BENORI

Sustainability in Motion – Key Trends across Industries

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Preface

Industries worldwide are embracing sustainable practices to mitigate environmental impacts, ensure long-term viability, and meet stakeholder expectations. As businesses become more aware of the environmental impact of their operations, we can expect to see even more sustainable initiatives in the future. There is also a considerable urgency among industries to upend and achieve their carbon emission targets driven by the pioneers within each industry or backed by the government.

Upcoming global conferences such as COP28 UAE will aim to establish new targets for stabilizing greenhouse gas concentrations at levels that safeguard against harmful consequences while allowing ecosystems to naturally adapt and promote sustainable development. Active engagement and collective efforts from governments and industries are crucial to achieving these objectives.

The current situation has sparked a significant drive for technological advancements and environmentally-friendly investments worldwide. The aim is to shift from a resource-consuming approach to one that focuses on resource recycling and transformation. While there is not a single dominant technology or initiative to achieve net-zero goals, a collaborative and unified effort from all sectors holds the potential for success.

Our report provides a concise overview of some recent and key trends across various industries that are being embraced, tested, or developed to contribute towards a sustainable future.

Key Sustainability Focus Areas

Waste and pollution

- Community outreach
- Emissions dashboard
- Environmental impact assessment
- E-waste management
- Government policies and regulations
- Hazard and disaster control
- Plastic waste reduction
- Process emissions
- Regulatory compliance
- Risk management
- Runoff management
- Scope 1, 2, and 3 assessments
- Waste monitoring and measurement
- Waste-to-resource
- Wastewater treatment
- Zero waste initiatives

Materials

- Bio-plastics
- Close-looped systems
- Life-cycle assessment
- Mono-material packaging
- Net-zero processes
- Process innovations
- Product life extension
- Recyclable and bio-degradable materials
- Remanufacturing and refurbishment
- Smart materials
- Sustainable paints and coatings
- Sustainable sourcing
- Technology assessment

Energy

- Bio-energy
- Bio-fuels
- Carbon capture
- Clean energy
- Decentralized energy systems
- Energy conservation
- Energy policy
- Green hydrogen
- Net-zero emissions
- Renewable energy
- Smart grids
- Sustainability certifications
- Sustainable energy technologies

Sectoral Highlights

Agriculture

Farming with AI, robotics, and drones| Smart greenhouses| Electrification of farming equipment

Agricultural sustainability is vital in mitigating threats to global well-being such as population growth, climate change, and soil degradation

Automotive

AI-powered advanced simulation| Modular production| Low-impact manufacturing

Automotive players are cognizant of growing buyer interest in sustainable vehicles and are trying to accelerate the shift to clean technology vehicles

Construction

3D printed buildings| Smart materials for passive solar building designs| Net-zero energy buildings

Construction industry is energy-intensive. It accounts for ~38% of global carbon emissions but is gradually getting greener despite complex challenges

Consumer goods

Mono-material packaging| Digitally enabled product innovations| Waste-to-energy systems

With 80% of the industry's emissions residing in the supply chain, FMCG companies ought to focus on aspects beyond optimizing in-house operations

Energy & utilities

Green hydrogen production| Decentralized energy systems| Bio-energy production from natural resources

The industry accounts for nearly three-quarters of global greenhouse emissions. But they are also the leaders in adopting sustainable practices

Information technology

Sustainable software engineering| Energy-efficient hardware | Data center PUE

With ~3.5M TB of daily data creation and ~57% of firms going for more viable machinery and processes, the IT industry is at the forefront of sustainability

Petrochemicals

Capturing emissions with bio-technology| Utilizing renewable feedstocks| Improved recycling and collection

The petrochemicals industry is driving sustainability by prioritizing product circularity and investigating alternative feedstocks and technologies

Pharmaceuticals

Mechanochemistry| AI &ML in drug development| Bio-plastics in medical products and packaging

The pharmaceuticals sector is focusing on sustainability through research on sustainable products, green manufacturing, and responsible packaging

01 Agriculture

Promoting environmental stewardship through sustainable food production and resource efficiency

The agriculture industry is actively adopting sustainability practices and scientific advancements to address environmental challenges and ensure its long-term viability. This includes leveraging AI, robotics, drones, smart greenhouses, and regenerative agriculture techniques to enhance soil health, precision farming methods, and the electrification of farming equipment. These practices exemplify the industry's dedication to sustainable food production, resource efficiency, and environmental stewardship.

Key Sustainability Themes

Farming with AI, robotics, and drones: AI-powered systems utilize environmental data, weather patterns, and crop conditions to optimize irrigation schedules and provide timely interventions, minimizing crop losses and reducing water consumption. These technologies promote optimal crop growth and efficient resource utilization. Moreover, robotics and drones play a crucial role in the precise application of fertilizers and pesticides, minimizing their usage and mitigating environmental impacts.

Smart greenhouses: Smart greenhouses equipped with advanced technology, including vertical farming, aeroponics, and hydroponics, enable precise control of variables like temperature, humidity, and lighting. This replication of ideal growth conditions enhances yields on small land parcels and maximizes resource efficiency.

Electrification of farming equipment: Fieldwork machinery in agriculture accounts for the largest carbon footprint. To address this, there is a transition from diesel-powered to electric-powered equipment, reducing greenhouse gas emissions per unit area. This shift not only lowers environmental impact but also allows for the integration of digital systems and IoT technology, further enhancing agricultural efficiency and sustainability.

Implementation Instances

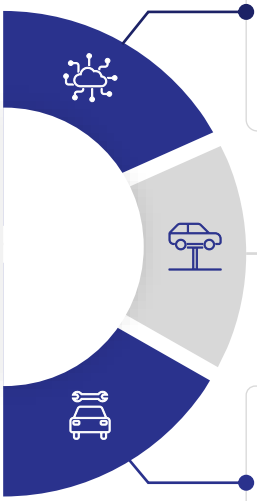
Organization	Use case	Details
Bayer	Farming with AI, robotics, and drones	Bayer utilizes AI technology to improve breeding techniques and create tailor-made seeds for farmers. Their precision breeding program harnesses AI to develop seeds suitable for specific conditions, optimizing yield and efficiency.
Department of Agriculture, Philippines	Smart greenhouses	The Korea and Philippines-funded Smart Greenhouse project serves as a smart farming demonstration and research facility, exhibiting a fully automated greenhouse production of strawberries, cherry tomatoes, and white potatoes.
John Deere	Electrification of farming equipment	John Deere's introduction of electric farming equipment, such as small tractors, crop spraying drones, and autonomous/semi-autonomous tractors in the UK, exemplifies its commitment towards transitioning to electrification.

02 Automotive

Addressing sustainability "Beyond the tailpipe" by focusing on advanced technology, modular production, and low-impact manufacturing

The automotive industry is recognizing the irreversible trends that shape our future and embracing sustainability as a fundamental principle across its entire value chain. This entails incorporating cutting-edge technology and innovations such as artificial intelligence (AI) in manufacturing and energy management, adopting a modular production approach to decrease costs and material waste, and embracing low-impact manufacturing practices.

Key Sustainability Themes



AI-powered advanced simulation: OEMs are increasingly adopting AI to optimize manufacturing processes, supply chains, and energy consumption. AI enables virtual simulation by digitally testing and fine-tuning processes before implementation, reducing the need for physical prototypes, and wasteful iterations caused by trial and error. This approach enhances operational efficiency, saves energy, and reduces emissions and waste.

Modular production: Modular production in the automotive industry involves building vehicles using independent modular components that are seamlessly integrated. It employs parallel assembly lines for simultaneous manufacturing and testing of different modules allowing production in larger quantities, reducing the need for individual parts, and reducing material waste.

Low-impact manufacturing: To establish a low-carbon mobility system, adopting low-impact manufacturing is essential. This entails utilizing sustainable materials like recycled plastic, bio-based materials such as soy and corn, natural fibers like hemp, flax, and sisal, as well as aluminum, carbon fiber, recycled steel, rubber and glass, cork, bamboo, etc.

Implementation Instances

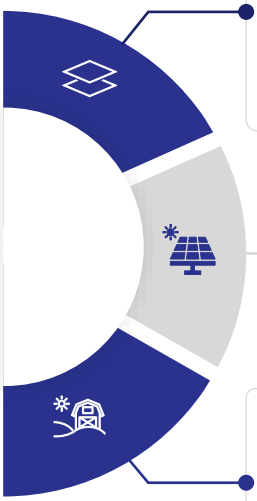
Organization	Use case	Details
Audi	AI-powered virtual simulation	Audi uses AI as a risk detection mechanism. An advanced early alert system examines publicly accessible information in over 50 languages from around 150 countries to identify sustainability hazards within the supply chain in real time.
Tesla	Modular production, also called unboxed process	Tesla's recent announcement to implement modular, parallel manufacturing techniques such as single-body castings can potentially cut costs by ~50% and industrial footprint by ~40%.
Renault	Low-impact manufacturing	In Oct'22, Renault Group launched "The Future Is NEUTRAL," an entity promoting circular economy in the automotive industry at every stage of a vehicle's lifecycle, including parts and raw materials supply, production, usage, and end-of-life.

03 Construction

Transforming the construction industry by harnessing sustainable technologies for substantial energy and cost savings

The construction industry emits 38% of global energy-related carbon emissions, making it a major contributor to climate change. Yet, it is undergoing a transformative shift driven by technology, regulations, and market demand, with notable advancements in sustainability practices. Key trends include 3D printing, smart materials in passive solar building designs, and the rise of net-zero buildings.

Key Sustainability Themes



3D printed buildings: 3D printing technology in construction revolutionizes material placement, allowing for the precise construction of components and entire buildings. This approach minimizes waste, conserves energy, and facilitates easy dismantling for material recycling or repurposing in future projects. Sustainable materials like hemp or clay, as well as recyclable materials like glass or plastic, are also being explored for these projects.

Smart materials for passive solar building designs: Smart materials in such buildings dynamically adapt to external factors such as temperature, light, or pressure. These materials effectively control sunlight penetration, reducing dependence on artificial lighting and cooling systems. This leads to optimized energy usage and reduced waste, making them essential in sustainable building design strategies.

Net-zero energy buildings: These buildings strive to produce as much energy as they consume over a year. This is achieved through a combination of energy-efficient design, on-site renewable energy generation, and smart energy management systems. Companies such as Skanska, DPR, and Turner are actively implementing net-zero energy strategies.

Implementation Instances

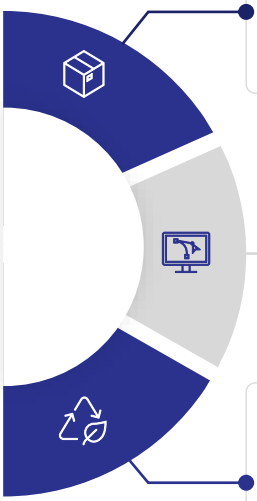
Organization	Use case	Details
Winsun	3D printed buildings	Winsun's Tea House project utilized 3D-printed concrete elements, including walls and various components, to effectively reduce material waste and maximize resource efficiency.
National Renewable Energy Laboratory (NREL)	Smart materials for passive solar building designs	NREL's perovskite-based thermochromic windows enhance energy efficiency in buildings. These windows effectively regulate temperature, significantly reducing the need for heating in highly glazed office buildings situated in cold or seasonal climates.
Skanska	Net-zero energy buildings	Skanska's Powerhouse Kjorbo project transformed an existing office building into a sustainable, energy-positive structure that generates surplus energy through rooftop solar panels and advanced energy management systems.

04 Consumer Goods

Embracing circular economy and driving sustainability from product development to packaging

Driven by mounting environmental concerns and the rise of conscious consumerism, sustainability has emerged as a strategic priority for consumer-facing companies. The consumer goods industry is actively embracing sustainable practices, placing a strong emphasis on sustainable packaging, employing cutting-edge technology for sustainable product development, and implementing waste-to-energy systems.

Key Sustainability Themes



Mono-material packaging: Consumer goods companies are actively incorporating innovation in packaging design restricting to just one type of material to mitigate packaging waste. The packaging becomes easier to collect, sort, reuse and recycle in addition to simplifying the value chain and creating sustainable outcomes for companies.

Digitally enabled product innovations: Consumer goods companies are leveraging digital techniques to launch new products 50% faster and achieve a cost reduction of one-third. Integration of physics-based and AI designs is enabling them to create innovative proteins and enzymes, replacing petrochemical ingredients for eco-friendly products with lower carbon and waste.

Waste-to-energy systems: Consumer goods companies are embracing waste-to-energy systems, converting waste into useful energy forms such as electricity, heat, and fuel. This tackles waste management and energy challenges simultaneously, enabling efficient and sustainable disposal while generating valuable energy resources.

Implementation Instances

Organization	Use case	Details
P&G	Mono-material packaging	Ariel's recently unveiled "ECOCLIC" box which is the first packaging for P&G's laundry capsules is made from FSC-certified materials and ~70% recycled fibers.
Unilever	Digitally enabled product innovation	Unilever and Arzeda used AI to develop new enzymes that fight stains in cleaning and laundry products. This accelerated development process by five times and could cut ingredient requirements in half for effective cleaning performance.
PepsiCo	Waste-to-energy systems	PepsiCo's €7.5 million investment in a new bio-digester will result in a 30% reduction in carbon emissions by converting 21,900 tons of organic waste into 4,818,000 Nm3 of bio-methane per year.

05 Energy & Utilities

Innovating energy solutions through green hydrogen production, decentralized energy systems, and bio-energy production

Prioritizing sustainability in the energy & utilities sector is essential not only for environmental preservation but also for long-term economic stability and meeting the rising energy needs of a growing global population. This involves shifting away from fossil fuels and investing in renewable and clean energy sources like green hydrogen and bio-energy production.

Key Sustainability Themes

Green hydrogen production: Green hydrogen is emerging as one of the most promising routes to accelerate the decarbonization of high-emission sectors that rely on coal, gas, and oil. These sectors include power generation, manufacturing processes in industries such as steelmaking and cement production, fuel cells for electric vehicles, heavy transport such as shipping, and electricity grid stabilization.

Decentralized energy systems: The Internet of Energy (IoE) is intricately connected with the concept of energy decentralization, which prioritizes the utilization of energy near its generation. LO3 Energy's Brooklyn Microgrid project uses a decentralized energy system that enables peer-to-peer energy trading.

Bio-energy production from natural resources such as bamboo: Biomass resources such as bamboo have significant potential as a renewable energy source, particularly for bio-energy production. Bamboo's fast growth and carbon sequestration abilities make it an appealing feedstock for bio-energy generation. Diverse techniques can be employed for converting bamboo into bioethanol, bio-gas, and other bio-energy products.

Implementation Instances

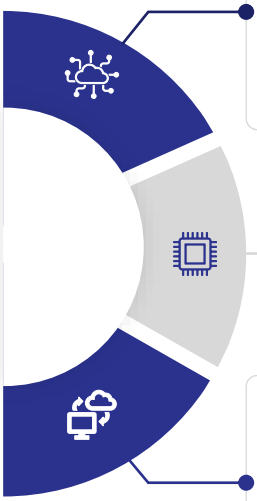
Organization	Use case	Details
NTPC	Green hydrogen production and fueling station	NTPC seeks to start operating India's first green hydrogen fueling station in Ladakh in the next 3 months. The project will produce 80 Kg per day of 99.7% pure hydrogen using electrolysis.
Power Ledger	Decentralized energy systems at the Fremantle Smart City Project	Households taking part in this project can monitor their real-time energy production and consumption, while the peer-to-peer trading functionality allows them to directly sell surplus solar energy to their neighbors instead of feeding it back into the grid.
Hungarian University of Agriculture and Life Science	Bio-energy production from natural resources such as bamboo	Researchers from the Hungarian University of Agriculture and Life Science highlight bamboo's transformative potential in renewable energy, using advanced techniques like fermentation and pyrolysis to convert it into bio-ethanol and bio-gas.

06 Information Technology (IT)

Empowering a greener digital future through sustainable software engineering, energy-efficient hardware, and green data centers

The IT industry is actively embracing sustainability by implementing practices such as sustainable software development, energy-efficient hardware, and green data centers. These initiatives prioritize environmental impact assessment and mitigation, optimizing energy usage, resource optimization, e-waste management, and responsible consumption. The industry's goal is to minimize waste, extend product lifespan, and reduce its carbon footprint.

Key Sustainability Themes



Sustainable software engineering: Integrating sustainability principles through platform engineering allows for building and operating self-service Internal Developer Platforms (IDPs) for software delivery and life cycle management. IDPs can help the software become sustainable through observation and optimization of environmental impact metrics such as hardware resource usage, energy consumption, and CO2 footprint.

Energy-efficient hardware: Electronic devices and components are being designed to minimize energy consumption resulting in power savings, longer battery life, and reduced carbon emissions. Achieving these outcomes involves optimizing power management, incorporating low-power components, enhancing thermal management techniques, and implementing intelligent power-saving algorithms.

Data center PUE: IT companies are actively striving to optimize energy efficiency in their data centers. One crucial metric they use is Power Usage Effectiveness (PUE), which measures the ratio of total facility energy to IT equipment energy. The ideal PUE ratio is 1.0, indicating that all energy is efficiently used for computing purposes. LinkedIn's Hilltop data center achieves a remarkable PUE of 1.06 through a waterside economizer system.

Implementation Instances

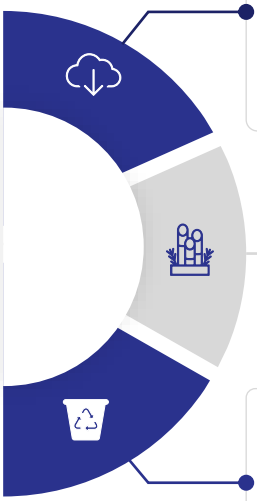
Organization	Use case	Details
Salesforce Inc	Sustainable software engineering	Salesforce recently launched 'Green Code,' an initiative to reduce carbon footprint of software. It provides sustainability best practices for technologists to cut emissions associated with IT, including heavy computational tasks.
Intel	Energy-efficient hardware	Intel plans to release its energy-efficient data center chip, Sierra Forest, in early 2024, which is expected to improve energy performance in data centers.
NTT Ltd	Advanced cooling technologies	NTT Ltd achieves up to 30% greater energy efficiency in their data centers by implementing advanced Liquid Immersion Cooling (LIC) and Direct Contact Liquid Cooling (DCLC) technologies.

07 Petrochemicals

Balancing complex demand for petrochemicals-derived products using sustainable practices within the industry

The petrochemicals industry is rapidly advancing sustainability through waste plastic recycling and initiatives encompassing energy efficiency, renewable energy integration, and eco-friendly product development. This involves enhancing manufacturing efficiency, adopting renewable energy sources, and exploring sustainable alternatives to traditional petrochemical products.

Key Sustainability Themes



Capturing emissions with bio-technology: Enzymatic carbon capture offers a cost-effective, energy-efficient, and sustainable solution for decarbonization by utilizing bio-degradable enzymes. It achieves over 90% CO2 capture from flue gas, rivaling conventional methods while providing enhanced affordability, sustainability, and operational convenience for a wide range of industrial applications.

Utilizing renewable feedstocks: Leading petrochemical companies are embracing sustainability by integrating renewable feedstocks, including bio-based and recycled materials, into their production processes. E.g., Braskem has developed a bio-based polyethylene derived from sugarcane to reduce its reliance on fossil-based feedstocks.

Chemical recycling of plastic waste: Petrochemical companies are adopting circular economy practices by improving the recycling value chain. LyondellBasell, for example, has partnered with waste management companies to develop technologies for recycling plastic waste into new products.

Implementation Instances

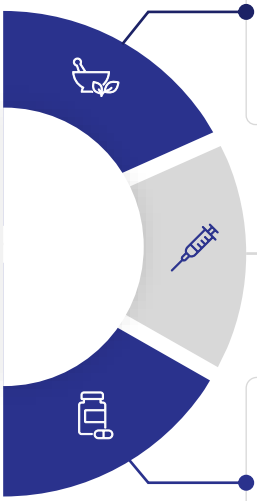
Organization	Use case	Details
Novozymes and Saipem	Capturing emissions with bio-technology	Novozymes and Saipem collaborate to offer enzymatic carbon capture solutions to petrochemical facilities and power plants. Saipem provides the carbon capture process and equipment, while Novozymes supplies the enzymes to optimize the process.
TotalEnergies	Utilizing renewable feedstocks	TotalEnergies' polystyrene recycling converts post-consumer polystyrene waste into a raw material for producing new polystyrene, reducing the need for virgin materials and minimizing environmental impact.
SABIC	Chemical recycling of plastic waste	SABIC's TRUCIRCLE initiative involves the creation of certified circular polymers derived from recycled plastic waste, and the incorporation of renewable feedstocks in their production processes.

08 Pharmaceuticals

Driving sustainable innovation in pharmaceuticals through mechanochemistry, AI & ML integration, and wider use of bio-plastics

The pharmaceutical sector accounts for 4.4% of global emissions, and without intervention may triple by 2050. To address this, the industry is actively pursuing sustainable practices in drug discovery, development, packaging, and disposal. This includes adopting advanced manufacturing processes, integrating AI and machine learning, and prioritizing the use of biodegradable or compostable materials for packaging to reduce energy consumption, hazardous chemicals, and waste.

Key Sustainability Themes



Mechanochemistry: Mechanochemistry is an emerging experimental approach that efficiently screens and synthesizes pharmaceutical materials using mechanical force, avoiding high temperatures and hazardous solvents. Recent findings indicate it can reduce ecotoxicity and carbon emissions by up to 85% while optimizing production costs by 12%.

AI & ML in drug development: Integration of AI in the pharmaceutical industry promotes sustainability through advanced manufacturing techniques and accelerated drug discovery, reducing trial and error. By leveraging existing drug knowledge and exploring vast chemical spaces, AI enables faster, more efficient, and cost-effective drug discovery processes.

Bio-plastics in medical products and packaging: Bio-plastics are plant-based plastics with a low carbon footprint, made from corn starch, trees, cellulose, and other biological sources. They provide a sustainable alternative between single-use and bio-degradable products. Unlike single-use plastics, bio-plastics are more eco-friendly, less carbon-intensive, and can be recycled and disposed of through existing waste streams.

Implementation Instances

Organization	Use case	Details
European Horizon Impactive Project	Mechanochemistry	The European Commission (EC) has awarded IMPACTIVE ~€7.7 million to study the possibilities of mechanochemistry in the synthesis of active pharmaceutical ingredients (APIs).
Absci	AI & ML in drug development	Absci recently announced the ability to create and validate de novo antibodies in silico (via a computer) with the use of zero-shot generative AI, a major milestone for the bio-technology industry.
Astellas Pharma	Bio-plastics in medical products and packaging	Astellas has invented the world's first plant-based packaging for pills. The new blister packs, made from carbon-neutral bio-plastic derived from sugar cane, address recycling difficulties associated with traditional packs that contain metal and plastic.

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