Neural Manufacturing™

Building on belief

Journal of Innovation and Transformation

Sustainable by Design

Building a Strategic Road Map for Manufacturing & Utilities Businesses

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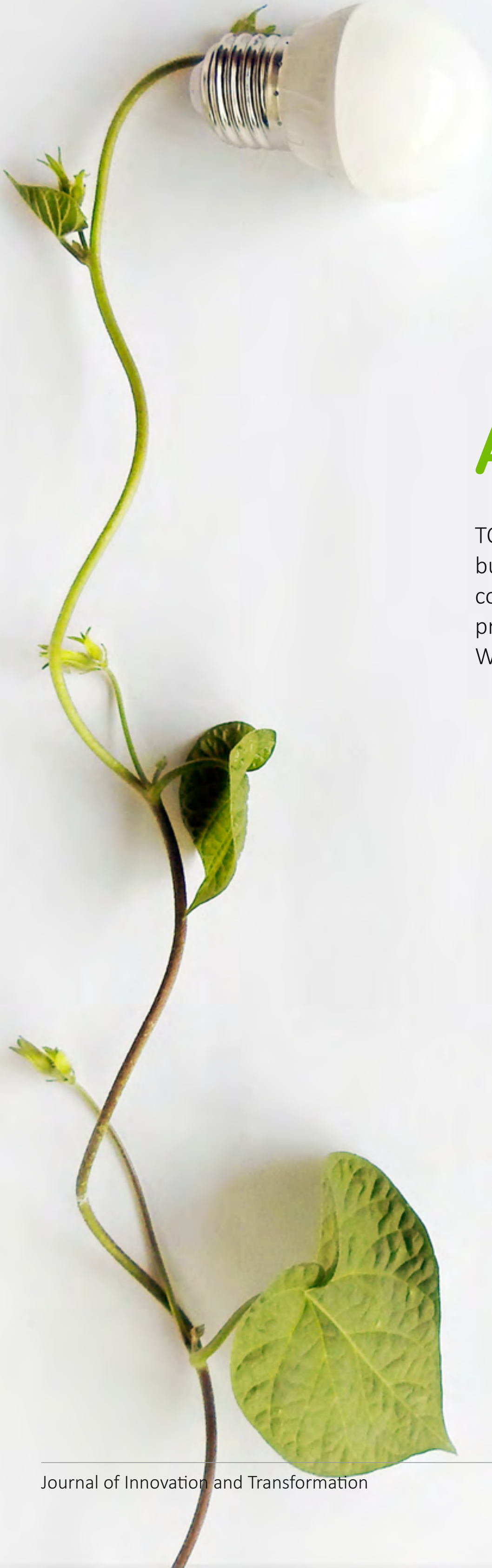

Acknowledgments

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Foreword

The fragility of the planetary ecosystem is best captured in boundaries such as climate change, biodiversity loss, land-system change, and biogeochemical flows, which we have already exceeded. Out of these four planetary boundaries, climate change and biosphere integrity are considered 'core', because crossing the threshold of either one independently, could significantly endanger humanity. By articulating the Sustainable Development Goals (SDG), the United Nations (UN) and think tanks globally have provided guidance for countries to jointly tackle climate change and biodiversity change impact. As a result, we see major regulations coming up across regions, which cascade down to businesses that operate and sell from the respective regions.

Over two thirds of TCS' Manufacturing & Utilities clients have declared their carbon neutrality goals following similar goals set by governments in major regions globally. Sustainability is emerging as a strategic lever for business growth for organizations, rather than being a mere compliance management activity.

Manufacturers carry additional responsibilities for ethical sourcing, material circularity, and lower product life cycle emissions over and above their in-house sustainability operations.

In this special edition of our Journal of Innovation and Transformation, we explore sustainability from diverse perspectives across industries such as aerospace, automotive, agriculture, and utilities, which in general are under the lens for their carbon footprint.

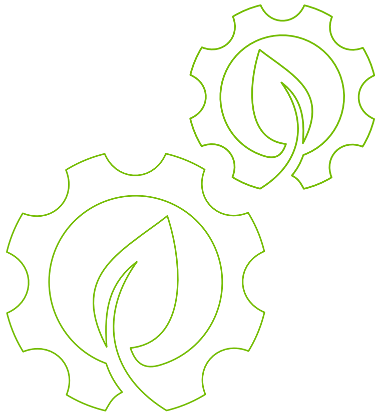
TCS' own journey towards sustainability is captured in strategic levers such as health, safety, and environment across all major markets, green building programs, TCS' Remote Energy Management System, green procurement, environmental reporting, freshwater consumption reduction initiatives, and our aspirations for zero waste disposal and zero discharge.

Of course, no move is simple. We believe organizational systems and processes must be designed to be sustainable by design. This paradigm shift entails a multifaceted program that involves widespread adoption of digital technologies to build an adaptive, resilient, and sustainable enterprise. We hope the cross-industry perspectives in this edition provide ample opportunities for our clients to reset their thinking around their operating models that will deliver on their sustainability goals. We will be keen to hear your comments and views on sustainability.

Happy Reading!

Sreenivasa Chakravarti
VP and Head- Manufacturing Business Practice
TCS

Reframing Success for Sustainable, Future-Fit Businesses



As we emerge from an extraordinary period of disruption and uncertainty, we have a unique opportunity to reboot to a new era where sustainability and prosperity are part of the same aspiration and success measurement. There has been an evolution in our collective understanding about the interconnectedness of our systems, the vulnerability of business models, people, planet, as well as the role we can play in creating a more sustainable future.

As purpose-led companies increase collaboration in the pursuit of achieving sustainability goals, more resilient and inclusive growth models are coming to the fore. We're seeing new blueprints that demonstrate how innovative approaches to working together across ecosystems can help solve some of the biggest sustainability challenges and accelerate positive outcomes for all.

Addressing sustainability challenges proactively

The rate of projected global warming is demanding our attention and commitment to significant changes in the ways we produce and consume. And while climate change may be the top priority for many, there are other priorities we need to address as well, such as waste, food, water, natural resource scarcity, and biodiversity loss. We are also in grave danger of losing the years of progress made in reducing poverty and inequity. The emergency is real and the challenges complex. These challenges translate to business risks with financial implications for the current and future value of companies.

The scale of change commands we rethink our future and create new perspectives on existing models, along with new models by using a sustainability lens that provides unique insights to successfully create value for all shareholders. We're not talking small improvements – we need to reimagine the economic models and business fundamentals that have delivered economic growth to date. In a similar manner, leaders need to see sustainability beyond a compliance or risk-based activity, instead building sustainability into their business strategy to create a future-fit business. Sustainable development represents a significant business opportunity for those prepared to pivot and engage.

Sustainability driven leaders demonstrate a commitment to stewardship, supporting intent with investment. By setting targets, tracking performance, and measuring the impact, they ensure long-term decision-making that harmonizes economic growth, social inclusion, and environmental protection. Corporate leadership is seen where sustainability is regarded as part of the business strategy rather than as a trade-off.

Creating long-term value

Today, the relevance for boards and executives is difficult to dispute, and businesses are powerful leaders in the sustainability-led transformation pathways that need to be developed and implemented. Understanding how business activities impact people and the planet needs a longer-term perspective in decision making and future investments, to ensure businesses meet the needs of multiple stakeholders.

The change we are seeing today is driven by several important stakeholder groups that frame success differently – regulators, investors, customers, partners, governments, communities, and employees. Environmental, social, and corporate governance (ESG) disclosure requirements are accelerating and becoming increasingly mandatory and this trend will change the way data is collected and reported. Transparency will increase as will the need for trust. Investors have clearly seen evidence that purpose-led, ESG-focused companies have performed better, showing greater resilience during the pandemic period and as a result, financial institutions are realigning portfolios and changing decision-making criteria.

Our customers have a greater awareness today of the role their wallet can play and are signalling an intent to consume consciously. Employees are also joining companies where action demonstrates commitment to purpose, and these values help firms retain talent in a globally competitive environment.

Sustainability by design

In rethinking a future-fit business, the sustainability lens provides unique insights to creating value, reducing risk, and innovating business models. Sustainability by design is a key tenet in this thinking and recognizes that while materiality may vary by company, industry, and geography, consideration of end-to-end value chain impact across materials (natural, substitute, recycled), human capital (skilling, modern slavery, fair wage), waste, new value (revenue from waste or soil-based carbon sequestration activities), traceability, and carbon measurement across the product and business are all part of the reimagined business. We see leaders investing in measuring carbon footprints, assessing climate risks, developing new products, rebalancing portfolios, and refining policies from guidelines to explicit directions. These actions help them shape initiatives, set targets, and plan their own net-zero ambitions.

Collaborative efforts

Bringing innovation, digitalization, and sustainability together at the strategy and investment levels will help accelerate more positive sustainable outcomes for businesses. However, this remains at a nascent stage of maturity for many large corporates.

Another area developing fast is the commitment to collaboration across ecosystems. Companies are creating new styles of engagement across value chains, harnessing partnerships both direct and indirect, to accelerate end-to-end change. We also see changes in procurement and related performance management that reinforce shared success metrics especially in carbon-related activities.

In conclusion

In the pursuit of sustainable development, the way corporates frame and measure success are evolving. Clarity of purpose, goals, strategies, key performance indicators (KPIs), and performance management are now increasingly part of executive-level KPIs, and the impacts are being linked to ESG outcomes. While the aspirations are getting clearer, the pathways and results are less so. This is why innovation and digitalization along with collaboration across ecosystems hold the key to pivoting and accelerating more sustainable outcomes for our planet, our way of life, and future-fit businesses. Our role at TCS is to help our customers achieve success in this new era.

About the author:

Michele Lemmens is the Head of Business Sustainability and the Chief Technology Officer for the Asia-Pacific region for TCS. In her current role, she is responsible for championing sustainability initiatives that bring the depth and breadth of TCS' Research & Innovation and COIN initiatives to TCS' customers and partners, helping them shape the narrative on sustainable development. Her focus has been on economic, social, and environmental outcomes that create impact and long-term value.

She has over 25 years of experience working across multiple geographies and domains, such as sustainability, innovation, consulting, financial services and insurance, information technology enablement, and not for profit. She brings deep experience in business model transformation, focusing on enterprise business models driven by new market entry, mergers and acquisitions, joint ventures, new business establishment, and strategic alliances. She is also a start-up mentor and has been a judge for Singapore's international annual SWITCH competition over the last three years.

She holds a bachelor's degree in management from the University of Waikato, New Zealand and a certificate in business sustainability management from the University of Cambridge, England. She has also completed the Tata Group Executive Leadership Seminar (TGELS) from the Stephen Ross School of Business of the University of Michigan, United States.

A Cross-Industry Perspective of Integrating Sustainable Manufacturing Practices

Corporate sustainability management is becoming crucial to the long-term success of organizations in the 21st century. With increasing public scrutiny and rising regulatory pressure, the adoption of conscious, climate-sensitive practices has become a business imperative. While the implication is universal, industry-specific challenges in the manufacturing sector call for the adoption of specialized strategies rooted in the circular economy and carbon neutrality.

This paper explores how leveraging a combination of best practices from other industries and artificial intelligence (AI) and machine learning (ML)-powered algorithms can help manufacturing firms rise to the challenge. Scaling on sustainable practices based on realistic transition and physical risk assessment models and accurate emission reporting practices, are at the crux of this transition.

From linear economy to circular: industries go green

Ecological equilibrium has been under duress since the advent of industrialization. Over the decades, incessant industrial development and burgeoning consumerism have triggered incremental environmental deterioration. This is now fast acquiring the critical mass required to set off a self-sustaining chain reaction that may ultimately lead the planet towards a climate-driven apocalypse. The issue of 'Code Red' by the Intergovernmental Panel on Climate Change (IPCC) in its sixth assessment report[1], 2021 underlines the urgency for action. Global bodies under the aegis of the United Nations and its instrumentations like the IPCC, United Nations Framework Convention on Climate Change (UNFCCC), United Nations Environment Program (UNEP), Clean Development Mechanism (CDM), Earth Summits, Montreal Protocol, and the Kyoto Protocol to the Paris Accord are all working to cap and reverse this trend.

[1]The Intergovernmental Panel on Climate Change;AR6 Climate Change 2021: The Physical Science Basis, Sixth Assessment Report; *https://www.ipcc.ch/report/ar6/wg1/*

While the recommendations for sustainable industrial practices are common to all sectors, there is greater incumbency on manufacturing firms due to the historical impact they have had on unsustainable production and consumption patterns. Consequently, agencies such as the Environment Protection Agency (EPA), USA, the European Environment Agency (EEA), and financial and insurance agencies are all urging manufacturing companies to be accountable and committed to sustainable manufacturing practices.

Redemption and responsibilities: manufacturing firms nudged to rise to the challenge

Manufacturing firms around the world are transitioning from one-way exploitation of natural resources to a more responsible, circular economy. This calls for equal emphasis on conscientious and efficient utilization of natural resources and a commensurate rate of restoration.

Of the 17 sustainable development goals (SDG)[2] for 2030, set by the United Nations, those on affordable and clean energy, clean water and sanitation, climate action, responsible consumption and production, life below water, and life above land, are pertinent to the manufacturing sector. Aligning with these goals calls for the adoption of cleaner technologies such as low to zero-emission technologies, decarbonization, carbon capture or carbon sequestering techniques, high-efficiency development mechanisms with minimal impact on ambient air quality, and industrious use of water with sufficient recycling to avert the depletion of water tables or the collapse of aquifers. Integration of stringent risk assessment and monitoring such techniques will play a crucial role in driving further, continuous process improvement.

While manufacturing enterprises mean well to implement these changes, they continue to face challenges in choosing appropriate methodologies to assess, measure, and monitor physical, transition, and liability risks. To achieve this, manufacturing firms need to identify and actualize:

- Appropriate models and algorithms
- Real-time, quality data
- Deployment of compliant tools and technologies

The key is to integrate the solutions to these challenges with consistent compliance to guidelines set by the Greenhouse Gases Protocol (GHG Protocol)[3] and ISO 14064 standards for emission computing and reporting. Consequently, Scope 2 and Scope 3 emissions reporting should factor in:

- Accounting for transactions in carbon emissions through the value chain
- Double counting or omission from disclosure

These obligations may render accountability a formidable exercise, rife with risks such as inaccurate aggregation of emissions by agencies like banks, regulators, and governments. To avert such risks and their cascading impact such as additional taxations and trade tariffs, manufacturing firms require smart digital solutions powered by analytics-backed insights.

Strategy for realizing sustainable manufacturing operations

In keeping with standards for Scope 1, Scope 2, and Scope 3, emission accounting and reporting by firms should comprise:

- Direct emissions occurring from sources that are owned or controlled by the firm
- Emissions from generated electricity that is purchased and consumed by the firm
- Emissions down the entire value chain of the firm, including sources not owned or controlled by the firm

In this context, averting non-omission of disclosure and double counting of emissions have often proved to be key challenges. The following four-fold approach has been designed to help manufacturing firms circumvent these challenges without compromising on productive efficiency or committed compliance:

1. **Emission by transaction unit**: Based on the costing principles to estimate emissions at a transaction unit level, this approach actualizes accounting for direct emissions as well as overhead emissions allocated to the transaction unit. This will be recorded as the transacted value of emissions.

[2] United Nations, Department of Economic and Social Affairs- Sustainable Development; The 17 goals; ***https://sdgs.un.org/goals***

[3] The World Resources Institute; Greenhouse Gases Protocol: Standards; ***https://ghgprotocol.org/standards***

2. **Emission invoicing**: Making emission invoicing mandatory will ensure that transactions in emissions are effectively recorded and clearly understood by the concerned parties.

3 **Unified emissions reporting regime**: Drawing upon the unified Goods and Services Tax (GST) model for checking tax leakages while avoiding repeated levy on taxes already paid, this model will allow the transferee to claim credit for reported emissions that may get double-counted under Scope 2 and 3 emissions. It will also reinforce the obligation for the transferee to account for unreported emissions.

4. **Distributed ledger technology (blockchain)**: Envisaged as an enabler for the Unified Emissions Reporting Regime, entities can leverage a blockchain-based accounting system for reporting emissions by borrowers and investees. Regulators may also host the platform to record emission and offsets transactions to achieve a realistic picture with respect to the regulated entities. Furthermore, the adoption of a standardized messaging protocol between disparate blockchains will enable seamless interoperability.

The proposition on blockchain can be reinforced by interfacing the emission accounting and reporting platform with other blockchain platform(s) to facilitate issuance and subscription of green funding financial instruments. It can also enable trading in carbon credit or green bond certificates (in secondary markets).

The following illustration captures the features of the above propositions on invoicing, unified emissions reporting, and blockchain-enabled platforms for emissions reporting, offsetting, and trading.

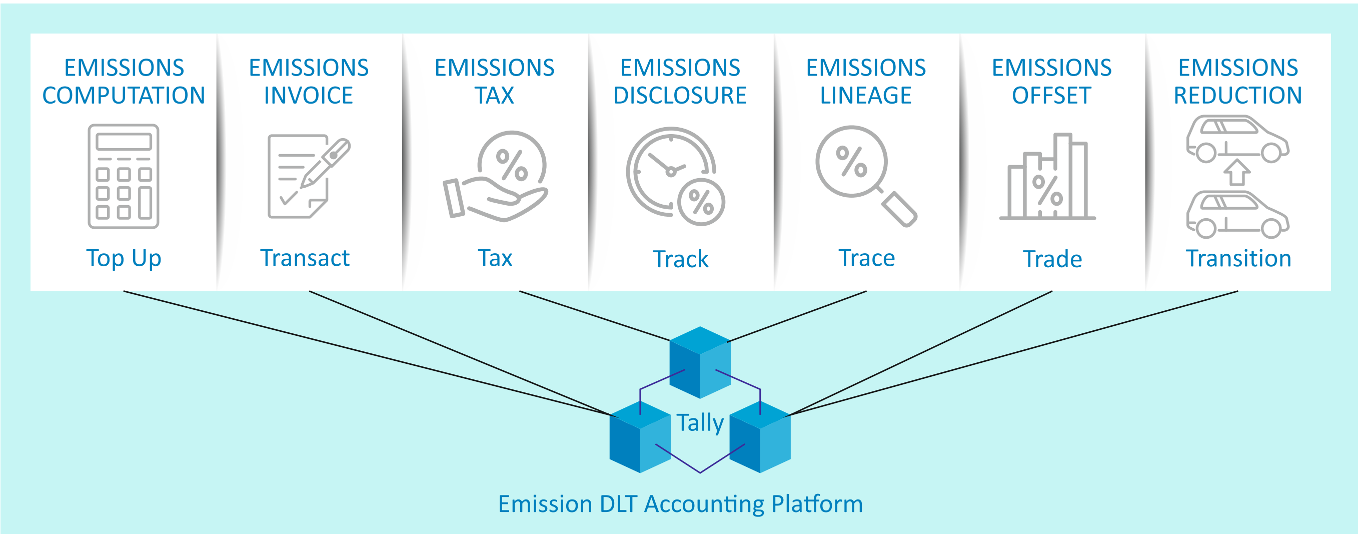


Figure 1: Emissions computation, invoicing, and accounting framework

Manufacturing entities can evaluate transition risk in terms of the cost of carbon once they have access to appropriate means to measure emissions. This current emission estimate can also serve as the basis to project a long-term emission path that will factor in changes in the scale of operation and countermeasures to minimize emissions. The difference between the projected and ideal or permitted emission value, with zero-to-minimal transition risk, can then be used as a basis for transition risks assessments.

Building a scenario-based case study and using the same for Bayesian inferences, followed by Monte Carlo simulation, can enable a more realistic and comprehensive way to assess transition risks. AI and ML-powered sentiment scoring algorithms to measure the prevalent sentiments of consumers, investors, and other stakeholders can be leveraged to obtain objective inputs for transition risk modeling. Current sentiment indices pertaining to a given firm and concerned sustainability issues can also be used to forecast its future trend in conjunction with other factors. Accordingly, future transition risk forecasts can be computed based on the sentiment score indices corresponding to that point in time.

Unlike transition risk, the methodology for physical risk assessment is quite advanced. Insurance companies have deployed catastrophe actuarial models to price their policies.

However, the forecast time is typically limited to a one-year horizon factoring in the annual renewal of policies. Physical risk, on the other hand, requires a model adapted to a longer time horizon. Thanks to research-backed climate hazard or perils forecasts linked to various representative concentration pathways, physical risk forecasting can be achieved by synchronizing the data of the granularity of the earth's lattice. The requisite data and models can be sourced from the data and model marketplace hosted by agencies like the Oasis Hub. Physical risk assessment is further enhanced by insurance organizations' intent to monetize the exposure data and loss data models.

Consortium platforms such as B3i are facilitating the availability of data models sourced from participating insurance companies. Exposure and loss data models availed from these sources can then be used to model specific physical risks using a data aggregation and model execution platform, as seen in the following illustration:

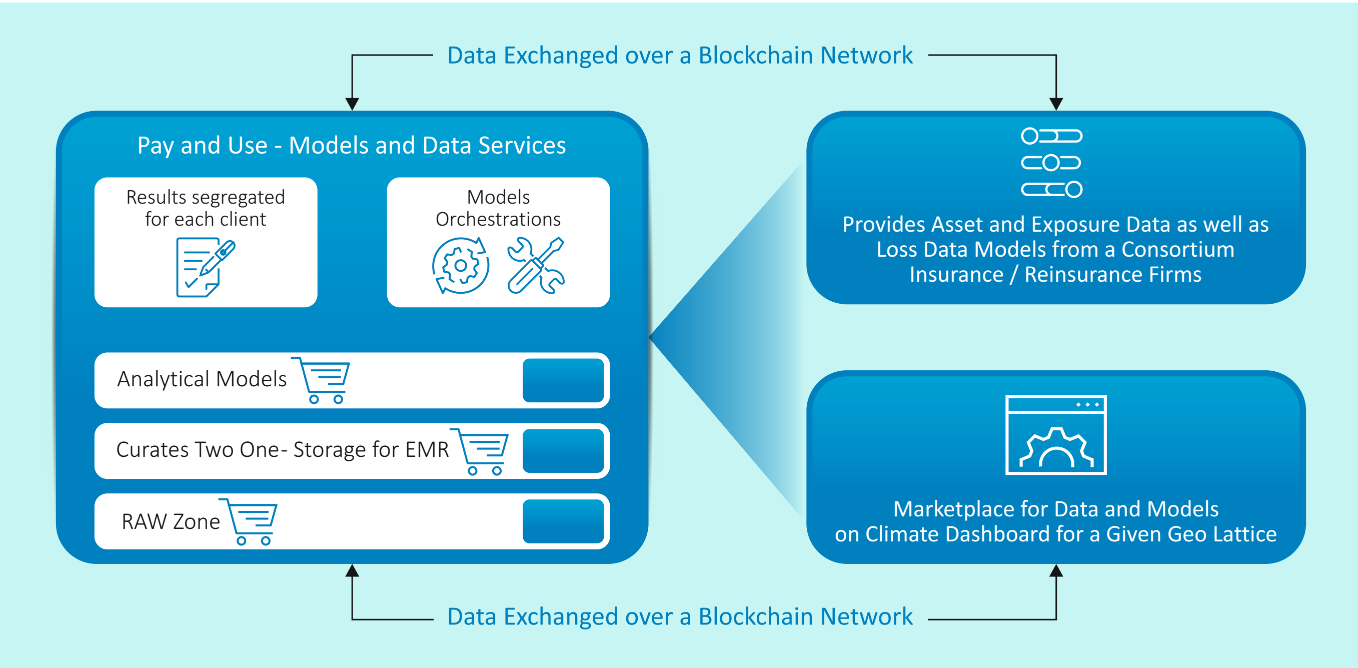


Figure 2: Physical risk data and model provisioning

Towards a sustainable future

Adopting sustainable and climate-sensitive enterprise operations have become an ongoing concern and a central imperative across sectors, and even more so for the manufacturing industry. Operations grounded in the circular economy and the minimization of emissions are among sustainable manufacturing practices that will define the way forward. Accurate estimation of emissions and subsequent management of climate risk are vital to this commitment. The four-fold approach for computing, reporting, invoicing, and accounting emissions is a futuristic solution that can achieve this commitment. Besides, the proposed resolutions for transition risk modeling, physical risks data, and model availability address key concerns on estimation, models, and data availability. Manufacturing firms will do well to adopt appropriate measures to emerge as sustainable, accountable, and future-ready organizations committed to restoring environmental balance.

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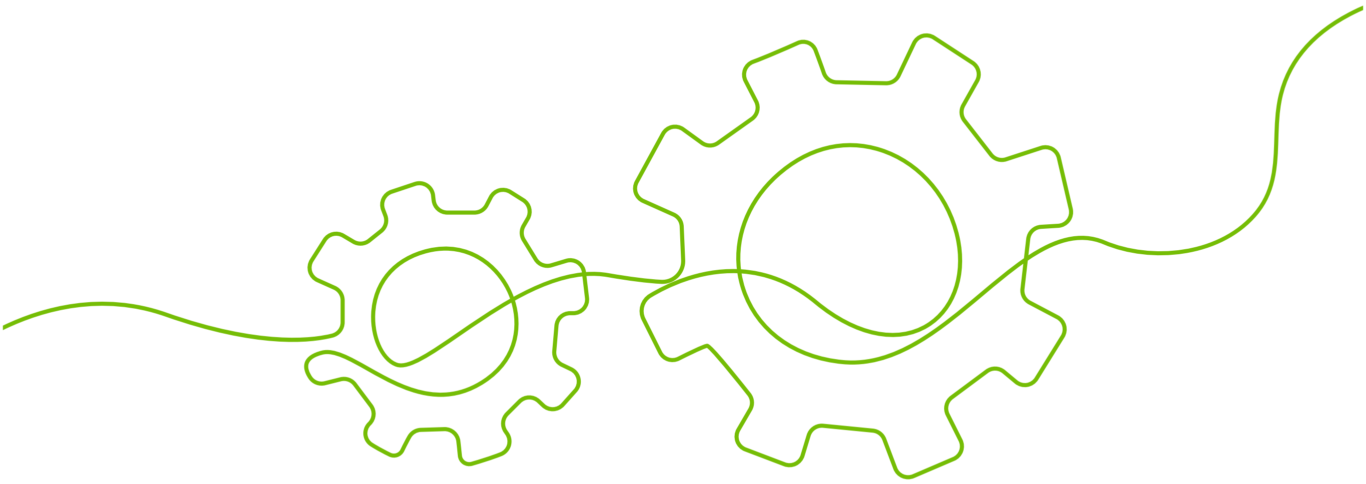


Sustainability in Agriculture

Best practices driving growth and resilience across the agribusiness value chain

By 2050, the population on earth is expected to rise to 10 billion[1]. However, water supply will fall by 40% in the same time frame, posing a challenge to meeting global water needs[2]. On the other hand, the rising costs of energy, nutrients and logistics, and fast-depleting viable, arable land, all exacerbated by unforeseen circumstances such as COVID-19, are deflating profit margins for the agribusiness sector. With rising incomes come altered perceptions to increasingly opt for clean, traceable, and ethical food. The mandatory need to cut greenhouse gas (GHG) emissions from agriculture brings the need for sustainable agricultural practices to the fore.

As part of the European Green Deal, the European Union (EU) is building a sustainable food system through a farm-to-fork strategy, which is attempting to redesign food systems to be resilient to crises such as the pandemic[3]. But the adoption of sustainability practices by agribusiness companies across the globe have remained mixed due to numerous economic and social conflicting priorities. This paper explores how agribusinesses can foster resilience and growth by embracing sustainable practices across the value chain.

[1] World Resources Institute; How to Sustainably Feed 10 Billion People by 2050, in 21 Charts; December 5, 2018; *https://www.wri.org/insights/how-sustainably-feed-10-billion-people-2050-21-charts*

[2] McKinsey & Company; Agriculture's connected future: How technology can yield new growth; October 9, 2020; *https://www.mckinsey.com/industries/agriculture/our-insights/agricultures-connected-future-how-technology-can-yield-new-growth*

[3] European Commission; Food Safety; Farm to Fork strategy for a fair, healthy and environmentally-friendly food system; *https://ec.europa.eu/food/horizontal-topics/farm-fork-strategy_en*

What hampers the advancement of sustainability in agribusiness?

Agribusinesses are facing numerous challenges in adopting sustainability practices like the need to align with the latest environmental, social, and governance (ESG) criteria. For example, the EU's Corporate Sustainability Reporting Directive (CSRD) has chosen the global reporting initiative (GRI) as its first choice for sustainability standards[4]. Emerging regulation and carbon pricing mechanisms have also resulted in increased operational costs for agribusiness companies. Additionally, the use of fully biodegradable or recyclable packaging and waste minimization in the entire food processing value chain pose challenges. To mitigate this, strategic formulation and implementation of a circular economy across the food value chain also needs to be addressed successfully.

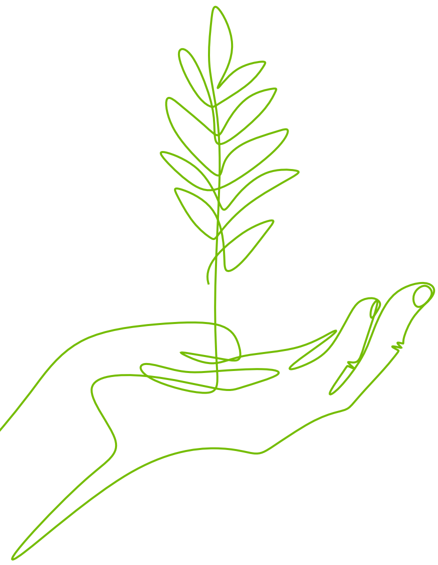
Because of drought, the agricultural sector, particularly in least developed countries (LDCs) and low to middle income countries (LMICs), has lost $37 billion in crops and livestock, according to data by the United Nations Food and Agriculture Organization (FAO)[5]. Furthermore, storms, wildfires, crop and livestock pests, diseases, and infestations pose additional threats to the development of a sustainable agribusiness model, as they impact food production, its nutritional value, and the overall economic development of the affected geographies. Agribusiness and food companies also face the risk of disruption in supply chains and associated factors, which shifts the focus away from the key goal of integrating sustainability into their operating models.

The revolution in agriculture in earlier decades was led by advances in machinery and farming techniques. Now, however, transformation in the sector is driven by data and digitalization, which promise more efficiency, greater yields, agility and scalability, and a much greater return on investment (ROI). But inadequate robust connectivity and infrastructure, which necessitate heavy spends from governments across diverse geographies, lands, and terrain are proving to be significant hurdles towards attaining sustainability in the industry.

Building resilience with sustainable ecosystems

Agribusiness companies bear additional responsibilities for responsible sourcing, material circularity, and reduced product life cycle emissions over and above their in-house sustainability operations. In the current landscape, the prerequisites to improved sustainability performance include the following unique capabilities:

- Purpose-centric ecosystems to deliver sustainable value through the life cycle
- Closed loop operations for driving reuse with cradle-to-cradle material visibility
- Visibility across the enterprise, value chain, and ecosystems
- Sense-perceive-act for proactive sustainability risk management
- Reimagining the operating model to align with sustainable business models



[4]Investment and Pensions Europe; GRI 'first choice' pick to work on EU sustainability reporting standards; July 9, 2021; *https://www.ipe.com/news/gri-first-choice-pick-to-work-on-eu-sustainability-reporting-standards/10053961.article*

[5]Food and Agriculture Organization of the United Nations; Agriculture on the proving grounds: Damage and loss; *http://www.fao.org/resources/digital-reports/disasters-in-agriculture/en/*

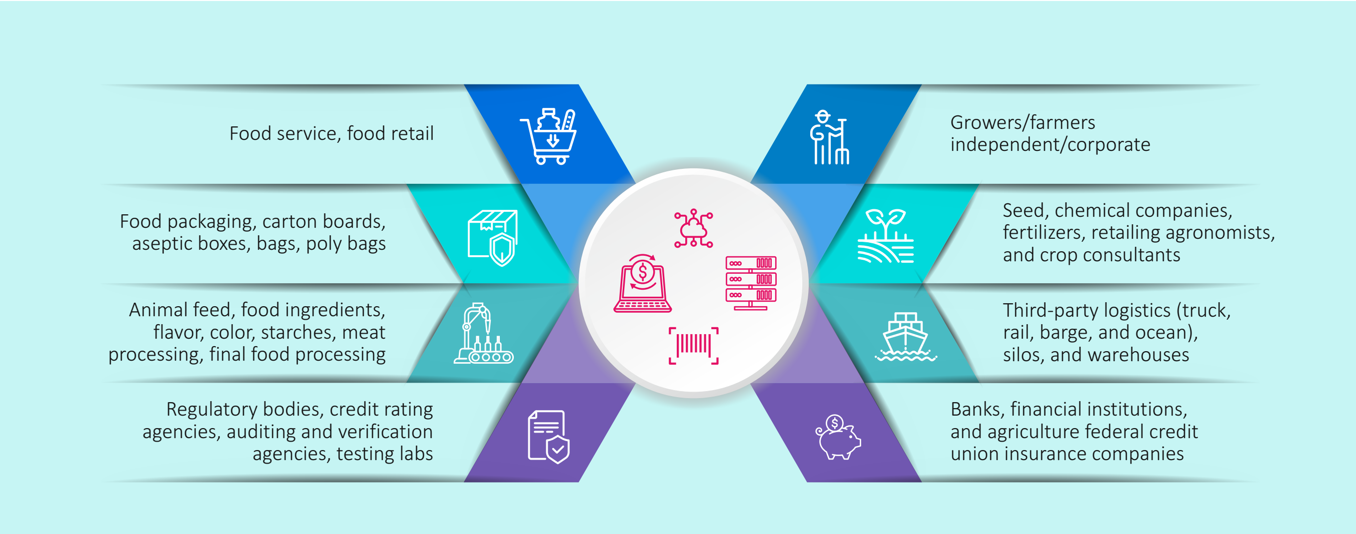


Figure 1: A digitally connected ecosystem network for agribusinesses

On the path towards sustainability, Figure 1 depicts that most partners in the agribusiness ecosystem across the value chain—from agri-input companies, growers, logistical service providers to financial institutions, food ingredient producers, and processors—are participating in various small to large cross-industry and cross-sector ecosystems.

Enabling personalized customer experiences can help agribusinesses build resilience with a sustainable ecosystem approach. For example, a US-based confectionery and pet food multinational used analytical models and a partner ecosystem enabled by global positioning systems (GPS) data to drive responsible sourcing and risk mitigation across over 150,000 suppliers, impacting 500,000 farmers. In another case, a US-based multinational agricultural and food processing major reduced annual energy spend by 5% to 7% by deploying advanced analytical models using machine learning (ML) or artificial intelligence (AI) on its energy consumption.

Sustainable by design to pave the Way for future engagements

We believe that sustainability can be achieved by the convergence of humanity, technology, and innovation. No single organization can create a sustainable future sans an ecosystem approach. To build a modern 21st century sustainable target operating model, which can help enterprises demonstrate cognitive behavior, enable closed-loop operations along circularity principles with extended value chain partners, and eventually adopt mutually beneficial partnerships, leveraging the power of digital technologies is critical.

A case in point: A large US-based agriculture retailer has launched a comprehensive carbon program, encompassing carbon capture, carbon credits trading, and more, to drive its sustainability commitments through collaboration, creating a network of growers, suppliers, and government and industry players[6]. The program was facilitated by collective information gathering, analytics, and digital technologies to accelerate and monetize the climate-smart efforts of the firm's grower customers.

Most agribusiness organizations have invested heavily in enterprise resource planning (ERP), customer relationship management (CRM), and other manufacturing systems. Yet, it is an uphill task for the firms to proactively address sustainability issues and mitigate risks. Depending on their business priorities and present stage of technology adoption, agribusinesses will benefit from embracing a sustainable by design approach across their enterprise and in their network of partners as well. This will support end-to-end visibility and enhance compliance and reporting in their operational processes. Besides driving sustainability as the core strategy to build products, processes, and operations, such an approach addresses ecosystem neutrality. Figure 2 below illustrates some specific interventions that can be adopted with the sustainable by design approach.

[6]Business Wire; Nutrien Launching Industry's Most Comprehensive Carbon Program to Drive Sustainability in Agriculture; November 30, 2020; *https://www.businesswire.com/news/home/20201130005304/en/*

Figure 2: Sustainable by design interventions

To build resilience, agribusinesses need to understand areas with the biggest positive impact to humanity that can be achieved by technology and innovation. Clayton Christensen in his seminal work, The Innovator's Dilemma, suggested the use of a portfolio approach towards innovation[7]. Essentially, as applied to sustainability, they are:

- Strengthen the core by building safe products that are leading the health dimension and are environmentally sustainable.
- Serve existing customers in newer and more profitable ways – that is, drive differentiated products and value-based pricing in specialty food ingredients, clean labels, and fully traceable food produce.
- Cater to new customers in existing ways by providing traceability and visibility to end customers in the food value chain.
- Serve new customers in new ways by building technology tools, including personalized nutrition tool sets, smart packaging tracking food quality, digital twin for food storage warehousing, and more.

Fostering a purpose-led sustainability strategy

As agribusiness companies continue to build a more purpose-led service model, environmental stewardship is becoming a core strategy element. The industry vision of decoupling business growth and ecological footprint from its operations to address the environmental bottom line is possible by striking the right balance with the use of modern technology.

By the end of this decade, enhanced connectivity in agriculture could add more than $500 billion to the global gross domestic product, a critical productivity improvement of 7% to 9% for the industry. We strongly believe that all stakeholders working together in the agribusiness ecosystem can achieve the required balance among humanity, technology, and innovation to create a sustainable future and unlock new business models.

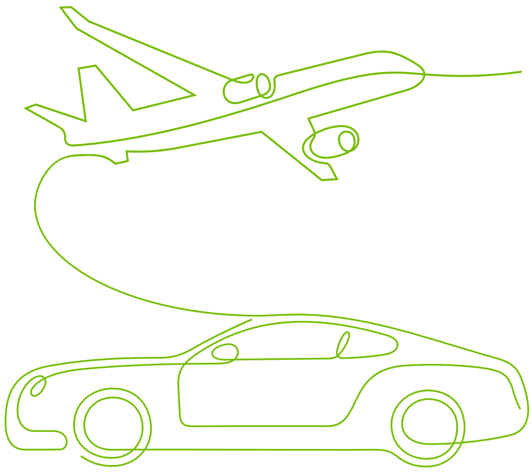
About the author:

Sourav Sengupta is an Industry Advisor for Manufacturing at TCS. He has over 24 years of experience across the agribusiness, food, paper, packaging, chemical, and process industries. He is an industry practitioner, providing advisory services for process industry firms in Asia Pacific, Europe, and North America. His areas of expertise are customer experience, manufacturing, supply chain, sustainability, and digital transformation. Sourav holds a bachelor's degree in Mechanical Engineering and a master's degree in business administration from the University of Mumbai, India.

[7] Harvard Business School; The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail; 1997; *https://www.hbs.edu/faculty/Pages/item.aspx?num=46*

Sustainability in the Automotive and Aerospace Sectors

Why a shared purpose can help manufacturers align to a circular economy



Manufacturing firms are having to pivot and embrace environment-friendly business models and services that can drive revenue, reduce costs, and improve return on invested capital (ROIC). Manufacturers are looking to achieve sustainability leadership through the power of ecosystems, even as they seek to maintain product differentiation, operational excellence, customer delight, and value delivery. This paper explores how manufacturers in the automotive and aerospace sectors can drive sustainability through distributed purpose and value creation across all levels of the extended manufacturing ecosystem and through sustained efforts to implement circular economy-based models and sustainable operations. These include options such as shifting to clean energy and emission control techniques.

The imminent shift from line to circularity

Manufacturing enterprises are embracing strategies aligned to environmental social governance (ESG) in keeping with revised corporate mandates from shareholders and evolving consumer choices. Sustainability is becoming integral to day-to-day operations and many companies have committed to the 17 Sustainable Development Goals (SDG 17) set by the United Nations.

Industry leaders including P&G, Unilever, 3M, Shell, Dow Chemical, BASF, LyondellBasel, Toyota, BMW, and Rolls Royce[1] are all adopting innovative technologies to incorporate the principle of repair, retrofit, reuse, and recycle. Other firms in the manufacturing sector are following suit and are increasingly investing in technologies and solutions that will facilitate their business

[1]Reuters; Rolls-Royce partners with Shell in sustainable aviation fuel push; July 1, 2021;
https://www.reuters.com/business/sustainable-business/rolls-royce-partners-with-shell-sustainable-aviation-fuel-push-2021-06-30/

[2]Gartner; Gartner Predicts Circular Economies Will Replace Linear Economies in 10 Years; September 26, 2019;
https://www.gartner.com/en/newsroom/press-releases/2019-09-26-gartner-predicts-circular-economies-will-replace-line

goals alongside sustainability expectations set by policymakers, customers, and value chain partners. In addition, manufacturers need to shift from linear economy to circular economy models that align with economic growth, innovation, and industrial transformation[2].

Sustainable fuels to elevate aviation business ecosystems to new levels

The highest and fastest proliferation of individual emissions has been traditionally attributed to passenger air travel. Adoption of decarbonizing technologies within the aviation industry may not be fully feasible until after 2040[3]. However, sustainability aviation fuel (SAF) might help redeem the industry in the meantime. With minimal changes in technology, the adoption of SAF can effectively reduce up to 80% of life cycle emissions as compared to conventional jet fuels[4]. Derived from renewable sources such as used cooking oil, municipal waste, and biomass, SAF was first introduced to the aviation industry in 2008 and has powered 250,000 flights globally. SAF accounts for less than 0.1% of the aviation fuel market[5]. Widespread adoption of SAF is staggered owing to the high costs and low volumes of production[6].

The recent Rolls-Royce and Shell collaboration to produce SAF for RR engines opens RR to the benefit of extended product life for existing fleets which would also become more sustainable with lower emissions. This shift will also enable value creation for new and existing actors in establishing collection, processing, storage, and management of re-usable sources. However, owing to the conventional power-by-the-hour contract, an airline may incur increased fuel charges that will be transferred as costs to the passenger.

Despite the cost implications, this pronounced shift of focus will have a lasting impact on the entire value chain. It thrives on the openness to collect, collate, and share information to model the impact on the environment, society, and economy from every actor at every stage of the value chain ecosystem, as illustrated in Figure 1.

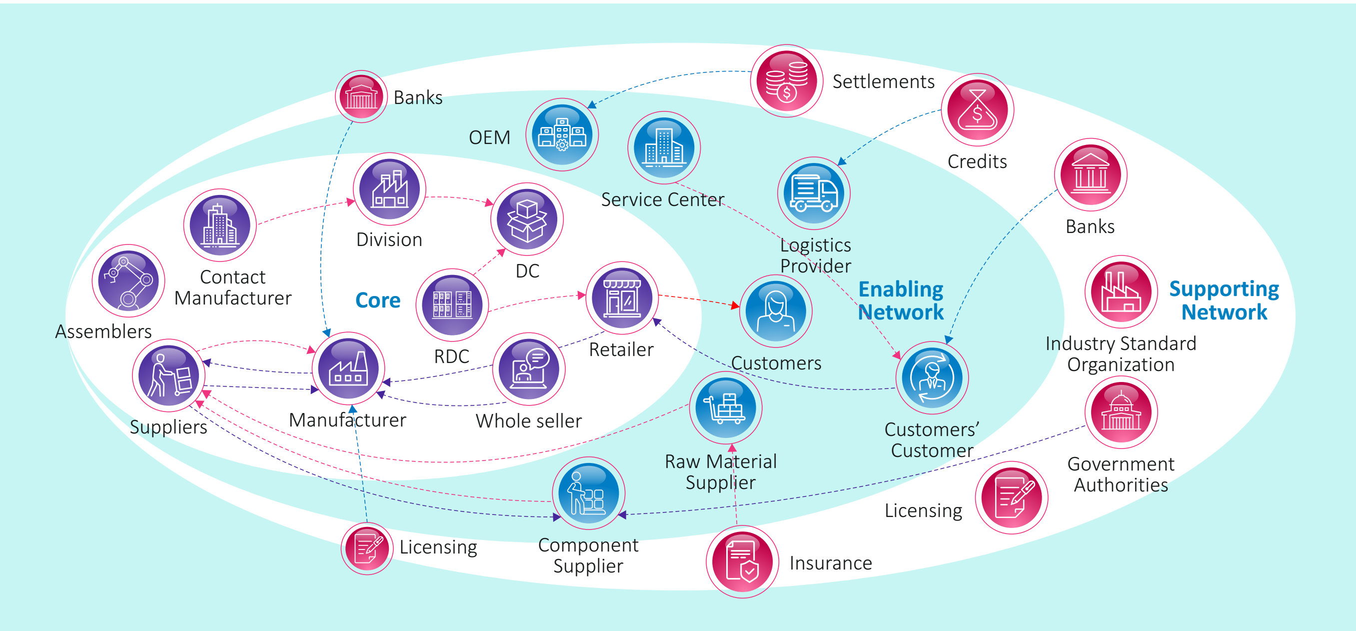


Figure 1: Ecosystem flow across the value chain

[3]Sustainable Aviation; UK aviation industry strengthens commitment to achieving net zero and launches first interim decarbonisation targets; June 22, 2021; *https://www.sustainableaviation.co.uk/news/uk-aviation-industry-strengthens-commitment-to-achieving-net-zero-and-launches-first-interim-decarbonisation-targets/*

[4]Aviation Today; Are EU Green Deal Aviation Targets Attainable?; July 16, 2021; *https://www.aviationtoday.com/2021/07/16/eu-green-deal-aviation-targets-attainable/*

[5]Shell; Sustainable Aviation Fuel; *https://www.shell.com/business-customers/aviation/the-future-of-energy/sustainable-aviation-fuel.html*

[6]IHS Markit; Sustainable aviation fuel still in short supply due to cost: IHS Markit; July 7, 2021; *https://ihsmarkit.com/research-analysis/sustainable-aviation-fuel-market-still-in-infancy-due-to-cost-.html*

The aviation industry is successfully collecting and sharing usage data, largely enabled by the internet of things (IoT) and system-wide connectivity. However, the techniques to translate this information to model the value chain's collective impact on the environment, using digital twins, and artificial intelligence (AI), are yet to be perfected. Accelerated adoption of these technologies will enable us to understand the future impact of sustainable innovations and support the refinement of these models.

Implementing circular model principles within the manufacturing ecosystem

Driven by technology and innovation, new sustainability consortiums, including Waste 360, Plastics Waste Consortium, Sustainable Packaging Coalition, Pacific Northwest (PNW) Secondary Sorting Project, Circular Plastics Alliance, the Polyolefins Circular Economy Platform (PCEP), Cyclyx, and many others, are fostering a palpable change.

The growing urgency for integration of sustainable practices has manufacturers embracing a holistic approach to meet sustainability goals and drive results in terms of revenue, costs, and ROIC, based on the interpretation of their business ecosystem encompassing original equipment manufacturers (OEMs), customers, suppliers, service providers, and consumers. Emerging new business models built on this interpretation aim to fulfill unmet needs concerning decarbonization, GHG emissions, the repair-recycle-reuse agenda for renewable energy resources, and so forth.

French multinational automobile manufacturer Renault[7] has deployed use cases around retrofit, restart, re-energy, and recycle, which have met with success in the aviation industry. Other automotive majors such as Jaguar Land Rover (JLR) and Nissan too have implemented similar approaches. This also shows that learning and implementing best practices from adjacent industries can foster the adoption of successful business models with opportunities to create value.

Coming together to power the ecosystem

Co-creation, collaboration, and accountability within ecosystems are critical as well as universal, be it at an industry level or within an organization. Every actor within the circular economy-based ecosystem is accountable for enabling product, service, and business model innovations through-

a. Significant extension of product life

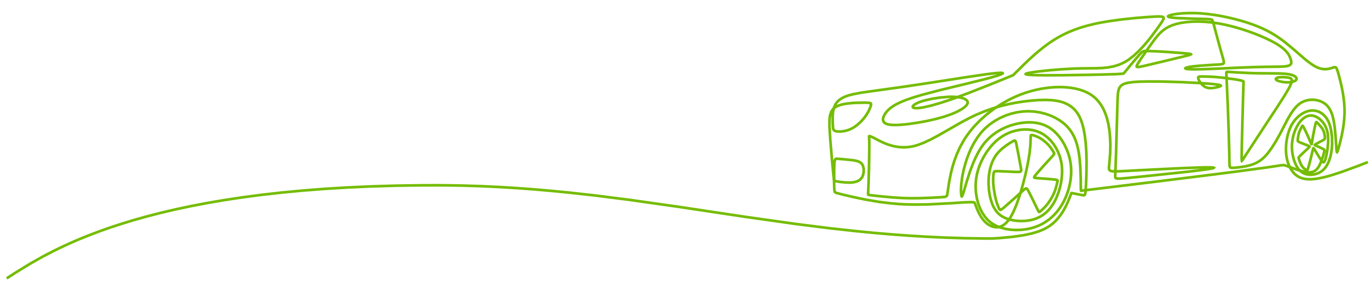
b. Implementation of innovative fuel/energy sourcing and production solutions

c. Optimized resource management through recycling and recovery

d. Openness to consistent innovation and knowledge sharing

Many companies in the automotive and aviation sectors are making efforts to reduce GHG emissions across facilities, operations, and purchased energy, in keeping with Scope 1 and 2 standards for emission accounting and reporting[8]. However, the bulk of the elements and aspects that impact climate falls in the highly complex Scope 3 emission category, down the entire value chain of the firm, including sources not owned or controlled by the firm. Adoption of circular economy principles enabled by digital technologies across a firm's downstream ecosystem partners (for example, suppliers, logistics providers, 3PLs, etc.) can help firms navigate challenges concerning Scope 3 emissions.

Manufacturers are challenged to establish a connected ecosystem with an inherent scope to collect and interpret a massive amount of real-time GHG emission data from all participants within the ecosystem. In this context, aligning to strategic models such as the three-horizon model, as illustrated in Figure 2, can facilitate purpose-led growth for manufacturers.



[7]Renault Group; Circular Economy; ***https://www.renaultgroup.com/en/our-commitments/respect-for-the-environment/circular-economy/***

[8]Greenhouse Gas Protocol; GHG Protocol supplies the world's most widely used greenhouse gas accounting standards; ***https://ghgprotocol.org/standards***

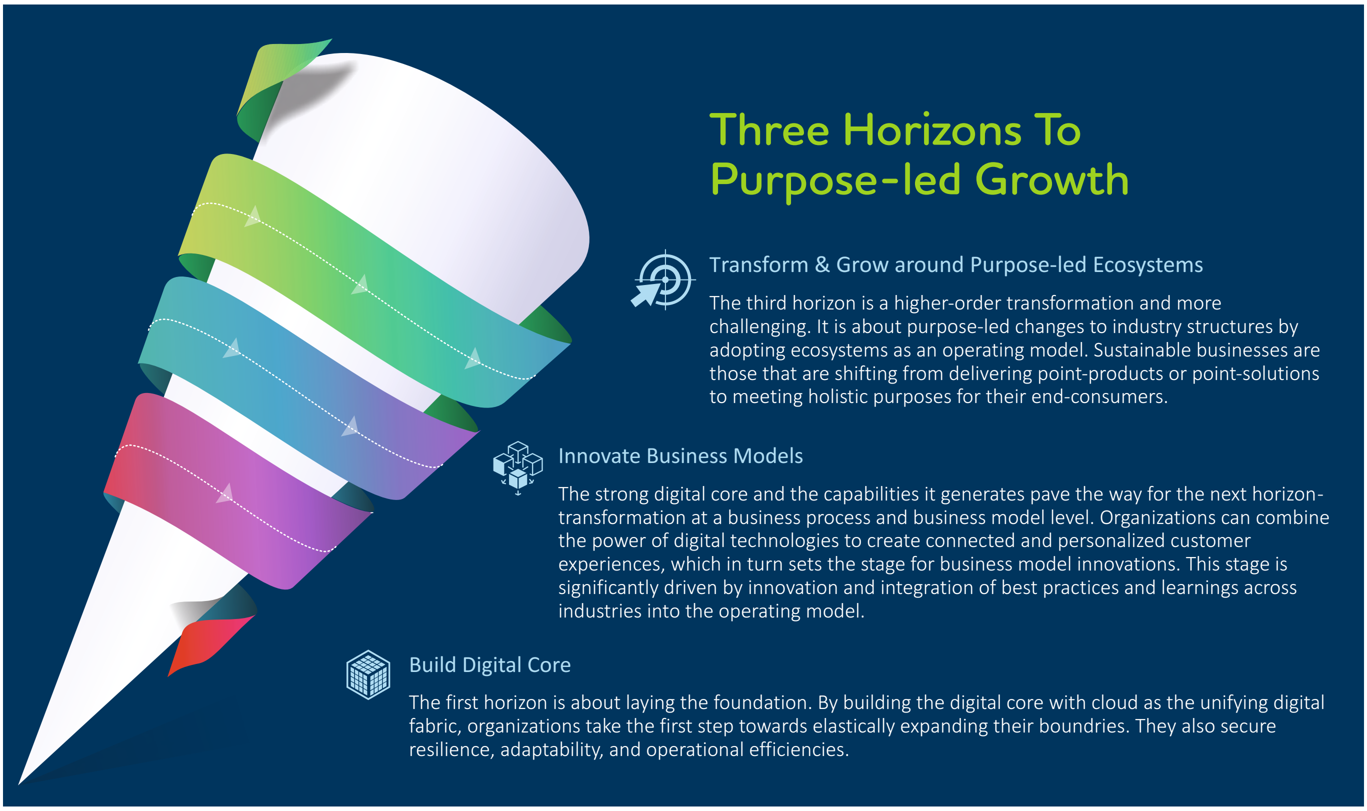


Figure 2: Three horizon model for purpose-led growth

The three-horizon model will handhold manufacturing firms through building a strong digital core with scope for designing new, innovative business models that will help firms transform and grow around circular economy-based ecosystems. It is also observed that manufacturing companies are better positioned to achieve purpose-led growth when they align the proposed three-horizon model with methods such as capturing their activities in journey maps, as illustrated in Figure 3.

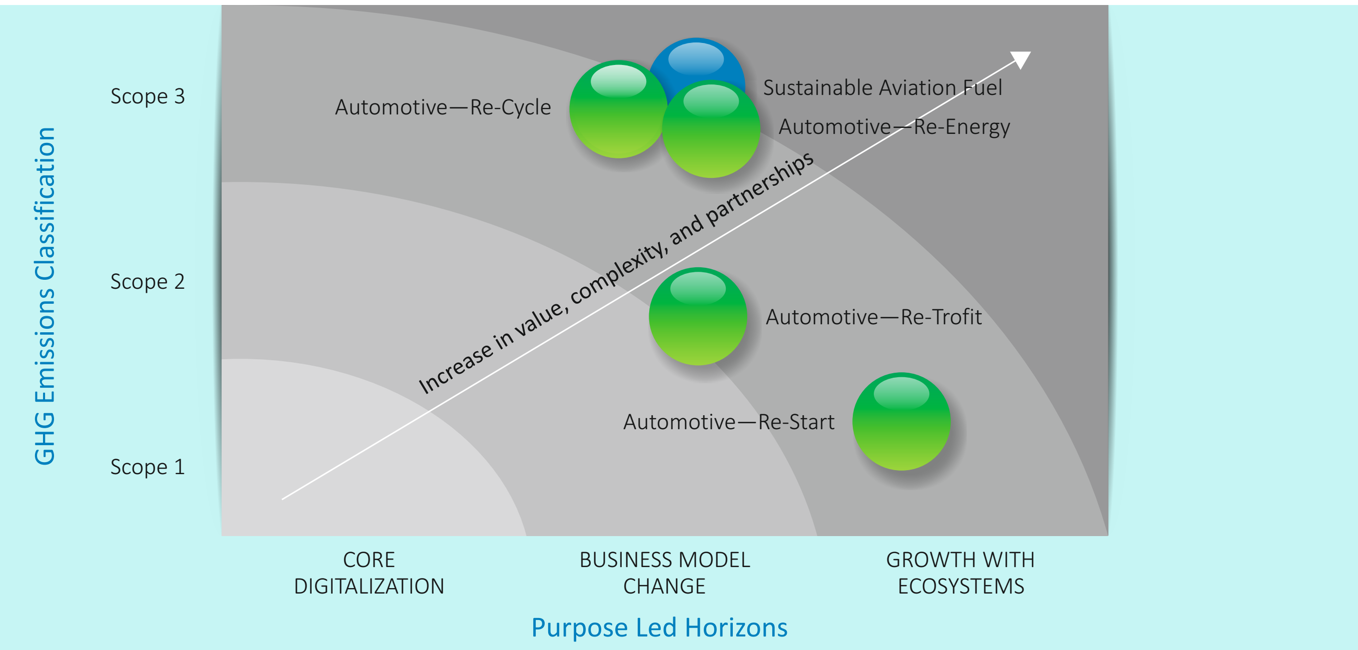


Figure 3: Journey maps for activities with GHG parameters

Carbon offsetting and insetting

While carbon offsetting concerns manufacturing firms and allied players in the ecosystem compensating for emissions within Scope 1 and Scope 2, some organizations are beginning to embark on carbon insetting[9]. Defined as a partnership or investment in an emission-reducing activity within the sphere of influence or interest of a company (outside Scopes 1 and 2), carbon insetting[10] generates benefits for every player involved. Insetting essentially mandates offsetting of emissions by companies through carbon offset projects within their value chains.

To illustrate, Shell Aviation in tandem with these trends, is collaborating with the Smart Freight Centre (SFC) and MIT Center for Transportation Logistics to develop a framework for carbon insetting within its aviation transportation value chain. This encompasses initiatives to increase the use of SAF and reducing CO2 emissions. The framework outlines an accounting and reporting system for SAF insets and will support the actors within air carriers, logistics service providers, freight shippers, business travellers, travel management companies, and fuel suppliers.

Integrating sustainable manufacturing practices into everyday life

The challenges which come with adopting a circular economy framework[11], pertaining to Scope 3 emissions, SDG 12, and achieving carbon neutrality, can be mitigated through internal action to reduce emissions, in line with insetting and offsetting carbon credits. With climate emergency becoming a tangible reality, integration of sustainable manufacturing practices and allied techniques can be realized through-

- Ensuring shared purpose and value creation through improved efforts for identifying and developing opportunities in collaboration within one's own as well as across other ecosystems
- Putting in place initiatives to build momentum, learn, and join external consortiums or alliances such as the Alliance to End Plastic Waste
- Interpreting challenges to set measurable goals. The transition from linear to circular economy will be challenging. Understanding how these changes will impact consumer preferences, profit margins, and associated aspects are essential to setting up measurable goals based on potential metrics such as percentages of recycled and reused materials for production and the reduction of single-use plastics and repair as inset measures.
- Building product innovation based on circular economy models. Manufacturing firms across sectors can implement best practices from the aviation industry, which is leading the concepts of design for serviceability that can also be extended to design for reuse and recycling.
- Aligning with policies and incentives implemented by governments and investors
- Complying with a carbon insetting framework that recognizes contributions from all players in the ecosystem
- Configuring platforms for sharing data as critical components that inform and guide firms through a transformational journey
- Leveraging digital technologies such as digital twin to assess business model impacts, blockchain for traceability, and so forth
- Comprehending that no single player can balance the economy, environment, and the planet; understanding that strong collaborative leadership is critical to facilitate sustainability by innovation.

The pandemic crisis had created a global emergency across economies, industries, and cultures that succeeded in building and bringing to the market ventilators, vaccines, and much more within a scope of 12 months. This demonstrates the capability of the global manufacturing community when driven by a shared purpose. This very capability can be scaled and adapted to reduce the impact on the environment as well. By adopting the circular economy framework and applying a relentless focus on SDGs, the manufacturing industry will come to neutralize and even create a sustained positive impact on climate change.

[9]The Guardian; Forget carbon offsetting, insetting is the future; January 9, 2015; *https://www.theguardian.com/sustainable-business/2015/jan/09/carbon-offsetting-insetting-supply-chain*

[10]Ecometrica; Is 'Insetting' the New 'Offsetting'?; April 2009; *https://ecometrica.com/assets/insetting_offsetting_technical.pdf*

[11]OECD; Business Models for the Circular Economy Opportunities and Challenges from a Policy Perspective; *https://www.oecd.org/environment/waste/policy-highlights-business-models-for-the-circular-economy.pdf*

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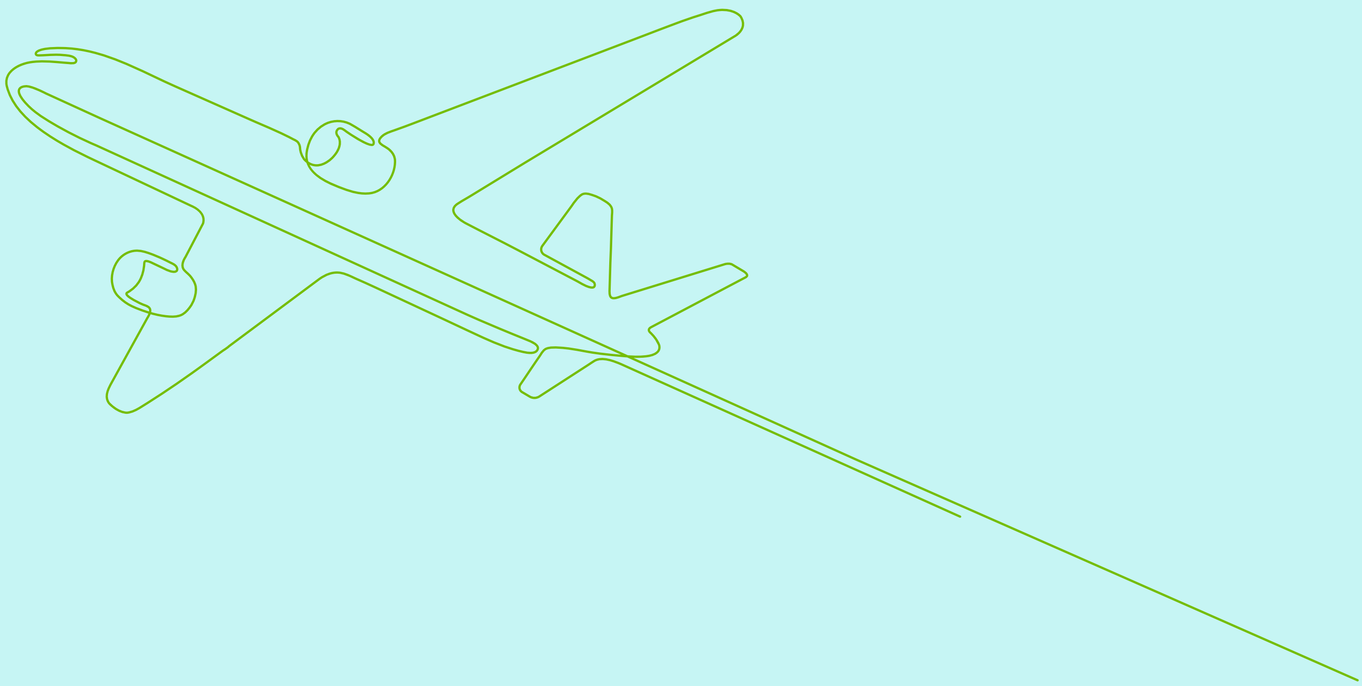
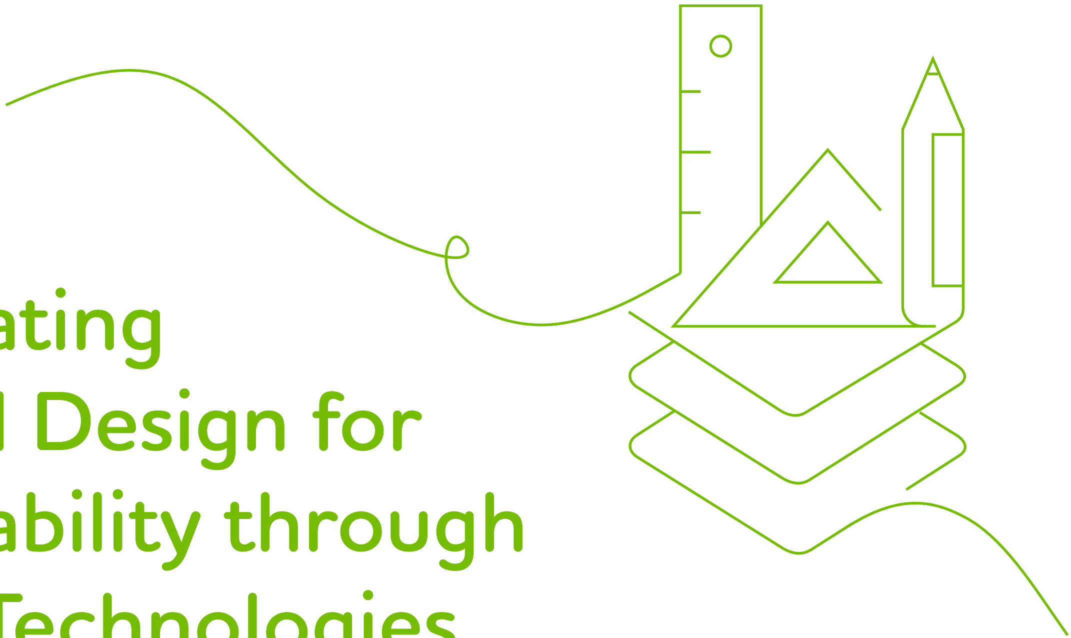


Accelerating Material Design for Sustainability through Digital Technologies



The selection and utilization of materials in products across various stages of design, manufacturing, and service require critical decision-making across the product life cycle. The choice of materials is significant not only for product performance but also on the product's impact on the environment throughout its lifetime. To address the fast-emerging need for sustainable products, the manufacturing industry must not only enhance the sustainability characteristics of existing materials, but also the development of alternate materials and manufacturing processes.

Recent advances in digital technologies offer the ability to carry out in-silico experiments and analysis to design, develop, and deploy materials faster and cheaper with fewer trials and greater insights. These techniques can be extended to consider emerging aspects of sustainability by incorporating appropriate goals and constraints. In this paper, we discuss the role of modeling and simulation with specific emphasis on integrated computational materials engineering, artificial intelligence (AI), machine learning (ML), and knowledge modelling. We have illustrated this through an automotive lightweighting example.

Sustainability in manufacturing starts with materials

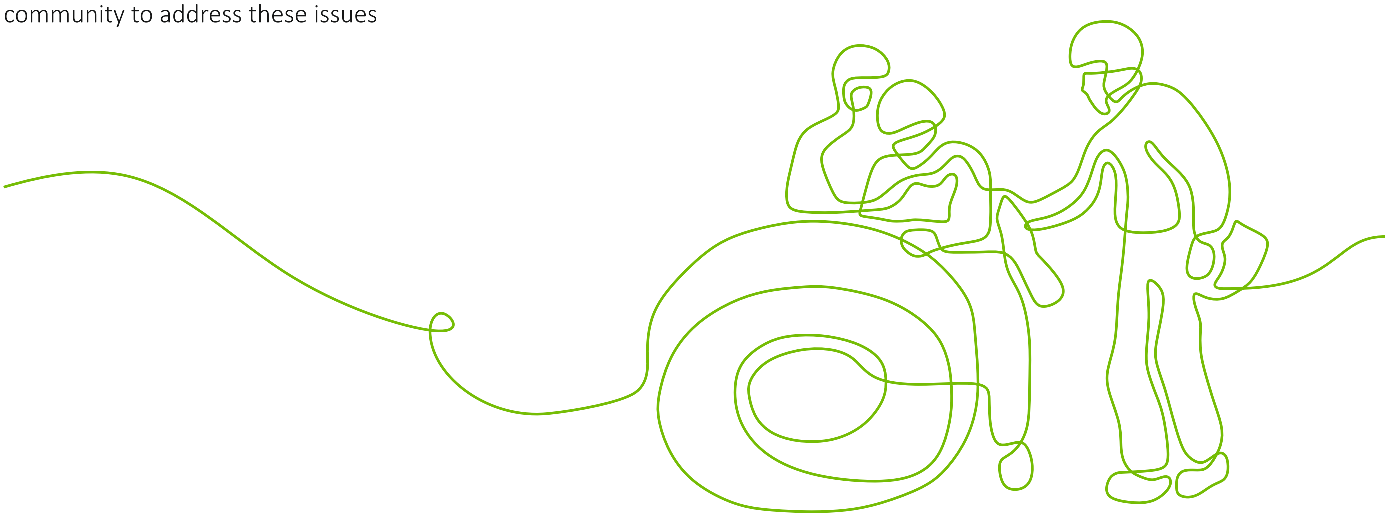
Industrial processes have had an adverse impact on the environment. Today, manufacturing organizations face immense pressure to adopt sustainability strategies and respond to regulations and customers' demand for sustainable products. The objective of sustainable manufacturing initiatives is the creation of products by means of energy-efficient and resource-saving manufacturing systems as well as reducing the impact of by products. The sustainability paradigm needs to address the environmental concerns, both in terms of the impact of product life cycle as well as resource depletion[1]. This is where the use of materials with consideration of their impact on a product's sustainability performance, besides functional performance, becomes critical.

Though emphasis has always been given to material selection to achieve the desired performance of any product, the role of materials in sustainability has always remained in the background. In the subsequent sections, we explore the role of materials in influencing the sustainability of products at various stages of their life cycle and the way emerging digital technologies can be leveraged by materials engineering community to address these issues

Reimagining material, product, and process design for sustainability

The selection of materials for products is a key aspect of design. Various forms of design and in-service knowledge can be used to understand and assess the performance of materials in a product at multiple stages from sustainability perspective. A digital thread can connect different stages of the product life cycle and establish the need to learn for the next cycle of design[2]. A digital thread can also manage data and knowledge about the sustainability of various industry tasks that can be used to arrive at the overall product sustainability index, which can then can become one of the design parameters, along with performance and cost.

An integrated life cycle assessment approach from design to end of service, as shown in Figure 1, should be adopted from sustainability standpoint while selecting the materials and not limiting the material selection only to cater to performance and cost requirements[3].



[1]Taylor & Francis Online; International Journal of Production Research; A survey on sustainability in manufacturing organisations: dimensions and future insights; November 26, 2018; ***https://www.tandfonline.com/doi/abs/10.1080/00207543.2018.1544723?journalCode=tprs20***

[2]Aerospace Research Central; The Air Force Digital Thread/Digital Twin- Life Cycle Integration and Use of Computational and Experimental Knowledge; January 2, 2016; ***https://arc.aiaa.org/doi/10.2514/6.2016-0897***

[3]Springer Open; Design of wind turbine blades; August 30, 2016***; https://doi.org/10.1007/978-3-319-39095-6***

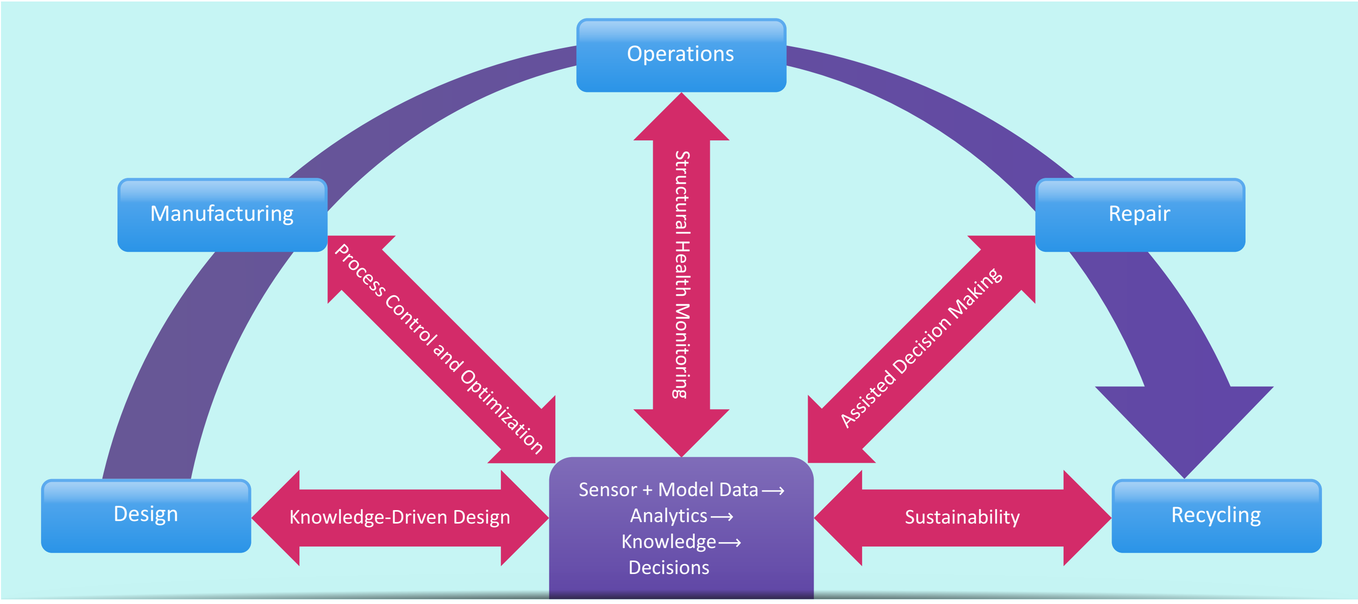


Figure 1: Sustainability through life cycle assessment

Design:

Product, process, and material design are driven through knowledge and data extracted over the entire product life cycle such as material behavior during manufacturing and in-service, material repair potential and recyclability, etc. Leveraging all these aspects during early-stage design and applying generative or iterative design concepts can lead to better selection of materials and processing as well as drive new material development based on the overall sustainability index.

Manufacturing:

The final product design is generally arrived at considering the manufacturing processes that are derived through considerable experiential knowledge around the impact of the manufacturing processes on material properties. From a sustainability standpoint, it is also important to reduce the environmental footprint of manufacturing processes in terms of energy consumption and emissions produced[4], without compromising on the material performance. For example, advanced manufacturing processes such as additive manufacturing through parts reduction and/or consolidation, can be considered as a viable alternative to traditional manufacturing operations, to reduce overall energy consumption, emissions, and scrap.

Operations:

Any large system comprises multiple components and the health of these individual components impact the system behavior. By observing the system through available sensing and no destructive evaluations (NDE)[5] carried out from time to time, further supported by soft sensing capabilities through a suite of digital twins, we can build structural health monitoring (SHM) systems to aid decisions for maintenance and performance, eventually impacting sustainability. Knowledge and data derived from the digital twin suite can be integrated into the design process through digital threads to improve and extend the life cycle of the products.

Repair:

Many components see damage and failure due to regular wear and tear as well as due to external uncontrolled circumstances such as accidents and natural calamities. Material selection and new material development during the design phase can be carried out with repair strategies that can extend the life of products. Newer, cheaper, and efficient repair processes along with repair materials can be considered in the early-stage design phase. Processes such as additive manufacturing are giving a new lease of life for many components that otherwise need retirement. The repaired product can then be updated in the performance digital twin and monitored for a new set of performance goals.

Recycling:

Knowledge of material degradation, reuse, and recycling will help develop better recycling strategies. Newer materials developed by recycling old materials will help in reusability of other products[6]. However, the selection of best choice recycling must consider the impact of the resulting material on the new product and the cost. The environmental impact of recycling processes will also need to be evaluated to obtain the real picture of its impact on sustainability.

[4]Elsevier; Life cycle impact assessment of different manufacturing technologies for automotive CFRP components; July 5, 2020; *https://doi.org/10.1016/j.jclepro.2020.122677*

[5]Elsevier; Progress and trends in nondestructive testing and evaluation for wind turbine composite blade; March 15, 2016; *https://doi.org/10.1016/j.rser.2016.02.026*

[6]Elsevier; The economic and mechanical potential of closed loop material usage and recycling of fibre-reinforced composite materials; March 18, 2019; *https://doi.org/10.1016/j.jclepro.2019.03.156*

Key digital technologies as enablers for sustainable design

Faster realization of design of materials for sustainability, their production, and their deployment in products on an industrial scale require organizations to leverage emerging digital technologies, such as integrated computational materials engineering (ICME), knowledge modelling, data analytics, AI/ML, and high-performance computing (HPC) for in-silico experimentation and analysis. This reduces not only the lead time and cost required for such developments but also reduces the impact of such development activities on the environment.

- **ICME:** This approach can be leveraged to design products with significantly higher awareness of materials, beyond selection, to include the full-chain impact of manufacturing methods by linking material models at multiple length scales to structural behavior simulations. ICME is increasingly being used in accelerated design and development of new materials that can improve product performance. The ICME paradigm combines the concepts of physics-driven multiscale modeling (see Figure 2) with data science, AI/ML, multidisciplinary design optimization, and systems engineering.

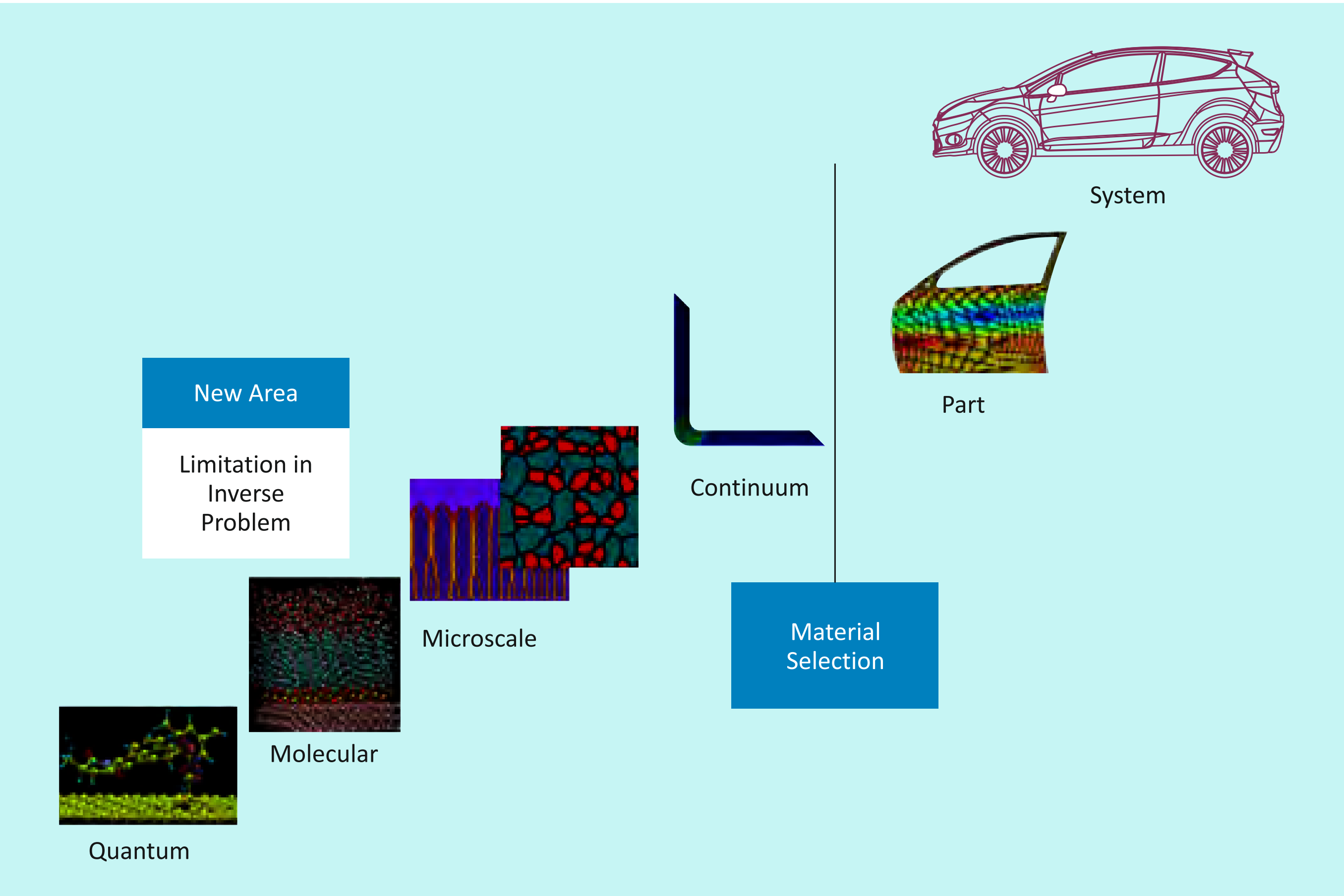


Figure 2: Multi-scale modelling leveraging the ICME approach

- **NLP and knowledge modelling:** One key aspect of lightweighting is selecting a suitable material and manufacturing process for the required application. Leveraging engineering rules such as Ashby plots coupled with the expertise and knowledge gained from past design iterations, can enable better decision-making.

For designers to find the right information, knowledge modelling can play a key role. Information from design manuals, standard operating procedures (SOPs), expert inputs, field reports, and academic literature can be curated and captured in an actionable form. Accurate decisions can then be made available using contextual graph matching algorithms, thereby helping engineers save time (see Figure 3).

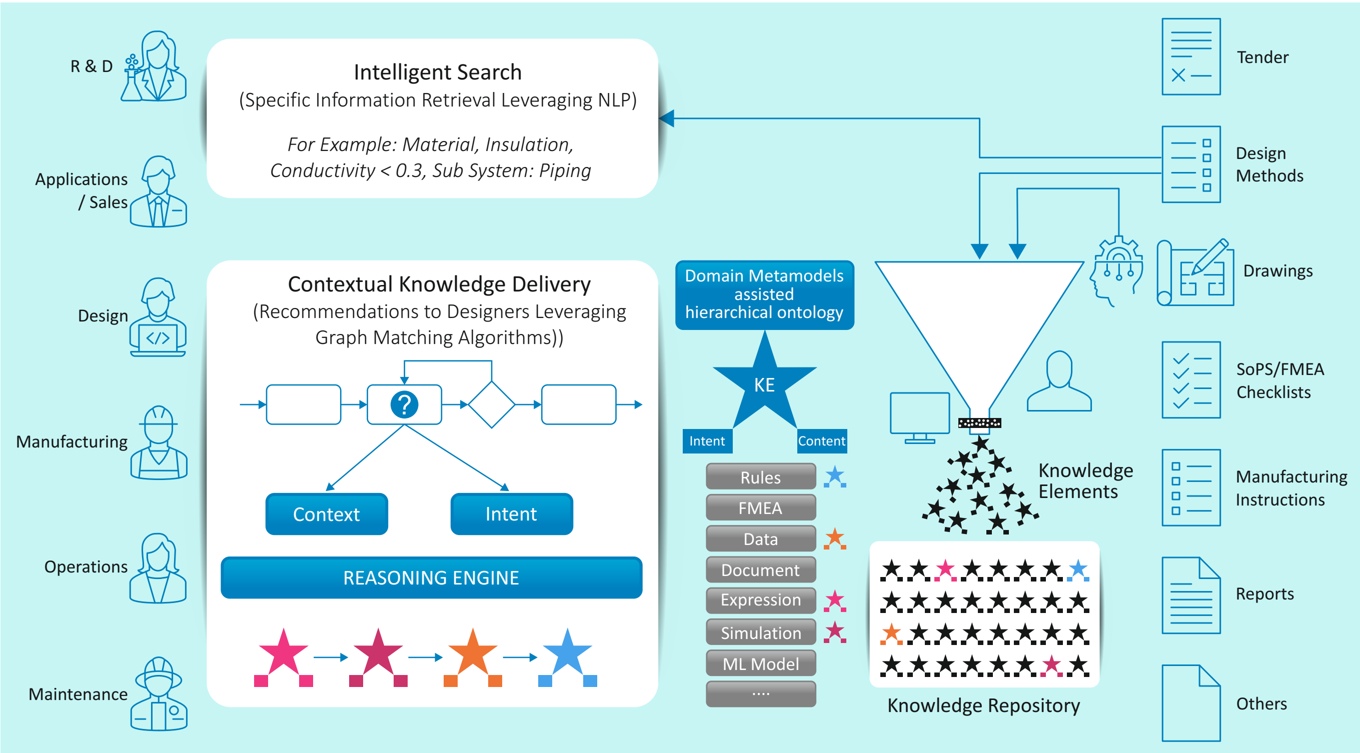


Figure 3: How NLP and knowledge modelling can facilitate decision making

- **AI/ML:** These techniques can accelerate ICME adoption by processing vast amounts of data generated from digital threads and digital twins. ICME facilitates material, product, and process design through computational material models to simulate the behavior of materials and performance of components. Active learning techniques can be the first step to reduce the design space that needs to be simulated. Simulated results from a smaller search space can be used along with techniques like transfer learning to identify the behavior of the entire search space. This will significantly reduce the number of simulations that need to be carried out for exploration of materials development for lightweighting. AI/ML can also help designers with the right material selection leveraging historical data around materials and their performance.

Conclusion

It is abundantly clear that manufacturers must consider the aspects of sustainability right from the early product design stage and throughout the life cycle, as these decisions play a major role in the eventual outcome. Such decisions need to consider several aspects related to manufacturing processes, the product’s in-field performance, as well as its recyclability or reuse. A combination of physics-driven computation, AI, ML, knowledge modeling, and generative design is likely to emerge as a key enabler for such a complex need. These technologies will form the backbone of digital thread comprising several digital twins to enable next-generation sustainable engineering.

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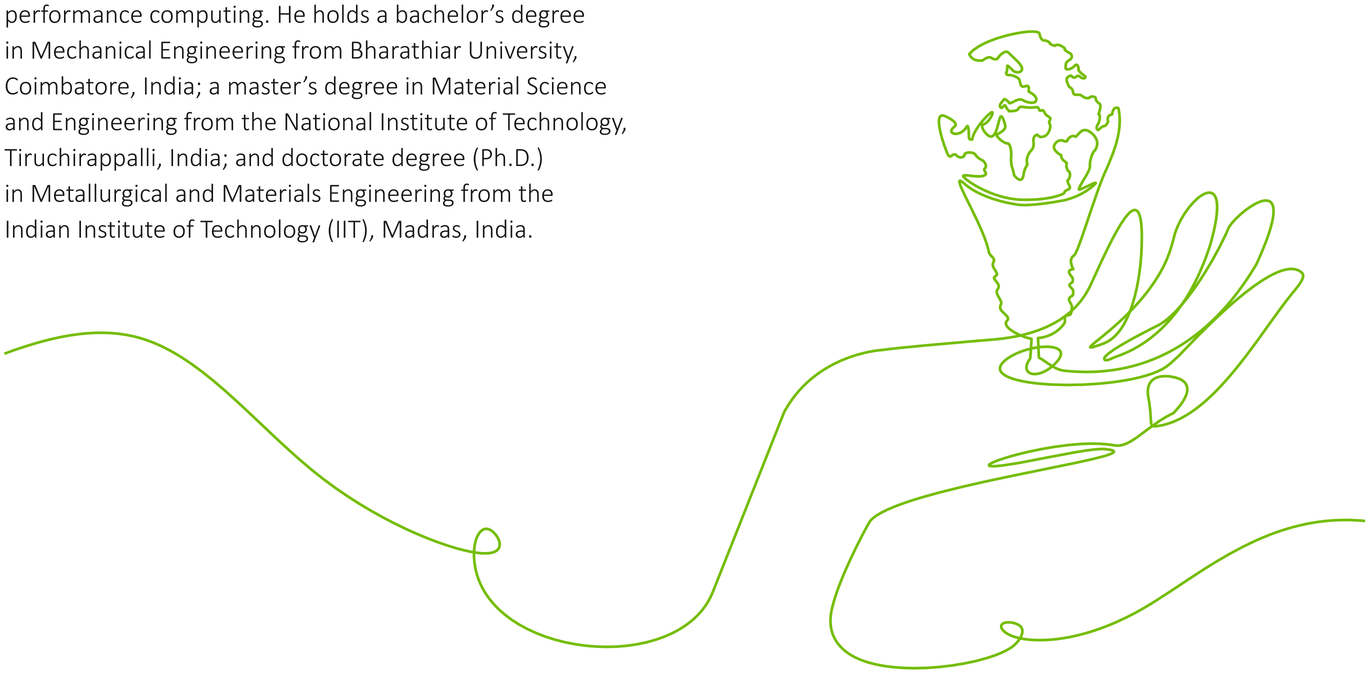

Renewables – The Untapped Opportunity for Utilities

A Sustainability by Design Strategy

Renewable energy is one of the biggest game changers for the utility industry today. It is not just a new area of focus, but a key priority for utilities and is fast emerging as the building block for many other emerging roles. Globally, we see utilities embarking on their renewables journey by building an ecosystem which is prosumer-centric – a likely win-win situation for shareholders across the value chain.

By embracing renewables, utilities can adhere to the environmental guidelines – mandatory and regulatory – to reduce greenhouse gasses (GHG), drive sustainability, manage peak loads, and create a new moment of truth for prosumers. For prosumers, this entails empowerment and self-sufficiency as well as avenues to garner new revenue streams. The success of this journey depends on the right adoption of digital technologies, defining the right business models, and building an ecosystem with the prosumer at the center.

This paper explores the processes and benefits of how digital solutions can help utilities transition to renewables and address the environmental challenges that come with this change.

Redefining utilities with renewables

Utilities today are transitioning from being mere energy sellers to affinity service providers. Renewables, as a fundamental building block, play a key role in this transition for utility companies.

Figure 1 depicts the outcome of a joint research study between TCS and International Data Corporation (IDC) conducted with over 120 senior executives of European utility companies[1]. It charts their responses on the evolving roles and responsibilities of utilities vis-à-vis the importance of the role.

The report reveals that low-carbon energy providers, an intrinsic characteristic of renewables, emerged as the most preferred role for utilities. Sustainability also acts as a catalyst to create other new emerging roles, such as micro-grid manager, electric vehicle (EV) infrastructure manager, or connected home service provider.

[1]TCS; Volume II: Innovation and Business Opportunities for Utilities by Collaborating with the Ecosystem; ***https://info.tcs.com/DigitalUtilities***

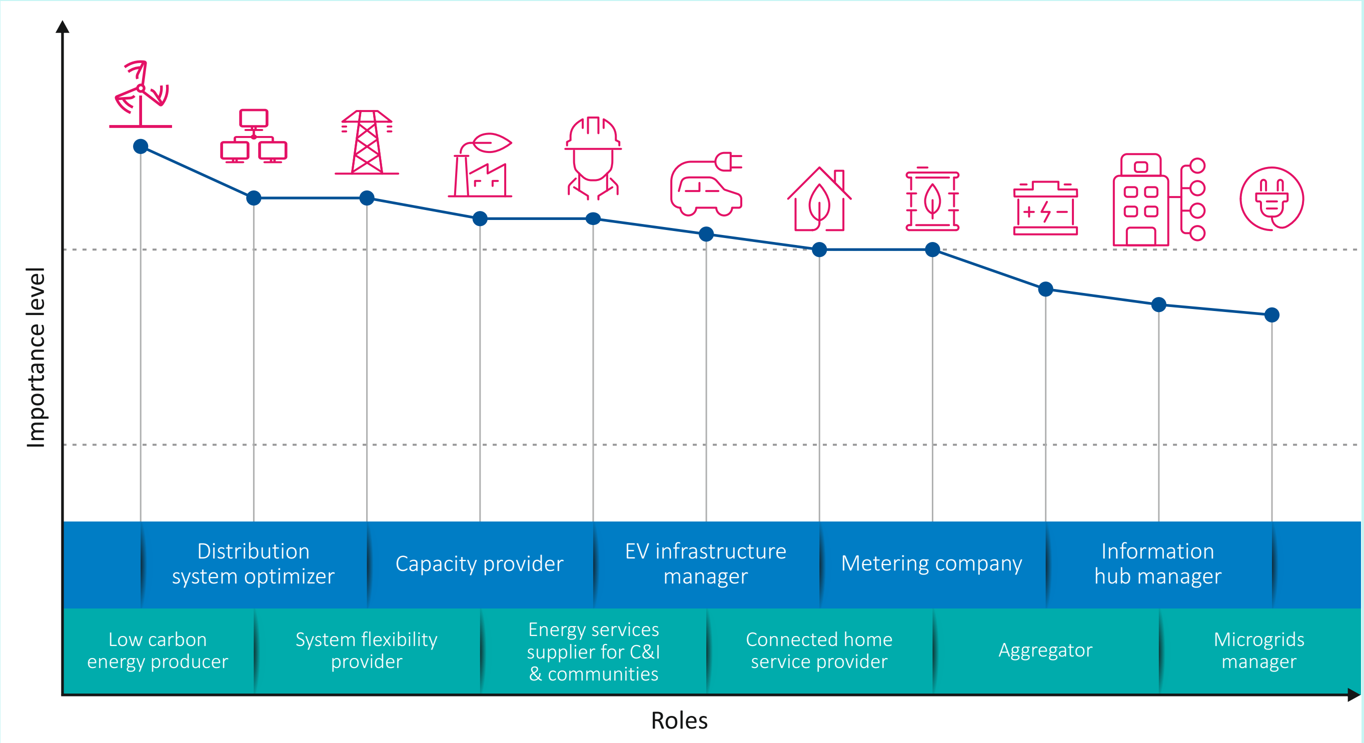

Figure 1: Future roles of utilities

Micro and macro trends shaping the utilities renewables journey

The following are some of the key micro and macro themes shaping the net zero journeys for utilities:

- **Stringent sustainability agenda from regulators** – Across the globe, federal regulators are mandating multiple sustainability targets towards achieving net zero emissions. For example, Reforming the Energy Vision (REV) in the US has an agenda for New York's state electricity utility to reduce greenhouse gas (GHG) emissions by 40% from 1990 levels, along with setting up generation capacity with a 50% renewable energy portfolio by 2030[2].
- **Low technology cost** – Due to rapid technology advancements and reduced equipment costs, the levelized cost of electricity generation from onshore wind and solar projects has decreased significantly.
- **Consumer empowerment** – The transition of consumers to prosumers is also shaping the net zero journey, as the modern consumer is actively participating in the utilities virtual power plant (VPP) program through their own power generation efforts. Furthermore, the renewables journey has also created an opportunity for utilities to create a moment of truth for their prosumers by offering them incentives for participating in their VPP journey.
- **Energy consumerization** – Consumerization of energy technologies among prosumers is on the rise, such as the adoption of rooftop solar panels, EVs, or grid-scale battery storage.
- **Incentive-based ecosystem approach with the prosumer** – Across the globe, utilities are increasingly adopting an incentive-based approach with prosumers for achieving net zero emissions. For example, customers enrolled in the renewable target program will receive billing credits for surplus energy contributed to the grid in addition to incentives for total energy generated from renewables.
- **Fusion of energy and exponential technologies** – There is an increasing fusion of energy technologies with exponential ones such as the internet of things (IoT) to manage the digital twin of renewable operations, or blockchain for EV infrastructure billing.

[2]NY Power Authority; Reforming the Energy Vision for NY; *https://www.nypa.gov/innovation/initiatives/rev*

The renewables journey across three different horizons

We foresee utilities transitioning towards renewables across three different key horizons:

- **Horizon 1** – Emphasis on internal processes to reduce GHG emissions. Some of the common examples include generation portfolio optimization, integration of renewables, and energy consumption optimization.
- **Horizon 2** – Reimagining and building prosumer-centric business models. Examples include e-mobility and demand side management, to mention a few.
- **Horizon 3** – Establishing an energy value ecosystem across the utility industry, including prosumers, partners, niche technology solution providers, and cross-industry players. Common examples include VPP, bring your own storage, and renewable energy certificates (REC) trading platforms, to name a new.

Table 1 below highlights the key performance indicators (KPIs) measured across the three different time horizons:

Horizon	Key Theme	Sample Business KPI
Horizon 1	Internal processes to reduce GHGs	■ GHG emissions from internal business processes such as combustion of fossil fuels ■ Percentage of renewables in the generation portfolio ■ Percentage decrease in the energy consumption
Horizon 2	New business models around prosumers	■ Number of prosumers with renewables ■ Number of customers participating in the utilities demand side management program ■ Number of the EVs on the road
Horizon 3	Building a distributed energy ecosystem (DEC)	■ Number of customers participating in the utilities VPP program ■ Customer-owned storage capacity in the utilities VPP program

Table 1: KPIs measured across three different time horizons

Prosumer at the center of the utilities renewables journey

Embracing a prosumer-centric focus across three different horizons empowers prosumers at a faster rate. Partnering with prosumers also creates support for utilities to enhance customer satisfaction, besides leveraging investment from prosumers to minimize or defer their own investments.

The entire process comprises three distinct phases of partnership between utilities and prosumers:

Adoption – Utilities are encouraging and promoting the adoption of renewables by prosumers through reimagined customer journeys such as discover, learn, join, use, and promote.

Maturity – In this phase, prosumers are building an ecosystem of distributed energy such as solar – including storage – to maximize benefits such as the potential of joint synergy among distributed energy resources so that the whole is greater than the sum of its parts.

Optimization – Prosumers participating in the utilities VPP program are enabled to optimally manage peak load requirements for utilities.

For example, a leading utility on the west coast in the US is partnering with prosumers to create a distributed solar-plus-storage ecosystem to manage peak load demands and meet regulatory norms.

Similarly, a leading utility company on the US east coast is building large-scale community solar programs. The subscription-led programs enable customers- commercial, industrial, and residential- to access solar-sourced power without the need for their own equipment as they can tap into the excess solar energy generated and implement the feedback onto the onto the public grid.

A plethora of new opportunities catalyzed by technolog

The utilities renewables journey with prosumers at the center has created a plethora of new opportunities across the value chain of generation, transmission, distribution, retail, and behind-the-meter services.

On the generation side, consumer-owned renewables participation in the utilities VPP program will meet the gentailers' demand for new capacity and may defer investment in new generation capacity. This will also help the utility industry to meet its sustainability agenda and reduce GHG emissions.

On the transmission and distribution front, utilities can leverage the prosumers' power to tide over peak power demand to avoid the high cost of power purchase from the market.

In retail and behind-the-meter service, renewables can create new business models for utilities, by rewarding consumers for their participation in the utilities' renewable program. Besides opening up new revenue streams by installing renewable equipment, utilities can also manage, operate, and maintain renewable installation of the customers.

These multiple opportunities come with new needs and business functionalities that utilities need to address to make their renewables journey seamless and successful. While utilities earlier focused on reliability, affordability, and efficiency, adopting renewables has added multiple new dimensions and prerequisites such as flexibility, resiliency, and optimization.

The deployment of digital technologies plays a critical role in addressing the above new business needs, besides shaping newer models. Prime among these technologies are:

- Artificial Intelligence (AI) – AI plays a pivotal role across the utilities value chain such as addressing business needs including forecasting of renewables, optimization of energy generation portfolio and operations in the grid, renewables bidding in the market, and pricing tariffs.

- Internet of Things (IoT) – IoT plays an important role in capturing renewable asset condition, remote operations and monitoring of assets, and predicting asset failures.

However, a successful renewables transition is fraught with challenges. To create exponential value for customers, amalgamating disruptive technologies such as IoT, AI, and machine learning (ML), cloud computing, drone technology, and 5G, with emerging trends such as energy efficiency, distributed energy resources (DER), electric vehicles, and storage are imperative. A case in point would be energy efficiency driven by AI for a demand side management (DSM) program, or it could be DER with IoT for remote monitoring of renewables.

The Way Ahead for Renewables

Fossil fuels such as coal and gas are exhaustible resources, fast depleting, and found only in a handful of diverse global geographies. Alarm bells are ringing as global warming - which is anthropogenic and chiefly attributed to the burning of fossil fuels - needs to be mitigated. Alternatives need to be found, and who else can they turn to besides the government.

For instance, Germany drafted a proposal to increase its current share of about 50% renewable power to 65% by 2030[3]. The Indian Government has set a target of installing 175 gigawatts (GWs) of renewable energy capacity by 2022[4].

Renewables are proving to be the cornerstones for utilities on the way ahead to achieve the mandated environmental goals besides ensuring sustainable growth. Technology will be a crucial enabler for this transformation journey. The fusion of energy and exponential technologies to create a distributed energy ecosystem is the key, where the sum will be greater than the parts.

About the Author:

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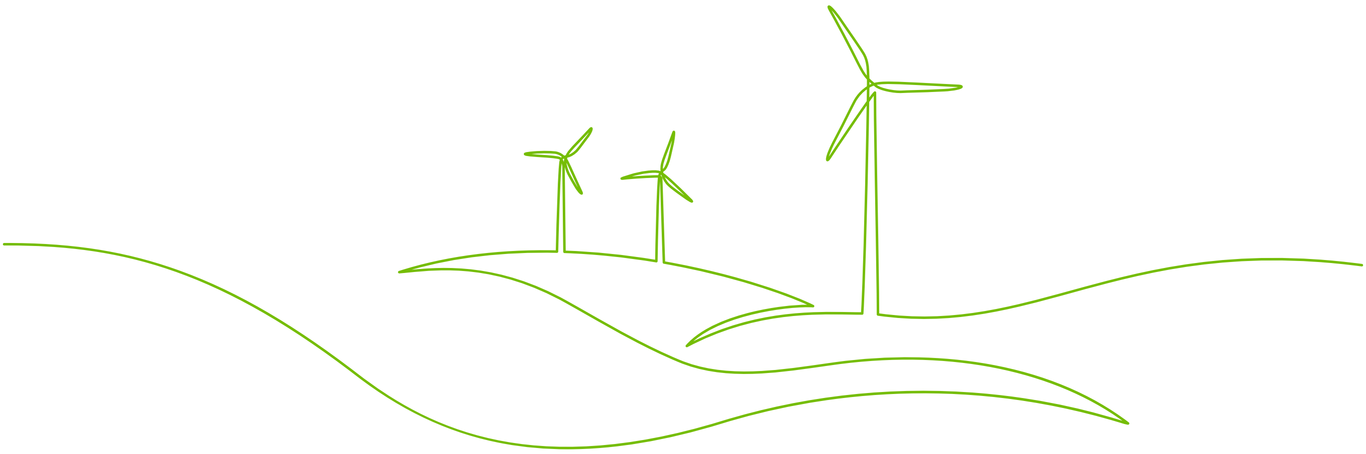

[3]Clean Energy Wire; Ministry plans renewables expansion push to reach Germany's 2030 target; September 2, 2020; *www.cleanenergywire.org/news/ministry-plans-renewables-expansion-push-reach-germanys-2030-target*

[4]United Nations Sustainable Development Goals Partnership Platform; India plans to produce 175 GW of renewable energy by 2022; September 15, 2021; https://sustainabledevelopment.un.org/partnership/?p=34566

Reflections on Our Environmental Sustainability Journey

Charting our future roadmap

We at TCS began our sustainability journey back in June 2006, when responsible corporate citizenship was still a new concept in the IT industry. We set up a small team to form a dedicated department for health, safety, and environment (HSE), arguably the first in the Indian IT sector. Our modest initiative to nurture environmental consciousness within the organization has gradually grown over the years to now become the guiding principle behind all our actions and decisions.

Our initial objective was to assess the impact of the IT industry on the environment and we quickly realized that there was a lack of understanding about the complexity of the problem. We took suitable measures to educate our internal stakeholders about the need to analyze the issue in its totality and one of our biggest wins was the adoption of a 'systems approach to management', towards implementing sustainability initiatives. With the objective of standardizing environmental practices across our global operations, we adopted the ISO 14001:2004 framework (updated now to the 2015 version), which specifies the requirements for environmental management systems in organizations.

A multi-pronged approach to sustainability

The sustainability initiatives at TCS that started with baby steps towards improving resource efficiency and administrative controls quickly gained momentum as measures, including energy saving, resulted in direct cost benefits to the organization. Our approach analyzes the various components of implementing sustainability measures, right from conscious procurement to employee training. The steps include:

Energy saving: We took up projects such as replacing fluorescent lights with light-emitting diode (LED) lamps, increasing the set temperatures in our offshore delivery centers (ODCs) and server rooms, and upgrading legacy heating, ventilation, and air conditioning (HVAC) systems. We also installed digital energy meters and connected them on a single platform using TCS' remote energy management system to effectively measure, monitor, and analyze energy consumption on a real-time basis.

Green IT: We undertook data center power management initiatives that have helped us achieve the target Power utilization effectiveness (PUE) of 1.65 at 21 data centers in the financial year 2020-2021. The key enablers of these initiatives were green data center practices leveraging technologies like modular UPS, cold aisle containment, in-row cooling, and rear door heat exchanger with a water-cooled rack. Now, there is a shift towards the use of servers that enable a high degree of virtualized hosting capability on smaller physical footprints, which reduce the overall requirement for space, power, and cooling. The focus is not restricted just to energy consumption of IT assets. We also include green certifications like EPEAT among the procurement criteria, which focus on green aspects that avoid use of toxic chemicals, heavy metals, and are reclyable.

Green building initiatives: To reduce our carbon footprint, we have institutionalized energy saving measures as an integral part of the 'Design for the Environment' approach in our green building program. We are progressively working towards setting up greener infrastructure that has better energy efficiency, optimal resource utilization, and environmentally responsible architecture and designs. The number of certified green buildings has increased from three in 2008 to 22 today, spanning over 26 million sq. ft.

Renewable energy: We moved incrementally towards renewable energy (RE) by means of onsite rooftop solar and third-party power purchase agreements for RE power (solar, wind, and hydro). Now RE accounts for more than 15% of our energy mix.

By implementing energy efficiency, green IT, green building initiatives, and renewable energy measures, as stated above, in the financial year 2019-2020, we had reduced more than 60% of our specific carbon footprint, in comparison to our carbon footprint levels in 2007-2008.

Responsible sourcing: Over a period, we have moved and upgraded from thin film transistor (TFT) to liquid crystal display (LCD) and now to LEDs and to state-of-the-art thin clients. We now base our purchase decisions on parameters including progressive ecolabels, lifecycle environmental footprint, and product carbon footprint. We have a similar set of guidelines for the purchase of non-ICT items, where we look at energy efficiency, recyclability, and safety (avoiding the use of hazardous chemicals).

Water conservation: We have set up water-efficient infrastructure such as dual flushing systems in toilets, taps with variable output and sensors, throttling valves, and drip irrigation systems, across our locations. By recycling used water, treating sewage, and storing rainwater, we plan to reduce our annual freshwater consumption by 3% until 2025. All new campuses have been designed for 50% higher water efficiency and 100% sewage treatment.

Waste disposal: With the aspiration to achieve zero-waste disposal and zero discharge, we initiated projects to recycle wet and green wastes to manure. TCS had an e-waste management policy in place well before they were mandated by regulatory authorities. We dispose our e-waste only through authorized recyclers approved by government agencies. All TCS campuses are equipped with onsite biodegradable waste treatment facilities such as biodigesters, vermicomposting pits, or organic waste converters. Our goal is to eliminate single-use plastics from our campuses in the current year, with a plan to recycle 100% biodegradable wastes by 2025.

Data collection: Over the years, our gathering and analysis of environmental data have improved and we have been collecting and aggregating segmented data on the usage of various resources including power, water, fuel, and paper as well as wastes generated and disposed. We use a cloud based, easy to use application for collecting & aggregating environmental data wherein customizable KPIs can be configured based on need which also enables analyse and report our sustainability performance flawlessly.

Employee engagement: Employee understanding and cooperation are integral to our sustainability journey. We focus on improving awareness on environmental issues among our associates through mandatory induction sessions and online modules. Our associate engagement program is based on the tenets of communication, engagement, and empowerment, encouraging our employees to contribute towards a better environment in their own capacities.

The way forward

With sustainability as the main focus, HSE has transitioned from a traditional role to a contemporary 'avatar' - Environmental Sustainability, Health, and Safety. Our initiatives have substantially paid off over the years. Renewable sources now account for more than 15% of TCS' energy mix. Some of the key future strategies planned include targets to achieve further improvements in energy efficiency across operations by expanding the use of renewable energy sources, working with supply chain partners to reduce value-chain emissions, and optimizing business air travel and employee commuting. We plan to achieve about 70% reduction in energy consumption by 2025 while aspiring for net-zero emissions by 2030. We have worked in the past with our transport vendors to ensure they only ply vehicles that meet the latest emission standard norms and we are now looking at creating an electric vehicle ecosystem for hired fleets.

Apart from optimizing our own operations, we are also actively engaging with customers and partners to improve their efficiencies and climate action through digital solutions. TCS' Neural Manufacturing™ suite of solutions embeds sustainability and circular economy principles to enable manufacturers to create responsible business ecosystems.

Our purpose-driven worldview inspires many of our employees to undertake volunteering in their local communities. All this and more help us take forward the Tata legacy to give back to the society many times over than what we take.

About the author:

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A part of the Tata Group, India's largest multinational business group, TCS has over 500,000 of the world's best-trained consultants in 46 countries. The company generated consolidated revenues of US $22.2 billion in the fiscal year ended March 31, 2021 and is listed on the BSE (formerly Bombay Stock Exchange) and the NSE (National Stock Exchange) in India. TCS' proactive stance on climate change and award-winning work with communities across the world have earned it a place in leading sustainability indices such as the MSCI Global Sustainability Index and the FTSE4Good Emerging Index.

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