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Unravelling Industry 5.0 for sustainable development

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As human civilisation moves faster towards every further milestone in development, the very concept of development also seems to change. While the wheel of economy essentially drives development and vice versa, the concept of Industry 5.0 has come to the forefront of the global discussion. Industry 5.0, the enhanced version, harnesses cobots and the bioeconomy to strike a fine balance between people, the planet, and profit. The Cover Story explains how this new era of development can be made more socially sensitive and environmentally responsible.



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Automation, electronics, and computer technology have played a vital role when it comes to Industrial Revolution



People, profit, and the planet are called the three pillars of development. Only a fine balance between all three can ensure consistent and sustainable development. Any imbalance could cause serious harm. Unfortunately, we have not been able to accomplish this, especially because of the enormous momentum of industrialisation. According to the report presented by the Inter-Governmental Panel on Climate Change (IPCC) in 2013-14, the average carbon emission in the pre-industrial era, that is, during 1750–1800, was 278 ppm. In 2021, it was 417 ppm, an increase of more than 50%!

Revisiting Industrial Revolution

The industrial era started with James Watt's invention of the steam engine in 1870 and the power loom, which later came to be known as Industry 1.0. What began as the famous Industrial Revolution, about a century later, in 1880, evolved into mass production and assembly lines where electricity replaced steam. This is referred to as the second wave of industrialisation Industry 2.0.

A century later, around the year 1969, the wave of electronics and computers emerged, and the use of Programmable Logic Control (PLC) further transformed the manufacturing sector. Automation, electronics, and computer technology took centre stage. This wave is referred to as Industry 3.0, another paradigm-shifting event.

While India had just about become comfortable with assimilating these, later around the years 2011–13, the next great transformational wave emerged. A wave that relied on each of the previous three and yet surpassed them entirely and ushered in the fourth dazzling epoch. This wave, now ubiquitously called Industry 4.0, has at its heart a Cyber-

Physical System (CPS), ie, a self-controlling autonomous framework that connects the cyber and physical worlds.

It is important to note that while Industry 1.0 to Industry 3.0 took about 100 years to evolve at each stage, Industry 4.0 emerged within just 40 years of Industry 3.0! It is also worth noting that the rate of proliferation of Industry 4.0 is exponential when compared to previous waves.

Society 5.0: Social Revolution

Interestingly, social development, just like industrial development, is said to be on the threshold of the 5.0 stage. The four earlier phases were, the Hunting Society (Society 1.0), The Agricultural Society (Society 2.0), The Industrial Society (Society 3.0), and the Information Society (Society 4.0). Society 5.0, also called the 'super-smart society', envisions a sustainable, inclusive socio-economic system, powered by digital technologies such as Big Data analytics, Artificial Intelligence (AI), the Internet of Things, and robotics. The CPS, in which cyberspace and physical space are tightly integrated, becomes a pervasive technological mode supporting Society 5.0. The 5th era is conceived as the 'smart' age.

Downside of Industrial Revolution

Undoubtedly, all these industry revolutions have immensely contributed to poverty eradication, mortality reduction, the progress of mankind's GDP growth, and so on. However, in hindsight, the incessant pursuit of growth and development has come at the expense of the environment. Uncontrolled carbon emissions from industry & transportation



Cobots are cost-effective, safe and offer several benefits

powered by fossil-based energy have been contributing to global warming and climate change. Massive deforestation for infrastructure and mining to extract fossil resources are wreaking havoc on planet Earth and its ecology.

Increasing automation is threatening to leave many individuals without jobs that pay a subsistence wage. Jobs involving more routine tasks, such as those in manufacturing, transportation, office administration, and food preparation, are the most vulnerable. If the situation assumes greater proportions, we may have civil unrest in the world, once again jeopardising social health. The widening chasm between the haves and have nots, or the rural and urban citizenry, for instance. The gap needs to be bridged.

To effectively address this scenario, measures like Universal Basic Income (UBI) and a robot tax are being envisioned. UBI will help all those who are left behind by this economic transformation avoid poverty. A robot tax is a legislative strategy to disincentivise the replacement of workers by machines and bolster the social safety net for those who are displaced.

Industry 5.0: Next frontier of Industry Evolution

The very concept of Industry 5.0 is mooted to resolve some of these serious issues that have been unintended outcomes of industrial development. This may be our best bet, as it is the only model that can accomplish industrial development and social development in tandem. It is important to note that this transformation from Industry 4.0 to Industry 5.0 has taken place within just 10 years! Two versions have emerged.

Industry 5.0 is expected to revolutionise the production process with higher autonomy for collaborative robots. It will also bring more creativity and innovation to the products by allowing robots to perform repetitive tasks. It is expected that humans optimally utilise their creative and intellectual capabilities. Thanks to fast progress in manufacturing techniques and production system digitisation, the sector today is moving from mass production to custom manufacturing.

Cobots

The first version (V1) of Industry 5.0 discusses human-robot co-working, also popularly known as cobots. The term itself implies congruence in society and technological development. In this version, humans will perform creative and transformational tasks, while robots will perform transactional and repetitive tasks. As a part of Industry 4.0, robots are functioning in the industrial environment for automation and in-service environment for domestic and professional use. Cobot applications contrast with traditional industrial robot applications, in which robots are isolated from human contact.

It all started with service robots known as cobots because they were designed to work alongside humans. However, recently, the concept has been extended to the industrial environment as well. Here, instead of the dreaded human-robot conflict, coexistence and cooperation are envisaged. In the coexistence mode, humans and robots work alongside each other without a fence, but with no shared workspace. Whereas in sequential, collaboration, humans and robots are



Bioeconomy is based on the core principle of sustainability

active in a shared workspace, but their motions are sequential, ie, they do not work on a part at the same time.

Cobots are cost-effective, safe and offer several benefits that include among other following:

1. **Compact:** Being small, compact robots, cobots can therefore be used almost anywhere in a production process without taking up too much space.
2. **Ease of installing and programming:** A cobot is easy to install by anyone and simple to program. With handy apps and software for smartphones and desktops, a cobot is operational in no time.
3. **Flexible:** A cobot can easily learn new operations and is, therefore, able to work in different places in the production process.
4. **Mobile:** Cobots are not heavy and easy to move around. Mounted on a mobile workbench, they can easily perform new tasks at different locations within a company.
5. **Consistent and precise:** Cobots always perform actions in the same way and with the same force. This ensures equal quality and accurately placed parts.
6. **Positive effect on employees:** Employees are spared monotonous or dangerous actions and are enabled to develop themselves by doing more creative work.
7. **Reduction of production costs:** Through the use of cobots, processes are streamlined and production goes up. Ultimately, this leads to a better bottom line.

Bioeconomy

The second version (V2) of Industry 5.0 elaborates on the

bioeconomy approach that smartly uses biological resources for industrial purposes and helps achieve a balance between ecology, industry, and the economy. It helps address important aspects of eco-friendly energy, sustainable materials, and industrial waste management, that were not even contemplated in the scheme of things hitherto.

Bioeconomy is based on the core principle of sustainability, what comes from the soil goes back into the soil in a classical 'Cradle-to-Grave' cycle. Carbohydrate-based goods and products are low-carbon and biodegradable; even agri-waste streams can be processed to produce organic manure. Biobased products have applications across diverse industry segments, eg, construction, packaging, chemicals, fertilisers, pharmaceuticals, etc. In fact, with rising awareness about - Environment, Society, and Governance (ESG) norms, more and more companies are actively exploring bio-based solutions for their needs.

Bioeconomy itself is a very vast topic, and if we take a closer look at industrial biotechnology, biomobility and bioprism have emerged as mainstays. The bedrock of industrial biotech remains well-oiled expertise in managing feedstock, technology, and products.

The transportation industry based on fossil fuel-based internal combustion engines is one of the fastest growing sectors worldwide, including India. Undoubtedly, it has a pivotal role in accelerating economic development by interlinking generation and consumption ends. At the same time, it is also identified, after industry, as the second largest consumer of energy and GHG emitter.

Sustainable decarbonisation of the ICE-based



Artificial Intelligence algorithms help to make smart decisions

transportation sector by reconfiguring mobility is a dire need of the hour. While the Bio-Mobility™ platform of technologies envisions the use of bio-based feedstock and organic waste to produce low-carbon renewable transportation fuels for all modes of mobility, including surface, air, and marine, sustainable development necessitates mitigation of the enormous carbon emissions, and the concept of bio-mobility aids that.

Expertise in processing diverse bio-based feedstock by developing and deploying advanced bio-chemical technology to produce biofuels and bio-chemicals & materials is the foundation of modern-day industrial biotechnology. Bio-based feedstock can be divided into four categories: sugary, starchy, lignocellulosic, and industrial waste. Using advanced biochemical technology, processes that undergo rigorous development and trials on 'Flask – Bench – Pilot – Demonstration' scale en route to commercialisation. As a result, we have low-carbon biofuels in liquid and gaseous form, as well as renewable chemicals and materials.

Bioeconomy has a positive social, economic and environmental impact on a nation's growth endeavors. It helps combat the evils of climate change through sustainable decarbonisation and carbon recycling, helping curb Green House Gases emissions. Bio-processing plants are typically located in the proximity of farms in rural areas, thereby, creating employment and entrepreneurship opportunities for youth in the farming community.

Industry 5.0 perspectives

Industry 5.0 enablers include Big Data and the Internet

of Things (IoT), as well as sensor-equipped machines, to secure a deep understanding of the subject. Artificial Intelligence algorithms allow for making smart decisions. Deploying cobots ensures quality, precision, and productivity with higher customisation. Industry 5.0 generates new kinds of job opportunities such as creative and innovative thinking, technology interface, managing cobots, creating artificial algorithms, and many more, while Industry 5.0 offers some distinct opportunities, it also comes with a set of challenges.

Opportunities of Industry 5.0

1. Highly automated manufacturing systems provide greater opportunities for customisation to customers.
2. Optimisation of human efficiency by unleashing greater opportunities for creative people to come and work.
3. Machines are versatile according to employee needs to create a high-level output.
4. Deeper operator engagement in the planning – enhanced efficiency.
5. Liberty of 'design to function' and allows more tailor-made and personal products.
6. Feeding real-time market data enables sharper and better manufacturing practices.
7. Increased safety at the workplace, cobots take up dangerous works.
8. Increased customer satisfaction and loyalty due to more personalised products and services.
9. Positively impacts profit and market share due to

The enhanced version of Industry 5.0 blends the unique benefits of advancements in digital technologies and the bioeconomy



- increased customer loyalty and new customer acquisition based on referral.
- 10. Increased human-machine interaction expands the platform for research & development.
- 11. Quality services can be provided at the remote locations.

- 8. Business strategies in industry 5.0 demands a higher level of dynamism to sustain competition due to differential customer preferences.

Challenges of Industry 5.0

1. Increased work polarisation; extremely trained and qualified; low-paid and unqualified employees. This may alleviate the skilled and unskilled divide in society.
2. Skill development is a massive undertaking that includes training the workforce, implementing advanced and cutting-edge technologies, and inducing behavioural change in interactions.
3. Smart manufacturing systems necessitate greater autonomy deviations from existing systems, such as integrated decision-making.
4. There is an increased cybersecurity threat due to its increased connectivity and use of standard communications protocols.
5. Demands a huge amount of investment to fully implement all its pillars, which is difficult for the industry and especially the SMEs and start-ups to adopt.
6. Due to the high amount of automation presence, challenging to fix accountability.
7. Due to mass personalisation, business strategy will be focusing more on customer-centric operations. Customer subjectivity changes over time and it is difficult to change business strategies and business models frequently.

Profits, planet and people

The enhanced version of Industry 5.0, builds on the merits of both versions of Industry 5.0 as well as Society 5.0 since it blends the unique benefits of advancements in digital technologies and the bioeconomy.

Industry 5.0 can bring about positive change in society, the economy, as well as environment. This development aims to make humanity smart and reliant on technology, while at the same time making conscious lifestyle choices that are in harmony with the environment. It is socio-centric as it has tremendous potential for employment generation in rural areas, as well as for rural enterprise and mitigating the damaging impact of pollution on health. It can bridge the gap between internal demand and supply, fuel the rural economy, and generate foreign exchange for the nation. Besides, it is intrinsically geared to alleviate climate change and accomplish the goals for sustainable development as stated by the UN.

Industry 5.0 enhanced version, thus, presents a delicate equilibrium between the proverbial “Profits, Planet, and People” trio, with a special emphasis on inclusiveness. The threat of climate change is real, and the time for sustainable climate action is NOW! Industry 5.0 is the enhanced version that positively impacts the environment, economy, and society. It is just the right recipe for ensuring sustainable development. □