The urgency to mitigate climate change has led to stringent global commitments to reduce greenhouse gas emissions. Nations and corporations alike are pushing for a transition to renewable energy sources. Digital tools enable the efficient integration of renewables by addressing their intermittent nature and ensuring grid stability.

Standards such as **BS ISO EN 50001** (Energy management systems) help organizations measure and improve energy performance, translating digital insights into tangible carbon reductions. Supporting standards like **BS EN ISO 14064 series** (Greenhouse gases – quantification and reporting) and **BS EN IEC 62446-2** (Grid-connected PV systems) provide frameworks for accurate emissions accounting and safe integration of renewable technologies.

Economic efficiency

Digitalization lowers operational costs through predictive maintenance, reducing downtime and extending the lifespan of assets. Enhanced energy efficiency practices translate into significant savings, making the economics of energy production and distribution more favourable. Digitalization can save up to 30% of electricity consumption.[8]

Through BSI's portfolio of smart grid and automation standards, including **BS EN IEC 61850 series** (Communication networks and systems for power utility automation), **BS EN 50549 series** (Requirements for generating plants to be connected in parallel with distribution networks), and **BS ISO 55001** (Asset management systems) — energy organizations can apply proven frameworks to ensure safe, efficient, and interoperable deployment of digital infrastructure.

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Technological advancements

Innovations in AI, data analytics, and IoT have made it feasible to implement sophisticated digital solutions. The decreasing costs of these technologies further accelerates their adoption across the energy sector.

BSI's support in international standardization, including **BS ISO/IEC 30141** (Internet of Things Reference Architecture), **BS EN ISO/IEC 22989** (Artificial intelligence concepts and terminology), and **BS EN ISO/IEC 27001** (Information security management systems) - ensures that emerging technologies are underpinned by robust frameworks for cybersecurity, data governance, and system interoperability.

Consumer demand

The modern consumer demands greater control, reliability and transparency in energy usage. Smart meters and home energy management systems provide this granularity, allowing consumers to become active participants in energy networks.

Standards such as **BS EN 50491 series** (General requirements for home and building electronic systems and **BS EN IEC 62056 series** (DLMS/COSEM for smart metering support the secure exchange of data between smart devices and utilities, helping consumers and providers build trust through consistent, verifiable information.

In addition, **PAS 1878** supports the integration of energy smart appliances (ESAs) into a flexible, low-carbon energy system. It provides a technical specification that helps domestic appliances operate effectively within demand side response (DSR) frameworks, enabling consumers to manage their electricity demand more efficiently and reduce costs associated with energy consumption.

More complex homes

The integration of Distributed Energy Resources (DERs) like solar photovoltaics (PV), heat pumps, battery storage, and electrical vehicles (EVs) in modern homes has driven a surge in energy system digitalization. These technologies generate large datasets that enable more sophisticated energy management, optimizing demand, storage and supply in real-time.

Between 2019 and 2021, 167 GW of distributed PV systems were installed, and by 2020, the number of electric vehicles surpassed 10 million, while 180 million heat pumps were in operation worldwide.[9] The US alone is expected to reach 387 GW of DER capacity by 2025, driven by $110 billion in cumulative investments.[10]

Standards such as **BS EN IEC 62933 series** (Electrical energy storage systems), **BS EN 50696** (Communication between EVs and charging stations), and **BS EN 14511 series** (Performance of electrically driven heat pumps) ensure that distributed technologies operate safely and efficiently within connected smart grids.

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Digital energy system components

1. Smart grids: Smart grids are foundational to digitalizing energy systems. They incorporate sensors, automation, and communication technologies to monitor and control electricity flows in real-time. This facilitates efficient energy distribution, quick fault detection, and integration of DERs like solar panels and wind turbines.

State Grid Corporation, China

Use case: Ultra-high voltage (UHV) and smart grids

UHV transmission lines are engineered to convey electricity across extensive distances with minimal energy loss. Operating at voltages exceeding 800 kilovolts (kV), these lines far surpass the capabilities of standard high-voltage lines. UHV technology facilitates the efficient delivery of substantial quantities of electricity from distant generation sites, like renewable energy farms, to densely populated urban areas with high energy demand.

Smart Grids allow digital communication, sophisticated sensors, and automation to improve the monitoring, control, and optimization of electricity distribution. This technology encompasses smart meters, real-time data analytics and automated systems for managing the grid efficiently.

Impact

Reduced transmission loss: The implementation has resulted in reduced transmission loss from 6.5% in 2010 to 4.5% in 2023.[11]

Pacific Gas and Electric Company (PG&E)’s Smart Grids, United States

Use cases: Smart meters and advanced grid management systems

In several US cities, such as San Diego and Denver, smart grid technologies have been introduced to modernize electricity distribution networks. These systems leverage a range of digital tools to enhance the management and optimization of energy flow. Notably, Pacific Gas and Electric Company (PG&E) has been at the forefront of this shift, incorporating smart meters and advanced grid management systems into its infrastructure.

Smart Meters deliver real-time information about energy consumption, enabling accurate billing and improved consumer insights. They are instrumental in identifying irregularities and optimizing energy usage. Advanced grid management systems use advanced algorithms and real-time data analytics to supervise electricity distribution, handle demand, and quickly address outages.

Impact

Reduced greenhouse gas emissions: As a result of an increase in smart grid adoption, greenhouse gas emissions from the power sector were reduced by 15% between 2016–2021.[12]

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Key smart grid standards

IEC TS 62939-2
(Smart grid user interface - Part 2: Architecture and requirements)

Standard provides an architecture to define interfaces for the information exchange between smart equipment/systems from the demand side and the power grid. It facilitates the interoperability between the IEC Common Information Model (CIM) and customer facility standards for smart grid applications.

BS IEC SRD 62913-1
(Generic smart grid requirements - Specific application of the use case methodology for defining generic smart grid requirements according to the IEC systems approach)

Standard provides a structured framework for describing and analyzing specific smart grid scenarios, ensuring consistency and interoperability across different smart grid systems. The document provides a common language and structure for smart grid stakeholders (e.g., utilities, regulators, technology providers) to ensure that system requirements are defined uniformly, making the grid smarter, more interoperable, and adaptable to various technological innovations.

BS IEC SRD 63268
(Energy and data interfaces of users connected to the smart grid with other smart grid stakeholders. Standardization landscape).

The standard depicts a comprehensive standardization landscape of the interfaces between the main grid stakeholders and the grid users (grid users comprising DERs and Customer Premises).

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Other components of digitalized energy systems



2. IoT and big data: IoT devices generate vast amounts of data, offering granular insights into energy consumption patterns and infrastructure performance. Big data analytics processes this information to identify trends, forecast demand and optimize operations. For instance, smart thermostats and appliances adjust usage based on real-time data analysis, reducing wastage and peak load pressures.

3. AI and machine learning: AI and machine learning algorithms enhance predictive maintenance, detect anomalies and optimize energy dispatch. These technologies can predict equipment failures before they occur, thereby preventing outages and reducing maintenance costs. AI also optimizes grid operations by managing supply and demand dynamics more effectively than traditional methods. In the UK, one nuclear facility operator has used AI to reduce 90% of its administrative burden. Another has used a combination of data, machine learning and digital twins for predictive maintenance, an important consideration for climate adaptation whilst also extracting up to 30% reduction in maintenance costs.[13]

4. Blockchain technology: Blockchain provides secure, transparent, and decentralized solutions for energy transactions. Peer-to-peer energy trading platforms allow prosumers (consumers who also produce energy) to trade surplus energy, creating localized energy marketplaces. This decentralization supports the proliferation of renewable energy sources and enhances grid resilience.

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Role of digital twins and the Common Information Model (CIM)



Digital twins are a digitalized technology enabled by the energy data standards known as the Common Information Model (CIM) and can revolutionize the way industries design, operate and maintain complex systems.

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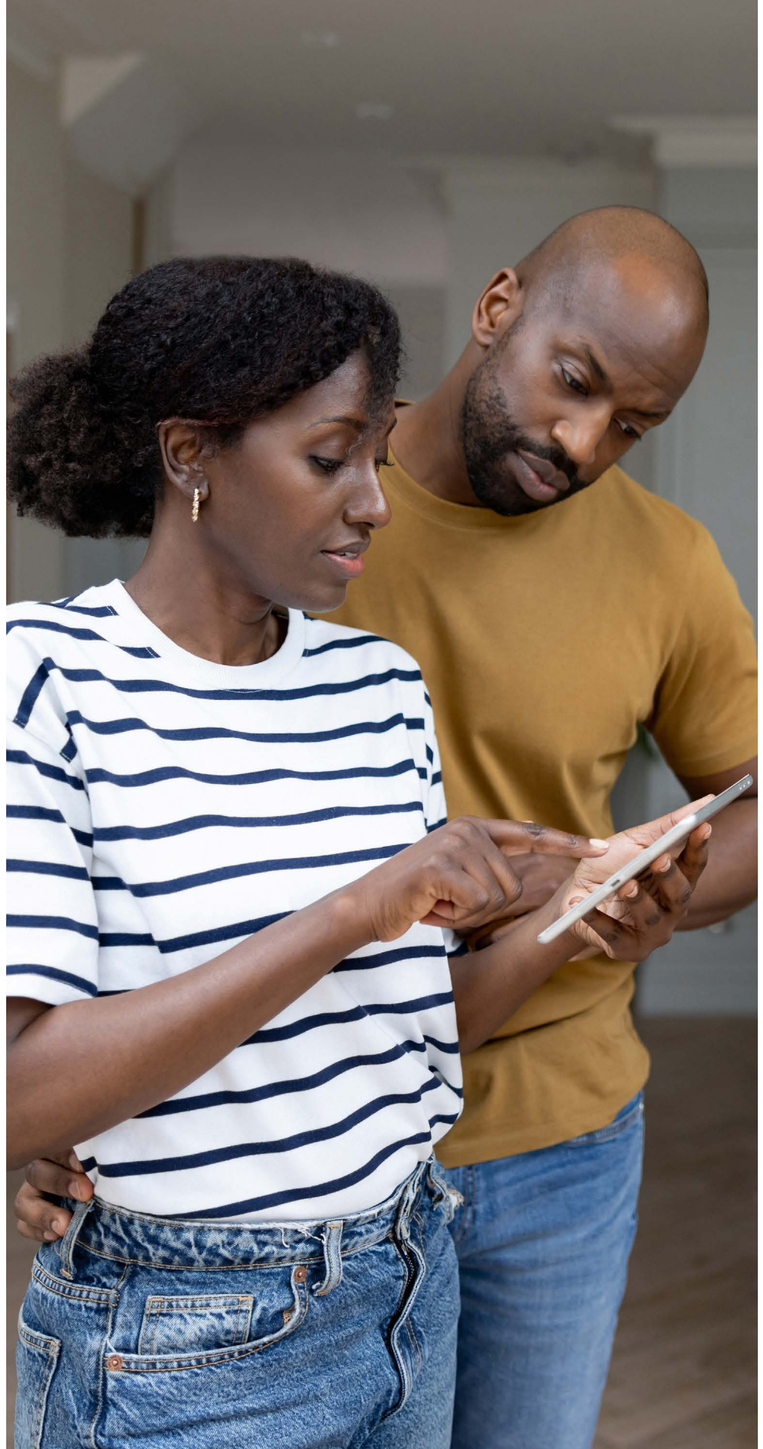
Digital twins

A digital twin is a virtual replica of a real asset, system or process created using IoT sensors, data analytics and AI. This virtual representation simulates the behavior and performance of its real counterpart in real-time, allowing for predictive maintenance, optimized performance and risk-free testing of new scenarios. Digital twins enable industries to gain valuable insights into the operation and performance of their assets, reducing downtime, improving efficiency and increasing productivity - provided the underlying data is consistent and shareable.

This is where the CIM comes in: by ensuring all participating systems speak the same data language, the CIM makes it far easier to build and update digital twins that integrate data from many sources.

International technical committee ISO/IEC JTC1/SC 41 is responsible for standardization in this area. Essential foundational standards for digital twin technology include:

- **BS ISO/IEC 20924**, IoT and digital twin. Vocabulary;
- **BS ISO/IEC 30141**, IoT. Reference infrastructure;
- **BS ISO/IEC 30173**, Digital twin.Concepts and terminology;
- **PD ISO/IEC TS 30149**, IoT. Trustworthiness principles.



Case study: National Grid ESO's Virtual Energy System, UK

Use case: Dynamic demand side response (DSR)

National Grid ESO's Virtual Energy System is a project that uses the CIM to create digital copies of Great Britain's energy system. By making these digital copies, they can better manage and improve the energy system across the country.

National Grid ESO uses advanced digital platforms to manage demand-side response. By leveraging real-time data and machine learning algorithms, the system can dynamically balance electricity supply and demand.

Impact

Reduction in peak demand: Approximately 3.3 GW hours of peak energy reduction was achieved through demand-side response programs during a trial run between 2022–2023.[14]

Cost savings: The government estimates that by 2050, DSR could reduce the cost of operating the electricity system by £10 billion annually, representing about 14% of the total system cost. Additionally, between 2020 and 2050, the cumulative savings are projected to range from £30 billion to £70 billion.[14]

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Common Information Model (CIM)

The CIM is a standard framework that enables the exchange and sharing of information between different systems, applications and stakeholders. The CIM is like a universal language for the energy sector. It provides a standard way to represent and share information about power system assets and operations. The CIM was developed by people in the industry and approved by organizations such as the International Electrotechnical Commission (IEC).

The CIM provides the framework for integrating digital twins with other systems, such as enterprise resource planning, supervisory control and data acquisition (SCADA), and geographic information systems (GIS), creating a comprehensive and unified view of the system or process.

The family of International Standards forming the CIM is maintained internationally by IEC, which creates and publishes international standards for electrical, electronic and related technologies.

The CIM standards include:

- **Grid: BS EN IEC 61970 series** focuses on integrating information exchanges through the integration of appliances within control of grid systems.
- **Enterprise: BS EN IEC 61968 series** provides a uniform language to describe utility operation data exchanges including metering.
- **Market: BS EN IEC 62325 series** focuses on market-related data exchanges (mostly applicable to European markets).

Ofgem has confirmed its intention to reform the Long Term Development Statement (LTDS) by adopting the CIM as its data standard. This aims to streamline data exchanges in the energy industry, with Great Britain (GB)-specific extensions added to ensure consensus and clarity. The CIM is based on the **BS EN IEC 61970**/**BS EN IEC 61968**/**BS EN IEC 62325** standards series.

BSI has taken on the role of governing body for the CIM to ensure its effective use, alongside the development of technically aligned GB CIM schema and their alignment with the IEC.

Find out more



Virtualizing power systems

A BSI led IEC publication, focuses on the benefits digital twins can bring. Effective use of digital twin technologies can help grid planners and grid operators manage their systems efficiently, helping them overcome infrastructural challenges. This also enables industry to meet net-zero goals by helping planners monitor and identify design alternatives to reduce carbon emissions.

Find out more

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Benefits of digital twins and the CIM

The use of a common data language like the CIM to enable the complex virtual modelling of digital twins has the potential to revolutionize energy and infrastructure systems, offering numerous benefits that transform the way assets are designed, operated and maintained.



1. Real-time monitoring and predictive maintenance

Digital twins enable real-time monitoring and predictive maintenance and simulate the behaviour of physical assets to identify potential issues before they occur. Digital twins also allow for proactive maintenance, reducing downtime and minimizing costly repairs. The CIM standardizes data exchange and integration, facilitating seamless collaboration between stakeholders and systems. The CIM also ensures accuracy, consistency and reliability of information.

2. Asset design and optimization

Digital twins simulate various scenarios to identify optimal design configurations that help reduce costs and improve performance through scenario analysis. The CIM ensures accurate sharing and integration of design data, streamlining the design process through unified data exchange.

3. Cybersecurity enhancement

Digital twins allow for real-time monitoring and aid in early detection and response to security threats. The CIM helps standardize data exchange that supports improved cybersecurity measures, enabling proactive protection of critical infrastructure.

4. Integration with renewable energy and smart grids

Digital twins simulate energy distribution and consumption for optimal energy management while the CIM ensures seamless data exchange between systems, supporting integration with renewable energy sources and smart grids.

5. Cost reduction and efficiency improvement

Digital twins and the CIM integration minimize downtime and optimize asset performance while streamlining design and maintenance processes that lead to significant cost savings and enhanced productivity.

In summary, integrating a common data language like the CIM enables digitalization at scale across the energy system, including digital twins. This can transform the energy and infrastructure industries by improving asset reliability, design and performance, while reducing costs and enhancing cybersecurity.

As the world becomes increasingly digital, the adoption of common data standards to enable digital technologies will play a vital role in shaping the future of these industries and their ability to digitalize.

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Case studies

Australian Energy Market Operator (AEMO), Australia

Use case: Distributed energy resources registration (DERR)

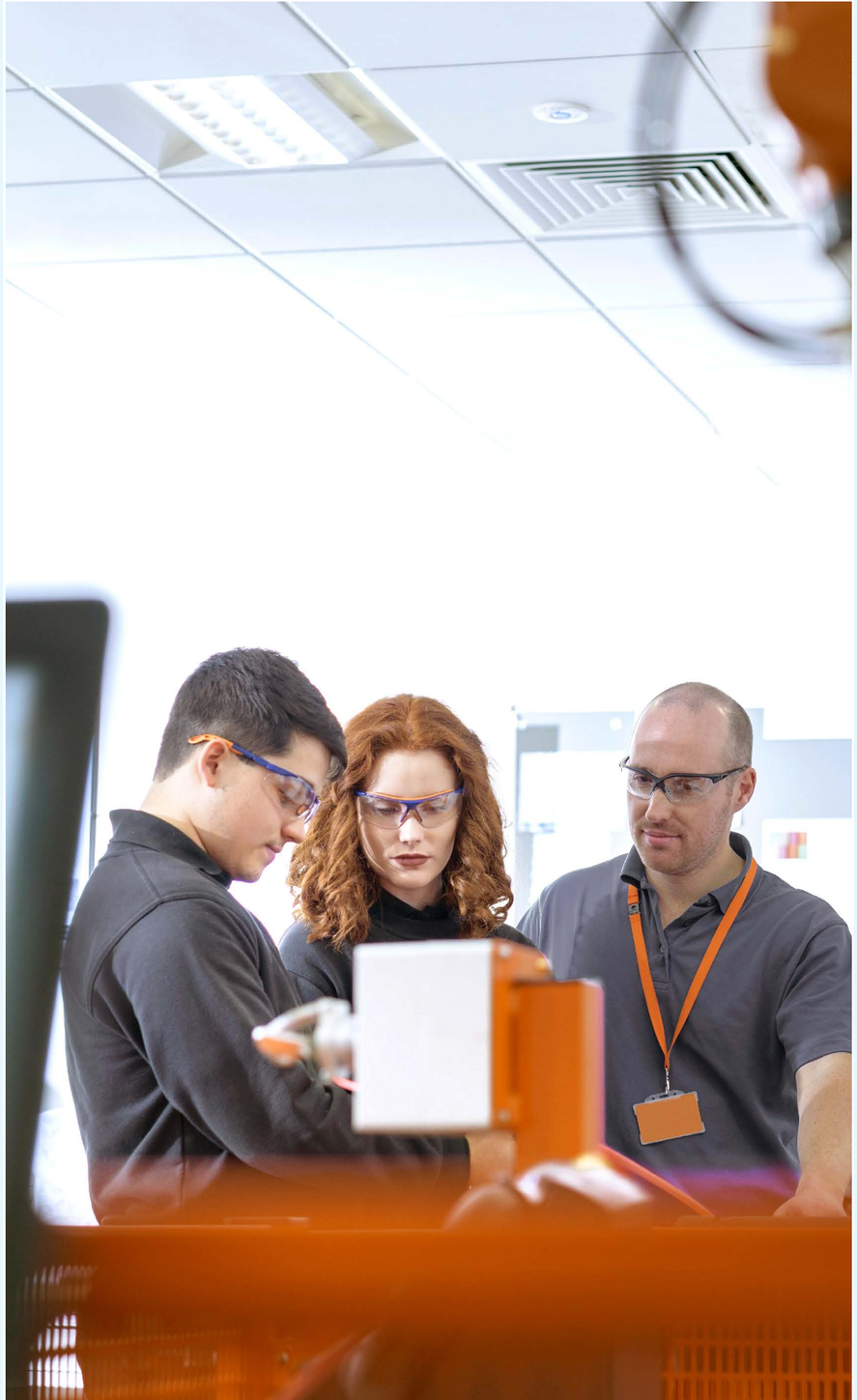
AEMO has developed a digital platform to streamline the registration and integration of DERs, including solar panels, batteries, and EVs. The platform enables these assets to be seamlessly incorporated into the energy market, supporting more effective system management and utilization.

By providing a single, unified registration system, DER owners and operators can easily register their assets, ensuring consistent recognition and management of DERs across the market.

Impact

DER capacity generation: Renewable energy generation witnessed an 18% increase in 2020-21, accounting for 27% of the total electricity produced.[15]

Economic value: DERs have the potential to deliver a $19 billion economic boost to the Australian economy by 2040.[15]



Governance of the CIM in GB (BSI, ENA and Ofgem), UK

Use case: Establishing a national governance framework for the CIM to enable first of a kind wide-scale digitalization at the electricity distribution level.

In 2023, Ofgem mandated the CIM as a license requirement for network data provided by Distribution Network Operators (DNO) to create a consistent, interoperable data approach across GB.

Ofgem appointed BSI as the GB CIM Governance Body. BSI established a collaborative governance framework with industry, regulators, software vendors and experts to maintain and evolve the CIM standards in line with UK and international needs.

Impact

Data consistency: All GB DNO are moving towards the same data schemas, reducing duplication and improving data quality.

Faster innovation: Standardized data enables quicker development of tools to improve grid planning, policymaking, and investment.

Stakeholder alignment: Over 100 organizations contribute to CIM in GB, remaining standards practical and aligned with IEC, while keeping pace with real-world application.

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Challenges of digital twins and the CIM

Implementing digital twins on a CIM foundation has revolutionized the energy and infrastructure industries, but it also presents several challenges that must be addressed.

1. Data accuracy and reliability

Data quality and standardization issues pose a significant challenge. Digital twins rely on accurate and consistent data, but integrating data from various sources can be difficult, and the CIM requires standardized data exchange protocols.

2. High implementation costs

Integrating digital twins and the CIM with legacy systems can be complex and costly. Many existing systems may not be compatible with digital twin technology or the CIM protocols, requiring significant upgrades or replacements.

The high upfront investment costs of implementing digital twins and the CIM can be a barrier. The costs of developing and integrating digital twins and the CIM can be substantial, requiring significant capital expenditures.

3. Cultural shift

Change management and training requirements can often provide useful routes to transition energy companies, businesses and systems towards digital processes and technologies so as not to lose out on the benefits of digitalization. The adoption of digital twins and the CIM requires a cultural shift and specialized skills, which can be a challenge for organizations with limited resources.

4. Skill gap

The management and analysis of large amounts of data generated by digital twins and the CIM require advanced analytics capabilities and data science expertise.
And ensuring the accuracy and validity of digital twin simulations and the CIM data is crucial, but can be challenging, especially in complex systems.

5. Cybersecurity threats

Cybersecurity and data privacy concerns are heightened when implementing digital twins and the CIM. The increased reliance on data and connectivity creates vulnerabilities that must be addressed through robust security measures.

In summary, while digital twins and the CIM offer numerous benefits, their implementation also presents several challenges that must be addressed.

By understanding these challenges, organizations can develop strategies to overcome them and fully realize the benefits of digital twins and the CIM.

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The role of standards in energy digitalization

Standards play a pivotal role in the successful implementation and scaling of digital technologies in the energy sector. They provide a foundation for interoperability, reliability and security, enabling various systems and devices to work seamlessly together. Different standards play different roles in energy digitalization, specifically those around digital twins, automation, IT and security.

Standards for digital twins

Interoperability: Standards ensure that digital twins, regardless of their origin, can integrate and communicate with various systems. They facilitate the seamless exchange of data across different platforms and vendors.

Accuracy and consistency: Standards define the metadata, data formats and modeling techniques, ensuring that digital twins accurately replicate physical assets and processes.

Lifecycle management: They provide guidelines for the creation, updating, and decommissioning of digital twins, ensuring consistency across their lifecycle.

Some key standards for digital twins are as follows:

- **BS ISO 23247 series**: This standard series is a guide for making and using digital twins in manufacturing. It covers standards for managing data, developing models and integrating with other systems.
- **BS EN IEC 61850 series**: This standard series is all about communication rules and data models for substation automation systems. Using digital twins in power generation, transmission and distribution systems is important. It gives guidelines for exchanging data and how various parts of energy systems can work together, ensuring digital twin solutions can be integrated seamlessly across the energy infrastructure.
- **BS ISO/IEC 30118 series**: This global standard is vital for supporting the creation and management of digital twins within varied and intricate IoT settings. By facilitating interoperability between OCF and oneM2M resources, the standard ensures smooth data integration, which improves the precision, scalability and efficiency of digital twins across multiple sectors and uses.

Impact

Efficiency: Enhanced operational efficiency, reducing maintenance costs by up to 18% through predictive maintenance facilitated by standardized digital twin technology.[16]

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Standards for the CIM

The CIM is made up of a trio of standard series that each cover a different aspect of energy information exchange. Together, these standards provide the interoperable structure that underpins digitalization of the grid.

Key CIM standards include:

BS EN IEC 61970 series: Defines the core CIM for energy management systems, standardizing how control-centre and transmission data is modelled and exchanged across grid operations. Ensuring that control centre applications and external systems (like generation or transmission operators) exchange information using the same definitions.

BS EN IEC 61968 series: Focuses on distribution and enterprise application integration. It defines a uniform message architecture for data exchanges among utilities' back-office systems (e.g. asset management, customer billing, meter data) and distribution grid operations. This standard series complements **BS EN IEC 61970 series** by extending the CIM to day-to-day distribution operations and metering.)

BS EN IEC 62325 series: Applies the CIM to electricity markets, standardizing scheduling, trading and forecasting data. It ensures that market participants (generators, suppliers, exchanges) speak the same data language, facilitating easier integration of market systems with operational systems, since all adhere to CIM conventions.

Impact

Unified data exchange: Together, these CIM standards reduce integration effort, improve data consistency and support faster deployment of interoperable digital energy solutions across operations and markets. Join the GB CIM Engagement Hub to learn more.

Find out more

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Standards for automation

Automation standards are important for ensuring automated systems in different industries are safe, reliable and efficient. These standards give guidelines for designing, implementing and maintaining automated systems and for putting different parts and technologies together.

Interoperability: Automation standards such as **BS EN 61499 series** and **BS ISO 15746 series** enable different automation systems to communicate and work together, enhancing overall system efficiency.

Safety and reliability: Standards like **BS EN 61508 series** or **BS EN ISO 13849 series** provide guidelines to ensure the safety and reliability of automated systems, critical for energy infrastructure.

Scalability: Standardized protocols and frameworks ensure that automation systems can be scaled and upgraded without compatibility issues.

Some other key automation standards:

- **BS EN IEC 61131 series**: This standard series defines the programming languages and software structure for programmable logic controllers (PLCs) used extensively in industrial automation.

Impact

Productivity: Increased productivity, with automation in the energy sector potentially boosting efficiency by 22–30%.[17]



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Standards for IT and security

IT & cybersecurity standards protect sensitive information, ensure systems work reliably and keep users' trust. These standards guide developing, implementing and managing IT systems and security measures.

Quality assurance: Standards ensure data quality, consistency and reliability, essential for data analytics and decision-making processes.

Data protection & management: They provide guidelines for data storage, access, data protection of consumers and critical operational data against breaches and leaks.

Compliance: Adherence to security standards ensures compliance with regulatory requirements, avoiding legal penalties and enhancing stakeholder trust.

Here are some key IT and security standards:

- **BS ISO/IEC 27000 series**: These standards provide a framework for information security management systems (ISMS). They cover things like assessing risks, putting security controls in place, and managing incidents.
- **BS 10012**: This provides a framework for managing personal data and helps organizations comply with data protection regulations, including GDPR. It helps in risk assessments and data protection policy.
- **NIST Cybersecurity Framework**: This framework gives a set of guidelines and best practices for organizations to manage and reduce cybersecurity risks. It's widely used across different industries and sectors.
- **BS EN IEC 62443 series**: This standard series is related to industrial automation and control systems (IACS) cybersecurity. It provides guidelines for assessing and mitigating security risks in these systems.

Impact

Operational efficiency: Businesses adopting automation through digital twin technology can witness substantial cost savings between 20-30% by reducing maintenance costs, and extending machine life by years.[18]

Financial impact: Reduced financial impact from cyber incidents by leveraging automation, with an average cost avoidance of $2.2 million due to enhanced security posture.[19]

Managing standards shouldn't slow innovation

Organizations operating across multiple sites often struggle to keep standards consistent, current and accessible. BSI Knowledge brings energy and digitalization standards together in one secure digital platform, so teams stay aligned, compliant and efficient.

Discover how BSI Knowledge supports evolving energy systems

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International use cases of energy technology

1. National Grid ESO's Virtual Energy System, UK

Use case: Dynamic demand side response (DSR)

National Grid ESO's Virtual Energy System is a project that uses the CIM to create digital copies of Great Britain's energy system. By making these digital copies, they can better manage and improve the energy system across the country.

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Impact

Reduction in peak demand: Approximately 3.3 GW hours of peak energy reduction was achieved through demand-side response programs during a trial run between 2022–2023.[20]

Cost savings: The government estimates that by 2050, DSR could reduce the cost of operating the electricity system by £10 billion annually, representing about 14% of the total system cost. Additionally, between 2020 and 2050, the cumulative savings are projected to range from £30 billion to £70 billion.[21]

2. UK Power Networks, UK

Use case: Low carbon network innovation through smart meter rollout in the UK

UK Power Networks is leading the way in incorporating low-carbon technologies into the UK's energy infrastructure. The company employs a blend of Internet of Things (IoT) devices, cutting-edge sensors and big data analytics to boost the performance and efficiency of local energy networks. This strategy addresses the complexities of contemporary electricity distribution, facilitates the integration of renewable energy sources and enhances overall grid reliability.

The successful rollout and integration of these technologies not only contribute to cost savings and reduced energy losses but also enhance customer satisfaction and support the UK's low-carbon energy goals.

Impact

Smart meter penetration: Over 60% of households are equipped with smart meters.[22]

Cost savings: Smart meter rollout is expected to generate total bill savings of £5.6 billion for households throughout the rollout.[23]

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3. Smart Grid Architecture Model (SGAM), Global

Use case: Global examples including FINSENY (Future Internet for Smart Energy) project operating in seven European countries, the Reference Architecture for Secure Smart Grids in Austria, Graph database modelling and high-availability web services in the USA, and risk assessments for Smart Grid projects in Australia.[24]

The Smart Grid Architecture Model (SGAM) is a framework that helps visualize and design smart grid systems by organizing them into five layers: Component, Communication, Information, Function and Business. These layers represent different aspects of the grid, from physical devices and data exchanges to business processes and energy flows. SGAM also divides the grid into three zones (generation, transmission, distribution) and across domains (like customers or market operations), allowing stakeholders to understand how various technologies and systems interact within the grid. This structured approach ensures interoperability and effective system integration across different energy sectors while accurately identifying the applicability of available standards (like the CIM and IEC 61850) and additional protocols to communicate necessary information across the grid.

Impact

Enhanced grid interoperability: SGAM enables better interoperability between different smart grid components, reducing integration challenges and improving the efficiency of energy systems. For instance, by ensuring standardized communication, Europe saw a 20% increase in the integration of renewables into the grid as smart grid solutions improved operational flexibility.[25]

Faster deployment of smart technologies: The adoption of SGAM-based frameworks accelerated the implementation of smart meters and other smart grid technologies across Europe, contributing to the EU's goal of reaching 72% smart meter coverage by 2023.[26]



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4. State Grid Corporation, China

Use case: Ultra-high voltage (UHV) and smart grids

UHV transmission lines are engineered to convey electricity across extensive distances with minimal energy loss. Operating at voltages exceeding 800 kilovolts (kV), these lines far surpass the capabilities of standard high-voltage lines. UHV technology facilitates the efficient delivery of substantial quantities of electricity from distant generation sites, like renewable energy farms, to densely populated urban areas with high energy demand.

Smart Grids enable digital communication, sophisticated sensors and automation to improve the monitoring, control, and optimization of electricity distribution. This technology encompasses smart meters, real-time data analytics, and automated systems for managing the grid efficiently.

Impact

Reduced transmission loss: The implementation has resulted in reduced transmission loss from 6.5% in 2010 to 4.5% in 2023.[27]



5. Pacific Gas and Electric Company (PG&E)'s Smart Grids, United States

Use cases: Smart meters and advanced grid management systems

In several US cities, such as San Diego and Denver, smart grid technologies have been introduced to modernize electricity distribution networks. These systems leverage a range of digital tools to enhance the management and optimization of energy flow. Notably, Pacific Gas and Electric Company (PG&E) has been at the forefront of this shift, incorporating smart meters and advanced grid management systems into its infrastructure.

Smart Meters deliver real-time information about energy consumption, enabling accurate billing and improved consumer insights. They are instrumental in identifying irregularities and optimizing energy usage. Advanced grid management systems use advanced algorithms and real-time data analytics to supervise electricity distribution, handle demand, and quickly address outages.

Impact

Reduced greenhouse gas emissions: As a result of an increase in smart grid adoption, greenhouse gas emissions from the power sector were reduced by 15% between 2016–2021.[28]

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6. TEPCO (Tokyo Electric Power Company), Japan

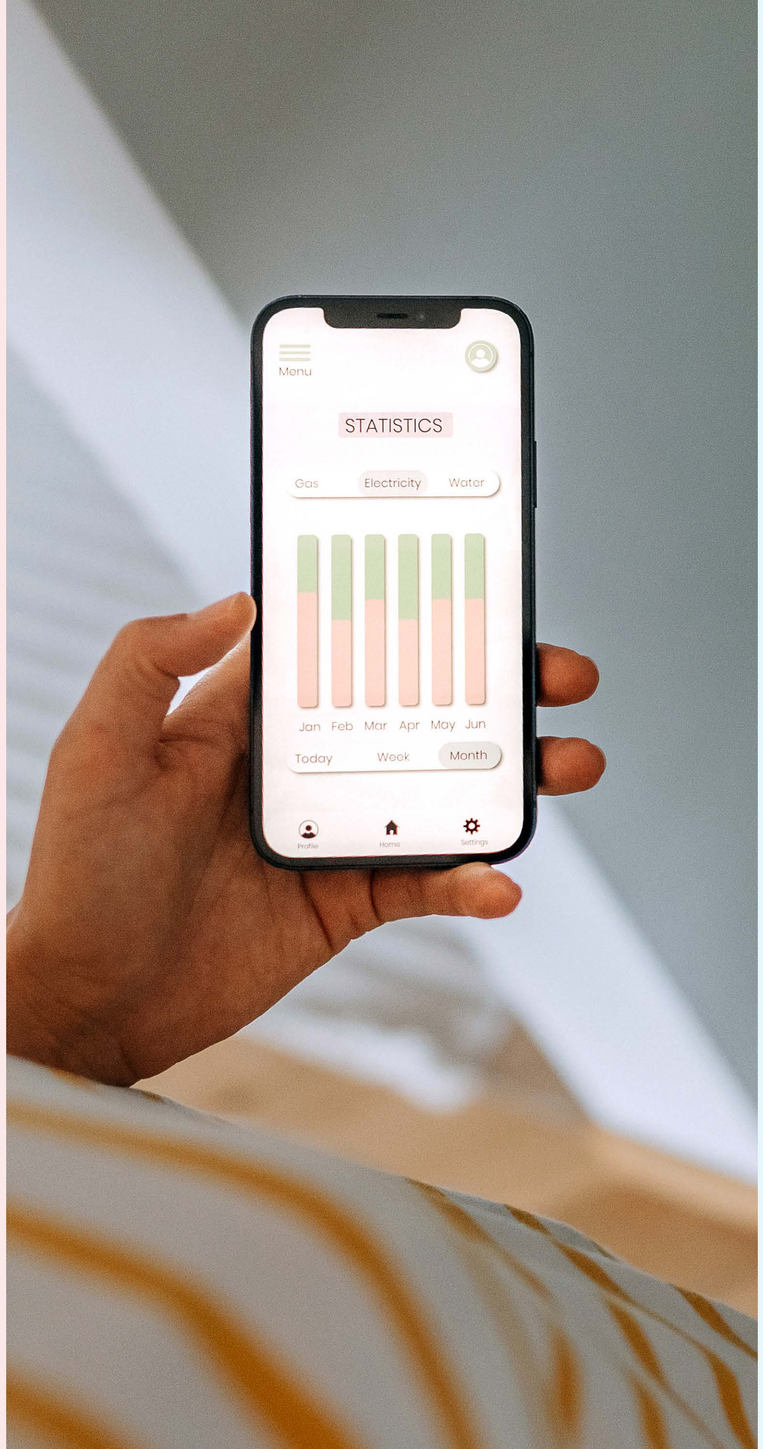
Use case: Energy demand forecasting

TEPCO employs AI-powered predictive analytics to improve the accuracy of its energy demand forecasts. By using sophisticated machine learning algorithms and data analysis, the company seeks to refine its demand predictions, which is essential for efficient energy management and maintaining grid stability.

This provides enhanced precision and aids in more effective planning and distribution of energy resources, minimizing the likelihood of supply shortages or excesses. Improved demand forecasts can result in cost savings by optimizing energy procurement and decreasing reliance on costly emergency power solutions. Additionally, this can lead to more stable and predictable energy pricing for consumers.

Impact

Renewables integration: Enhanced the integration capacity of renewables, installing 10 GW of renewable energy as of 2023, contributing significantly to Japan's sustainability targets.[29]



7. Australian Energy Market Operator (AEMO), Australia

Use case: Distributed energy resources registration (DERR)

AEMO has implemented a digital platform to simplify the registration and integration of DERs, such as solar panels, batteries, and EVs. The platform supports the seamless participation of these assets in the energy market, improving visibility, coordination, and overall system efficiency.

Through a single, centralized registration process, DER owners and operators can register their assets easily, ensuring consistent treatment and management of DERs across the market.

Impact

DER capacity generation: Renewable energy generation witnessed an 18% increase in 2020–21, accounting for 27% of the total electricity produced.[30]

Economic value: DERs have the potential to deliver a $19 billion economic boost to the Australian economy by 2040.[31]

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8. Energiewende: A Comprehensive Energy Transition, Germany

Use case: Digital tools for real-time monitoring

Germany's Energiewende, or "energy transition," is a ground-breaking national policy designed to shift the country's energy system from dependence on fossil fuels and nuclear energy to one predominantly powered by renewable sources. A key aspect of this transition is the widespread use of digital technologies, which are vital for handling the complexities that arise from a high proportion of renewable energy in the grid.

Germany has deployed advanced digital tools for real-time monitoring and control of its energy grid. These tools are crucial for maintaining grid balance, as renewable energy sources like wind and solar are naturally variable and can change with weather conditions. The real-time data gathered by these systems allows grid operators to quickly adjust, ensuring a stable energy supply that consistently meets demand.

Impact

CO2 emissions reduction: Germany reduced its greenhouse gas emissions by over 45% between 1990 and 2023.[32]



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Conclusion

The global energy sector is undergoing a significant transformation fuelled by the digitization of energy systems. Across the world, governments and companies are increasingly embracing digital technologies to enhance efficiency, sustainability, and resilience within their energy infrastructures. From advanced demand response systems and virtual power plants (VPPs) that optimize operations and reduce emissions to smart grids that improve grid stability and integrate renewable energy sources, the advantages of digitalization are becoming more apparent and impactful.

These advancements are not only revolutionizing the management of energy resources but are also making substantial contributions to economic growth, environmental protection and energy security. Countries like the UK, Germany, Japan, and other European nations are at the forefront, implementing innovative solutions that set benchmarks for others. The data and examples presented in this booklet illustrate the significant impacts of energy digitalization, highlighting its potential to foster a cleaner, smarter, and more reliable global energy system.

A key factor in this transformation is the role of standards, available in BSI Knowledge that offer crucial frameworks and guidelines to ensure that digital technologies are implemented effectively, securely and sustainably. These standards support the integration of renewable energy, optimization of energy systems, and reduction of carbon footprints – critical elements in the global push toward achieving net-zero emissions.

By ensuring consistency, safety, and best practices across the energy sector, standards help streamline the adoption of new technologies, mitigate risks, and maximize benefits. As we progress, the ongoing adoption and innovation of digital technologies, supported by strong standards, will be essential in addressing the challenges of climate change, increasing energy demand, and the need for sustainable development.

Next steps: Advancing digitalization with standards

To accelerate digital transformation in the energy sector responsibly, organizations can:

1. **Benchmark against international best practice**: Identify which standards (such as **BS EN 61850 series**, **BS ISO/IEC 30173**, and **BS EN ISO 50001**) align with your digitalization roadmap.
2. **Adopt a standards-led approach**: Use standards to ensure interoperability, cybersecurity, and safe integration of emerging technologies.
3. **Explore BSI Knowledge**: Access, manage, and apply the latest energy and digitalization standards in one digital platform for multi sites and departments.
4. Book a demo of BSI Knowledge to discover how your teams can stay compliant, efficient, and informed as energy systems evolve.

Book a demo of BSI Knowledge

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References

1 Bloombergnef (2026), ‘Energy Transition Investment Trends’, Available at https://about.bnef.com/insights/finance/energy-transition-investment-trends/ [Accessed 15 April 2024].

2 IEA (2024), ‘World Energy Investment 2024’, Available at https://www.iea.org/reports/world-energy-investment-2024 [Accessed 11 October 2024].

3 IOT Analytics (2024), ‘Smart Electricity Meter Market 2024: Global Adoption Landscape’, Available at https://iot-analytics.com/smart-meter-adoption/ [Accessed 11 October 2024].

4 IEA (2024), ‘World Energy Investment 2024’, Available at https://www.iea.org/reports/world-energy-investment-2024 [Accessed 11 October 2024].

5 ‘Smart Meter Statistics in Great Britain: Quarterly Report to end December 2025’, Available at https://assets.publishing.service.gov.uk/media/69b80e30b84f01b2be53a2b1/Q4_2025_Smart_Meters_Statistics_Report.pdf [Accessed 15 April 2026].

6 IEA (2024), ‘Digitalisation’, Available at https://www.iea.org/energy-system/decarbonisation-enablers/digitalisation [Accessed 11 October 2024].

7 IOT Analytics (2024), ‘Smart Electricity Meter Market 2024: Global Adoption Landscape’, Available at https://iot-analytics.com/smart-meter-adoption/ [Accessed 11 October 2024].

8 Elsevier (2023), ‘Electrification and digitalization effects on sectoral energy demand and consumption: A prospective study towards 2050’, https://www.sciencedirect.com/science/article/pii/S0360544223013865 [Accessed 11 October 2024].

9 IEA (2022), ‘Unlocking the Potential of Distributed Energy Resources’, Available at https://www.iea.org/reports/unlocking-the-potential-of-distributed-energy-resources [Accessed 11 October 2024].

10 Wood Mackenzie (2020), ‘The next five years will see massive distributed energy resource growth’, Available at https://www.woodmac.com/news/editorial/der-growth-united-states/ [Accessed 11 October 2024].

11 Slotta, D., Statista, ‘Electricity Transmission Losses in China From 2010 to 2023’, Available at https://www.statista.com/statistics/302292/china-electric-power-transmission-loss/ [Accessed 29 October 2024].

12 KPMG (2023), ‘Smarter Grids: Powering decarbonisation through technology investment’, Available at https://assets.kpmg.com/content/dam/kpmg/cn/pdf/en/2023/05/smarter-grids.pdf [Accessed 11 October 2024].

13 BSI (2024), ‘No one left behind: Working together on the road to net zero’, Available at https://pages.bsigroup.com/l/35972/2024-05-13/3t7tl43/35972/1715608319OzHokFeE/BSI_2024_Net_Zero_Barometer_FINAL_13.05.2024.pdf [Accessed 11 October 2024].

14 Capper, T., Oxby, J., UK Parliament Post (2024), ‘Demand Side Response: A Tool For Lowering Household Energy Bills’, Available at https://researchbriefings.files.parliament.uk/documents/POST-PN-0715/POST-PN-0715.pdf [Accessed 29 October 2024].

©2026 BSI. All rights reserved.

15 Institute for Energy Economics and Financial Analysis (2024), ‘DER could provide $19 billion economic boost by 2040’, Available at hhttps://ieefa.org/resources/der-could-provide-19-billion-economic-boost-2040 [11 October 2024].

16 Twinview (2024), ‘Maximising ROI with Digital Twin Technology: A Comprehensive Guide for Facilities Managers’, Available at https://www.twinview.com/insights/maximising-roi-with-digital-twin-technology-a-comprehensive-guide-for-facilities-managers#:~:text=Reduced%20Downtime%20and%20Maintenance%20Costs&-text=On%20average%2C%20Digital%20Twins%20can,supporting%20the%20facility%27s%20overall%20productivity. [Accessed 11 October 2024].

17 McKinsey & Company (2020), ‘How tapping connectivity in oil and gas can fuel higher performance’, Available at https://www.mckinsey.com/industries/oil-and-gas/our-insights/how-tapping-connectivity-in-oil-and-gas-can-fuel-higher-performance [Accessed 11 October 2024].

18 Deloitte, Insights2Action (2023), ‘Digital twins can pump up industrial outcomes’, Available at https://action.deloitte.com/insight/3503/digital-twins-can-pump-up-industrial-outcomes [Accessed 11 October 2024].

19 IBM (2024), ‘Cost of a Data Breach Report 2024’, Available at https://www.ibm.com/downloads/cas/1KZ3XE9D [Accessed 11 October 2024

20 UK Parliament (2024), ‘Demand Side Response: A Tool For Lowering Household Energy Bills’, Available at https://researchbriefings.files.parliament.uk/documents/POST-PN-0715/POST-PN-0715.pdf [Accessed 11 October 2024].

21 UK Parliament (2024), ‘Demand Side Response: A Tool For Lowering Household Energy Bills’, Available at https://researchbriefings.files.parliament.uk/documents/POST-PN-0715/POST-PN-0715.pdf [Accessed 11 October 2024].

22 Department for Energy Security and Net Zero (2023), ‘Smart Meter Statistics in Great Britain: Quarterly Report 2024’, Available at https://assets.publishing.service.gov.uk/media/66589b088f90ef31c23ebc73/Q1_2024_Smart_Meters_Statistics_Report.pdf [Accessed 11 October 2024].

23 Department for Energy Security and Net Zero (2023), ‘Energy Security Bill Factsheet: Smart Metering’, Available at https://www.gov.uk/government/publications/energy-security-bill-factsheets/energy-security-bill-factsheet-smart-metering [Accessed 11 October 2024].

24 MDPI (2019), ‘Applying the Smart Grid Architecture Model for Designing and Validating System-of-Systems in the Power and Energy Domain: A European Perspective’, Available at https://www.mdpi.com/1996-1073/12/2/258 [Accessed 11 October 2024].

25 IEA (2022), ‘Unlocking the Potential of Distributed Energy Resources: Executive summary’ Available at https://www.iea.org/reports/unlocking-the-potential-of-distributed-energy-resources/executive-summary [Accessed 11 October 2024].

26 GTM (2020), ‘5 Major Trends Driving the $110B US Distributed Energy Resources Market Through 2025’, Available at https://www.greentechmedia.com/articles/read/5-takeaways-on-the-future-of-the-u.s-distributed-energy-resources-market [Accessed 11 October 2024].

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27 Statista (2024), ‘Electricity Transmission Losses in China From 2010 to 2023’, Available at https://www.statista.com/statistics/302292/china-electric-power-transmission-loss/ [Accessed 11 October 2024].

28 KPMG (2023), ‘Smarter Grids: Powering decarbonisation through technology investment’, Available at https://assets.kpmg.com/content/dam/kpmg/cn/pdf/en/2023/05/smarter-grids.pdf [Accessed 11 October 2024].

29 Tepco (2023), ‘Tepco Integrated Report 2023’, Available at https://www.tepco.co.jp/en/hd/about/ir/library/integratedreport/pdf/TP2023_en_web.pdf [Accessed 11 October 2024].

30 Australian Government, Department of Climate Change, Energy, the Environment and Water (2022), ‘Australian Energy Update 2022’, Available at https://www.energy.gov.au/sites/default/files/Australian%20Energy%20Statistics%202022%20Energy%20Update%20Report.pdf [Accessed 11 October 2024].

31 Institute for Energy Economics and Financial Analysis (2024), ‘DER could provide $19 billion economic boost by 2040’, Available at https://ieefa.org/sites/default/files/2024-04/DER%20could%20provide%20%2419%20billion%20economic%20boost%20by%202040_Feb24.pdf [11 October 2024].

32 IEA (2020), ‘Germany 2020’, Available at https://www.iea.org/reports/germany-2020 [Accessed 11 October 2024].



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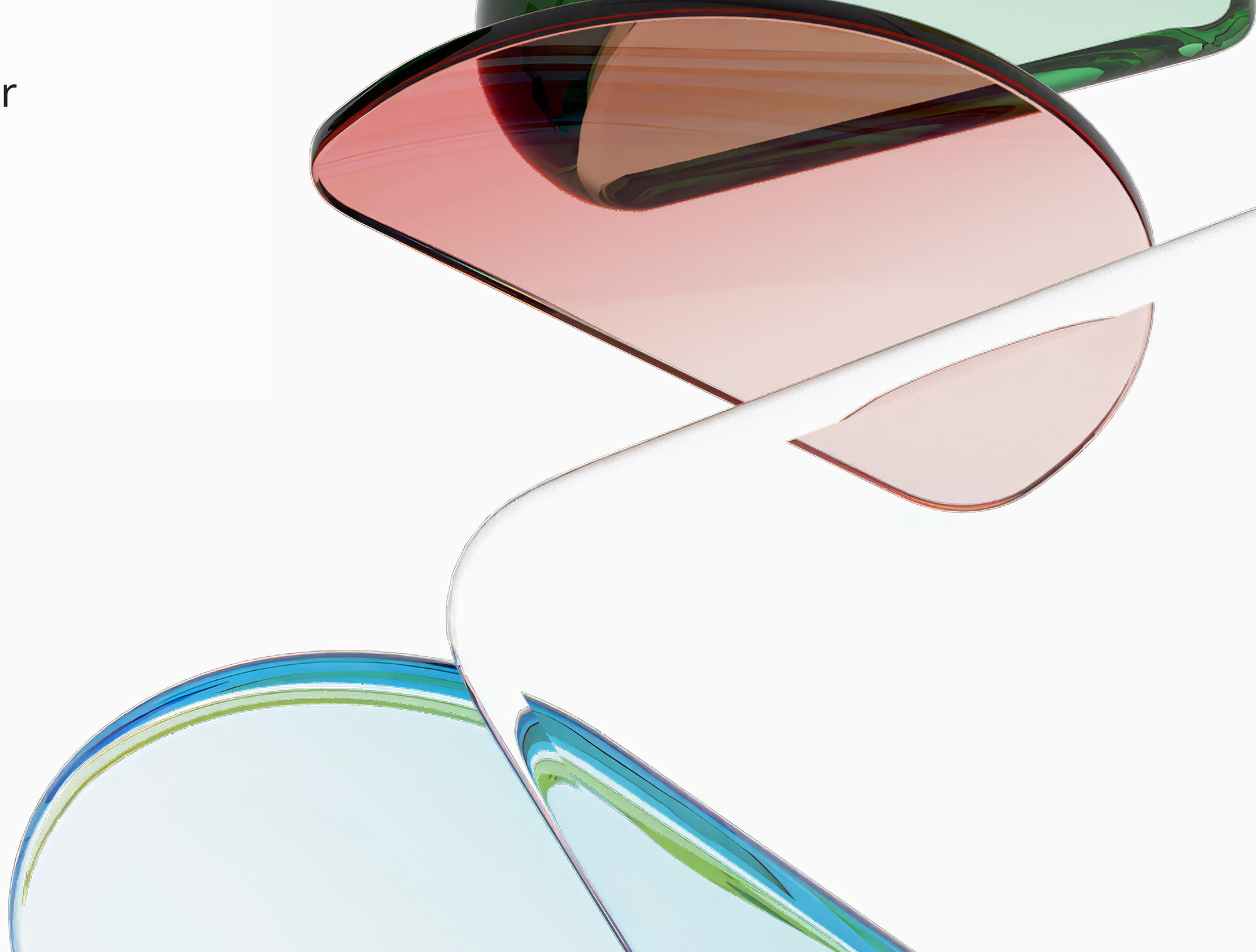


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