Hype Cycle for Environmental Sustainability, 2023

Published 3 August 2023 - ID G00790700 - 147 min read

By Analyst(s): Shanna Grafeld, Kristin Moyer, Simon Mingay

Initiatives: Executive Leadership: Sustainability; CIO Technology and Innovation Leadership

Applying technologies to overcome environmental sustainability challenges enables enterprises to shift from ambition to action. Although many technologies and innovations in this Hype Cycle are in the early stages of maturity, they can help executive leaders address sustainability challenges.

More on This Topic

This is part of an in-depth collection of research. See the collection:

- 2023 Hype Cycles: Deglobalization, AI at the Cusp and Operational Sustainability

Analysis

What You Need to Know

Executive leaders are capitalizing on technologies as a driver in their sustainability programs. These innovations can help organizations meet environmental sustainability goals and ambitions when applied well.

The adoption of sustainable technologies has progressed slowly — despite their demonstrated capability to address sustainability issues. This is due to the disconnect between what organizations express about their sustainability ambition and the actual operationalizing change implemented into daily organizational behavior.

The most rapid advancement on this year's Hype Cycle for Environmental Sustainability — formerly Hype Cycle for Sustainability — has been from voluntary carbon offsets, and carbon accounting and management software. These innovations have progressed significantly along the Hype Cycle. This rapid growth reflects the impact of regulations, such as the EU's Carbon Border Adjustment Mechanism (CBAM), on sustainable technologies. Most of the other technologies have advanced slightly rather than leaped forward.

For energy-related technology, see Hype Cycle for Low-Carbon Energy Technologies, 2023.

The Hype Cycle

The Hype Cycle for Environmental Sustainability includes 40 must-know environmental sustainability technologies and innovations. We have profiled high-impact technologies and innovations addressing some of the most controversial and disruptive sustainability-related matters. Examples include greenhouse gas emissions (GHG) management, climate risk mitigation, supply chain management (SCM) and the circular economy. Overall, this Hype Cycle focuses on sustainable technologies and innovations with cross-industry potential and implications.

The collection of technologies and innovations included in this Hype Cycle fit into three categories:

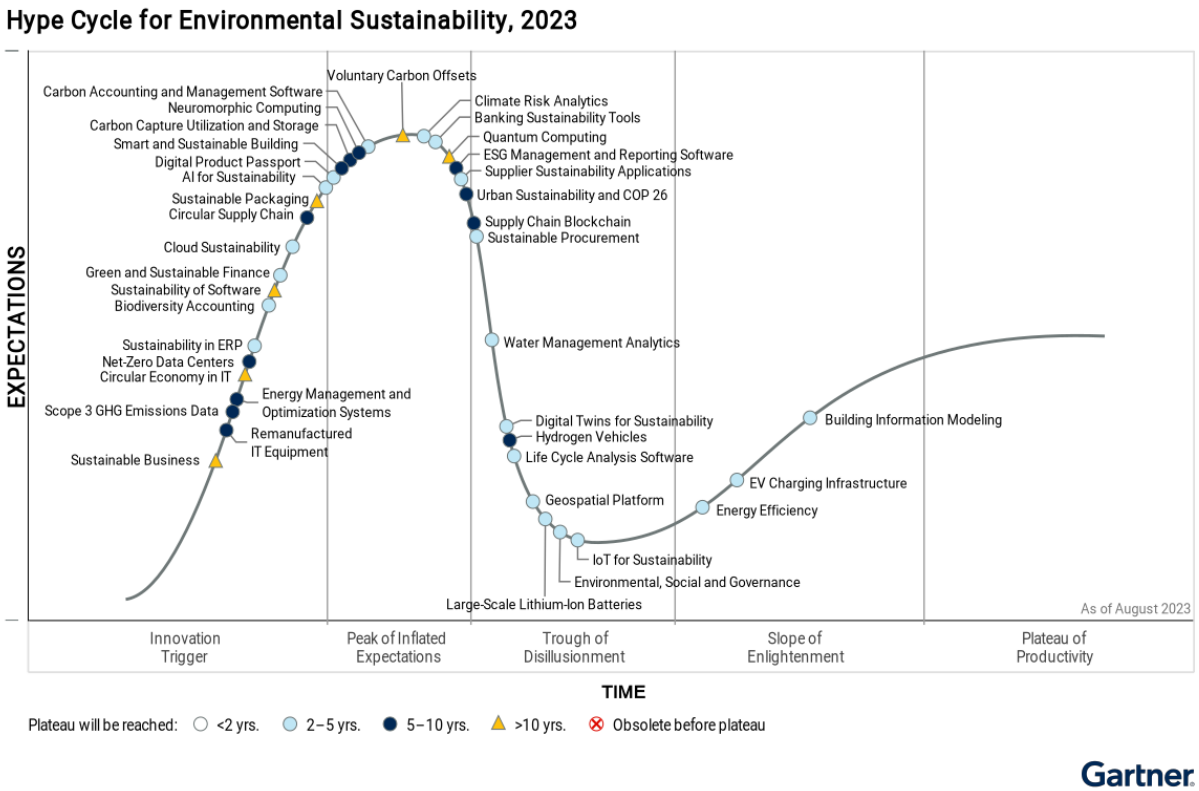
- Resource optimization technologies and capabilities — such as energy efficiency, sustainable packaging, smart buildings and net-zero data centers.
- Data and analytics, and digitally-enabled insight — such as AI for sustainability, water risk analytics, geospatial platforms, carbon accounting, life cycle analysis tools and supply chain blockchain.

- Underlying catalysts, concepts and capabilities — such as the circular economy, environmental, social and governance (ESG), Scope 3 GHG emissions data, green and sustainable finance and voluntary carbon offsets.

None of the sustainability technologies in this Hype Cycle are expected to reach mainstream adoption within the next two years. However, the majority are anticipated to achieve this within 10 years. Sustainability-related legislation will likely force the adoption of many of these technologies and innovations within the next five years. This will create new market challenges as technology providers scale quickly to meet demand.

Executive leaders who adopt technologies and innovations at early stages of maturity could achieve competitive market advantage and differentiation. Still, this will result in higher costs and possibly expose the organization to risks before scaling up. A portfolio approach — where sustainability innovations are applied to low-risk areas — can minimize risks and help identify the most appropriate options before extending technology integration to the entire business. Early adopters will enhance their sustainability proposition and achieve reputational and innovation benefits, such as improved customer satisfaction and sustainable product development.

Figure 1: Hype Cycle for Sustainability, 2023



The Priority Matrix

Table 1: Priority Matrix for Sustainability, 2023

(Enlarged table in Appendix)

Benefit	Years to Mainstream Adoption			
↓	Less Than 2 Years ↓	2 - 5 Years ↓	5 - 10 Years ↓	More Than 10 Years ↓
Transformational		Carbon Accounting and Management Software Digital Product Passport Green and Sustainable Finance IoT for Sustainability Large-Scale Lithium-Ion Batteries	Carbon Capture Utilization and Storage Circular Supply Chain Neuromorphic Computing Scope 3 GHG Emissions Data Smart and Sustainable Building Urban Sustainability and COP 26	Quantum Computing
High		AI for Sustainability Banking Sustainability Tools Biodiversity Accounting Building Information Modeling Climate Risk Analytics Cloud Sustainability Digital Twins for Sustainability Energy Efficiency Environmental, Social and Governance Geospatial Platform Sustainability in ERP Water Management Analytics	Energy Management and Optimization Systems ESG Management and Reporting Software Net-Zero Data Centers Supply Chain Blockchain	Circular Economy in IT Sustainability of Software Sustainable Business
Moderate		EV Charging Infrastructure Life Cycle Analysis Software Supplier Sustainability Applications Sustainable Procurement	Remanufactured IT Equipment	Voluntary Carbon Offsets
Low			Hydrogen Vehicles	Sustainable Packaging

Source: Gartner (August 2023)

Off the Hype Cycle

The following changes have been made to 2023 Hype Cycle for Environmental Sustainability:

- Energy-related technologies have been moved to 2023 Hype Cycle for Low-Carbon Energy Technologies.
- Supply chain risk management has been removed and replaced with climate risk analytics. The second is more specific to environmental sustainability.

- Sustainable communications service provider (CSP) infrastructure has been removed because we are limiting the inclusion of industry-specific innovations.

On the Rise

Sustainable Business

Analysis By: Shanna Grafeld, Kristin Moyer

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Sustainable business is a strategy that positions an organization for a low-carbon future by incorporating environmental factors, such as carbon emissions, resource efficiency and climate change into decision making and execution.

Why This Is Important

Sustainable business represents a shift in enterprise operations, business models and ecosystems — where sustainability is no longer a "bolt on" addition but a "built in" component. How businesses navigate this shift, largely driven by regulatory change and stakeholder pressures, will be essential for their future success in a low-carbon economy. Enterprise leadership teams will need to sense change early and stay at least a step ahead of their stakeholders to maximize value.

Business Impact

Sustainable business impact on enterprise activities will be high overall. Whether the impact has a negative or positive effect on any singular organization will largely depend on their preparation and ability to capitalize and grow in a low-carbon economy. However, in some industries, the change will be transformational. This is especially true for asset-intensive industries or any business with a complex supply chain or exposure to strict environmental regulations.

Drivers

- Customers are demanding sustainability-related performance data and indications of engagement. In the 2022 Gartner Sustainability Opportunities, Risks and Technologies Survey, 80% of surveyed organizations cited customers as creating pressure to act on sustainability initiatives.

- Organizational focus on sustainability is increasing. Eighty-seven percent of those surveyed organizations anticipate increasing their sustainability budget over the next two years.
- Sustainability-related regulations and associated fines for noncompliance are becoming commonplace across all major geographies.
- Many organizations have made public commitments to sustainability outcomes such as net zero GHG emissions, science-based targets, or the United Nations Sustainable Development Goals, among others. In many cases, these commitments stretch out for 10 to 30 years.

Obstacles

- For many organizations, sustainability has been a siloed activity and has not become embedded in strategic planning, financial planning or business processes.
- Investment in digital technology to accelerate sustainability progress has been slow to date. Many solutions are available, but have not yet reached widespread implementation.
- A rapidly evolving sustainability solutions landscape has led to a confusing landscape of vendor providers and capabilities.
- There is a disconnect between enterprise sustainability ambition and technology related risk appetite. Many organizations express high ambition, but demonstrate low risk tolerance. The policy initiatives that advance the climate economy are developing a distinct geopolitical dimension, with arguably protectionist objectives.
- There is a talent knowledge and skills gap. Many executives have not received formal training on sustainability yet and have been expected to deliver results.

User Recommendations

- Define organizational sustainability ambition. This ambition exists on a spectrum from compliance with sustainability regulations to sustainability transformation. Most organizations lie somewhere in the middle and clarifying the level of ambition is an essential step in identifying relevant capabilities and technologies.
- Align sustainability goals and risk appetite and manage or reset expectations accordingly.
- Drive sustainability into decision-making and long-term financial plans.

- Define appropriate short-, mid-, and long-term targets.
- Engage the entire executive leadership team around sustainability.
- Close the sustainability skills gap by building up internal capacity. This can be accomplished through formal training for leaders and strategic consulting arrangements that bolster organizational skills.
- Communicate sustainability plans and accomplishments with internal and external stakeholders.

Gartner Recommended Reading

Climate Economy: A Clean, Digital and Circular Revolution

2023 Growth Agenda: Sustainability is an Opportunity for Business Growth

2023 CEO Survey: Grow Through Digitally Enabled Sustainability

How to Set Strategic Ambition for Sustainability

Remanufactured IT Equipment

Analysis By: Autumn Stanish

Benefit Rating: Moderate

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Remanufactured IT refers to a process that goes beyond traditional refurbishment to restore IT equipment (devices, switches, servers, etc.) to a state of “like new” or “better than new.” This is accomplished through cosmetic restoration, upgraded components and quality testing. Once completed, equipment is either resold or redeployed for reuse. This approach looks to reuse IT hardware in a sustainable manner that improves costs, maximizes utilization, and reduces carbon footprint and e-waste.

Why This Is Important

Remanufactured IT equipment processes offer a new avenue for IT equipment to be resold and reused in a manner that has minimal impact on the environment, while providing financially attractive and more-frequently available sources of material. The drawbacks to traditional refurbished IT, in terms of reliability, are remediated out of this process. Most providers of remanufactured equipment offer warranty coverage for as long as three years.

Business Impact

Remanufactured IT equipment offers IT organizations the opportunity to improve their financial and environmental performance by procuring certified carbon-neutral equipment that can save as much as 40% on overall hardware spending. In addition, having a remanufacturer relationship enables the organization to take advantage of availability in a less-competitive resource stream, when supply is constrained.

Drivers

Demand for remanufactured IT equipment has been driven by a variety of factors:

- Environmental sustainability is changing the way IT products and services are produced, purchased and consumed. The shift to a carbon-cutting “climate economy” is driving demand for secondary markets and new business models designed to reharvest value from e-waste.
- In France, IT hardware procurement deals must consist of at least 20% recycled or refurbished products. Legislation is being considered in other countries throughout Europe.
- Equipment manufacturers have begun prioritizing modularity in their product designs as the “right to repair” movement strengthens, with codifications in New York and potentially more states throughout the U.S., making remanufacturing a more-viable process.
- Carbon emissions from equipment manufacturing make up nearly half of IT’s carbon footprint in most organizations, causing those with IT sustainability strategies to leverage remanufactured equipment as a way to contribute to the circular economy and avoid emissions.

- Budgets have grown increasingly constrained as the cost of IT equipment remains elevated. Remanufactured IT equipment offers a financially advantageous alternative to organizations looking to reduce costs, while providing a desirable IT experience for employees.
- The affordability of premium device types, such as Apple Macs, has become an appealing way to provision more-expensive, preowned equipment at a fraction of the cost.

Obstacles

Embracing remanufactured IT equipment can be challenged in several ways:

- The stigma against refurbished IT equipment as unreliable and low-quality
- Windows 11 hardware requirements, which limit the pool of eligible commercial devices
- Limited configuration options resulting from inconsistent availability of equipment models
- A growing focus on the digital employee experience and the desire to offer the newest and greatest devices with sleeker design for employee retention
- Trade-offs between efficiency improvements of new technology and the design constraints of older equipment
- Availability of support — hardware parts for warranty, as well as OS support and bug/security fixes for drivers and firmware
- The trade-off between energy consumption and manufacturing emissions, which complicates servers' sustainability benefits — a newer server could do more with less energy during its life cycle, which is more efficient than an older server (depending on the energy source)

User Recommendations

- Ensure that providers offer specific quality certifications, such as BSI Kitemark, Renewd and ISO9001.
- Select a core group of users, such as administrative workers or call center agents, who require only simple configurations, to pilot and test the performance of remanufactured devices in the organization's environment.
- Discuss take-back and recycling strategies with the vendor at the forefront of the deal to ensure full circularity after its second life.
- Require the original vendor to provide updates that fix security issues for the expected life of the solution.

Sample Vendors

Circular Computing; Recommerce

Gartner Recommended Reading

The Complete Guide to a Sustainable Device Life Cycle Using the IT Circular Economy

Unlock the Business Benefits of Sustainable IT Infrastructure

Positioning I&O for Environmental Sustainability

Climate Economy: A Clean, Digital and Circular Revolution

Energy Management and Optimization Systems

Analysis By: Lauren Wheatley

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Energy management and optimization systems (EMOS) are modular platforms that allow commercial and industrial (C&I) customers to better manage their energy use. An EMOS combines a holistic view of the main energy consumption sources with advanced optimization capabilities to interact with automation systems and production goals. It consumes data from meters and sensors and communicates with an energy supplier, grid operator or market to orchestrate operational use cases.

Why This Is Important

Volatility in energy cost and supply is hurting business and driving inflation. Commercial and industrial (C&I) companies need to proactively mitigate immediate energy price and security concerns while still making meaningful progress toward emissions reduction goals, such as net zero. Managing energy costs will require C&I consumers to increase investment in energy management and optimization technologies.

Business Impact

C&I enterprises are prioritizing cost and environmental impact in their energy-related decision making and are looking to proactively control energy sourcing and consumption. This has resulted in growing markets for energy services by subscription. The move toward service-based models requires the rapid adoption of digitalized products by E&U companies such as offering EMOS capabilities to help customers conserve energy, save money, manage GHG emissions and comply with regulatory mandates.

Drivers

- C&I and community-entity energy customers are increasingly seeking greater control of their energy supply chains to control costs and build energy resiliency.
- There are growing markets for energy technology, energy services and energy-as-a-subscription services.
- Industrial digitalization is instrumenting the asset base, enabling EMOS platforms to proactively optimize energy loads.
- EMOSs require an ecosystem of partners, data, hardware and software that may be provided by multiple vendors. This gives energy company CIOs the opportunity to work with vendors to deploy a composable EMOS platform that aligns most closely with their energy and sustainability strategy.
- Increasing investments in smart grids and smart energy meters allows connection and coordination of all of an enterprise's equipment and devices, enabling continued advancement of EMOSs. By using IoT data and applying tools such as AI and predictive maintenance, EMOS products can provide intelligent operations capabilities, a strategy where physical systems are represented, configured and controlled by intelligent software.
- Volatility and rising energy prices mean that technologies, such as digital twins and AI to enable bidirectional coordination and automation that weren't financially feasible and lacked technical maturity just a few years ago, are now viable.
- The drive toward digital business is about rethinking what is possible, and for E&U companies, how their customers can engage with distributed energy resources in the future. This is particularly important where exponential innovation beyond the meter has delivered consumer energy technology and consequent grid parity, challenging existing energy supply assumptions creating new business models and new opportunities.

Obstacles

- C&I companies seek low-risk solutions that can be easily scaled with a limited management overhead and capital investment, allowing them to focus on critical business activities. However, EMOS system implementation and integration can require energy management expertise and a sophisticated understanding of the financial and risk implications of various purchasing options.
- When creating new business models and opportunities, be aware of the internal challenges faced by customers and align with C&I enterprises' priorities such that they can execute at a lower cost point and unlock additional opportunities.
- C&I business leaders do not trust the data they have to support ROI calculations, agree on priorities or support the digital solutions.
- While there is a myriad of vendors entering the market, many have limited capabilities focused predominantly on dashboarding and reporting rather than insights and energy optimization.

User Recommendations

- Prepare to support an energy services business by factoring EMOS functionality and solutions into deployment roadmaps.
- Invest early to enable commercial success by establishing energy consumption data and information management strategies that will support an energy services business that delivers cost reduction programs and environmental management goals to C&I enterprises. Establish a roadmap to consolidate enterprise real-time data by integrating IoT infrastructure from edge to cloud.
- Align business and digital strategies with changing C&I enterprise drivers. For years, E&U customer engagement focus has been on customer service while managing a narrow scope of commodity transactions, but during this era of transition, customer experience will define the breakout enterprise. CIOs must design customer experience/total experience (CX/TX) that is fit for purpose across the energy transition.

Sample Vendors

C3 AI; Dametis; Energy21; EnergyCAP; GE; Honeywell; IMS Evolve; METRON; Schneider Electric; Siemens

Gartner Recommended Reading

Market Guide for Energy Management and Optimization Systems

Quick Answer: How Electric Utility CIOs Can Respond to Changing Customer Expectations

2022 Sustainability Survey: Energy CIOs Can Help to Retain C&I Enterprises as Customers

Scope 3 GHG Emissions Data

Analysis By: Kevin Lawrence

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Scope 3 greenhouse gas (GHG) emissions include indirect emissions that occur in an enterprise's value chain, including its upstream supply chain, and downstream, such as use and consumption of its products and services. Enterprises aim to share accurate, complete and up-to-date emissions to report and make better decisions.

Why This Is Important

Scientific studies suggest the world economy needs to be net-zero GHG emissions by 2050, requiring transformatory changes in enterprise operations. While enterprises rightly start by tackling their Scopes 1 and 2 direct emissions, pressure from stakeholders is mounting to measure and manage all material Scope 3 categories emissions. Scope 3 accounts for 80% of emissions on average, and while it occurs outside an enterprise's direct control, improvements are not beyond its ability to influence.

Business Impact

Enterprise Scope 3 reporting expectations or obligations are set to increase significantly, with pressure coming from investors, regulators and direct customers. This pressure is cascading both up and down the supply chain. The speed with which the pressure mounts and associated timing will vary by sector and geography, but this will impact most enterprises over the next five to 10 years.

Drivers

- Mitigation of carbon risk in the enterprise value chain occurs more effectively than the competition, thus creating business value or competitive advantage.
- Emerging regulatory requirements occurring now and over the next two to three years will require reporting Scope 3 emissions.
- Long-term risk planning inclusive of the effect of climate change is forcing companies to integrate GHG emissions into their business models, strategy, operations and supply chain management choices.
- Mitigation of risks related to voluntary or mandated carbon pricing.
- Companies looking to leverage sustainability into their market positioning and demonstrate progress will need Scope 3 GHG emissions data to be successful.

Obstacles

- Skills and capabilities are lacking within enterprises to measure and manage all GHG emissions, especially Scope 3.
- A lack of standards and scalable guidelines to consistently calculate, account for and verify emissions are lacking, leaving too much room for interpretation.
- Trust across value chains is lacking and suppliers are often unwilling or unable to share their data.
- Survey and spreadsheet tools are extensively used to collect data and are inadequate.
- No integrated, consistent or harmonized digital platforms are available to share data across the value chain. An increasing number of vendors offer platforms, but none dominate or are obvious winners.
- Product/service-level emissions data is often considered to be competitive, and as such, it is protected.
- Accurate product-specific data is critical; however, it can be difficult to calculate and time-consuming to source. Use of averages can result in drastic variations in emissions and prompt misinformed action.

User Recommendations

- Determine a baseline inventory of Scope 3 GHG emissions by conducting a screening to identify material contributors to GHG emissions. Establish a roadmap to improve data accessibility and accuracy with key supply chain partners.
- Track stakeholder expectations and emerging regulatory environments across all jurisdictions in which the enterprise operates to determine when they will require reporting and managing each of the Scope 3 categories (15 in total).
- Create a three-year data and technology strategy with the goal to increase primary emissions data acquisition and data quality for material categories.
- Evaluate emerging emissions calculation solutions that offer extensive emissions factors and aid in operationalizing emissions into business decisions and overall enterprise measurement.
- Prioritize Scope 3 emissions reduction levers for material drivers of impact, assess feasibility and reduction potential, and craft a decarbonization roadmap to track progress.

Sample Vendors

BigMile; carbmee; Climatiq; IBM (Envizi); Optera; Persefoni; Salesforce; Sphera; VesselBot; Watershed

Gartner Recommended Reading

3 Steps to Accelerate Scope 3 Carbon Emissions Reduction Goals in the Value Chain

Market Guide for Supplier Sustainability Applications

Market Guide for Enterprise Environmental, Social and Governance Software

Circular Economy in IT

Analysis By: Simon Mingay, Sarah Watt

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Emerging

Definition:

A circular economy enables IT vendors and end-user enterprises to decouple consumption of IT assets from growth in demand. Three principles form a basis of a circular economy: design out waste, keep materials in use at the highest quality for long and return materials to the environment in a way that has a positive impact. The IT sector must meet strong regulatory requirements for e-waste in many places, notably the EU, but has challenges around engaging strategically with circularity.

Why This Is Important

IT asset life cycles are short. In a linear economy, old products become seen as waste; either lost to landfill or selectively recycled. The circular economy maximizes value. Assets are supported, repaired, upgraded, returned, refurbished and resold. Successful deployment relies on thoughtful design, new materials, reverse supply chains, the economics of residual value, repair and refurbishment partners and the application of new business models. A circular economy limits environmental impact, grows market share and creates new experiences.

Business Impact

Positive business impacts of the circular economy include enabling new “as-a-service” business models, meeting customer needs in constrained supply environments and acting as a hedge against raw material price increases. These benefits are realized when product design, support, parts availability, warranty, usual technology obsolescence issues, are addressed, and supply chain mechanisms are in place to pull back strategic products from the market for refurbishment.

Drivers

- **Legislative Drivers:** The “right to repair” provides access to spare parts and technical information to extend product life. EU waste policy aims to ensure that high-quality resources are not lost from the economic system. Concerningly, 60% of EU household e-waste still goes to landfill (see E-Waste in the EU: Facts and Figures (Infographic), the European Parliament).
- **Supply Chain Fragility:** Fragile supply chains can be addressed through the circular economy either by meeting customer demand through second-life products or by reclaiming raw materials for manufacturing new products.
- **Climate Change:** A circular economy has the potential to reduce climate change impacts, as product-embodied energy (and emissions) is used more efficiently. By slowing the rate of material, component, *new* product consumption, demand for new raw materials (and their concomitant emissions) is reduced. Hardware vendors must undertake life cycle analysis to review the environmental impacts of end-of-life options, enabling trade-off decisions to be made (for more information, see A New Circular Vision for Electronics, World Economic Forum).
- **Enhanced Value:** The circular economy enables enterprises to offer new, more sustainable business models and products, sustainability-focused performance analytics and a differentiated sustainability narrative.
- **Innovation:** The circular economy is a catalyst for innovation by equipment vendors. Examples include modular design for repairability, design for reuse and longevity, use of innovative materials such as bio-based components, and design for disassembly (for more information, see The Global Electronics Council).
- **Cloud:** Cloud services are inherently based on resource-sharing business models and offer significant potential to dematerialize parts of the IT sector, should the cloud service providers choose to make the most of that potential.

Obstacles

- **Mindset Shift:** A mindset shift is needed to scale the circular economy for IT.
- **Partnerships:** Scaling the circular products relies on engaging with ecosystem partners. Partner capabilities vary by market.
- **Impact:** No clear harmonized metrics or standards have been agreed on to report progress on circular activities. Comparison between enterprises is challenging.
- **Product Complexity:** Electronic devices are complex, frequently containing materials that require careful, expensive disassembly and specialized processing. Materials toxicity presents a reuse, health and safety challenge.
- **Obsolescence:** Premature obsolescence is a significant problem in the IT sector. In part due to design and vendor business model issues, and in part enterprise procurement and asset management practices.
- **Fashion:** Technology as fashion accessory, and the need for the latest, slimmest, sleekest, fastest device.
- **Security Policies:** Many enterprises have security policies that demand that media (such as hard-disk drives and SSDs) must be shredded. More sustainable software sanitization options available.

User Recommendations

- **Select Circular Solutions:** Favor public cloud solutions. Focus on cloud providers demonstrating leading circularity practices. Select products with improved circularity performance by making use of ecolabels such as EPEAT and TCO Certified. Favor products that avoid materials of concern, such as mercury, PVC and brominated flame retardant.
- **Assess OEM Circularity Ethos:** Engage with your key OEMs, and assess the extent to which they are designing their products and business models for circularity. Favor vendors that demonstrate a strategic and systemic approach to circularity.
- **Extend Utility:** Look to extend the life of less energy-intensive devices such as phones, PCs and monitors. Increase asset utilization, and minimize overprovisioning capacity.

Gartner Recommended Reading

Industry Insights: The Value of Circular Economies

Build a Circular Supply Chain to Unlock Growth and Improve Environmental Impact

3 Circular Economy Interventions That Will Mitigate Supply Chain Disruption

3 Accelerators to Advance the Circular Economy in Supply Chain

Quick Answer: How Will Degradable Electronics Enhance Sustainability?

Net-Zero Data Centers

Analysis By: Simon Mingay, Philip Dawson, Autumn Stanish, Matthew Brisse

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Emerging

Definition:

Net-zero data centers aim to achieve a net-zero climate target by minimizing their direct and indirect greenhouse gas (GHG) emissions, and offsetting the balance appropriately. They should be able to demonstrate world-class energy and water efficiency, circularity practices, and asset utilization.

Why This Is Important

Enterprises and data center/cloud service providers are under mounting pressure from customers, investors, regulators and employees to reduce GHG emissions, increase energy efficiency, and establish a credible sustainability narrative. Pressure is growing on infrastructure and operations (I&O) leaders to adopt methods to increase transparency and performance, in order to make their data center operations efficient and environmentally sustainable.

Business Impact

IT leaders are confronted by a significant, unrelenting, year-on-year growth in compute and storage capacity, with spiraling energy consumption and associated GHG emissions. For enterprises with energy and GHG reduction targets, this is unsustainable. To meet cost targets, organizations must make radical improvements in data center, and I&O efficiency and emissions. Net-zero data centers will be essential infrastructure for all enterprises with ambitious or net-zero GHG targets.

Drivers

- Alignment of I&O with the organization's energy and GHG targets.
- External stakeholders' (specifically customers, investors and regulators) net-zero expectations.
- The need to mitigate the liability associated with costs of energy and GHG emissions.
- The need to build resilience in the face of increased contention for electrical and renewable supply capacity.
- Increased emphasis on cost reduction in IT systems.
- Increased consumption of cloud services, moving workloads out of the enterprise data center.
- Data center consolidation, caused by office consolidation following the COVID-19 pandemic, end of economical life of data centers and refocus of business operations.
- Customers demanding GHG footprint transparency from data center and cloud service providers.

Obstacles

- Unrelenting and significant growth in compute and storage capacities.
- Lack of a strong business case in the absence of ambitious enterprise GHG reduction goals.
- Lack of availability and cost of renewable energy, along with lack of capital to invest in power purchase agreements.
- Imprecise, complex and costly measurement, management, and mitigation of Scope 3 GHG emissions.
- The immaturity of circular economy practices and services.
- Costs of transition to more efficient cooling and HVAC systems, using technology such as immersion and free air cooling.
- Reducing water consumption.
- Lack of cost-effective low-carbon alternatives to diesel generators.

User Recommendations

- Secure a long-term supply of renewable energy.
- Measure the success of the data center sustainability program in broader enterprise sustainability initiatives by creating realistic KPIs for GHG emissions and water consumption.
- Conduct an audit of the data center's GHG emissions, waste and water consumption to understand its footprint. Liaise with the enterprise's sustainability, energy management, real estate and legal teams to build the business case and support the program.
- Reduce the data center's emissions footprint by investing in energy efficiency measures, GHG, and water and waste reduction.
- Follow through the full green value chain and do not consider the cloud as a legitimate offset of responsibility.
- Support the development of global industry/university consortia to focus on innovative solutions and standards for low-power computation, and data communication and storage.

Gartner Recommended Reading

Strategies to Plan for GHG Emissions Reduction

Building a Low-Carbon Energy Strategy

Ignition Guide to Building a Net-Zero Greenhouse Gas (GHG) Emissions Roadmap

Maverick Research: Net Zero Will Stall Tech Growth and Innovation

Toolkit for Estimating Data Center Build and Modernization Costs by Tier Level

Sustainability in ERP

Analysis By: Greg Leiter, Denis Torii, Neha Ralhan

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

As stakeholders and regulators increasingly demand that organizations transparently report their progress against sustainability goals, ERP vendors are responding to these demands by incorporating sustainability capabilities into their solutions. Embedding of sustainability and environmental, social and governance (ESG) data within core ERP enables improved optimizations and decision making.

Why This Is Important

Sustainability cannot be managed as a discrete area of performance. Enterprises must include sustainability goals and data, alongside other business objectives and data, to enable integrated optimizations of enterprise operations. Execution of sustainability and ESG goals requires integration of data into core business processes (planning, execution and feedback) to inform sound decision making, balancing trade-offs between cost, cash flow, service, and environmental or social impacts.

Business Impact

ESG and sustainability data visibility, integrated with existing core business processes, aligned to appropriate roles and functions, creates accountability and informed optimized action, and enables better automated process execution. It enables putting decision-making frameworks in place that include sustainability-related factors in addition to traditional business levers, and enables roles to understand how their actions directly impact a broader set of enterprise goals and activities.

Drivers

- Enterprises with ambitious ESG and sustainability goals have a sense of urgency to substantially improve the sustainability-related capabilities of their core business applications.
- Effective analytics and insights require the integration of ESG and sustainability data, processes and metrics into the business to enable new points of optimization, and to link with financial and other operational data.
- CIOs are reluctant to add new application vendors and software, preferring to extend capabilities supported in the existing applications portfolio.
- The need to improve data quality and reduce gaps in data collection and usage across a variety of business activities and processes. Foundational data needed for ESG reporting is often sourced from ERP solutions.
- Empowering employees and automating process execution and decision making will ensure that sustainability objectives are achieved in more scenarios, rather than being an afterthought or an exceptional isolated initiative.

Obstacles

- Sustainability and ESG data has historically been highly fragmented and suffered from significant gaps, with any consolidated view held only by a few specialist roles, or in niche applications and/or spreadsheets.
- Best-of-breed or niche application vendors will move much more quickly than many of the established ERP and enterprise business application vendors, but integrating their specialized solutions into major core applications is not well supported by their legacy architectures.
- Best practices, standards and regulations in relation to ESG and sustainability data and processes are immature and change quickly, making it tempting for incumbent application vendors to delay investment.
- Lack of data, not just within the enterprise, but examples where the data simply does not exist — such as reliable, accurate Scope 3 emissions data.

User Recommendations

- Embed sustainability and ESG into your enterprise, application and data architectures, and technology roadmaps. Ensure there is a feedback loop between planning, execution and reporting.
- Work with ERP vendors to integrate ESG and sustainability. Apply a more tactical and innovation-led approach to meet needs with narrower point solutions, but be aware of necessary integration and data management efforts
- Assess current core business application portfolio to understand the sustainability and ESG data and capabilities that are supported and assess vendor roadmaps to understand and influence ESG capabilities
- Leverage the enterprise materiality assessment to decide which sustainability and ESG issues and associated capabilities and data points should be implemented or made available.
- Put in place frameworks that codify the integration of sustainability and ESG data as part of decision making.

Sample Vendors

Epicor; IFS; Infor; Microsoft; Oracle; QAD; SAP

Biodiversity Accounting

Analysis By: Bettina Tratz-Ryan, Aapo Markkanen

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Biodiversity accounting enables organizations to assess, benchmark and report the biodiversity impact on their economic activities and their business ecosystem. The accounting encompasses the focus on quantifying spatially detailed information on key species in terms of abundance, richness, conservation status and other characteristics such as health in alignment with the Convention on Biological Diversity (CBD) and System of Environmental Economic Accounting (SEEA).

Why This Is Important

Commitments of the UN Biodiversity Conference led to the global diversity framework that identifies drivers, goals for 2030 and 2050 and potential remedies such as equitable resource sharing. Leaders in industries that leverage nature-based assets need to apply spatial and visual data analytics to account for their utilization as well as the harm to biodiversity and ecosystem functions, in addition to human health.

Business Impact

Biodiversity accounting offers a fact base that allows a risk assessment for organizations with high biodiversity ecosystem exposure alongside the supply chain. Organizations like Swiss Re establish a Biodiversity and Ecosystem Services risk index, which ranks the fragility of the ecosystem that will directly impact the resilience of organizations with business in those markets. Biodiversity accounting strategies standardize organizational environmental accounting practices with the UN SEEA statistical framework or PBAF.

Drivers

- **Economic impact on GDP:** According to the World Economic Forum, half of the global GDP depends on nature-based materials, and inactivity will impact major industries like food, agriculture, transportation sites, urban extensions or mining.
- **Linking awareness to accountability:** In the past, biodiversity loss has been singled out as an individual issue. Using biodiversity accounting and environmental economic accounting, the impacts of organizations, industries and market approaches become visible and reportable to market partners, regulators and stakeholders.
- **Product innovation:** With impact analysis and due diligence comes the opportunity to change product designs and sources toward a more effective material use and toward a circular business strategy, including recycling or reuse. This will avoid the need to extract primary materials linking it to biodiversity risk.
- **Analysis of influencing factors:** In comparison to resource accounting and efficiency, applying the spatial impacts of water on the ecosystem will allow the assessment of water stress level and lack of irrigation requirements on biodiversity.
- **Guide investments in incentives such as forestation:** Investments in natural capital programmes, TNFD and TCFD understand the performance and risk goals but also lead to improving impacted industries by mitigating crop yields, loss of pollinators, soil erosion and human damages.
- **Data standardization and exchange:** Spatial data, tabular data and time series are data sources that are offered by different data statistics and source providers, such as the European Environment Agency (EEA), Data.gov in the U.S. or Protected Matters Search Tool in Australia, offer open source and API abstracted data for standardized data modeling accessible to all stakeholders, including sustainability and digital offices. In addition, there are ecosystem data exchanges such as the Open Source Biodiversity Platform Initiative.

Obstacles

- **Insufficient supply chain and procurement alignment of third parties:** Information flows of the ecosystems are often incomplete because they require due diligence in procurement and market participation or social factors of communities in which organizations are operating.
- **Insufficient data skills and software capabilities:** Biodiversity accounting needs in-depth domain expertise to handle the complexity of data, and sustainability professionals with relevant skills are in short supply. Also, software tools are very niche.
- **Lack of business context on biodiversity accounting:** Biodiversity effects' implications caused by business activities and biodiversity loss on business continuity are not commonly understood by organizational leadership.
- **Misalignment of reporting priorities:** While biodiversity is an element in many nature-based reporting standards, there are unintended consequences when carbon emission offsets are prioritized by planting monoculture vs. the biodiversity requirements of a given landscape.

User Recommendations

- Create an outreach mechanism with the sustainability stakeholders in the organization and across, that gamifies and contextualizes information and insight flows generated by biodiversity accounting. It supports the understanding and transparency of the biodiversity scope and risk.
- Identify short-term critical biodiversity ecosystem taxonomy while contributing to databases and supply chain modeling that can be helpful to avoid harm to human life or habitats.
- Experiment with AI for good and new forms of generative AI to establish a comprehensive analysis for long-term goals and unintended consequences derived by prioritizing carbon over natural impacts.
- Monitor the development of biodiversity loss as a form of enterprise risk by following the work of TNFD or directly engaging with it.
- Build out internal and external resources to support biodiversity accounting by recruiting in-house experts, contracting sustainability consultancies, partnering with academic researchers, or engaging with relevant startups.

Sample Vendors

AECOM; Anthesis Group; Arcadis; BIOTOPE; Esri; KC Harvey Environmental; KPMG; NatureFinance; NatureMetrics

Gartner Recommended Reading

3 Sustainable Business Responses to Biodiversity LossEmerging Tech Impact Radar: Environmental Sustainability

Green and Sustainable Finance

Analysis By: Alistair Newton, David Furlonger

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Green and sustainable finance describes any financial product/service created to deliver positive environmental and sustainability outcomes, or address sustainability regulations. Lending costs will be influenced by the environmental footprint of the asset being funded. So funding a coal mine will incur higher funding costs than for a wind farm. And retail consumers buying a home will pay a higher mortgage interest rate for a home with low energy efficiency than for a highly efficient home.

Why This Is Important

Green financing flourished for years in lending contexts, such as development bank financing. Now fresh impetus is added by numerous government initiatives and industry initiatives, such as multiple banks committed to the Glasgow Financial Alliance for Net Zero (GFANZ; see Investment Bodies React to New UK Green Finance Strategy, International Investment). Growing regulatory and stakeholder pressures for enterprises to address sustainability issues will add further momentum. Green finance will address these pressures by pricing sustainability and environmental costs into lending and capital.

Business Impact

Green and sustainable finance will require new approaches to managing and assessing sustainability lending risk:

- Banks will need better insight on sustainability risks in the operating environments of their customers.
- Enterprise measurement of sustainability impacts of projects will become mandatory, domestically and across multiple geographic borders.
- Pricing and risk models will need to adapt in real time to reflect operational data.
- New customer facing engagement dashboards and tools will be required by customers.

Drivers

- Many retail and institutional funds that provide the banks with their liquidity are looking to align with stakeholder pressure for more explicit sustainable or green principles.
- Multiple levers can be utilized to encourage desired behaviors around the environment and other social endeavors. For banks providing capital and their customers consuming that capital, the most direct impact will be derived by allocating wider sustainability and environmental costs to the funds used to invest in particular assets, projects or enterprises.
- This approach was endorsed by multiple FSI CEOs as they established the GFANZ initiatives at the COP26 meetings in Glasgow in 2021, although there remain challenges in driving these initiatives forward (see Mark Carney's Green Alliance Rides Out Stormy Waters, Financial Times).
- The emergence of multiple green taxonomies that start to define the assets and activities that combine to impact sustainability goals (see Green Taxonomies Around the World: Where Do We Stand?, ECOFACT).
- The maturation of financed emissions as a methodological concept, such as the Partnership for Carbon Accounting Financials (PCAF) (see Enabling Financial Institutions to Assess and Disclose Greenhouse Gas Emissions Associated With Financial Activities, PCAF).
- The rollout of publicly funded green investment schemes, such as the Inflation Reduction Act in the United States and the European Green Deal.
- The European Investment Bank (EIB) reported a 24% increase in green finance funding from 2020 through 2021, to support both infrastructure adaptation and mitigation (see Multilateral Development Banks' Climate Finance in Low and Middle-Income Countries Reaches $51 Billion in 2021, EIB).
- Costs of funds for these investments are actively linked to sustainability outcomes, spreading from the development sector to mainstream investment initiatives, as highlighted by the World Economic Forum (WEF) (see It's Never Been This Expensive to Finance a New Coal Power Plant, WEF). And in the retail lending space, mortgage lending is adopting these principles, as mortgage providers offer lower rates to borrowers who use the funds to buy an energy-efficient home or improve the energy efficiency of their existing home.

Obstacles

- In Sustainable Business and ESG Actions for Bank CIOs, Gartner highlighted the opportunities for new sustainably focused product developments. But many banks will only focus on short-term operational and regulatory issues, and miss product opportunities.
- Technology challenges may also limit growth. Green finance will increasingly require operational data feeds to fuel product development. Pricing and risk systems will often be deeply embedded in legacy core banking systems.
- Guaranteeing the authenticity and accuracy of the data, especially for Scope 3 emissions, will be critical in terms of the quality of outputs from those risk and pricing systems.
- Shocks and impacts from events like Russia's invasion of Ukraine and extensive economic slowdowns may lessen demand-side appetite for green financing.
- Positive environmental outcomes cannot be guaranteed. Projects fail. And greenwashing of project data can bring negative reputational, legal and financial outcomes.
- Not all FSI will be able to maintain the same path, as Vanguard's withdrawal from the GFANZ group clearly highlights (see Vanguard Quits Net Zero Climate Effort, Citing Need for Independence, Reuters).

User Recommendations

- Sense-check demand from line-of-business colleagues for the inclusion of green financing initiatives in your digital banking strategies and broader sustainability initiatives, and update IT roadmaps accordingly.
- Assess your technology preparedness for the new flows of sustainability-related data from both internal and external sources. Ensure you have adequate data management capabilities, including quality controls, analysis, integration and storage. Emerging generative AI technologies may have a role to play in this space.
- Stress-test existing pricing and risk management engines, as well as dashboards. Update toolsets and interfaces to accommodate real-time, externally sourced data.
- Recognize the dynamism of regulatory positions, data sources, customer sentiment and stakeholder activity in this space by building an adaptive architecture for your data management and reporting.

Sustainability of Software

Analysis By: Nick Jones, Simon Mingay

Benefit Rating: High

Market Penetration: Less than 1% of target audience

Maturity: Emerging

Definition:

Sustainability of software refers to the principles, guidelines, methodologies, capabilities, practices and tools related to architecting, designing, developing, deploying, operating and maintaining software in a way that is optimized for resource efficiency.

Why This Is Important

Sustainability is growing in importance driven by a wide range of stakeholders — including the board of directors, governments, investors and partners. This in turn drives greater scrutiny of the sustainability of the organization's information and communication technology (ICT) activities and demands improved efficiency in software operations and development, sometimes known as "green software" initiatives.

Business Impact

The business needs to understand and improve software sustainability for three reasons:

- To determine which aspects of its ICT operations have a material impact on the organization's overall sustainability goals and merit attention.
- To reduce the carbon footprint and operational cost of ICT.
- To provide relevant and quantified information to external stakeholders, such as customers and investors.

Drivers

The demand for more-sustainable software is driven by factors such as:

- Growing awareness of the environmental footprint of ICT. For example, in 2021, an ACM technology brief estimated that the ICT sector generated between 1.8% and 3.9% of global carbon emissions.

- A need to understand and moderate the environmental impact associated with increasing use of ICT in all areas of the business and society.
- To reduce ICT electricity consumption so as to be better able to source energy from renewable sources, whose capacity will likely be outstripped by demand.
- To satisfy requests from third parties, such as customers and investors, who may need sustainability information as a condition of doing business.

Obstacles

- Sustainable software skills are scarce, and in 2023, best practices, methodologies, metrics and frameworks for sustainable software engineering are immature.
- Tools to measure and optimize software energy consumption are immature, incomplete and usually specific to certain platforms or situations.
- Difficulty of allocating responsibility for specific quantified and bounded workloads to specific software teams.
- In many cases, software is not the organization's largest source of carbon emissions, so there may be lower-hanging fruit to address in other areas.
- Understanding and optimizing software energy consumption across complex multitier architectures that potentially involve many suppliers and partners is challenging.
- Financial justification for sustainable software is immature; it's difficult to make quantified investment decisions that balance sustainability and other business goals.
- Improvements in software sustainability may incur business costs (e.g., more-sustainable websites may have an inferior user experience).

User Recommendations

- Develop a sustainable software strategy in conjunction with other business stakeholders by identifying where sustainability matters to them, what trade-offs they'll accept to achieve it and what success metrics they require.
- Seek quick wins and pragmatic tactical benefits by prioritizing investment on big-ticket systems that will have a material impact on the organization's sustainability targets.
- Educate staff and business peers in the art of the possible, and engage with external organizations that are developing best practices in the area (see the Sample Vendors section).
- Engage with your key enterprise software and cloud service providers to understand what they're doing to improve software efficiency, and to provide the information you need to plan sustainable software investments.

Sample Vendors

Green Software Foundation; Responsible Computing; The Green Web Foundation

Gartner Recommended Reading

Is Sustainable Software a Distraction or an Imperative?

Cloud Sustainability

Analysis By: Ed Anderson

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Emerging

Definition:

Cloud sustainability is the use of cloud services to achieve sustainability benefits within economic, environmental and social systems. As such, cloud sustainability refers to both the sustainable operation and delivery of cloud services by a cloud service provider, as well as the consumption and use of cloud services by organizations and individuals to achieve sustainability outcomes.

Why This Is Important

Cloud sustainability is a key digital technology supporting organizations in their use of technology to achieve their sustainability ambitions. Cloud computing models are well-suited to deliver sustainability benefits because of their ability to operate at scale using a shared services model, which results in efficient use of computing resources. Hyperscale cloud data centers can be physically located near renewable energy sources further extending their potential to lessen environmental impact.

Business Impact

Increasing attention and focus on environmental and social issues is motivating organizations to improve their sustainability posture. Pressure from customers, investors, partners, regulators, employees, and the public at large is motivating organizations to establish sustainability goals and to demonstrate sustainability outcomes. Cloud computing has great potential to improve sustainability outcomes through efficient operations and the delivery of cloud-based technology innovations.

Drivers

- Sustainability is a rising imperative for organizations across all industries and in all countries and regions around the world. Although sustainability encompasses environmental, social and economic factors, environmental sustainability receives the most attention.
- Corporate climate and decarbonization commitments are typically cascaded to individual business functions, including IT. Consequently, IT organizations are looking at all possible ways to implement such strategies, including cloud sustainability initiatives.
- Market data shows that customers, investors, regulators, citizens and employees increasingly value organizations with demonstrable commitments to sustainability.
- Sustainability investments correlate with operational efficiency. Most organizations operating in an increasingly sustainable fashion also recognize other benefits such as reduced spending on energy, reductions in waste and improvements in water use.
- Cloud providers, being among the world's largest data center operators, show strong commitments to cloud sustainability and are making demonstrable progress toward delivering sustainable cloud service offerings.
- Regulatory and legislative mandates for sustainability are increasingly common across regions and industries. The use of cloud services and other digital technologies will help organizations comply with future regulatory reporting requirements.

Obstacles

- Sustainability definitions, metrics and reporting standards are inconsistent, varying by region and industry. Defining, tracking and reporting sustainability performance is complex for most organizations.
- Cloud providers claim to have made great strides in offering sustainable cloud solutions, but these claims are often difficult to verify and contribute to potential "greenwashing." The lack of sustainability reporting standards makes it difficult to interpret and validate provider claims.
- Achieving cloud sustainability outcomes is a shared responsibility between the cloud provider and the customer. Cloud providers must demonstrate sustainable cloud operations, and cloud consumers must employ sustainability practices in their use of cloud services.
- Renewable energy is a key enabler of cloud sustainability and yet there is insufficient capacity to generate and store the energy required to meet the needs of the world's cloud service offerings.

User Recommendations

- Establish internal sustainability goals including specific metrics and sustainability outcomes by doing a materiality assessment to determine which sustainability outcomes are most important to your organization.
- Determine the role cloud sustainability will play in the achievement of sustainability outcomes. Build internal credibility for cloud sustainability by ensuring that the sustainability benefits of specific cloud service offerings are independently validated.
- Engage relevant executives and other internal stakeholders proactively that are tasked with creating and achieving sustainability goals. Establish credible metrics for measuring and reporting cloud sustainability outcomes.
- Look to cloud providers and other experts, including IT service providers, for best practices in operating and consulting cloud services in a sustainable manner.

Sample Vendors

Alibaba Cloud; Amazon Web Services; Google; IBM; Microsoft; Oracle; Salesforce; SAP; Scaleway; VMware

Gartner Recommended Reading

Executive Leadership: Sustainability Primer for 2023

Quick Answer: How Green Are Public Cloud Providers?

Build an Environmental Cloud Sustainability Strategy

Make Sure Technology Helps More Than Hurts Sustainability

Sustainability: A Customer Priority and Provider Imperative

Circular Supply Chain

Analysis By: Laura Rainier, Sarah Watt

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

Circular supply chain is the application of circular economy principles to the end-to-end supply chain. A circular supply chain decouples consumption from growth using three principles: design out waste, keep material in use at the highest quality for as long as possible and return materials to the environment to have a positive impact. Benefits of the circular supply chain include enhanced customer engagement, raw material security and containment of inflationary-driven costs.

Why This Is Important

A circular supply chain decouples resource consumption from growth, enabling leaders to maintain business competitiveness while reducing environmental impact. According to the 2022 Gartner Future of Supply Chain Survey, engaging in circular economy activities is important to 75% of supply chain leaders. Additionally, 92% of high-performing supply chain leaders expect to have sufficient capabilities to enable circular economy benefits in three to five years.

Business Impact

A circular supply chain uses resources more efficiently by designing waste out of products, packaging and processes, and better-leveraging materials through product take-back, refurbishment, product life extension and other means. The approach shifts economic incentives toward durability and material efficiency and provides a hedge for materials volatility. Digital technology allows for product orchestration while also gathering insights into customer use, which is fed back into product design.

Drivers

- Legislative drivers: Various regulatory requirements are emerging to drive enhanced circularity. For example, the “right to repair” requires access to spare parts and technical information to enable products to be kept in use for as long as possible. EU waste policy aims to ensure that high-quality resources are not lost from the economic system. Concerningly, 60% of EU household waste still goes to landfill.
- Supply chain resilience: Circular supply chains enable the organization to meet customer demand amid disruption through second-life products or by reclaiming raw materials for manufacturing new products.
- Impact on climate change and biodiversity: A circular approach has the potential to reduce climate change impacts, as product embodied energy (and emissions) is used more efficiently. By slowing the rate of consumption, the circular supply chain reduces its reliance on the extraction/production of new raw materials and their associated emissions. Enterprises must undertake life cycle analysis to review the environmental impacts of end-of-life options, enabling trade-off decisions to be made.
- Enhanced value: The circular economy enables enterprises to access new markets, offer new business models and products, and build a differentiated sustainability narrative.
- Innovation: The circular economy is a catalyst for innovation. Examples include design for reuse and longevity, innovative business models and design for disassembly.
- Customer expectations: According to the 2022 Gartner Circular Economy Survey, customer demand for circular products is the biggest driver of changes to the physical supply chain network to enable circular economy outcomes.

Obstacles

- Metrics: Traditional ROI metrics do not effectively capture the benefits of the circular supply chain due to short-term focus, siloed thinking and a transactional approach. Circular strategies capture more value from materials, over a longer period of time.
- Stakeholder engagement: Scaling the circular supply chain relies on engaging with partners across the organization and ecosystem. Partnership is required to enable product return flows, materials recovery, industrial symbiosis between organizations and additional customer value offerings. Convening external stakeholders and sharing relevant data with the ecosystem is a key barrier.
- Execution: Take-back models enable remanufacturing and reuse, but the supply chain has less control over what is returned. This can create excess inventory without a productive next use.
- Impact: Standards are emerging to measure the impact of circular initiatives, but accurate assessment of environmental and other trade-offs is complex.

User Recommendations

- Prioritize products: Select the products best positioned for the circular strategy by assessing which products deliver the most financial and nonfinancial benefits, evaluating the customer appetite for circular products and assessing the feasibility of circular models.
- Enable: Apply circular design guidelines (for example, modularity, durability), craft circular business models (for example, reuse, product as a service), and implement processes that enable material loops (for example, reverse logistics, reverse planning).
- Pilot: Demonstrate how to overcome common leadership concerns, such as the cannibalization of market share.
- Digitalize: Leverage digital technology for product use insights, and to improve the speed, rate and quality of second-life products. Formulate performance scorecards to aggregate data from multiple parts of the organization.
- Organize: Organization structure is a key enabler in advancing circular economy strategy. Use centers of excellence to embed circular economy into operating models.

Gartner Recommended Reading

3 Criteria to Select “Winning” Circular Economy Products to Enable Growth

3 Accelerators to Advance the Circular Economy in Supply Chain

Use Circular Economy to Mitigate Inflation, Drive Growth and Deliver Value Amid Economic Uncertainty

Craft a Reverse Supply Chain Strategy to Enable Circular Economy at Scale

How to Structure Your Organization to Drive Circular Economy Integration

Sustainable Packaging

Analysis By: John Blake

Benefit Rating: Low

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

Sustainable packaging is the development and use of packaging that results in improved utilization of materials, and decreases the negative impact of packaging on the environment. It can include recycling, recycled content, reuse, material substitution and reduction in the carbon footprint of packaging.

Why This Is Important

Sustainable packaging has become a core aspect of sustainability commitments as packaging and plastics have been deemed major contributors to pollution and greenhouse gas (GHG) emissions. Organizations need to address packaging to meet their environmental, social and governance (ESG) goals and the expectations of customers and consumers in order to protect their brand’s reputation. In addition, the rapid advancement of global packaging legislation is heightening the urgency to adopt sustainable packaging practices.

Business Impact

Consumer and customer sentiment drove voluntary sustainable packaging goals, but now there is a rise in packaging legislation globally that will mandate changes in how packaging is designed and utilized. Sustainable packaging is complicated and can be costly to implement. It's estimated that many 2025 commitments will be missed, risking brand reputation. Significant levels of innovation and investments may be required to meet voluntary and mandated targets.

Drivers

- **Consumer/customer pressure:** There is an awareness of the harm that products and packaging have on the environment and this is driving purchase decisions. Brand reputation, waste and the contribution to Scope 3 emissions are being scrutinized.
- **Legislation:** 2022 marked not only the first of its kind — a Plastic Packaging Tax implemented in the U.K. — but it also marked California becoming the fourth state in the U.S. to pass Packaging Extended Producer Responsibility (EPR) legislation. Meanwhile, 2023 ushered in new packaging taxes in Spain and there are (at the time of publication) over 10 states in the U.S. with proposed packaging EPR legislation. These are just a few of the examples of global packaging legislation.
- **ESG strategy:** As the value of having a clear and actionable ESG strategy becomes clear, organizations are moving beyond focus on Scopes 1 and 2 emissions and are increasingly setting their attention to Scope 3, which includes packaging. Further, boards are increasingly stepping up their oversight of ESG, as they recognize its necessity for long-term resilience and the very visible nature of packaging and packaging waste.
- **The war on plastic:** As awareness of the impact of plastics and plastic packaging on the environment increases, organizations need to develop a position regarding its use. There is a desire to replace plastics, drive a circular economy through recycling, eliminate or minimize use of virgin or petroleum-based polymers and move from single use to reusable packaging.
- **Costs:** The overuse or misuse of packaging has cost implications as well as sustainability implications. Another cost risk is the growth in legislation. Organizations will be penalized for the quantity and types of packaging they produce. However, reducing or optimizing packaging through the lens of sustainability can also reduce packaging costs.

Obstacles

- **Complexity:** Visions of fully recyclable, reusable and plastic-free are harder to implement than anticipated, due to financial and technical feasibility (such as product protection, costs, recycling infrastructure and sourcing limitations).
- **Data maturity:** Packaging specification data practices are at a low maturity level. Common challenges include insufficient processes and systems of record, as well as accuracy/completeness of data. Software for packaging specification management is an emerging market.
- **Infrastructure:** Investments in recycling infrastructure and by packaging suppliers has not kept up with the promises or needs of brand owners.
- **Costs:** Material shortages, reusable packaging supply chain and manufacturing assets are driving cost pressures.
- **Collaboration:** Packaging's impact is cross-functional, requiring stakeholder support to navigate change management challenges.
- **Greenwashing:** Overpromising, under delivering or misleading consumers poses risks of legal or consumer backlash.

User Recommendations

- **Data:** Establish the baseline for any sustainable packaging strategy by capturing data on current packaging consumption.
- **Upstream innovation:** Optimize products and packaging through the lens of sustainability and consumer needs.
- **Feasibility:** Assess the business impact and feasibility of sustainable packaging by engaging cross-functional teams in the process of setting or resetting packaging goals. Key considerations include sourcing and quality of packaging, material and capital costs as well as operational changes.
- **Stakeholders:** Engage stakeholders to support necessary changes and investments. Sustainable packaging often involves development, financial commitments and change management to advance beyond pilots.
- **Investment:** Determine where investments are needed to support sustainable packaging by starting with specification data visibility. This will prove critical as legislation evolves. Map required investments in manufacturing assets, as well opportunities for strategic investments with packaging suppliers.

Gartner Recommended Reading

Quick Answer: How to Create a Sustainable Packaging Strategy

Quick Answer: How to Advance Sustainable Packaging Goals

Quick Answer: How to Comply With Sustainable Packaging Legislation

Market Guide for Packaging and Product Specification Management

At the Peak

AI for Sustainability

Analysis By: Erick Brethenoux, Simon Mingay

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Emerging

Definition:

AI for sustainability will improve business operations and optimize difficult-to-abate processes to reduce carbon and environmental footprint and mitigate material risks. AI can be made environmentally sustainable by using AI techniques that help create and run models at the lowest carbon footprint without partially or wholly compromising on accuracy. This extends to using AI to monitor, predict, mitigate and improve environmental issues.

Why This Is Important

Optimizing resource allocation and unveiling opportunities under extreme uncertainty are what combined AI techniques (composite AI) do best. AI can apply its resourcefulness to expand the social and governance aspects of ESG performance as well as deliver competitive advantage and reduced environmental impact via more efficient resource management.

Business Impact

Business impact of AI include:

- Monitoring and predicting (sense and interpret resource consumption, automate decisions and take actions)
- Optimizing resources and materials usage and enhancing circularity
- Reporting and disclosure (stakeholder-centric sustainability narratives and reporting)
- Mitigating energy costs and risks (hedge future consumption, leverage distributed energy resources and microgrids)
- Traceability and trust (record transactions and create a tamper-proof log of sensitive activity)

Drivers

AI for sustainability has both technology and use-case drivers.

Technology drivers:

- Composite AI
- Generative AI
- Adaptive systems
- Decision intelligence
- Causal AI
- Agent- and model-based reasoning methods and simulation techniques
- Advanced machine learning (ML) and optimization techniques (e.g., reinforcement learning, AutoML)
- Ambient intelligence (including computer vision)
- Verticalized AI

Use-case drivers have four categories.

Climate change:

- Monitoring, prediction and mitigation
- Flooding, drought and water management
- Wildfire and vegetation management
- Air quality management

Societal and environmental:

- Environment — social media monitoring (e.g., activism, citizen monitoring)
- Compliance and regulation alignment
- Society, human centricity and consumption

- Conservation and biodiversity management
- Agtech and fair trade

Sustainability and circularity:

- Equipment sustainability
- Waste management and recycling optimization
- Material productivity optimization
- Alternative resources and materials discovery

Optimization:

- Energy grid management
- Water and sanitation optimization
- Route optimization, transportation and mobility
- Sustainable buildings and facilities (including data center energy optimization)

Obstacles

- To implement AI techniques, enterprises embarking in AI engineering often seek “unicorn” experts to productize AI platforms. Few vendors provide AI engineering capabilities; as a result, such skills are hard to find.
- Lacking skills to leverage multiple AI techniques or fixating on custom-built AI when verticalized or augmented solutions are available could prevent organizations from efficiently solving specific problem types.
- Gaps exist in standards, responsible AI governance practices and data availability and/or quality (such as Scope 3 GHG emissions data).
- For organizations that have focused exclusively on technical skills, the other critical parts of human decision making — psychological, social, economic and organizational factors — have gone unaddressed.

- Rapidly evolving AI technologies — including tools for explainability, bias detection, privacy protection and regulatory compliance — lull organizations into a false sense of responsibility, while mere technology is not enough.

User Recommendations

- Develop AI model governance practices that align model performance, human behavior and delivery of business value. Make it easier for business users to adopt AI models by incorporating stakeholder trust and speed to value as primary inputs for model design.
- Extend AI experts' skills to also cover graph analytics, optimization or other required techniques for composite AI extended to generative AI. In the case of rules and heuristics, skills for knowledge engineering should also be available.
- Examine and quantify the advantages and limitations of generative AI. Use it first to improve an existing process.
- Tailor the choice of decision-making technique to the particular requirements of each decision situation by collaborating with subject matter experts, AI experts and business process analysts.
- Establish ethics principles and, optionally, an AI ethics board to resolve AI dilemmas by adopting responsible AI procedures. Ensure diversity of participants and the ease to voice AI concerns.

Sample Vendors

Amazon; Fairly AI; IBM; MathWorks; Microsoft; MoBagel; SAS; Windward

Gartner Recommended Reading

Quick Answer: How Do I Make AI Environmentally Sustainable?

Infographic: AI Use-Case Prism for Sustainability and ESG

Explore Secured, Accurate and Green AI With Federated Machine Learning

Human Controls for AI Dangers (SignatureValue Bank)

A Comprehensive Guide to Responsible AI

Carbon Capture Utilization and Storage

Analysis By: Simon Cushing

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Carbon capture, utilization and storage (CCUS) technologies enable the trapping of carbon dioxide (CO2) produced by burning hydrocarbons or during other industrial processes and storing it so that it cannot enter the atmosphere. Captured CO2 can be stored indefinitely, or reused as a commercial byproduct and the process can be referred to as carbon capture and sequestration or carbon capture, utilization and storage.

Why This Is Important

According to the IPCC, emissions from current and planned fossil-fueled infrastructure over its lifetimes, mostly in power generation, exceed those consistent with 1.5 degrees Celsius global warming. Replacing current or planned infrastructure with low-carbon energy will require capacity growth at levels well above any so far achieved. Removing fossil fuel energy without alternatives would significantly disrupt most societies. CCS can reduce fossil fuel-based emissions in the short term, particularly in the absence of a rapid acceleration of alternatives.

Business Impact

CCS technologies can accelerate a balanced energy transition. Carbon sequestration offers opportunities for oil and gas companies to earn from depleted fossil fuel assets, for example through carbon capture and storage as a service (CCSaaS). Captured CO2 reuse offers industrial emitters an opportunity to monetize captured carbon by selling it onwards, offsetting costs, or generating new earnings. Potential new revenue streams and business models can add momentum to CCS deployment.

Drivers

- Since 2010, global greenhouse gas (GHG) emissions reductions have been more than offset by increasing energy, industrial, and transport activities. On current emissions reduction trends, the world remains likely to exceed the 1.5 degrees Celsius Paris Agreement global warming target.
- CCS can help accelerate emissions reduction. The probable scale of economic and societal disruption resulting from an unbalanced removal of fossil fuel energy strongly incentivizes governments against rapid fossil fuel elimination. CCS at scale potentially allows a more balanced transition away from fossil fuels while accelerating emissions reduction.
- According to the International Energy Agency (IEA), currently there are around 35 industrial, power generation and fuel transformation CCS facilities in operation, capturing 45 mt of CO2 per year. Plans have been announced for around 200 more projects by 2030, raising the captured yearly total to 220 mt CO2.
- CCS offers emitters a choice of pathways to direct emissions reduction or to offset them. Companies can fit capture technology to plants, or they can pay for carbon-capture-as-service, receiving carbon credits or recognized offsets from specialist companies who trap, transport and sequester CO2 directly.
- A number of startup ventures have started offering, or plan to offer, CCSaaS in the near future.
- While post- and pre-combustion technologies are well established, research is ongoing into novel capture routes and recent advances, particularly in direct air capture (DAC), that hold promise of improvement in CCS practicality and economics.
- Research is also advancing the range of possible CO2 uses, including to produce synthetic fuels, chemicals, plastics and building aggregates.

Obstacles

- CCS facilities add cost. Energy and products with CCS are less competitive than those without, disincentivizing investment.
- The performance of CCS technologies is mixed. As per a 2022 IEEFA report, the majority of 13 major CCS projects in power generation underperformed or failed. Continued innovation proves feasibility, reduces costs and improves scalability.
- Carbon capture does not fully eliminate emissions and costs escalate with the percentage of CO2 captured. DAC is currently land-intensive.
- CO2 sequestration involves geological storage sites such as depleted oil and gas reservoirs, and salt caverns, requiring significant and long-term investment.
- Captured CO2 reuse may not lower CO2 emissions, depending on the source, displaced use, consumed energy and duration of retention, among other variables. CO2 reuse is unlikely to contribute to reaching climate targets in desired timeframes.
- Cost-effective CCS at scale needs major investment and research advances. Policy and regulatory action including pricing-in carbon emissions from fossil-fueled processes accelerate CCS adoption.

User Recommendations

- Create a roadmap for CCS as mitigation or as a source of value based on ranking and prioritization of potential available pathways benchmarked against the current state.
- Engage with regulators, investors, startup providers and research bodies to improve CCS feasibility and economics improvement and create novel captured CO2 uses.
- Explore opportunities for business model innovation based on CCS-relevant assets or resources and in the context of local regulatory frameworks.

Sample Vendors

Aker Carbon Capture; Baker Hughes; Batelle; Carbon Clean Solutions; Carbon Engineering; CGG; Climeworks; Northern Lights JV; Occidental Petroleum; Talos Energy

Gartner Recommended Reading

Market Guide for Gas Emissions Management Solutions

Digital Product Passport

Analysis By: Sohard Aggarwal, Lillian Oyen-Ustad

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Emerging

Definition:

Digital product passport (DPP) is part of the proposed Ecodesign for Sustainable Products Regulation and one of the key actions under the European Commission's Circular Economy Action Plan (CEAP). It provides a method of digitally recording and sharing information about a product across its entire value chain. In particular, this includes traceability of the finished product, its components and usage, and end of life.

Why This Is Important

DPP as a tool and a regulation aims to capture product data from suppliers, manufacturers and customers, enabling transparency, traceability, and consistency across the value chain. By providing data on a product's environmental footprint, it enhances trust, allows consumers to make informed buying decisions and can lead to circular models. Because of regulatory requirements and expected fast-track adoption (EU-specific regulation in effect by 2024), DPP is at its Peak of Inflated Expectations.

Business Impact

Any manufacturer selling a product on the EU market will need to provide a product passport for both the finished product and each of its individual parts. This will require them to:

- Centralize and standardize product information.
- Provide access to reliable and comparable product sustainability information.
- Promote innovative thinking on circularity, resource optimization and energy efficiency.
- Enable sustainable investment decisions by exposing manufacturers' environmental, social and governance (ESG) credentials.

Drivers

- Regulatory changes and proposals under the European Green Deal and Circular Economy Action Plan, with a long-term target of enabling the European Economic Area to reach net zero emissions by 2050, are primary drivers for the introduction of DPPs. Other geographies are exploring similar initiatives; most notable is the U.S. FDA's Food Safety Modernization Act (FSMA).

- According to the 2023 Gartner CEO and Senior Business Executive Survey, environmental sustainability became a top 10 business priority for manufacturing CEOs. Customers, investors, regulators and employees are further creating pressure to act on or invest in sustainability initiatives. This includes supporting material and energy efficiency, extending product lifetimes, and optimizing product design, manufacturing, use and end-of-life handling.

- DPP is important to provide new business opportunities to economic actors through circular value retention and optimization (for example, product-as-a-service activities, improved repair, servicing, remanufacturing, and recycling), based on improved access to data.

- Government, regulatory authorities and customers alike are demanding more reliability, transparency, and credibility in ESG reporting and compliance. A simple, faster and predictable framework will enable manufacturers to better differentiate their sustainable products and claims.

- The 2022 Gartner Circular Economy Survey shows that only 21% of manufacturers have been applying circular economy principles in their strategy over the past 3.2 years to just 16.7% of their product portfolio showing the need to accelerate adoption. Legal obligations like DPPs will be a catalyst to accelerate adoption of circular economy principles, establish responsible sourcing policies, design out waste and maximize resource utilization.

- Consumer demand for easily digestible information and transparency to a product's environmental footprint, replacement parts, and warranties is further driving demand for such initiatives.

Obstacles

- The creation of a DPP requires a full understanding of a product life cycle, which is only possible by collecting product information across the supply chain, much of which is not currently available.
- Lack of trustworthy and verifiable information about product, components, usage, and recycling potential remains a challenge.
- Manufacturing already struggles with complexity related to multitiered supply chains, service providers, transporters, and others who need to provide trusted data and make it shareable. Getting visibility across their extended supply chain would be key to success, but will require significant change management.
- DPP mandates all participants to make information electronically available in machine-readable and interoperable formats and services. Given that organizations vary in their digital maturity and data sharing capabilities, this will require significant organizationwide efforts.

User Recommendations

- Familiarize yourself with the requirements and implications of DPP. Prepare to follow the legislation as it evolves across stages.
- Champion deployment of technologies such as product information management (PIM), product life cycle management (PLM), and life cycle impact assessment (LCA) tools and data management techniques.
- Engage with caution and conduct due diligence before adopting DPP, as the market for DPP-specific technologies is quickly emerging.
- Include circular principles in your design and sourcing. Look for strategic partnership with suppliers, vendors and business partners as part of an ecosystem to make this implementation a success.

Sample Vendors

Amazon Web Services; DNV; iPoint; Kezzler; Siemens; Twintag

Gartner Recommended Reading

Quick Answer: What Data and Analytics Leaders Need to Know About Digital Product Passports

Predicts 2023: Consumer Goods Manufacturers Must Adopt Data-Driven Innovation

Leverage Digital Initiatives to Enable Sustainability in Manufacturing Organizations

Smart and Sustainable Building

Analysis By: Gavin Tay, Tori Paulman

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

A smart and sustainable building is a facility where multiple functions cooperate to achieve work-life ambiance and broader sustainability outcomes. Such outcomes encompass automation, efficiency, experience, wellness, safety, sustainability and security through the analysis of contextual and real-time information, shared among Internet of Things (IoT), information and communication technology (ICT), and operational technology (OT) systems.

Why This Is Important

Smart and sustainable buildings advance with a heavy reliance on smart technologies although a common data environment is at the core. Building management system (BMS) adoption rates are fairly slow due to its legacy nature. Hardware for HVAC and lighting implemented with new construction has a lifetime of 10 to 20 years. System failure retrofits have heightened with stringent standards of safe management accelerating the importance of experience, well-being, safety and sustainability.

Business Impact

- Increasing people centricity and a growing focus on sustainability will demand not only decarbonization, but also a shift from energy efficiency to incorporating renewable energy.
- Building performance can be optimized and predictive and preventive maintenance can be improved by responding to real-time human preferences based on activities, emotions and reactions.
- Formulating holistic solutions will stretch alignment of cross-functional teams to address work-life ambience and sustainability.

Drivers

- Today, the operating elements of a smart building typically include space, environment and maintenance management, along with wellness, safety, energy management, sustainability and workplace experience. Such rapid evolution of smart buildings means that facilities and real estate professionals will want to leverage the CIO portfolio.
- Energy efficiency such as use of solar panels has long been a key area of investment for smart building technologies. However, incorporating or reselling surplus renewable energy is emerging at an exponential rate.
- As the pent-up delay of new building construction gets underway, demand for a reinvigorated experience particularly in commercial buildings and coworking spaces will rally a surge for an orchestrated AI-augmented infrastructure alongside expertise to bring it to reality.
- The demands and expectations of workers from workplaces are shifting from merely good air, temperature and hygiene to work-life ambience. As a result, a smart building experience requires the exploitation of an ever-growing number of IoT business solutions that are intelligently cohesive.
- IoT and AI have the potential to speed up the implementation of more IT into a common data environment by extending and augmenting existing equipment. Cost savings can be achieved by integrating the sensors with BMS software in older buildings. Sometimes, it is more economical to upgrade rather than adapt to an older system.
- Various nations and organizations have a strong commitment to sustainability, driving the focus of management from pure energy to broader environmental parameters such as water, air quality and waste.

Obstacles

- CIOs assembling smart and sustainable buildings lack a clear vision of the architectural building blocks comprising a common data environment and an understanding of the privacy and data security implications increasingly.
- Delivering total experience is diverse and complex, when managing a multivendor IoT landscape and technology architecture with limited exposure to governing moving parts and the flow of activities in buildings.

- Gartner estimates that by 2028, there will be over four billion intelligently connected IoT devices in commercial smart buildings, making it hard for CIOs to provision, manage, connect and analyze their data.
- Coordinating varied expectations, use cases and budgets from different stakeholders such as facilities management, HR, and CISO (security, privacy and data sovereignty) adds to existing complexity.

User Recommendations

- Broaden corporate priorities in construction and building management by focusing on decarbonization and other sustainability initiatives.
- Address energy inefficiencies by using real-time data from the IoT and IT infrastructure to enable communication between the different BMSs or energy management systems (EMSs) in a building. According to ENERGY STAR, average buildings waste 30% of their energy in lighting, heating and cooling areas that are not occupied.
- Leverage the advantages of IoT to build holistic, engaging experiences while increasing building efficiency and competitiveness. Alleviate the potential business and technical challenges of creating a piecemeal smart building.
- Opt for flexible payment methods, and don't treat such investments as a capital liability. Channel the savings obtained from building efficiencies to the repayment of these solutions or services, making it an operating expense instead (e.g., energy management contracts).

Sample Vendors

Eutech Engineering; General Electric (GE); Honeywell Forge; Intel; Johnson Controls; Schneider Electric; Siemens; Signify; Spacewell; Terminus

Gartner Recommended Reading

Tech CEO Insight: Align the Smart Building Value Communication With the Shift Toward Well-Being and Sustainability

Creating Sustainable and Innovative Smart Buildings Through Data

How Technology and Data Can Be Used to Develop Smart Building Solutions

Emerging Technologies: The Future of Sensing

Carbon Accounting and Management Software

Analysis By: Aapo Markkanen, Chet Geschickter

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Carbon accounting and management software facilitates data collection, analytics and reporting of past, present and future emissions data across all three scopes of the Greenhouse Gas (GHG) Protocol. These tools enable enterprises to improve their reporting capabilities while also providing insights to drive concrete emission reduction measures. “Carbon” in the term is synonymous with all types of GHG emissions.

Why This Is Important

To meet their increasing regulatory requirements and voluntary commitments to stakeholders, organizations are under pressure to improve their carbon accounting practices. Typical areas of improvement concern the completeness, granularity, quality and update cadence of data. At the same time, such pressures are not limited to the accounting layer, but extend also to management of emissions sources. Both aspects of enterprise decarbonization require new, purposely developed software tools.

Business Impact

Enterprise reporting expectations, obligations and complexity are set to increase. Companies must baseline, report, reduce, forecast and offset their emissions for their operations (Scopes 1 and 2) and value chain (Scope 3). Many will need to go further and be able to allocate emissions at more granular levels such as products, services and facilities. Benefits of greater transparency and decarbonization advancement span domains such as risk, cost, capital, talent and overall competitiveness.

Drivers

- Various carbon pricing mechanisms are expanding in both regional and vertical terms, representing a competitive advantage to companies that are able to manage their GHG emissions better.
- Enterprises must respond to diverse regulations related to GHG transparency, reporting and reduction, such as TCFD and the EU's CSRD.
- Customers are demanding suppliers to report increasingly granular data that supports their own decarbonization initiatives, such as the product-level carbon footprints.
- Investors are seeking to understand and mitigate their climate risks, especially by measuring their footprint of financed emissions.

Obstacles

- The global regulatory environment involves uncertainty and fragmentation, undermining enterprises' appetite for major software investments with multiyear subscription costs.
- Accounting for Scope 3 emissions, in particular, is hindered by the lack of reliable primary data from suppliers and methodological gaps on industry-specific emissions sources.
- The available tools represent a nascent market that consists largely of recently founded startups and unproven product initiatives from large incumbents, entailing relatively high vendor risks.
- Different business functions have different requirements for GHG data and tools, making the key use cases often too fragmented for a single vendor to address effectively.

User Recommendations

- Prioritize in the selection the vendors that demonstrate a track record and expertise in your industry vertical, as well as (secondarily) ones whose other products are already used by your organization.
- Ensure that the Scope 3 capability includes the ability to fill primary data gaps with secondary data from inventory databases, with a clear product vision for further capability improvements.
- Scrutinize the vendors' current ability and near-term potential for automation and other means of scalability, applying extra caution to ones whose offering relies on extensive consulting.
- Complement the tooling of GHG management with methodological and strategic support from the software vendor, a third-party consultancy or internal sustainability experts.

Sample Vendors

carbmee; Greenly; Normative; Persefoni; Salesforce; SAP; SINAI Technologies; Sphera; Sweep; Watershed

Gartner Recommended Reading

4 Scenarios to Guide Your ESG and Sustainability Software Choices

Strategies to Plan for GHG Emissions Reduction

Sustainable IT: 3 Steps to Mitigate Asset GHG Emissions Throughout the Product Life Cycle

Neuromorphic Computing

Analysis By: Alan Priestley

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Definition:

Neuromorphic computing is a technology that provides a mechanism to more accurately model the operation of a biological brain using digital or analog processing techniques. These designs typically use spiking neural networks (SNNs), rather than the deep neural networks (DNNs) of the current generations of AI technologies, feature non-von Neumann architectures and are characterized by simple processing elements, but very high interconnectivity.

Why This Is Important

Currently, most AI development leverages parallel processing designs based on GPUs. These are high-performance, but high-power-consuming, devices that are not applicable in many deployments. Neuromorphic computing utilizes asynchronous, event-based designs that have the potential to offer extremely low power operation. This makes them uniquely suitable for edge and endpoint devices, where their ability to support object and pattern recognition can enable image, audio and sensor analytics.

Business Impact

AI techniques are rapidly evolving, enabled by radically new computing designs.

- Today's deep neural network (DNN) algorithms require the use of high-performance processing devices and vast amounts of data to train these systems, limiting scope of deployment.
- Neuromorphic computing designs can be implemented using low-power devices, bringing the potential to drive the reach of AI techniques out to the edge of the network, accelerating key tasks such as image and sound recognition.

Drivers

- Different design approaches are being taken to implement neuromorphic computing designs — large-scale devices for use in data centers, and smaller-scale devices for edge computing and endpoint designs. Both these paths leverage spiking neural networks (SNNs) to implement asynchronous designs that have the benefit of being extremely low power when compared with current DNN-based designs.
- Semiconductor vendors are developing chips that utilize SNNs to implement AI-based solutions.
- Neuromorphic computing architectures have the potential to deliver extreme performance for use cases such as DNNs and signal analysis at very low power.
- Neuromorphic systems can be trained using smaller datasets than DNNs, with the potential of in situ training.

Obstacles

- Accessibility: GPUs are more accessible and easier to program than neuromorphic computing. However, this could change when neuromorphic computing and the supporting ecosystems mature.
- Knowledge gaps: Programming neuromorphic computing will require new programming models, tools and training methodologies.
- Scalability: The complexity of interconnection challenges the ability of semiconductor manufacturers to create viable neuromorphic devices.
- Integration: Significant advances in architecture and implementation are required to compete with other DNN-based architectures. Rapid developments in DNN architectures may slow advances in neuromorphic computing, but there are likely to be major leaps forward in the next decade.

User Recommendations

- Prepare for future utilization as neuromorphic architectures have the potential to become viable over the next five years.
- Create a roadmap plan by identifying key applications that could benefit from neuromorphic computing.
- Partner with key industry leaders in neuromorphic computing to develop proof-of-concept projects.
- Identify new skill sets required to be nurtured for successful development of neuromorphic initiatives, and establish a set of business outcomes/expected value to set management's long-term expectations.

Sample Vendors

AnotherBrain; Applied Brain Research; BrainChip; GrAi Matter Labs; Intel; Natural Intelligence; SynSense

Gartner Recommended Reading

Emerging Technologies: Tech Innovators in Neuromorphic Computing

Emerging Technologies: Top Use Cases for Neuromorphic Computing

Forecast: AI Semiconductors, Worldwide, 2021-2027

Emerging Tech Impact Radar: Artificial Intelligence

Voluntary Carbon Offsets

Analysis By: Chet Geschickter, Lauren Wheatley, Aapo Markkanen

Benefit Rating: Moderate

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Voluntary carbon offsets are credits for capturing or eliminating a ton of carbon dioxide equivalent (CO2e) to fund carbon sequestering or reduction projects or processes. Offsets provide organizations a mechanism to achieve sustainability goals by funding projects that have a positive contribution to the environment and, therefore, balance out their GHG emissions. Carbon offsets do not include carbon credits from cap-and-trade markets, such as the EU Emissions Trading System.

Why This Is Important

Voluntary carbon offsets provide ownership of quantities of CO2e that are physically removed from the atmosphere by specific projects, assets or activities. Alongside direct emissions reductions by an enterprise, carbon offsets represent a very important tool to move the world economy to net zero by 2050. Large quantities of high-quality carbon offsets are needed to fund new carbon sequestration technology development and scale up proven approaches.

Business Impact

Enterprises can purchase and use carbon offsets within decarbonization pathways to net zero. Originators that sell carbon offsets can use funds to develop and scale projects that sequester carbon. Examples include protecting forest land, changing agricultural practices (for example, no-till farming) or distributing high-efficiency cooking stoves in low-income markets.

Drivers

- Corporate interest growth continues in carbon offsets as a component of decarbonization roadmaps that contribute to a low-carbon economy.
- Climate entrepreneurs, developers of new carbon removal technologies and parties with carbon sequestering resources are driving offset creation.
- Standards: (1) Article 6 of the Paris Agreement provides a framework to transfer carbon credits from one nation to another and a framework for international carbon markets. (2) Carbon registries establish criteria for qualifying projects and enable carbon offset purchase and sale. (3) Evolving best practices continue to address challenges associated with long-term sequestration — for instance, establishing a buffer or reserve for negative events such as forest fires that release carbon from tracts of sequestered land.
- Investment: (1) Corporate and private investor funding is increasing for development of carbon capture technologies and industrial projects. (2) Traditional energy companies are pursuing energy transition strategies. Some oil and gas companies are developing strategies to apply industrial engineering capabilities, geological expertise and underground storage assets for industrial carbon removal. (3) There is ongoing research and development of emerging industrial technologies, such as direct air capture, and nature-based solutions, such as cultivating kelp and agricultural practices like no-till farming and cover crops.
- Technology (emerging digital capabilities): (1) Blockchain can enable reliable and transparent issuance, distribution and pricing of tokenized carbon credits. (2) Remote sensing facilitates the monitoring of offset schemes for their real-life impact. (3) Offset marketplaces provide access to specific offset generating projects, activities and investments. Some vendors are also directly marketing offsets to individuals and organizations and facilitating their purchase.

Obstacles

- Methodologies to measure and verify the performance of offsetting schemes are immature.
- There is a shortage of verifiable and high-quality offsets and risks of double counting.
- Enterprises that rely on offsets before pursuing available renewable energy and energy efficiency options risk greenwashing.
- Industrial solutions such as direct air carbon capture or effluent capture are expensive, with limited availability.
- Viable underground storage options are geographically constrained.
- Protecting a forest does not increase sequestration, resulting in validity concerns.
- Longevity of carbon sequestration — e.g., shift in land usage can release carbon; deforestation occurs to increase agriculture resources.
- Speed of regenerating carbon offsets — e.g., newly planted trees can take 100 years or more to reach peak sequestration.

User Recommendations

- Appoint an executive to create an enterprise offset strategy and to establish board-level oversight.
- Use carbon offsets as an adjunct to, but not a replacement for, energy efficiency and renewable energy investments.
- Conduct due diligence and vet carbon offsets before purchase; ensure methodology, assurance and project controls are adequate.
- Assess longevity as only long-term carbon offsets have true value. Hence, think decades and centuries, not years.
- Set realistic expectations. Experimental technologies might not generate adequate volume at expected costs.
- Focus on offsets that are validated by reputable sources, such as longstanding carbon offset marketplaces with quality controls and verification programs.
- Differentiate between direct investment in new projects and storage capacities that increase carbon removals versus trading offsets in secondary markets that do not.
- Take early action to invest in long-term carbon offset projects as costs may increase over time.

Sample Vendors

Gold Standard; IncubEx; Pachama; Plan Vivo Foundation; Puro.earth; SOCIALCARBON; Supercritical; Sylvera; United Nations Carbon Offset Platform; Xpansiv

Gartner Recommended Reading

Building a Low-Carbon Energy Strategy

3 Practical Actions to Address Uncertainties in Pathways for Reducing GHG Emissions

Ignition Guide to Building a Net-Zero Greenhouse Gas (GHG) Emissions Roadmap

Banking Sustainability Tools

Analysis By: Alistair Newton

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

As part of environmental, sustainability and governance (ESG) initiatives in banking, tools are being developed to help customers assess their impact on the environment and suggest corrective actions — for example, by providing a carbon footprint based on customer transactions. These differ from investment-focused indexes, which help investors pick environmentally or socially responsible investments. Most tools are customer-facing — being developed independently or via collaborative models.

Why This Is Important

Issues of environmental and social responsibility are increasingly important to a range of banking customers. For retail customers, understanding their personal impact may be important. For SMB and business banking customers, the need is to address regulations on reporting their sustainability impacts while remaining competitive. Environmental and social impact tools are being leveraged by multiple banks to build advice-focused products and services around core payment and lending products.

Business Impact

Business impacts of banking sustainability tools include:

- Banking is at the forefront of the growing focus on social and environmental factors. These factors are cited as key influencers on which companies customers will buy from or invest in.
- Business banking and SMB customers are increasingly asking for help quantifying the sustainability impact of their transaction banking.
- Environmental- and social-focused tools offer banks the chance to shift their customer relationships from transactional to advisory, while addressing Scope 3 regulatory requirements.

Drivers

- These tools are aimed at helping bank customers to measure and act on the wider environmental impact of their day-to-day transactions and operations. They mainly include carbon tracking, calculators and risk management solutions.
- Some banks have announced carbon calculator tools. Example prototypes or product tools include those from Commonwealth Bank, Islandsbanki, Alandsbanken, Deutsche Bank and National Westminster Bank.
- Other banks have focused on the commercial banking space. For example, BNP Paribas in Poland invited startup companies to help it build a carbon calculator for its small and midsize enterprise and corporate clients (see Bank BNP Paribas Is Looking for a Carbon Footprint Calculation Tool for Companies Among Startups, BNP Paribas). Other banks have formally launched tools, like Rand Merchant Bank in South Africa and its ESG risk platform.
- Many are being built by nonbanks, leveraging open banking technology to link customers' payment transactions to the indexes and analyze ESG impacts. Examples include those from Cogo, Svalna, Greenly, Doconomy and Connect Earth.
- Some nonbanks have leveraged existing indexes to deliver mainstream banking products to the market. The prime example is Doconomy, in partnership with Mastercard, offering credit cards that provide both financial and environmental data for each transaction by leveraging Alandsbanken's Aland Index.
- Gartner believes this trend will accelerate as banks and other nonbanks increasingly integrate these tools into products and services, either directly or through open banking interfaces.
- It is likely that these indexes will become more aligned with accounting and regulatory standards being developed across a number of industry sectors. These standards and regulations are targeted to help enterprises quantify their wider impact on the environment and society.
- But in providing tools to help customers, the banking industry will need to avoid falling into greenwashing traps and take a realistic and transparent view on the real-world impact of this information and insight on their clients.

Obstacles

- Sustainability tools are complex to build and maintain, and variable in their accuracy assessing impact on society and the environment.
- The data sources themselves vary hugely in accuracy and consistency — multiple providers of data add to this lack of consistency.
- While the solutions have multiplied and matured, they generally lack sufficient granularity to be of genuine use to customers. They continue to use broad working assumptions on what consumption and transactions might specifically relate to, and will need more time to develop that specificity.
- Few of the models that underpin these tools have a direct link to an ongoing future income stream. Most are predicated on this assumption, but the link is not direct or proven.
- Most immediate initiatives within many banks will focus on addressing specific regulatory requirements, or on the investment services side of the business, by analyzing ESG impacts on customers' investment portfolios. These initiatives are likely to take priority over other ESG indexes.

User Recommendations

- Acknowledge that sustainability debates generate many divided opinions. Development or use of such tools does not involve a positive or negative endorsement of the underlying environmental or social arguments.
- The objective of the tool will be to provide better insight to customers and, for business customers, help them manage their own reporting requirements more effectively. Link business banking initiatives to other nonbanking activities provided via your application marketplace.
- These models need scale input. Look to local partnership models with other banks, environmental- or philanthropic-focused bodies, and academic institutions to develop collaborative national or regional indexes.
- Look for solutions from both banks and fintech providers, especially if you operate in a country where open banking regulations apply. Collaborations between banks and fintechs will also proliferate as they will allow banks to leverage their open banking investments.

Climate Risk Analytics

Analysis By: Aapo Markkanen

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Emerging

Definition:

Climate risk analytics are the use of analytic tools that enable private and public sector organizations to improve and automate their climate risk management. Such tools support the modeling and assessment of physical risks from climate change, in relation to lives and property, and transition risks, in relation to investment assets. In addition, they have potential to advance the understanding of litigation and greenwashing risks, which currently remain less formalized forms of climate risk.

Why This Is Important

With physical risks, climate risk analytics represent a major upgrade from established catastrophe modeling software, which struggles to address the complexity of climate change and the lack of historical data on its effects. With transition risks, the tools stand to accelerate various entities' understanding of how business and policy actions to mitigate climate change may affect companies, industries and national economies.

Business Impact

Climate risks analytics support environmental, social and governance (ESG) and risk processes in sectors such as banking, asset management, insurance and legal services. In other industries, they have relevance to business functions interfacing with these services, besides which they may also find traction in supply chain, facilities and operations. In the public sector, they can contribute to climate adaptation — when it comes to, for example, zoning and disaster planning, or public health.

Drivers

- The urgency over climate change in both the private and the public sector, as well as the awareness over its potential business implications, continues to increase rapidly.
- Framework development used in climate-related financial disclosures is starting to turn climate risk into a more standardized element of enterprise risk management.
- Many enterprises, especially in non-carbon-intensive industries, have been slow to initiate climate risk assessments, leaving them with technical gaps that new analytic tools can help fill.
- Climate risk assessments conducted and maintained by internal or external ESG risk experts remain a labor-intensive, high-cost activity, which improves the returns on software investment.

Obstacles

- The software layer can accelerate climate risk assessments and make them a more scalable activity, but the incorporation of insights into business decisions still requires in-depth human expertise.
- The different forms of climate risk differ from each other greatly in the methodological sense, which undermines the development of complete analytic offerings.
- The progress on incorporating climate risk into enterprise risk management has been inconsistent, so the level of available funding can vary notably between otherwise similar organizations.
- Climate risk management suffers from “the tragedy of the horizon,” in which the materialization of risks is too far out in the future to be fully applicable to near-term business decisions.

User Recommendations

- Reduce the cost of initial and especially ongoing climate risk assessments by utilizing the climate risk analytics tools that are applicable to the organization’s risk profile.
- Execute on the business implications of climate risk by incorporating the generated analytic insights into the other, more established risk tools and processes used within the organization.

Sample Vendors

Cervest; CoreLogic; Esri; Formosa Climate Smart Service; IBM; Jupiter Intelligence; Moody's; S&P Global; Risilience; Verisk Analytics

Gartner Recommended Reading

What Is Climate-Centered Innovation, and Why Focus on It Now?

Use These 7 Principles to Effectively Disclose Climate-Related Risks

CSCOs: Embed Climate Change Into Supply Chain Decision Making to Respond to Risk

Quantum Computing

Analysis By: Chirag Dekate, Matthew Brisse

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Definition:

Quantum computing is a type of nonclassical computing that operates on the quantum state of subatomic particles. These particles represent information as elements denoted as quantum bits (qubits). Qubits can be linked with other qubits, a property known as entanglement. Quantum algorithms manipulate linked qubits in their entangled state, a process that addresses problems with vast combinatorial complexity.

Why This Is Important

Quantum computing will not displace conventional computers. However, it will disrupt areas such as some classes of BQP (bounded-error, quantum, polynomial time) problem, quantum realistic simulations (used in material science, chemical simulations and drug discovery) and cryptography (security), where it will deliver results beyond what is feasible using classical techniques. Quantum computing could also advance the speed and/or quality of machine learning and optimization solutions.

Business Impact

With minimal investment required to investigate a broad range of quantum use cases, the potential rewards hugely outweigh the risks. Multiple use cases, such as optimization, run optimally on quantum computing system architectures. Also, the growing maturity of quantum ecosystems enables organizations to choose from a variety of quantum computing as a service (QCaaS) offerings. Enterprises need to plan for four key areas of impact: optimization, simulation, BQP and security.

Drivers

- Significant investments by governments, major corporations and startups amount, in aggregate, to more than $2 billion yearly.
- Enterprise and academic research teams have produced promising results for diverse use cases, including optimization and materials simulation, using current-generation noisy intermediate-scale quantum (NISQ) systems.
- Demonstrations of foundational quantum technology using electrons, ions, cold/neutral/helium atoms and photons are resulting in potential pathways to scalable quantum computing.
- The scale of superconducting gate-based quantum systems continues to increase, with some quantum computing vendors developing systems that scale to hundreds of qubits.
- Error correction algorithms and new methods such as error mitigation and error suppression are in development. These promise to make NISQ systems more usable.
- Managed service providers, including boutique quantum services companies, are partnering with enterprises to identify use cases and develop quantum algorithms.

Obstacles

- With few use cases guaranteeing an ROI, enterprises might deprioritize investments in quantum computing.
- Current, limited-scale qubit technology is too noisy and delivers returns of limited value.
- Standardization is lacking across programming, middleware and ecosystems.
- The market is highly fragmented, with over 600 startups operating in high-risk macroconditions. This exposes enterprises to innovation risk.
- Although small numbers of qubits can represent large amounts of data, quantum computers cannot convert large amounts of data to a quantum state, due to quantum RAM's immaturity.
- Unlike computing-on-silicon technology, there is no single physical computing stratum for quantum computing, and it is not possible to mix platforms at the quantum level. This results in a highly diverse range of potential platforms and in enterprises choosing platforms that might prove incompatible with future quantum computers.
- Enterprise leaders recognize that quantum computing will take more than 10 years to mature. This results in limited short-term investment.

User Recommendations

- Be frugal when it comes to investment in quantum computing. Focus on the problem you want to solve and ways to mature the quantum computing ecosystem. Quantum innovation is a long-term endeavor, so it is imperative to temper expectations.
- Create a pipeline for quantum computing talent by funding academic research projects that closely align with your use cases. When quantum computing becomes relevant to your organization, even a few quantum-capable employees will make a material difference.
- Plan for quantum-inspired classical optimization projects for skills development in areas such as warehouse routing, traffic routing, portfolio balancing and workforce planning.
- Plan for innovations in chemistry and materials science. Quantum computing has the potential to enable quantum-realistic simulations that could prove important in diverse fields, such as manufacturing, aerospace and defense.

Sample Vendors

Classiq; Google; IBM; Infleqtion; IonQ; IQM; PASQAL; Quandela; SandboxAQ; Zapata Computing

Gartner Recommended Reading

Cool Vendors in Quantum Computing

Infographic: How Use Cases Are Developed and Executed on a Quantum Computer

Preparing for the Quantum World With Crypto-Agility

ESG Management and Reporting Software

Analysis By: Lillian Oyen-Ustad, Chet Geschickter, Aapo Markkanen, Simon Mingay

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Emerging

Definition:

ESG management and reporting software is used to manage, measure and improve enterprise sustainability performance and provide a consolidated data collection method to report to ESG reporting standards and regulatory reporting obligations. Capabilities include support for data collection from diverse sources, analytics and decision support, KPI dashboards and visualizations, and identification of actions that advance ESG performance and ESG program management.

Why This Is Important

Enterprises are prioritizing transparency in response to stakeholder pressure — notably, regulators, investors and customers. Now that many enterprises measure and report ESG data, and have made public sustainability commitments, they need to make decisions and take actions to drive ESG performance. As such, executive leaders are looking toward systems that meet internal ESG program needs and external reporting requirements, and ensure verifiable, traceable data.

Business Impact

Fully featured and well-implemented enterprise ESG software can:

- Streamline ESG data collection and management.
- Improve ESG program management and visibility.
- Enable tracking and managing progress toward sustainability ambitions.
- Provide forecasting and decision-modeling tools for decision support.
- Streamline ESG reporting, enabling more focus on engagement and improvement activities.

Drivers

Market demand for enterprise ESG software is on the rise. Drivers include:

- Increased scrutiny and demands for transparency from external stakeholders, including the expectation of regulators to provide third-party verified data.
- A fragmented, complex and evolving regulatory environment, including regional variations in a regulatory approach.
- Investor pressure for data to inform ESG portfolio construction.
- Evolving sustainability ambitions and strategies among executive leadership, boards of directors and investors.

Corporate ESG programs are also growing in complexity and scope. Drivers include:

- Identification and inclusion of wide-ranging material ESG issues in program design.
- Challenges in identifying and collecting necessary data from diverse internal systems and external partners, especially up and down the supply chain.
- Challenges in balancing financial and economic considerations with ESG progress.
- Social commitments from an increasing number of corporations addressing diversity, equity and inclusion concerns.

Obstacles

- Responsibilities for ESG management are often spread across a range of functions and roles, making it difficult to collaborate, as well as identify material issues and data requirements.
- Diverse and distributed data often resides in a variety of systems and functions and across the value chain, complicating solution implementation.
- Shifting and uncertain regulatory requirements and fragmented standards complicate the process of establishing clear requirements.
- Executives often think they just need a solution for historical reporting to produce reports structured around specific standards. In reality, they need much better tools to provide operational insight and planning and modeling tools.
- The solution landscape is very dynamic and fragmented, with adjacent vendors expanding into ESG and pure-play vendors entering the market, making selecting the “right” vendor difficult.

User Recommendations

- Work with ESG stakeholders to identify material issues and data requirements as a basis to specify solution requirements. Consider how to instill a process that engages the organization to look for opportunities to improve ESG reporting and embed ESG into operational decision making.
- Review current reports that your organization produces, including corporate social responsibility reports, mandated regulatory filings and information for ESG rating services, and look for opportunities to integrate these and consolidate effort.
- Review standards, and identify relevant frameworks for your industry, such as the U.N. SDGs, CSRD, ISSB, TCFD, GRI and CDP.
- Assess needed data, source systems, and people and datasets that you will need to rely on to provide estimates and answers to questions about processes and practices.
- Improve the vendor selection process by focusing on vendors with experience in your industry, roadmaps and capabilities that align with relevant, evolving regulatory requirements.

Sample Vendors

Cority; Figbytes; IBM; Nasdaq; Sphera; Workiva

Gartner Recommended Reading

Market Guide for ESG Management and Reporting Software

Key Competitive Scenarios Product Managers Must Prepare for in Sustainability and ESG Software

Emerging Tech: Sustainability and ESG Software Will Underpin the New ESG Era

Supplier Sustainability Applications

Analysis By: Miguel Cossio

Benefit Rating: Moderate

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

Supplier sustainability applications help companies collect and assess suppliers' environmental, social and governance (ESG) performance. These applications use self-assessments covering multiple ESG issues, which allow organizations to measure how well suppliers meet sustainable procurement requirements.

Why This Is Important

A fast-evolving regulatory landscape, increased customer expectations and heightened awareness on a broad set of ESG topics are placing increased pressure on companies to report how suppliers meet sustainability requirements. Supplier sustainability applications enable companies to simplify and scale the data collection process from their supply base using self-assessments to assess supplier performance and identify areas of improvement.

Business Impact

Nearly all organizations will benefit from a supplier sustainability application. Stakeholder expectations and regulatory changes will continue to evolve and force organizations to scale sustainable procurement initiatives. By deploying a supplier sustainability application, companies can prove that the right level of due diligence is being exercised to ensure supplier adherence to multiple ESG topics and proactively manage reputational risks.

Drivers

- Changing regulatory landscape across geographies, covering a broad range of topics such as modern slavery, climate change and water stewardship.
- Customers increasingly request evidence that organizations are performing the due diligence needed to identify and resolve sustainability risks in their supply chains.
- Companies looking to drive growth by including sustainable practices and products in their value proposition for competitive advantage.
- According to the 2022 Gartner/SPP Sustainable Procurement Pulse Survey, 79% of organizations are committed or somewhat committed to achieving their sustainability goals. To enable their strategy, 45% of respondents are planning to use survey-based digital tools in the next two years.

Obstacles

- Poor supplier experience driven by survey fatigue and lack of improvement insights can limit supplier adoption of a sustainability application.
- There is an inherent tension between vendors offering standardized assessments that can drive supplier adoption versus fully customizable ones that can adapt to specific company needs.
- The technology landscape for applications that can enable sustainability outcomes is extremely fragmented, with vendors having varying capabilities and different focus areas. As a company's sustainable procurement ambition grows, several applications might be needed.
- Sourcing groups often find supplier sustainability initiatives hard to enforce and sustain. Some initiatives are perceived to be overheads that do not deliver direct value to their organization.
- Other challenges include a lack of executive sponsorship, too many suppliers to manage effectively and difficulty in justifying the business case.

User Recommendations

- Self-assess the need to invest in a supplier sustainability application by looking at the scope of your sustainable procurement program. In some cases, existing procurement applications will offer basic capabilities that can support your strategy in the short term without the need of investing in a purpose-built supplier sustainability application.
- Create a shortlist of vendors based on the ESG issues you want to address, the application capabilities needed, and the need to go beyond Tier 1 suppliers or collect product-level data. Less mature organizations should prioritize vendors that can provide materiality guidance and offer data validation capabilities.
- Increase the rate of supplier adoption by selecting applications that emphasize a positive supplier experience and enable suppliers to reuse data across multiple customers, therefore reducing the reporting burden on the suppliers.

Sample Vendors

Achilles; EcoVadis; ImpactBuying; IntegrityNext; NQC; SupplyShift; Transparency-One; Worldfavor

Gartner Recommended Reading

Market Guide for Supplier Sustainability Applications

Quick Answer: How to Select a Supplier Sustainability Application

Quick Answer: How Can Technology Be Used to Support a Sustainable Procurement Program?

Urban Sustainability and COP 26

Analysis By: Bettina Tratz-Ryan

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

Cities are becoming environmental and sustainability centers of excellence due to commitments made to the U.N. Framework Convention on Climate Change in 2021 (COP 26), as well as the U.N. Sustainable Development Goals (SDGs). Almost 1,000 cities that made this commitment are focusing on climate change risk management and opportunity identification. Urban sustainability is using measurements like ISO 37120 to measure impacts and delivery on climate resilience while protecting citizens.

Why This Is Important

Cities face issues of rising sea levels, rising temperatures and biodiversity loss, as well as multiple adverse environmental threats. The pandemic's aftermath has exposed social issues, including inequality of social sustainability, for instance, in mobility or housing. Many local governments are addressing these issues with "resilience strategies" to rebuild infrastructure, support sustainable industries and ensure holistic citizen engagement through a focus on SDGs.

Business Impact

Cities will demand more sustainable services and transparency. COP 21 was the launchpad for COP 26 declarations by city leaders/nonstate parties on digital sustainability goals. CIOs can innovate by linking technology projects to green initiatives. Data becomes instrumental for policy decision making, and CIOs can develop architectures and shared infrastructure that balance services with related greenhouse gas (GHG) emissions and a wider, circular environmental impact from IT.

Drivers

- The European Green Deal is making carbon emission reductions and circular economy key enablers for sustainable living. The diversity of political and demographic environments will, however, change the momentum for local governments due to inflation, funding and economic discussions. The polarization between citizens, government and urban ecosystem is driving the hype, and it is moving this technology faster through the Peak of Inflated Expectations.
- The momentum and adoption rate are driven by citizen, business and investor concerns about climate change. For example, the lack of or slow response to addressing climate change in cities has led to heat islands in cities, exposing vulnerable citizens and requiring a redesign of spatial planning and urban site development. Using rooftops for solar energy supports the renewable energy strategy of cities. Interest groups, such as C40 for cities and European Green Capital share insights on carbon reduction, sustainability initiatives and key performance indicators (KPIs) to measure impact.
- Based on some local impacts and the social cohesion and contextualization of the urban service environment generated through projects that address cities' distinctive needs, cities will outpace countries and regions in sustainability and environmental momentum and execution.

Obstacles

- Climate crisis in cities is a result of climate change, loss of biodiversity, pollution and inefficient resource use. An intelligent urban ecosystem can manage sustainability impacts with good data on primary and secondary material impacts on the city and citizens. Datasets are rarely available in scale from the industry and need to be standardized on public platforms, especially for Scope 3 GHG, pollution or social sustainability.
- Data sharing needs to include GHG emission data so industry partners (e.g., insurance, real estate development, banking, and logistics and supply chain) can model their impacts to avoid a business risk and data security concerns.
- Reaching sustainability goals needs to be more transparent, granting CIOs options for frameworks such as STAR Communities and World Bank Group's CityStrength Diagnostic to orchestrate data.
- Meeting sustainability goals will likely require businesses and government leaders to make difficult short-term decisions that require political will.

User Recommendations

- Define the KPIs of smart city initiatives in sustainability terms. Create advisories on usage of Internet of Things by citizen advisory boards for measuring emissions, air pollution, waste and recycling rates.
- Using a materiality understanding for sustainability impacts, apply technology to assess operational efficiency, data sharing and business process alignment to condense the urban asset footprint, while visualizing this impact in various channels. Support developing collaboration and dashboarding of sustainability-minded citizens who will engage in environmental activities, such as restricting high-emission vehicles in city centers and offering energy conservation and green energy options for streetlights and buildings.
- Cooperate in public-private partnerships with utilities, waste management companies and consumer goods providers to create business awareness and end-to-end, circular, city life cycle applications in microgrids, recycling, and smart building and home ecosystems.

Sample Vendors

CDP; Cowlines; Deloitte; E.ON; Esri; Libelium; Nesting; QCumber; Sphera; Urbaser

Gartner Recommended Reading

Maverick Research: Metaverse Is the Ally for Smart Cities and Urban Sustainability

Predicts 2023: Sustainable Smart City Decision Making Using Urban Data

Sliding into the Trough

Supply Chain Blockchain

Analysis By: Leonard Ammerer, Dwight Klappich

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Emerging

Definition:

Supply chain blockchain is an expanding list of cryptographically signed, irrevocable transactional records shared by all participants in a predefined network. Each record contains a time stamp and reference links to previous transactions. With this information, anyone with access rights can trace back a transactional event, at any point in its history, belonging to any participant. A blockchain is one architectural design of the broader concept of distributed ledgers.

Why This Is Important

Supply chain blockchain use cases continue to emerge tied to physical goods movements, contractual service requirements, traceability and authentication, as well as capturing immutable records of transactions. However, there are few, if any, supply chain blockchain projects being deployed at scale. Interest in potential applications across supply chains remains stable, with some vendor offerings being enhanced by blockchain technology.

Business Impact

Value perception of blockchain in supply chains has shifted year over year. Before 2020, there was much interest, discovery and hype around potential solutions. Since 2020, interest slowed down with a revised value perception. Still, with blockchains' more agile role as a service to a broader portfolio of applications, its role in shaping digitized workspace and its ability to ratify contractual requirements in B2B or B2C transactions, blockchain continues to remain on the radar.

Drivers

- Though the potential of blockchain technologies is high, a significant difference exists in the execution of blockchain applications for supply chain compared to its origins in financial services use cases (for example, fintech). This is especially in areas that require readiness for collaboration and the digital exchanges of data between supply chain participants.
- Recent trends and shifts have seen blockchain being offered more as a service component to complement existing technology deployments supporting functional or high-risk initiatives. It is also being considered in network planning in areas such as responsible sourcing, sustainability, data mobilization, security and digitalization.
- Presently, initiatives continue to be a mix of vendor-led, stakeholder-, industry- and consortium-driven discussions. Multiple business use cases for blockchain across supply chains are yet to be proven. As supply chains become more mature and digital, the opportunity to cover niche requirements with blockchain technology increases.
- In contrast to early trials and pilots across extended pools of supply chain participants, solution adoption is anticipated to see acceleration in compact ecosystems of stakeholders (or even focused on single B2B or B2C transactions). This acceleration will happen especially in supply chain zones with heavy transaction and processing load such as logistics, supply and transportation. Smaller, compact ecosystem partners allow greater cadence to formalize governance, shared-value creation opportunities and lockdown rules of engagement that would constitute a block (immutable record) or groups of connected blocks — the “blockchain.”

Obstacles

- Blockchain technologies must adapt to use cases that can empower maturity to bridge physical levels of authentication and data capture, and to the needs for interoperable digital data exchange across all types and tiers of responsible trading partners within a company’s ecosystem.
- Blockchain in the supply chain suffers from a lack of cultural and maturity factors impacting modern supply chain networks. These factors include standards for governance across transactions, scalable distributed consensus systems and technical expertise enhancing the strategic positioning or placement across formalized technology planning and process roadmaps.

- The technology's potential to radically transform economic-related interactions should raise critical questions for society, governments and enterprises. Finding answers to the critical questions will be a prerequisite for the contribution of blockchain technology during the rise of programmable economy and more mobilized work environments. Although, at present, there are no clear answers to these questions, it is important to find the answers during the rise of the programmable economy and more mobilized work environments.

User Recommendations

- Identify how the term "supply chain blockchain" is being used and applied internally and by providers to better understand the possible return on capital employed, and the incremental value that could be realized beyond proven technology options.
- Identify high-risk or process-intensive areas of supply chains that exhibit transactional complexity across multiple stakeholders. The following are prime candidates for blockchain: trade contracts, automation, asset management, transportation and traceability.
- Shift to a broader and more thorough review of other viable technology options for consideration against objectives. Place more emphasis on blockchain services or its complementary role as part of a strategic positioning in roadmaps, but remain skeptical on value contribution and alert to limitations of the technology.

Sample Vendors

Arc-net; CHAINSTEP; Chronicled; Circulor; Guardtime; IBM; Omnichain; OriginTrail; SupplyBloc; Vechain

Gartner Recommended Reading

How to Detect Fakes in a Zero-Trust World Using Artificial Intelligence and Blockchain

Top Trends in Strategic Supply Chain Technology 2023

Truth and Transparency in Supply Chain: 3 Case Studies on How Blockchain, AI and IoT Are Shedding Light

Garbage In, Garbage Forever: Top 5 Blockchain Security Threats

Quick Answer: How Can I Assess Whether Blockchain Ensures Sufficient Trust in Supply Chain Traceability to Justify Investment?

Sustainable Procurement

Analysis By: Laura Rainier

Benefit Rating: Moderate

Market Penetration: More than 50% of target audience

Maturity: Adolescent

Definition:

Sustainable procurement embeds environmental, social and governance (ESG) issues into the process by which organizations acquire goods and services. Sustainable procurement ambition ranges from risk mitigation and regulatory compliance to driving positive change across the ecosystem.

Why This Is Important

Suppliers represent significant risk and opportunity related to ESG performance. Significant human and labor rights risks are present in many key raw materials and manufacturing processes. According to CDP, more than 90% of greenhouse gas emissions occur in the upstream supply chain, with suppliers contributing a significant share (see Transparency to Transformation: A Chain Reaction, CDP). Procurement is a key point of leverage to address these impacts.

Business Impact

Organizations are under increasing stakeholder pressure to enhance supply chain due diligence and reduce Scope 3 emissions. Fifty-six percent of respondents to the 2022 Gartner/SPP Sustainable Procurement Pulse Survey reported that customer retention is a key driver of their sustainable procurement program, as sustainability requirements are increasingly present in their customers' supplier selection and scorecarding processes.

Drivers

- **Regulatory compliance:** Regulatory requirements are increasing in key markets and expanding the scope of sustainable procurement programs, including a significant increase in due diligence and reporting requirements in the U.S., U.K., Germany and Norway. In the 2022 Gartner/SPP Sustainable Procurement Pulse Survey, 58% of organizations reported that regulatory compliance is a key driver of their sustainable procurement program.
- **Sustainability goals:** Organizations' ambition to improve their impact on society and the environment is growing. For example, 41% of Forbes 2000 companies have goals to achieve net-zero greenhouse gas emissions. Procurement represents a significant opportunity to impact these goals.
- **Customer retention:** Sustainable procurement expectations are becoming a customer requirement, key to customer retention. Organizations are experiencing pressure from current and potential customers to meet increasing regulatory requirements and make progress toward voluntary sustainability commitments.
- **Resiliency:** Forty-nine percent of organizations reported resiliency and risk mitigation as a key reason for their sustainable procurement strategy. A sustainable procurement strategy proactively assesses and mitigates supplier risks.

Obstacles

- **Internal resources:** Insufficient staff and limited internal capabilities in sustainable procurement are among the top barriers to achieving sustainable procurement goals.
- **Conflicting goals:** Sustainable procurement goals are often not aligned with purchasing decisions, creating confusion for suppliers or mitigating program impact.
- **Supplier capability building:** In the 2022 Gartner/SPP Sustainable Procurement Pulse Survey, only 21% of organizations reported being effective/highly effective at supplier capability building, which is key to driving progress with suppliers.
- **Data/Digital tools:** Procurement lacks digital tools and access to supplier data. Visibility to supplier data is particularly challenging for upstream (Tier 2 and beyond) suppliers.
- **Supplier fatigue:** Traditional sustainable procurement methods include on-site audits and supplier self-assessments, which are time-consuming and provide little supplier value. Survey and audit fatigue can mitigate suppliers' ability to deliver improvements.

User Recommendations

- Build capability on the procurement team to prioritize sustainable procurement by investing in new talent or building the skills of procurement leaders.
- Align purchasing practices with sustainability goals by embedding sustainability requirements and outcomes into core procurement processes. Engage suppliers to cascade expectations upstream.
- Assess and monitor supplier sustainability performance using digital tools, like supplier sustainability applications, to scale the sustainable procurement program across the supply base.
- Collaborate with competitors and other ecosystem partners to align the expectations of suppliers and ease the supplier reporting burden.
- Ensure the sustainable procurement program includes remediation of issues and capability building to improve outcomes in the supply chain. Due diligence and reporting do not have an impact unless the findings are addressed and improved.

Gartner Recommended Reading

Survey Findings: The State of Sustainable Procurement in 2022

The Journey to Responsible Sourcing: Key Elements for Success

3 Steps for Effective Supplier Engagement in Sustainability

Water Management Analytics

Analysis By: Bettina Tratz-Ryan

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Water management analytics are divided into two parts. First is fresh water monitoring for hydrological management, including rainfall, groundwater monitoring, quality review, supply and demand management. The second is waste-water treatment, including quality review and water-loss analysis.

Why This Is Important

Water management requires a differentiated set of technology and service skills. These technologies enable effective water quality, quantity and distribution management, including assessment of risks. As fresh-water resources become increasingly scarce, enhanced water management will increase in importance. Water management data will require more solution capabilities related to an entire management cycle that includes operations, user billing and monitoring, and forecasting of demand and quality.

Business Impact

Consolidating data points to manage and control water issues — from regulation to reuse and recycling — provides water suppliers and municipalities with the ability to achieve cost-effective potable water quality. It improves the interface between asset tools for pumping stations, meters and monitors for better customer services, with fewer water-supply failures and better water quality. Partnerships with IT and water operations have to be built to connect data and information sources.

Drivers

- Residential water needs will compete with business needs, and analytics will be needed to resolve them. South Africa and the state of California are examples for this competition, where water shortage and erratic natural rain are leading to water rationing of society.
- Artificial intelligence (AI) is being used to address infrastructure resilience issues. Adoption is accelerating as emergency response around water crises in drought and flooding, relative to shifts in weather patterns, has captured the attention of local governments and utilities from a risk perspective.
- Water-quality issues triggered by agriculture fertilization are driving up water prices in cities by 50% year over year in countries like Germany or from agricultural pollution. That is accelerating the deployment of new water management solutions and increasing the time to deliver water to customers.
- Climate change priorities are shifting toward water sustainability, capturing the attention of industry players. Government initiatives and the developments in pricing of water will also drive water management — once meters are installed to monitor true consumption.
- Water management is a growing application area for industry and business uses, including touristic sites like beaches and lakes. The recurring red tides in coastal areas in Florida is part of the water temperatures rising, together with pollution that will cause harm to people and livestock.
- Water management offers insights into disaster recovery for water-related issues in manufacturing operations.
- Cities are applying Internet of Things sensors across wastewater infrastructure to measure drug and pharma content and pollution, and provide an epidemiology assessment through the wastewater streams.

Obstacles

- The position of the profile has moved in 2023 in the Hype Cycle because water management has developed more complex use cases.
- While local utility and freshwater supply is experiencing more water intelligence, shortage of climate-related resources and natural disruption are not priced in the supply, thus artificially keeping the delivery cost low.

User Recommendations

- Evaluate the implementation of data management and analytics for water infrastructure and quality. Users (industries and commercial) and suppliers (municipalities) must report, or comply with, tightening wastewater regulations, while improving efficiency and reducing loss and waste-disposal costs.
- Implement security standards in the water management process, the physical infrastructure and the privacy policy on consumer data. For municipal water utilities or sewage plants, water management dashboards will assist in providing real-time data on water quality.
- Develop an adaptive and flexible water management strategy, integrating the legacy of IT and operational technology. IT professionals in utility and municipal contexts can develop strategy based on intelligent information received from environmental sensor and satellite networks, smart water meters and deep computing, and analytics engines.

Sample Vendors

ABB; ADASA Sistemas; Arcadis Gen; Atos; EcoExam; KISTERS; Schneider Electric; SUEZ

Gartner Recommended Reading

Quick Answer: How to Meet a Net Positive Water Commitment

Digital Twins for Sustainability

Analysis By: Alfonso Velosa

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Adolescent

Definition:

Digital twins for sustainability are software proxies that mirror the state of a thing such as an asset, person, organization or process to meet business and sustainability objectives. The three types of digital twins for sustainability are discrete, composite and organizational, which serve different types of decisions. Building blocks include model, data, unique one-to-one association and monitorability. These are built-in software like analytics, GIS, CRM and Internet of Things (IoT).

Why This Is Important

Digital twins for sustainability help enterprises meet sustainability outcomes — such as improved visibility and documentation, energy and waste reduction, and new business models — by creating virtual representations of unclear, difficult to achieve and time-consuming activities/tasks. Specific examples include improving supply chain decisions via better supply and demand visibility, and reducing unplanned downtime by monitoring equipment state.

Business Impact

Enterprises, from oil production to manufacturing to real estate, are implementing digital twins for sustainability to:

- Acquire visibility into things, such as equipment or purchasing processes, that otherwise would have led to waste or duplication of effort.
- Assess, simulate and optimize operations by improving the design to eliminate inefficiency and reduce energy or resource consumption.
- Improve employee safety and training certification.
- Contribute to sustainability documentation requirements.

Drivers

- Enterprises are using digital twins for sustainability to address the increasing pressure to improve resource and energy efficiency, and increase transparency, across their operations, supply chains and wider ecosystems.
- Enterprises are pushing hard to reduce greenhouse gas (GHG) emissions across their operations and supply chain. Asset-intensive sectors, such as oil and gas, manufacturing, and aviation, are using digital twins for sustainability to integrate emissions data into business process optimization.
- Leading OEMs are deploying digital twins for sustainability to help add energy efficiency or align to their enterprise customers' sustainability objectives.
- Leading-edge enterprises are implementing digital twins for sustainability to feed simulation models to predict benefits from emissions reduction or cost optimization.
- Technology providers, from large cloud vendors to startups, are identifying potential ways to serve customers' sustainability goals using digital-twin-enabling product portfolios. In particular, they are developing libraries of templates to demonstrate energy reduction, minimize waste or reduce emissions.

Obstacles

- Enterprises often lack an understanding of what they are trying to achieve, the full potential of and the success metrics for their investments in digital twins for sustainability. This limits investment into initiatives that can take advantage of digital twins for sustainability.
- Currently, only a few enterprises have cross-functional fusion teams like business, finance, operations and IT, required to develop objectives to achieve digital twins for sustainability.
- Digital twins for sustainability challenge most enterprises technically due to the blend of operational and information technologies needed.
- Pricing remains an art, and most vendors focus on their technology differentiation, despite enterprises looking for business value and sustainability outcomes.
- Standards remain emergent across a range of digital twins for sustainability integration, metadata and other technical issues.

User Recommendations

- Co-create the digital twins for sustainability strategy with the enterprise business unit to identify opportunities and challenges.
- Establish clear success metrics, identify sponsors, super-users and budget support, and build a roadmap that starts small and scales up.
- Avoid digital twins for sustainability projects that lack a business sponsor, as this is key to success and lack of internal sponsorship will waste IT resources.
- Identify IT organization technology, governance and skills gaps, and build a plan to resolve them.
- Develop an architectural, security and governance framework to manage large numbers of discrete, composite and organizational digital twins for sustainability.
- Select vendors that demonstrate the ability to deliver both strategic sustainability objectives and tactical business results, based on their existing portfolio of technologies and libraries of prebuilt templates, for digital twins for sustainability.

Sample Vendors

Accenture; Atos; Capgemini; Cognite; Envision Digital; NTT; Tata Consultancy Services; Xemelgo

Gartner Recommended Reading

2023 Oil & Gas Trend: Digital Twins Expansion

Quick Answer: What Is a Digital Twin?

Emerging Tech: Tool — Digital Twin Business Value Calculator

Life Cycle Management of Software-Defined Vehicles: Step 3 — Vehicle Digital Twin 2.0

Hydrogen Vehicles

Analysis By: Pedro Pacheco

Benefit Rating: Low

Market Penetration: Less than 1% of target audience

Maturity: Emerging

Definition:

Hydrogen vehicles use hydrogen as a fuel to power internal combustion engines or fuel cells. A fuel cell is a device that converts chemical potential energy into electrical energy. Fuel cells require hydrogen combined with oxygen in the air and produce water, heat and electricity.

Why This Is Important

Regulation in major markets like China, EU and the U.S. will lead to the progressive phase-out of internal combustion engines (ICEs). Battery electric vehicles (BEVs) still present limitations in terms of charging speed and, in some cases, driving range. These give an opportunity to hydrogen vehicles, as refueling takes less than five minutes and their driving range can easily go beyond 600 km (373 miles). In addition, fuel cell vehicles could actually clean the air as they drive by.

Business Impact

The business impact of hydrogen hinges heavily on public incentives — EU's $5.2 billion fund for hydrogen projects, for instance — and the pace of BEV technology. Hydrogen still has a chance if incentives can enable an economically-sustainable, price-competitive green-hydrogen distribution network before BEVs can address their weaknesses, even after incentives are discontinued. However, this is a narrow window of opportunity, given there is a lot more investment on BEVs than hydrogen.

Drivers

- Both the EU and China have put together regulations and incentives promoting hydrogen vehicles, even if those incentives are on par with BEVs. In addition, the EU is also financially supporting the production of green hydrogen — something that will accelerate the creation of a hydrogen distribution network.
- Hydrogen is seen by some governments as a cornerstone of their overall energy strategy. For instance, the EU predicts hydrogen's part of the energy mix will grow from 2% to 13-14% by 2050. It describes hydrogen as "a technology which can bridge the gap between electricity production from renewable energy and the goal of decarbonizing a large share of the EU's energy consumption by 2050." Looking at the energy ecosystem holistically, hydrogen can be used for renewable energy storage (without the negative environmental impact of batteries), heating and energy to power land, sea and air transportation, as well as industrial processes. Under this holistic perspective, it makes sense that hydrogen is also used to power road vehicles.
- Europe's need for greater energy security provides a new opportunity for hydrogen, especially as a replacement for natural gas.
- The oil and gas industry is a major proponent of hydrogen since the production and distribution of hydrogen share several similarities with those from other existing hydrocarbon fuels. As such, these companies have a vested interest in developing hydrogen refueling infrastructure if or when they get strong signs of interest vehicle manufacturers.

Obstacles

- Production and distribution of green hydrogen are far from cost-effective.
- The main OEMs advocating for hydrogen (General Motors, Hyundai and Toyota) are now investing more in BEVs than in hydrogen.
- Fuel cell vehicles present much lower well-to-wheel efficiency (from fuel production to vehicle use) than BEVs (30% to 40% against 80% to 90%). This is now even more of an issue after the sharp increase in energy prices.
- The business case for hydrogen is very weak when there is an absence of incentives and regulations.
- BEV technology moves at a faster pace due to the higher number of companies committed to it. For instance, a Mercedes EQS already offers a worldwide harmonized light vehicles test procedure (WLTP) driving range of 770 km (478 miles) — more than any production hydrogen car. The rise in charging power and new battery tech, such as solid-state, will bring charge time below 15 minutes.
- It is hard for fuel cell's cost reduction roadmap to be more aggressive than BEV's as there are many more companies investing in the latter.

User Recommendations

- Focus on the development of hydrogen powertrains mostly for larger vehicles used for long-haul applications, given that BEV technology is already way ahead for passenger cars and urban trucks.
- Develop a whole business model rather than just vehicles or infrastructure in isolation. Just as Tesla did by setting up their own charging network, gigafactories, dealer network and online sales, proponents of hydrogen technology must tackle all hurdles that make the usage of hydrogen vehicles expensive, inconvenient and inefficient. In many cases, this will mean establishing partnerships with a broad number of companies in order to produce a strong impact on the whole energy and transportation ecosystem.
- Focus on B2B use cases where companies need hydrogen for other purposes besides transportation.
- Influence regulations to make sure these recognize and benefit fuel cells' ability to purify the air while in operation.

Sample Vendors

Ballard Power; General Motors; Honda Motor Company; Hyundai; Toyota

Gartner Recommended Reading

Technology Innovation and Global Regulations Drive New Interest in Alternative Fuel Trucks

Utilities Technology Trends 2022: Green Hydrogen Can Help Displace Fossil Fuels and Stabilize Energy Markets

Apply Technology to Reduce Greenhouse Gas Emissions in Logistics

Life Cycle Analysis Software

Analysis By: Lindsay Azim

Benefit Rating: Moderate

Market Penetration: 1% to 5% of target audience

Maturity: Adolescent

Definition:

Life cycle analysis (LCA) is a methodology that enables the end-to-end assessment of environmental impacts of products, assets or services. LCA requires complex data analysis to establish product carbon footprints, identify resource-intensive processes and prioritize product design changes to reduce environmental impacts. LCA software reduces the complexities of collecting data and completing the analysis, enabling organizations to assess trade-offs and make quicker strategic decisions.

Why This Is Important

LCA provides data-driven insight into where enterprises can make improvements across life cycle stages, including design, material inputs and resource-intensive processes, to reduce environmental impact. LCA software enables faster and more accurate data analysis needed for organizations to make trade-off decisions between environmental impact categories, differentiate themselves with customers, meet industry standards, and engage with suppliers on improvement activities.

Business Impact

Visibility of environmental impacts through LCA enables targeted improvements to meet reduction targets. LCA data verified by a third party is used to substantiate consumer-product claims to limit potential accusations of greenwashing. Additionally, requests for cradle-to-gate LCAs from suppliers help track and uncover hot spots for Scope 3 emissions reduction. The time required to collect data and perform a complex impact assessment necessitates the use of LCA software.

Drivers

- Pressure for increased transparency through product carbon footprint data is accelerating. There is a need to reduce cost, cycle times and complexity in establishing product carbon footprints.
- There is increased scrutiny of environmental claims and concerns of greenwashing by advertising regulators and NGOs, in addition to the stakeholder pressure to report the environmental impacts of products and services.
- Flexibility is needed to perform varying levels of analysis depending on the business need. This spans from full LCAs, which require significant budget and time investment, to an LCA “lite,” which is faster, able to be completed by nonspecialized staff, and suitable to inform internal decisions on strategic focus and new product development.
- Organizations need to interpret results and make quicker decisions on the environmental trade-offs between alternatives. LCA software makes it easier to perform a side-by-side comparison of one, or more, products and raw material inputs for product development.

Obstacles

- LCA software provides a modeled view of environmental impact, and the reliability depends on the quality of source data. A mix of primary and modeled data is collected and the level of uncertainty is often unknown. Supplier data (Scope 3) requires additional resources to review data quality.
- Full LCAs are no small feat and come with a significant price tag. In addition to software, outside experts and specialized skills are needed to complete this analysis. Additional costs are required for third-party verification if results are published.
- LCA software is a mix of generic, industry-specific or niche product tools (such as packaging), and it is difficult to select the most appropriate software to meet enterprise needs.
- There are a number of LCA standards (ISO 14040, 14044) in addition to country guidelines, such as PAS 2050 Carbon Footprint (U.K.) and International Life Cycle Data System (ILCD) on Life Cycle Assessment (EU). The variance in approach is a limitation to data comparability that makes using software more complex.

User Recommendations

- Assess the business need prior to selecting an LCA software. LCA software can speed up high-level assessments and decision making. However, in addition to software investments, full LCAs require additional data collection and external collaboration with industry experts.
- Determine the availability of data, including supplier (Scope 3) data, and understand how boundary conditions and assumptions will impact assessment uncertainty.
- Assess how the results from the LCA will be used, and integrate into process, design and strategic decision making.
- Determine what additional skills are needed internally to utilize software and complete an LCA. Budget for collaboration with external experts and third-party verification if necessary.

Sample Vendors

iPoint; One Click LCA; openLCA; SimaPro; Sphera; Trayak

Gartner Recommended Reading

Quick Answer: How Does Life Cycle Analysis Advance Sustainability?

How to Create Product Carbon Labels

Emerging Technologies and Trends Impact Radar: Environmental Sustainability

Geospatial Platform

Analysis By: Nicole Foust, Lloyd Jones

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

Geospatial platforms are platform as a service (PaaS) and data as a service (DaaS) offerings in the context of spatial data processing, such as web mapping, mobile geospatial apps, location services, imagery services, analytics and geoevent processing. They also include other features such as digital marketplaces with subscription-based licensing and revenue-sharing mechanisms, for partner- and customer-generated apps and content.

Why This Is Important

Location and time are important items of information for contextualizing operational, transactional, mobile and sensor data. Analyzing operational data in the context of location can uncover spatial trends, dependencies and patterns that are otherwise undetectable. Asset-intensive organizations (especially those with spatially distributed assets) are expanding capabilities to manage and optimize spatial location data, which is essential for the optimization of an enterprise.

Business Impact

A geospatial platform will help asset-intensive organizations with a pace-layered strategy toward intelligent operations, deploying innovative applications that leverage time- and event-stamped locational transactions. Geographic information system (GIS) developers in IT organizations and “citizen developers” in business units can easily develop web and mobile applications that access geospatial services. Maps can be easily put to business use in an agile delivery model to improve transactional data quality and timing.

Drivers

- Organizations seek to capture the value of location to understand and engage customers, improve sustainability capabilities and initiatives (such as climate risk modeling), optimize supply chains and asset usage, develop and interact with a broader ecosystem, and improve operational efficiencies.
- Investments in the Internet of Things (IoT), cloud, analytics, edge capabilities and more, are driving greater adoption, broader utilization, and new use cases and services. In these investments, ecosystem partners are building capabilities to augment platform products and expand opportunities further.
- Geospatial platforms are foundationally a spatial information system of record. Core geospatial functions are expressed as web services, and interfaces are expressed as restful APIs and HTML5-based applications that consume these services. The web map has become the digital expression and real-time operational view of geospatial content.
- Geospatial platforms can support real-time modeling; visualize electrical, gas, and/or water and pipeline networks; model geological and surface feature relationships; and depict the relationship between assets and the environment. These can support the creation and management of the geospatially referenced plant and network models necessary for the planning, design, construction, and operations of the locations and the specification of assets.
- Energy and utility organizations are expanding the geospatial platform footprint to reduce the time to value for geospatial application development, and simplify end-user collaboration across departmental or company boundaries.
- In addition, geospatial platforms are evolving faster than industry-specific GIS applications, making them ideal for organizations that are adopting a pace-layering approach to geospatial application development.

Obstacles

- Accessing data in legacy GIS can be difficult without the help of GIS analysts, and the cost of application development and maintenance can be substantial. The quality, storage and management of spatial data can be a challenge for many organizations. However, modern applications leverage geoprocessing workflow capabilities with low-cost, commercial data layers, satellite imagery, aerial photogrammetry and mobile GPS.
- Business and software silos are an ongoing challenge in digitalization journeys. Increasingly, public, private or hybrid GIS deployment options are available, which create significant collaboration opportunities both inside and outside the enterprise.
- Asset, network and field mobile applications, when integrated with geospatial and enterprise systems, can further improve operational capability, data quality and business performance.
- Supplementing a GIS with improved land-based data, aerial photography, location-based services and customer engagement applications can make GIS useful for a wider variety of users.

User Recommendations

- Identify a comprehensive geospatial platform that meets the geospatial application requirements of multiple business units, and that supports cross-enterprise collaboration and workflow mapped to specific business goals.
- Resolve barriers to geospatial platform adoption by addressing licensing, security, architecture and information governance early on. Cloud-based deployments may be appropriate for managing the sharing of maps and metadata outside the organization.
- Evaluate the benefits and costs at an ecosystem level, when concerns about vendor lock-in and pricing arise. As with other software platforms, the investment and relationship are with the overall ecosystem, not just the platform provider. Business owners can explore subscription licensing and business partner relationships that can lower the total cost of ownership.

Sample Vendors

Bentley Systems; CARTO; Esri; General Electric; Hexagon; QGIS; Supergeo Technologies; SuperMap Software; TatukGIS; Trimble

Gartner Recommended Reading

Market Guide for Geospatial Information Systems for Energy and Utilities

How Utility CIOs Can Unlock the Business Value of Geospatial Information Systems

Digital-Outcome-Driven Metrics for Utilities

Market Guide for Enterprise Asset Management Software

Research Roundup: Top 10 Trends Shaping the Utility Sector in 2023

Large-Scale Lithium-Ion Batteries

Analysis By: Lloyd Jones

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Early mainstream

Definition:

Lithium-ion (Li-Ion) solid-state batteries with energy density and delivery voltages per cell, make them ideal for high-power applications. Li-Ion cells are stacked to support short duration (less than four hours) storage at a MW scale. Large-scale storage addresses energy unbalance created by renewables' intermittency and improves system resilience while reducing operating costs.

Why This Is Important

Electrical peak demand is growing forcing faster ramp rates. Ramping was covered by gas peakers, however Li-Ion batteries at large scale are providing an affordable alternative. Li-Ion batteries can be reconfigured to cover use cases from short-term peak power, to ancillary services, such as operating reserve to frequency control. When deployed alongside renewable energy sources can smooth and stabilize energy production, creating production and price certainty.

Business Impact

Strategically sited large-scale storage is a valuable alternative to grid upgrades, at both centralized and decentralized locations. Solar is dominating the system profile — reducing midday net load and raising the ramp rate to the evening peak. Li-Ion battery technology accelerated by electric vehicle research has created a technology price performance sweet spot for short-duration (less than four hours) rapid response storage. Large-scale Li-Ion batteries currently exceed 300 MW/1200MWh.

Drivers

- Estimates of large-scale storage needed by 2030 exceed 600 GW in the IEA Net Zero by 2050 scenario.
- Li-Ion batteries are able to respond rapidly to the need for additional energy resources to meet the demand but for a limited period of time, typically less than four hours, but projects with upto eight hours are in the pipeline.
- Li-Ion battery costs dropped by 97% from $7,523/kWh in 1991 to $350/kWh in 2020, but supply chain issues saw the first price rise in 2023, strengthening the value proposition for energy arbitrage and deferring infrastructure upgrades.
- Lithium iron phosphate (LiFePO)-based batteries are gaining popularity as they do not need rare earth metals, such as cobalt and nickel, and have lower cost and toxicity, improved safety, and longer life cycle.
- Forward forecasts suggest technology innovation can drive costs toward $150/kWh for four-hour duration large-scale storage use cases by 2050.

Obstacles

- Storage plays a key role as an energy transition enabler. Storage can defer capacity upgrades but also competes with operational strategies such as demand response and voltage conservation.
- Li-Ion has a tendency to overheat, and can be damaged at high voltages. Li-Ion can experience thermal runaway and combustion, requiring safety mechanisms to limit voltage and internal pressures. Li-Ion performance degrades due to aging, losing capacity and then failure. Li-Ion has a limited life span compared to alternatives such as flow batteries.
- The emergence of new storage technologies, such as Nickel-Cadmium (Ni-Cd), and flow batteries, at significantly lower cost points may moderate or delay uptake of Li-Ion batteries.
- Sodium-ion batteries from CATL are a potential disruptor achieving 255Wh/kg in 2022 compared to the more expensive Li-Ion with a density of 260Wh/kg.

User Recommendations

- Incentivize deployment of large-scale storage with direct support for storage through mandates and policies.
- Participate in standards and regulations to ensure that regulations are transparent and open to develop markets for capacity, flexibility and ancillary services so that storage can compete with other technologies and measures.
- Ensure that any proposed Li-Ion energy management system includes temperature monitoring with fail-safe disconnects.
- Ensure Li-Ion energy management systems feature both passive and active cooling to dissipate heat gains.
- Research alternative storage technologies when examining longer-duration storage business toward 12 hours or more.
- Invest in API interfaces to integrate Li-Ion storage control and management systems into utility IT and OT domains.
- Invest in AI to optimize physical Li-Ion storage dispatch and charging operating cycles against the wholesale markets behavior.

Sample Vendors

AMP Energy; Contemporary Amperex Technology (CATL); General Electric; NGK Group; Panasonic; Samsung; Tesla

Gartner Recommended Reading

Research Roundup: Top 10 Trends Shaping the Utility Sector in 2023

Environmental, Social and Governance

Analysis By: Malcolm Murray

Benefit Rating: High

Market Penetration: More than 50% of target audience

Maturity: Early mainstream

Definition:

Environmental, social and governance (ESG) is the process for setting, managing and reporting strategy and metrics for an organization's environmental and social impacts, governance mechanisms, and related policies. It allows the board and company leadership to synthesize and weigh stakeholder interests to inform corporate strategy, manage a new set of risks, and communicate ambitions and progress to external audiences.

Why This Is Important

ESG finds itself at a crossroads. After many years of being a top priority, the uncertain economic conditions, geopolitical volatility and evolving regulatory requirements are chipping away at the once-impenetrable armor of ESG. ESG is still a must-have for organizations' long-term sustainability; it is requested by customers and employees, and it is required or about to be required by regulators in several large jurisdictions. But the ESG journey has become a more complex one to navigate.

Business Impact

ESG impacts organizational strategy and operations through:

- **Risk-balanced progress:** ESG impacts both the risks (e.g., regulatory, reputational) and the opportunities (e.g., access to capital, customer loyalty).

- **Wide-ranging touchpoints:** ESG now impacts all areas of organizational decision making — suppliers, mergers and acquisitions, etc.
- **Decision timing:** ESG impacts the timing of decisions — too soon may lead to additional costs, while too late may lead to stranded assets or regulatory noncompliance.

Drivers

- **ESG investing:** Investor appetite for ESG assets rose significantly for many years. It took a bit of a breather in 2022, due to geopolitical concerns and changes in how ESG funds were labeled. The year 2023 looks likely to continue the long-term trend, however, as the benefits of ESG investing remain solid.
- **Regulatory disclosures push:** Most of the world's largest economies (the U.S., EU, the U.K., China, India and Japan) now either have in place or are soon to release new guidelines or regulations for ESG disclosures.
- **Customer preferences:** Customers are increasingly concerned about enterprises' environmental and social impact, and are making value-based choices in their purchases of products, choice of employers and votes for officials.
- **Policy:** Enterprises are increasingly impacted by the incentives and disincentives being put in place by policymakers. To hit targets, policymakers are putting in place taxation, bans, penalties and new market mechanisms.
- **Social pressure:** Enterprises increasingly need valid supplier ESG performance and data from deeper in the value chain for Scope 3 greenhouse gas (GHG) emissions. They are focused on responsible sourcing, assessing labor, health safety and environmental risks.
- **ESG strategy:** As the value of having a clear and actionable ESG strategy becomes clear, 94% of public companies now either have or are in the process of setting up an ESG program. Further, boards are increasingly stepping up their oversight of ESG, as they recognize its necessity for long-term resilience.

Obstacles

- **Political backlash in the U.S.:** In the U.S., some states have seen political backlash against ESG and bans on using ESG in investments.
- **Competing demands:** The Russian invasion of Ukraine created geopolitical risk and energy crises that were at cross-purposes to ESG.
- **Macroeconomic environment:** The uncertain macroeconomy has led to a focus on cost, leaving less room for ESG investments.
- **Internal governance:** There is no one place for an ESG program to sit in the organization and there is often duplication of work and unclearly defined responsibilities.
- **Data alignment:** ESG data gathering and comparability remain challenging due to the lack of standardization and the lack of maturity in the vendor space.
- **Quantifying benefits:** Improving ESG performance is often seen as an intangible benefit, where it is difficult to connect to direct financial rewards.
- **Visibility of impact:** The majority of impact is further down in the value chain and organizations struggle to get visibility of supplier performance.

User Recommendations

- **Link ESG objectives to long-term financial stability:** ESG needs to drive a business outcome of long-term sustainability of financial performance.
- **Build capabilities, not program components:** In order to make ESG truly integrated, think ESG building capabilities, not program components.
- **Build in, don't bolt on ESG capabilities:** Don't create new processes where not needed; leverage existing capabilities and processes.
- **Create governance:** Create a governance framework that enables the organization to set goals, targets, KPIs and metrics, and monitor and report on them consistently.
- **Include the value chain:** Identify environmental and social impacts, not only under direct control, but also in the value chain. Track supplier performance.
- **Align key performance indicators (KPIs) with compensation:** Build ESG measures into senior leaders KPIs, tying performance to compensation.

Gartner Recommended Reading

Market Guide for ESG Management and Reporting Software

Predicts 2023: Achieving ROI With ESG — Leadership Perspective

Anatomy of an ESG Program

Maverick Research: To Do Good, Stop Following ESG Standards

Prepare for the SEC's New Proposed Climate Disclosure Requirements

IoT for Sustainability

Analysis By: Alfonso Velosa, Annette Zimmermann

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Adolescent

Definition:

The Internet of Things (IoT) is an enabler and accelerator for sustainability initiatives at enterprises. IoT enables enterprises to improve sustainability-focused processes and decisions with asset information via embedded technology to communicate and sense/interact with their internal states or external environment. IoT sustainability solutions span from compliance reporting to process optimization (such as energy savings and waste avoidance) to marketing and creating new revenue strategies.

Why This Is Important

Sustainability initiatives benefit from IoT data. Most enterprises lack real-life data to drive sustainability initiatives or reporting. IoT capabilities benefit activities such as farming, power generation, shipping, building operations, product circularity analysis and beverage manufacturing. IoT provides a better understanding of the environment, resource consumption, emissions to air/water/land, and carbon footprint. This enables enterprises to optimize operations and simplify reporting.

Business Impact

IoT impacts sustainability strategy, operations, reporting and customer engagement by enabling:

- **New revenue:** New sustainable products and services drive revenue.
- **Process optimization:** Enterprises are improving asset health and conserving resources.
- **Asset optimization:** Ambient monitoring ensures asset operations optimize water and energy usage and avoid unplanned downtime that wastes resources.
- **Visibility and compliance focus:** Documenting alignment to regulations and preventing wasteful breakdowns.

Drivers

- Increasing regulations for energy usage to meet global net-zero targets drives adoption of IoT-based asset optimization solutions. For example, the 2030 climate and energy framework in the EU prescribes a 32.5% improvement in energy efficiency, increasing enterprise focus on reducing energy usage and subsequently carbon emissions.
- Enterprises are investing in resource optimization across a wide range of use cases, for reasons of productivity and yield improvements, reduced cost, environmental footprint, risk management, and/or compliance.
- OEMs, building and other companies are increasingly adding IoT capabilities to document and emphasize their sustainability credentials and drive premium pricing.
- Shorter payback time frames (six to 18 months on average) and financial outcomes (cost savings and resource efficiency) make IoT-enabled sustainability projects attractive.
- Technology and service providers have realigned their go-to-market strategy to highlight sustainability value to enterprise customers. This includes a spectrum of services such as equipment improvement, compliance reporting and cost savings from operational efficiencies.

Obstacles

- Business leaders underestimate and underinvest in the political capital required to support IoT-enabled sustainability projects. These are business process change projects that require engagement with business and operations stakeholders to change “the way we do things.”
- Leaders often fail to set clear metrics or KPIs for capturing the sustainability benefits of IoT-enabled projects, or communicate their importance.
- There is a lack of a cross-functional center of excellence to engage sponsors and relevant stakeholders to develop best practices and innovation capabilities, and share them internally. This helps in driving the alignment of IT and operational technology (OT), and in allocating budgets, people and resources.
- Cross-organizational budget and profit-and-loss authority limit deployment of IoT-enabled solutions, even when sponsored by the CEO.

User Recommendations

- Establish a sustainability cross-functional center of excellence, including business, engineering and IT stakeholders, with a focus on identifying the initial, “smaller” IoT sustainability projects, their financial and sustainability benefits, and a plan to scale up.
- Invest time and effort on culture change processes and training to foster cross-organizational collaboration around desired IoT-enabled sustainability outcomes.
- Ensure the sustainability team works with IT to develop a multiyear IoT architecture to achieve continuous sustainability benefits from IoT while addressing technology complexity, security and integration challenges.
- Plan to implement a multivendor approach for IoT platforms, analytics and applications when implementing multiple sustainability use cases, such as energy consumption, building operations or manufacturing efficiency.

Sample Vendors

Atos; Danfoss; Energybox; Envision Digital; iotblue; Itron; Siemens; Sofar Ocean; Wiliot; Wirepas

Gartner Recommended Reading

Magic Quadrant for Global Industrial IoT Platforms

Magic Quadrant for Indoor Location Services

Infographic: IoT Use-Case Prism for Sustainability and ESG

Important and Compelling Innovations for Commercial IoT Use Cases

Climbing the Slope

Energy Efficiency

Analysis By: Sarah Watt, Lauren Wheatley

Benefit Rating: High

Market Penetration: More than 50% of target audience

Maturity: Mature mainstream

Definition:

Energy efficiency enables a given amount of work to be undertaken using less energy. Practices range in scale from behavioral changes that can result in incremental energy savings to transformational projects such as equipment replacement. Projects rely on engineering skills, technology availability and capital investment. These projects can address multiple stakeholder drivers and as a result energy efficient enterprises can effectively reduce energy demand, manage emissions and contain costs.

Why This Is Important

Rising energy prices drive inflation across materials, transportation and operational costs. Energy efficiency actions can reduce energy demand, lowering costs and carbon emissions, which contributes to net zero goals. It is often an overlooked opportunity; the International Energy Agency reports that energy intensity has improved on average 1.3% in the last five years, but a 4% yearly reduction is needed to achieve net zero emissions by 2050.

Business Impact

Proactive management of energy costs creates a competitive advantage. Energy efficiency has three direct business impacts: energy demand management, cost containment and greenhouse gas emissions reduction. Energy efficiency activities may also catalyze strategic decisions on energy security in a dynamic political environment, such as dependence on Russian natural gas. Employee involvement in identifying ways to save energy improves engagement and project impact.

Drivers

- **Volatile energy market:** Energy is usually one of the top five costs businesses have to manage. Volatility in energy cost and supply is hurting business and driving inflation. On the supply side, oil and natural gas investments are declining while clean technologies have not scaled at sufficient pace to address the gap.
- **Technology and innovation:** Democratization of energy supply and cost-effective options for self-generation spotlights the need for enhanced load management. Improved automation with operational technology can improve energy efficiency, reducing the need for self-generation.
- **Energy transition:** Country commitments to net zero greenhouse gas emissions is a catalyst for the energy transition toward a low-carbon economy. Existing legislation such as the EU's Energy Directive, focusses business on energy savings, enabling the bloc to meet a 55% emissions reduction by 2030 (compared to 1990). Future taxes and carbon border adjustment mechanisms also act as catalysts for improved energy management.
- **Supply chain costs:** Energy efficiency opportunities and sharing best practices is not only an enterprise conversation, but must extend to supply chain partners. Reducing energy consumption and improving efficiency can limit increased raw material costs.
- **Energy efficiency gamification:** Increasing real time data is increasing the adoption of energy efficiency gamification either as part of data and analytics or as a stand-alone program/application. Typical strategies include increasing visibility; contests and rewards for conserving energy and water; social media elements, such as communities; and indicators of status and success, like badges and leaderboards.

Obstacles

- **Financial constraints:** Enterprises may not prioritize capital to energy savings projects. Alternative funding mechanisms include internal carbon pricing, which raises capital through each business unit being taxed on their greenhouse gas emissions.
- **Strategic goals:** Short-term energy efficiency activities may be hampered by the strategic goals of the enterprise. In mature slow-growth industries that have a large share of the market, leaders may not see the benefits. Alternatively, parts of the business that are being considered for divesture will not be prioritized.

- **Risk of stranded assets:** Previous energy efficiency decisions may result in stranded assets, as increased regulations are put in place to transition to a low-carbon economy. For example, a combined heat and power plant, which enables efficient generation of electricity and hot water, may be subject to increased tax, natural gas costs or security of supply issues.

User Recommendations

- **Increase visibility:** Identify significant manufacturing energy loads by conducting an energy site audit, undertaking a pareto analysis and identifying opportunities for improvement.
- **Utilize technology:** Install energy management and optimization systems to create visibility of energy use by equipment and process.
- **Develop site energy plans:** Use the increased visibility and insights gained in collaboration with engineering teams to develop a site energy savings plan. Use this plan as an input to the annual budget process to demonstrate projects cost, implementation timelines and returns. Where capital is not available, explore alternative financing arrangements such as energy performance contracts or government grants.
- **Implement projects:** Leverage engineering resources and third-party experts to help identify and implement energy savings projects. Ensure that anticipated savings are actually delivered, and if not, conduct a root cause analysis to identify corrective actions.

Gartner Recommended Reading

Tool: Identify Manufacturing Energy Savings Opportunities

Quick Answer: What Financing Options Are Available to Support My Sustainability Goals?

Market Guide for Commercial and Industrial Energy Management and Optimization Systems

Quick Answer: How Are Electricity Markets Changing as the Energy Transition Accelerates

Use-Case Prism: Tactical Energy Conservation Solutions

EV Charging Infrastructure

Analysis By: Lauren Wheatley

Benefit Rating: Moderate

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

The EV charging infrastructure, or electric vehicle supply equipment (EVSE), is a component of the overall supply system for the recharging of EVs and plug-in hybrid EVs. Different means of providing electricity to charge EV batteries exist, including slow residential AC charging and fast commercial DC charging. Ownership models include private, publicly owned, municipal or commercial charging points, including those owned by EV manufacturers, fleet owners and individuals.

Why This Is Important

Current momentum in EV sales can only be sustained if the majority of the population have access to convenient and affordable charging infrastructure, both publicly available and private chargers at residences and workplaces, among other destinations. EV charging infrastructure has implications for utility companies, depending on the role they want to have in the electrification of transportation; there is significant benefit for those owning, managing and operating EV charging infrastructure.

Business Impact

The major areas of utility impact will be delivery (charging infrastructure life cycle management) and retail. Owners of the distribution network will have to ensure their infrastructure can handle additional load introduced by EV charging. The impact of EV charging on distribution networks can be mitigated with charging control to avoid periods of peak demand. Ownership of the EV charging infrastructure provides network operation benefits, in addition to increased electricity sales.

Drivers

- EV charging infrastructure needs to increase more than twelvefold by 2030 to support the growth of electric cars projected in the International Energy Agency's Global EV Outlook 2022, adding 22 million charging points per year. This will require a cumulative installed charger capacity of over 1.9 terrawatts, and have a significant impact on electricity supply and demand.
- Charging infrastructure is not yet ubiquitous. In the U.S., together the Inflation Reduction Act and the Infrastructure Investment and Jobs Act have earmarked nearly $11 billion for the establishment of a network of EV chargers. Many European countries still fall short of the Directive 2014/94/EU of the European Parliament and of the Council recommendations, while automotive companies are creating joint ventures, e.g., Daimler Truck, TRATON GROUP and Volvo Group, to install high power charging points near highways and logistics hubs.
- EVSE infrastructure continues to rapidly evolve, with some countries installing large-scale interconnected EV charging stations along main transport routes. Key considerations for developing charging networks include digitalization, interoperability and planning roadmaps.
- In markets where there is strong public and policymaker support for EV, the network operator may explore EV charging as an extension of energy delivery infrastructure, with a traditional investment recovery model. In other markets, utility organizations use this as an unregulated business opportunity. The ability to gather consumption patterns will help utilities mitigate the impact on the distribution grid and may result in additional future revenue growth as electricity displaces gasoline as the preferred transportation fuel.
- The electrification of heavy freight trucks is underway and long-term planning for megacharger infrastructure (1 MW or more) is required.
- The Open Charge Point Protocol (OCPP) allows EV chargers to expand their digital functionality, allowing advanced interoperability between charger and OS.

Obstacles

- Recharging EVs places a high load on the electrical grid when they are not scheduled for periods of reduced load or reduced electricity costs.
- Market fragmentation and lack of a common unifying platform slows maturation and adoption of EV charging infrastructure.
- EV charging technology evolves at a slower pace than EV technology due to longer product life cycles, limited R&D investments and because EV charger replacement rate is slow in relation to cars.
- Regulation is often an obstacle to the adoption of smart charging technology. For instance, Germany and some U.S. states have mandated the adoption of card payment terminals at public chargers, which indirectly discourages charge point operators from adopting “plug and charge,” the most convenient technology.

User Recommendations

- Invest in electric charging infrastructure if you operate in markets where there is a significant government sponsorship for EV adoption. In those markets, utilities (mostly distribution network operators) can recover the investment in EV charging through regulated distribution tariffs where investments enable new business models that deliver convenience and price competitiveness to end customers.
- Leverage EV charging infrastructure to get better insight and some control over EV charging implications on existing distribution grid and improve asset utilization.
- Ensure your EV infrastructure strategy aligns with your jurisdiction’s regulatory treatment of EV infrastructure investment. The regulatory structure has strong implications for the ownership structure and organizational arrangements of charging infrastructure.

Sample Vendors

ABB; Blink Charging; ChargePoint; EVBox; EVgo; General Electric; Schneider Electric; Siemens; Tesla

Gartner Recommended Reading

Market Guide for Electric Vehicle Charging Solutions

Emerging Tech Impact Radar: Electrified Vehicles, 2022

Building Information Modeling

Analysis By: Marc Halpern, Bettina Tratz-Ryan

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

Building information modeling (BIM) is the discipline supported by software to capture, organize and manage information needed to design, create, monitor, repair, evolve and operate facilities from earliest conception to demolition.

Why This Is Important

Increases in regulations governing design, construction, operations and maintenance of facilities compounded by the number of roles involved in these activities require better means of managing and accessing information. So, organizations in many industry sectors including construction, government, manufacturing and retail need better means of organizing and accessing content about their facilities to streamline facilities design, construction, management, operations, modernization and demolition.

Business Impact

BIM delivers the following benefits:

- Reduces lost time and unnecessary costs associated with using wrong or out-of-date content throughout the life cycles of facilities.
- Improves ability to find and access content to support any activity such as facilities design, construction, operation, upgrade, maintenance and demolition of facilities.
- Improves collaboration across many roles responsible for the life cycles of facilities.
- Enhances sustainability and circularity over the life cycles of facilities.

Drivers

- As the costs of constructing and operating facilities continue to rise, facility owners, construction firms and operators seek means to increase efficiency of life cycle activities by reducing cost and time.
- Product development team members working from remote locations, instead of at a central location, need a platform with rich collaboration capabilities that also includes requisite design and engineering functionality.
- Technology advances and growing experience with BIM encourages more companies to adopt it.
- Prevalence of SaaS for other business software encourages cloud-native BIM.
- Manufacturers, utilities and architectural engineering and construction firms seek better means of complying to a growing number of regulations (such as those here in Six construction regulatory issues looming in 2020 by Construction Management) that they believe BIM will support more efficiently.
- Stakeholders in facilities seek to reduce costly mistakes with BIM by enabling better access to more timely and accurate information.
- BIM enables improved collaboration across roles participating in life cycle activities from remote locations.

Obstacles

- Engineers and contractors are deeply invested in their current culture and processes, making it difficult to adapt to new ways of working that BIM requires.
- Reaching consensus on BIM priorities and architecture proves challenging given the number of involved roles both inside and outside an enterprise.
- There will be a need for a champion investor.
- The lack of digitized data, especially among constructors, poses challenges to BIM adoption.
- BIM champions struggle to make compelling business cases for the investment.
- Building BIM content in proprietary design software formats will decrease its utility over time, cause vendor lock-in and increase the cost to maintain BIM.
- BIM projects will fail if scope creep creates higher-than-expected costs and lower-than-expected ROI. Insufficient supplier, partner and customer participation in BIM initiatives can lead to gaps in key content.
- Inflexible or incorrect BIM model design undermines future usefulness or possibly makes it obsolete before the end of a facility's service life.

User Recommendations

- Reduce the risk of failed BIM implementations by phasing the implementations into smaller, focused projects that build upon each other.
- Structure BIM initiative using governance or maturity models. Use both the BSI Levels 0 through Level 4, and incorporate 2D BIM to 7D BIM (as explained by NBS in BIM Levels explained) categories of data as the company moves from one level of BIM maturity to the next.
- Address BIM data architecture challenges by assigning IT architects to work with key BIM stakeholders.
- Encourage BIM adoption by redefining job performance metrics that encourage potential users to adopt BIM.
- Assign a BIM lead to run a project defining corporate standards for creating and modifying BIM models, and establish a training program to educate the user community.

Sample Vendors

Asite; Autodesk; Bentley Systems; Hexagon; Nemetschek Group; RIB Software; Trimble

Gartner Recommended Reading

Innovation Insight for Building Information Modeling

Creating Sustainable and Innovative Smart Buildings Through Data

Appendixes

See the previous Hype Cycle: Hype Cycle for Sustainability, 2022

Hype Cycle Phases, Benefit Ratings and Maturity Levels

Table 2: Hype Cycle Phases

(Enlarged table in Appendix)

Phase	Definition
Innovation Trigger	A breakthrough, public demonstration, product launch or other event generates significant media and industry interest.
Peak of Inflated Expectations	During this phase of overenthusiasm and unrealistic projections, a flurry of well-publicized activity by technology leaders results in some successes, but more failures, as the innovation is pushed to its limits. The only enterprises making money are conference organizers and content publishers.
Trough of Disillusionment	Because the innovation does not live up to its overinflated expectations, it rapidly becomes unfashionable. Media interest wanes, except for a few cautionary tales.
Slope of Enlightenment	Focused experimentation and solid hard work by an increasingly diverse range of organizations lead to a true understanding of the innovation's applicability, risks and benefits. Commercial off-the-shelf methodologies and tools ease the development process.
Plateau of Productivity	The real-world benefits of the innovation are demonstrated and accepted. Tools and methodologies are increasingly stable as they enter their second and third generations. Growing numbers of organizations feel comfortable with the reduced level of risk; the rapid growth phase of adoption begins. Approximately 20% of the technology's target audience has adopted or is adopting the technology as it enters this phase.
Years to Mainstream Adoption	The time required for the innovation to reach the Plateau of Productivity.

Source: Gartner (August 2023)

Table 3: Benefit Ratings

Benefit Rating ↓	*Definition* ↓
Transformational	Enables new ways of doing business across industries that will result in major shifts in industry dynamics
High	Enables new ways of performing horizontal or vertical processes that will result in significantly increased revenue or cost savings for an enterprise
Moderate	Provides incremental improvements to established processes that will result in increased revenue or cost savings for an enterprise
Low	Slightly improves processes (for example, improved user experience) that will be difficult to translate into increased revenue or cost savings

Source: Gartner (August 2023)

Table 4: Maturity Levels

(Enlarged table in Appendix)

Maturity Levels ↓	*Status* ↓	*Products/Vendors* ↓
Embryonic	In labs	None
Emerging	Commercialization by vendors Pilots and deployments by industry leaders	First generation High price Much customization
Adolescent	Maturing technology capabilities and process understanding Uptake beyond early adopters	Second generation Less customization
Early mainstream	Proven technology Vendors, technology and adoption rapidly evolving	Third generation More out-of-box methodologies
Mature mainstream	Robust technology Not much evolution in vendors or technology	Several dominant vendors
Legacy	Not appropriate for new developments Cost of migration constrains replacement	Maintenance revenue focus
Obsolete	Rarely used	Used/resale market only

Source: Gartner (August 2023)

Document Revision History

Hype Cycle for Sustainability, 2022 - 11 August 2022

Recommended by the Authors

Some documents may not be available as part of your current Gartner subscription.

Understanding Gartner's Hype Cycles

Tool: Create Your Own Hype Cycle With Gartner's Hype Cycle Builder

Hype Cycle for Low-Carbon Energy Technologies, 2023

2023 CEO Survey: Grow Through Digitally Enabled Sustainability

2023 Growth Agenda: Sustainability Is an Opportunity for Business Growth

Table 1: Priority Matrix for Sustainability, 2023

Benefit ↓	*Years to Mainstream Adoption*			
	Less Than 2 Years ↓	***2 - 5 Years*** ↓	***5 - 10 Years*** ↓	***More Than 10 Years*** ↓
Transformational		Carbon Accounting and Management Software Digital Product Passport Green and Sustainable Finance IoT for Sustainability Large-Scale Lithium-Ion Batteries	Carbon Capture Utilization and Storage Circular Supply Chain Neuromorphic Computing Scope 3 GHG Emissions Data Smart and Sustainable Building Urban Sustainability and COP 26	Quantum Computing

Benefit	*Years to Mainstream Adoption*			
↓	*Less Than 2 Years* ↓	*2 - 5 Years* ↓	*5 - 10 Years* ↓	*More Than 10 Years* ↓
High		AI for Sustainability Banking Sustainability Tools Biodiversity Accounting Building Information Modeling Climate Risk Analytics Cloud Sustainability Digital Twins for Sustainability Energy Efficiency Environmental, Social and Governance Geospatial Platform Sustainability in ERP Water Management Analytics	Energy Management and Optimization Systems ESG Management and Reporting Software Net-Zero Data Centers Supply Chain Blockchain	Circular Economy in IT Sustainability of Software Sustainable Business
Moderate		EV Charging Infrastructure Life Cycle Analysis Software Supplier Sustainability Applications Sustainable Procurement	Remanufactured IT Equipment	Voluntary Carbon Offsets
Low			Hydrogen Vehicles	Sustainable Packaging

Source: Gartner (August 2023)

Table 2: Hype Cycle Phases

Phase	*Definition*
Innovation Trigger	A breakthrough, public demonstration, product launch or other event generates significant media and industry interest.
Peak of Inflated Expectations	During this phase of overenthusiasm and unrealistic projections, a flurry of well-publicized activity by technology leaders results in some successes, but more failures, as the innovation is pushed to its limits. The only enterprises making money are conference organizers and content publishers.
Trough of Disillusionment	Because the innovation does not live up to its overinflated expectations, it rapidly becomes unfashionable. Media interest wanes, except for a few cautionary tales.
Slope of Enlightenment	Focused experimentation and solid hard work by an increasingly diverse range of organizations lead to a true understanding of the innovation's applicability, risks and benefits. Commercial off-the-shelf methodologies and tools ease the development process.
Plateau of Productivity	The real-world benefits of the innovation are demonstrated and accepted. Tools and methodologies are increasingly stable as they enter their second and third generations. Growing numbers of organizations feel comfortable with the reduced level of risk; the rapid growth phase of adoption begins. Approximately 20% of the technology's target audience has adopted or is adopting the technology as it enters this phase.
Years to Mainstream Adoption	The time required for the innovation to reach the Plateau of Productivity.

Phase	Definition

Source: Gartner (August 2023)

Table 3: Benefit Ratings

Benefit Rating	Definition
Transformational	Enables new ways of doing business across industries that will result in major shifts in industry dynamics
High	Enables new ways of performing horizontal or vertical processes that will result in significantly increased revenue or cost savings for an enterprise
Moderate	Provides incremental improvements to established processes that will result in increased revenue or cost savings for an enterprise
Low	Slightly improves processes (for example, improved user experience) that will be difficult to translate into increased revenue or cost savings

Source: Gartner (August 2023)

Table 4: Maturity Levels

Maturity Levels ↓	*Status* ↓	*Products/Vendors* ↓
Embryonic	In labs	None
Emerging	Commercialization by vendors Pilots and deployments by industry leaders	First generation High price Much customization
Adolescent	Maturing technology capabilities and process understanding Uptake beyond early adopters	Second generation Less customization
Early mainstream	Proven technology Vendors, technology and adoption rapidly evolving	Third generation More out-of-box methodologies
Mature mainstream	Robust technology Not much evolution in vendors or technology	Several dominant vendors
Legacy	Not appropriate for new developments Cost of migration constrains replacement	Maintenance revenue focus
Obsolete	Rarely used	Used/resale market only

Source: Gartner (August 2023)