The Role of Engineers to Meet the Objectives of Sustainable Development Goals

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Abstract. The United Nations Sustainable Development Goals (SDGs) provide a global framework for ending poverty, protecting the planet, and ensuring prosperity for all by 2030. Engineers play a pivotal role in achieving these objectives by designing, building, and maintaining the products and systems that underpin modern society. This paper explores the contributions of engineers across multiple SDGs, including clean water and sanitation (SDG 6), affordable and clean energy (SDG 7), industry, innovation and infrastructure (SDG 9), sustainable cities and communities (SDG 11), climate action (SDG 13), good health and well-being (SDG 3), quality education (SDG 4), and responsible consumption and production (SDG 12). Special emphasis is placed on emerging technologies like energy-efficient heat pumps, renewable energy systems, and smart urban solutions. Also initiatives for climate change mitigation are covered as this is a major issue being faced in the world currently. The study highlights how engineers integrate innovation, resource efficiency, ethical practice, and cross-disciplinary collaboration to advance sustainable development. Future research should focus on adopting AI, IoT, and green technologies to further improve the impact of engineering on global sustainability.

Keywords: Sustainable Development Goals (SDGs); Engineers; role; products and systems, Renewable energy; Heat pumps; Smart cities; Climate action.

1 Introduction

The United Nations Sustainable Development Goals (SDGs), adopted in 2015, represent a universal call to action to end poverty, protect the planet, and ensure peace and prosperity for all by 2030. The 17 goals cover a wide range of global challenges, including clean water and sanitation, affordable and clean energy, sustainable cities, climate action, responsible consumption and production, good health, quality education, and innovation-driven economic growth (AZoCleantech, 2023; UN, 2025). These goals are interconnected and require collaboration among governments, industries, communities, and individuals. SDGs provide a framework for guiding policies, investments,

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ments, and technological innovations toward sustainable and equitable development. Achieving these goals requires the combined effort of governments, communities, industries, and professionals. Among these, engineers play a pivotal role, as they design, build, and maintain the systems and products that shape modern society.

Engineering, at its core, is about problem-solving. From providing safe drinking water to designing renewable energy systems and creating efficient transportation, engineers are uniquely positioned to develop innovative solutions to global challenges. The integration of sustainability into engineering practice ensures that technological progress aligns with ecological balance and social equity (Chen *et al.,* 2022).

World Engineering Day 2025 was celebrated on 4 March, under the theme "Unleashing the Power of Engineers to Advance the Sustainable Development Goals (SDGs)". This year's theme emphasizes how engineering innovations are essential to achieving the 17 SDGs by 2030, from clean water and sanitation to sustainable cities and climate action (UNESCO, 2023; UN, 2025). Engineers are being called upon to contribute to SDG 6 (Clean Water and Sanitation) by designing resilient water systems that can cope with scarcity, floods, and climate variability. With a growing urgency around climate change, engineering plays a major role in SDG 13 (Climate Action), helping to develop renewable energy systems, reduce emissions, and build more resilient infrastructure. The theme also spotlights SDG 9 (Industry, Innovation and Infrastructure), stressing the need for robust and sustainable infrastructure, plus innovation in materials and processes (Ramos *et al.,* 2024). Gender equality (SDG 5) is another priority, with the day addressing the underrepresentation of women in engineering and calling for more inclusive policies and educational environments. Engineering education and capacity building underpin SDG 4 (Quality Education), ensuring that future engineers are equipped with the skills to tackle sustainable development challenges. The theme encourages engineers to support SDG 11 (Sustainable Cities and Communities) by designing urban systems and infrastructure that are safe, resilient, and environmentally friendly. Through collaborative initiatives like Hackathons, public-private partnerships, and global knowledge exchange, the day reinforces SDG 17 (Partnerships for the Goals) (UNESCO, 2023). The World Engineering Day 2025 reminds us that engineering is not just about technical problem solving, but about shaping a future where all SDGs are advanced in a balanced, equitable, and sustainable way.

The contribution of engineers toward SDGs can be framed through the following key objectives:

- Innovation for Sustainability: Develop technologies and processes that reduce environmental impact, conserve resources, and support long-term ecological balance (Rivera *et al.,* 2020).
- Access and Inclusivity: Ensure that engineering solutions improve the quality of life for all people, especially marginalized communities, by addressing inequality in access to energy, healthcare, infrastructure, and education (Ramos *et al.,* 2024).
- Resilient Infrastructure: Design and maintain infrastructure that is durable, adaptable to climate change, and capable of withstanding disasters.

- Resource Efficiency: Promote circular economy practices by reducing waste, reusing materials, and enhancing energy efficiency.
- Ethical and Responsible Practice: Uphold professional ethics by prioritizing human well-being, environmental stewardship, and intergenerational equity in every engineering decision.

These objectives reflect the alignment of engineering practice with SDGs such as Goal 6 (Clean Water and Sanitation), Goal 7 (Affordable and Clean Energy), Goal 9 (Industry, Innovation, and Infrastructure), Goal 11 (Sustainable Cities and Communities), and Goal 13 (Climate Action). The Sustainable Development Goals are listed in Fig. 1.

Fig. 1. Sustainable Development Goals

The following sections illustrate and give details about how engineers can contribute in achieving the objectives of the relevant SDGs.

2 Affordable and Clean Energy (SDG 7)

Energy drives economic growth, health, education, and overall well-being. Yet nearly 700 million people in the world still lack electricity, while billions rely on polluting fuels for cooking. At the same time, dependence on fossil fuels accelerates climate change. The United Nations' Sustainable Development Goal 7 (SDG 7) seeks to ensure universal access to affordable, reliable, sustainable, and modern energy by 2030.

The challenge lies in expanding energy access while keeping it clean and cost-effective. Renewable energy offers a solution but requires overcoming issues of high capital

costs, intermittency, and the need for advanced storage and grid integration. These hurdles, however, create opportunities for innovation, green jobs, and sustainable development.

Mechanical, electrical, and civil engineers contribute to designing renewable energy systems such as solar panels, wind turbines, hydropower stations, and bioenergy plants. They also improve energy storage technologies and optimize distribution networks to ensure reliable and affordable energy for all.

Renewable sources form the backbone of clean energy. Solar power is versatile but requires storage to address night-time gaps. Wind energy is cost-effective in suitable locations, while offshore wind promises higher yields at greater investment. Geothermal provides continuous base-load power but is geographically limited. Hydropower, biomass, and ocean energy supplement the mix but need careful environmental management. For any renewable project, factors such as capital investment, availability and storage, and operation and maintenance must be considered. While upfront costs are high, technology developments and supportive policies make projects increasingly viable. Storage solutions like batteries, pumped hydro, or hydrogen are essential for stability, while efficient O&M (Operation and Maintenance) ensures long-term performance.

Equally important is energy efficiency, often described as the "first fuel." Reducing demand through efficient motors, HVAC) Heating, Ventilation and Air Conditioning) systems, insulation, lighting, electric vehicles, and smart grids can cut emissions, lower costs, and complement renewable generation. In conclusion, achieving SDG 7 requires a dual focus: expanding clean energy supply and improving efficiency. By harnessing renewables and reducing demand, societies can ensure reliable, affordable, and sustainable energy for all—paving the way for a greener and more equitable future.

3 Industry, innovation and Infrastructure (SDG 9)

Engineers are at the forefront of building sustainable infrastructure—roads, bridges, airports, and industrial plants—which need to be energy-efficient and climate-resilient. Through advancements in materials science and digital manufacturing, they help industries become more productive while reducing their carbon footprint.

Sustainable Development Goal 9 (SDG 9) focuses on building resilient infrastructure, promoting inclusive and sustainable industrialization, and fostering innovation. This goal is central to engineering, since almost every engineering discipline such as mechanical, civil, electrical, chemical, computer, and others directly contribute to industry, innovation, and infrastructure development (Okokpujie *et al.,* 2019). For engineers, SDG 9 represents both an opportunity and a challenge. Modern industries are no longer satisfied with conventional outputs; they demand solutions that are efficient, cost-effective, environmentally sustainable, and globally competitive. The expectations from engineers have therefore expanded: they must not only apply technical knowledge but also embrace problem-solving, creativity, digital tools, and teamwork across disciplines.

The requirements also vary depending on career paths. A production engineer may focus on improving efficiency and reducing waste; a project engineer must ensure timely and quality delivery of infrastructure; R&D engineers develop new products, materials, or technologies; while those in sales, marketing, or service act as the bridge between technical solutions and customer needs. Despite these different roles, the ultimate goal remains the same to support the growth, profitability, and sustainability of the organization (www.wfeo.org). By aligning with SDG 9, engineers contribute to economic growth while ensuring responsible use of resources and long-term resilience. They help industries adopt cleaner technologies, design smarter infrastructure, and foster innovation that addresses societal needs. In doing so, engineers not only advance their companies but also contribute to national development and global sustainability. SDG 9 places engineers at the heart of progress. Whether in production, projects, service, or R&D, their role is to combine technical excellence with innovation and responsibility (Rivera *et al.,* 2020), ensuring that industry and infrastructure evolve in ways that are profitable, resilient, and sustainable.

4 Sustainable Cities and Communities (SDG 11)

Sustainable Development Goal 11 (SDG 11) focuses on making cities inclusive, safe, resilient, and sustainable. In India, rapid urbanization is reshaping society. A significant portion of the population is moving to cities, and even Tier 2 and Tier 3 cities are expanding rapidly. This growth creates both opportunities and challenges in terms of infrastructure, transport, housing, and environmental quality. One of the major requirements of sustainable cities is well-planned infrastructure. Roads, bridges, drainage systems, and public transport networks must be designed to handle growing population efficiently and safely. Reliable, affordable, and eco-friendly public transport reduces congestion, pollution, and dependence on private vehicles.

Urban planners and engineers design smart cities with efficient transportation systems, sustainable housing, and eco-friendly construction materials. Concepts such as green buildings, waste-to-energy plants, and intelligent traffic management systems directly support more liveable and sustainable urban environments.

5 Climate Action (SDG 13)

Climate change is one of the most pressing challenges of our time, threatening ecosystems, economies, and human well-being. Rising global temperatures, extreme weather events, melting glaciers, and sea-level rise are stark reminders of the urgent need for action. The Paris Agreement sets a global target to limit temperature rise to well below 2°C, with efforts to keep it under 1.5°C. Achieving this requires a dramatic reduction in greenhouse gas (GHG) emissions and a shift toward low-carbon development pathways. The challenge, however, is multi-dimensional. Technological solutions such as renewable energy, carbon capture, electric mobility, and green buildings must be rapidly scaled up. At the same time, social awareness and behavioural change—such as energy conservation and sustainable consumption—are equally vital.

Energy transition demands significant investment in clean technologies and fair mechanisms to support workers and industries in moving away from fossil fuels. Furthermore, political commitment is essential to create policies, regulations, and global cooperation that can drive large-scale climate action. Engineers, innovators, policymakers, and communities all have a role to play. By combining technology, awareness, investment, and governance, the world can work collectively toward mitigating climate change and building resilience. SDG 13 thus calls for urgent, united, and sustained action.

Engineers design technologies for carbon capture, renewable integration, and low-emission vehicles. They also assess climate risks in infrastructure projects and propose solutions to mitigate greenhouse gas emissions. Their role extends to disaster risk reduction through resilient designs that protect communities from floods, storms, and heatwaves.

5.1 Climate Change mitigation

Climate change mitigation demands a holistic approach that integrates multiple strategies across energy, industry, transport, and urban systems. This can be done by accelerating the deployment of renewable energy, promoting net-zero buildings, and adopting efficient technologies like heat pumps and electric vehicles (Meyer *et al.,* 2024). Nature-based solutions such as afforestation, alongside advanced measures like carbon capture and the development of green hydrogen, further strengthen decarbonization efforts. Enhancing energy efficiency and addressing Scope 3 emissions ensures that both direct and indirect impacts are minimized throughout the value chain. Moreover, thoughtful urban planning that reduces the heat island effect contributes to sustainable and resilient cities. Together, these initiatives directly support several Sustainable Development Goals—especially SDG 7 (Affordable and Clean Energy), SDG 11 (Sustainable Cities and Communities), SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action), and SDG 15 (Life on Land)—and pave the way toward a low-carbon, sustainable future. Following is a brief review of various initiatives and related SDG's:

- Renewable energy (SDG 7 & 13): Expanding solar, wind, and other renewable sources reduces reliance on fossil fuels and lowers greenhouse gas emissions.
- Net Zero Buildings (SDG 11 & 13): Designing energy-efficient buildings with zero operational emissions helps create sustainable cities and combat climate change.
- Afforestation (SDG 15 & 13): Planting and restoring forests enhances carbon sequestration and strengthens ecosystem resilience against climate impacts.
- Carbon Capture, Utilization and Storage (CCUS) (SDG 9 & 13): CCUS technologies capture CO_2 from industrial sources and store or reuse it, significantly cutting atmospheric emissions.
- Green Hydrogen (SDG 7 & 13): Producing hydrogen from renewable energy offers a clean fuel alternative, supporting deep decarbonization across sectors.
- Energy Efficiency Improvement (SDG 7 & 13): Enhancing energy efficiency in homes and industries reduces energy demand and emissions while lowering costs.

- Heat Pumps (SDG 9 & 13): Adopting heat pump technology improves heating efficiency, cutting energy use and emissions in buildings (Shamoushaki and Koh, 2023).
- Heat pumps are emerging as a key technology in the transition to sustainable energy systems. By transferring heat rather than generating it through combustion, heat pumps provide high energy efficiency, often delivering three to four units of heat for every unit of electricity consumed. This makes them vital in reducing dependence on fossil fuels for heating and cooling, directly supporting SDG 7 (Affordable and Clean Energy) and SDG 13 (Climate Action). In residential, commercial, and industrial sectors, heat pumps can replace conventional boilers, reduce greenhouse gas emissions, and cut operating costs. Their application extends beyond space heating and cooling to water heating, drying, and even integration with renewable energy sources such as solar or wind. When paired with smart grids, heat pumps can also support SDG 11 (Sustainable Cities and Communities) by enhancing energy resilience and reducing peak demand (Meyer *et al.,* 2024).
- The challenges include higher initial capital costs, the need for skilled technicians, and performance variations in extreme climates. However, continuous innovations, policy incentives, and wider adoption are making heat pumps more accessible and cost-competitive. Thus, heat pumps not only offer technical efficiency but also play a strategic role in achieving sustainability, decarbonization, and energy security in line with global development goals.
- EVs/Hybrid Vehicles (SDG 11 & 13): Transitioning to electric and hybrid vehicles reduces dependence on fossil fuels and lowers transportation-related emissions.
- Reducing Scope 3 Emissions (SDG 12 & 13): Addressing indirect emissions across the value chain helps companies achieve comprehensive climate goals.
- Urban Planning to Reduce Heat Island Effect (SDG 11 & 13): Sustainable city planning with green spaces, reflective materials, and better airflow mitigates urban heat and lowers cooling energy demand.

6 Quality Education (SDG 4)

Engineers not only apply technology but also share knowledge, mentor young professionals, and collaborate across borders. International partnerships, open-source innovations, and cross-disciplinary research expand the impact of engineering for sustainable development.

Sustainable Development Goal 4 (SDG 4) emphasizes ensuring inclusive and equitable quality education and promoting lifelong learning opportunities for all. Education forms the foundation of sustainable development, equipping young minds with the skills and knowledge to shape a better future. While university students focus on specialized fields such as Mechanical or Automobile Engineering, it is equally important to share fundamental science and mathematics knowledge with school students, strengthening their basics and sparking curiosity.

Indian Society for Heating, Refrigerating, and Air-conditioning Engineers (ISHRAE) is a professional society working in the HVAC&R field. Under the ISHRAE

K-12 programme, engineering students and professionals actively engage with school children to simplify concepts of energy, environment, air conditioning, and related sciences. By presenting these topics in an interactive and practical way, they help younger students understand how science connects with daily life. This initiative not only promotes STEM (Science, Technology, Engineering and Mathematics) education but also inspires students to pursue careers in engineering and technology. Such outreach creates a multiplier effect. School students gain exposure to real-world applications, while engineering students develop communication, mentoring, and leadership skills. Together, these activities bridge the gap between theoretical learning and practical understanding. In essence, SDG 4 reminds us that quality education is not confined to classrooms—it thrives when knowledge is shared across age groups, ensuring that future generations are better equipped for sustainable progress.

7 Responsible Consumption and Production (SDG 12)

Mechanical and production engineers develop manufacturing systems that minimize waste and promote recycling. By integrating life cycle assessment into product design, engineers help industries transition to circular economy models. Sustainable Development Goal 12 (SDG 12) focuses on ensuring sustainable consumption and production patterns. In industrial operations, engineers play a critical role in implementing these principles, as the way raw materials, components, and energy are utilized directly impacts resource efficiency, environmental sustainability, and product quality. In most industries, input materials form the backbone of production. Conservative and optimized use of these resources reduces wastage, lowers costs, and minimizes environmental impact. For instance, mechanical engineers can design processes that maximize material utilization, while quality engineers ensure that products meet stringent standards, reducing the need for rework or scrap. Production engineers and managers can implement lean manufacturing, just-in-time inventory, and recycling strategies to enhance efficiency and reduce resource consumption.

Responsible consumption also extends to energy and water usage, packaging materials, and supply chain practices. By adopting sustainable practices, industries can produce high-quality products for customers while minimizing their ecological footprint. SDG 12 emphasizes that sustainability in production is not optional—it is a responsibility. Engineers, through careful planning, process optimization, and innovation, ensure that industries consume resources wisely, produce efficiently, and contribute to a more sustainable and environmentally responsible future.

8 8. Other SDG's

Apart from the key SDGs listed above in which engineers play an important role, there are other SDGs also which need engineers' involvement in designing, manufacturing and maintaining systems. The following are two of these SDGs.

8.1 Good Health and Well-being (SDG 3)

In hospitals and healthcare facilities, engineers ensure safe infrastructure by designing efficient HVAC systems, sterilization units, and wastewater treatment to minimize infection risks. Biomedical engineers innovate life-saving devices such as ventilators, diagnostic equipment, and prosthetics, enhancing both treatment and patient care. The rise of robotic surgery highlights another engineering frontier. Robotics, control systems, and AI integration allow surgeons to perform highly precise, minimally invasive procedures, reducing recovery time and improving patient outcomes. Thus, while doctors and nurses remain the frontline of healthcare, engineers form the backbone of the systems, tools, and environments that make modern medicine possible. By driving innovation, ensuring safety, and enabling accessibility, engineers contribute significantly to SDG 3; Good Health and Well-being, making healthcare more effective, equitable, and resilient. Biomedical engineers innovate in medical devices, prosthetics, and healthcare equipment. Civil engineers design hospitals with efficient layouts and safe water systems, while mechanical engineers work on climate control systems to ensure hygienic conditions.

8.2 Clean Water and Sanitation (SDG 6):

Engineers develop water treatment plants, efficient irrigation systems, and wastewater recycling technologies. By innovating in desalination, rainwater harvesting, and smart water management systems, they ensure safe and sustainable water supply for both urban and rural populations.

9 Conclusions and Future Scope

Engineers play a pivotal role in achieving the United Nations Sustainable Development Goals, as their expertise shapes the infrastructure, technologies, and systems that underpin society. From ensuring clean water and sanitation (SDG 6) to promoting renewable energy (SDG 7), building resilient industries and infrastructure (SDG 9), designing sustainable cities (SDG 11), and mitigating climate change (SDG 13), engineers contribute across a broad spectrum of development priorities. Beyond technical solutions, engineers also enhance healthcare, education, and responsible production, demonstrating the interdisciplinary impact of engineering on global well-being.

Future research should focus on integrating emerging technologies—such as AI, IoT, green materials, and energy-efficient systems—into sustainable engineering practices. Collaborative, cross-disciplinary approaches and real-world pilot projects can accelerate innovation while addressing social, economic, and environmental challenges. By emphasizing sustainability, resilience, and ethical responsibility, engineers can continue to drive transformative solutions that advance SDGs, ensuring a more equitable, low-carbon, and sustainable future for all.

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