



United Nations
Educational, Scientific and
Cultural Organization



Engineering for Sustainable Development

EXECUTIVE SUMMARY



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Educational, Scientific and
Cultural Organization

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under the auspices of UNESCO

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Engineering for Sustainable Development

● Delivering on the Sustainable Development Goals

SHORT SUMMARY

Engineering the SDGs

The report highlights the crucial role of engineering in achieving each of the 17 SDGs. It shows how equal opportunities for all are key to ensuring an inclusive and gender-balanced profession that can better respond to the shortage of engineers for implementing the SDGs. It provides a snapshot of the engineering innovations that are shaping our world, especially emerging technologies such as big data and AI, which are crucial for addressing the pressing challenges facing humankind and the planet. It analyses the transformation of engineering education and capacity-building at the dawn of the Fourth Industrial Revolution that will enable engineers to tackle the challenges ahead. It highlights the global effort needed to address the specific regional disparities, while summarizing the trends of engineering across the different regions of the world.

By presenting case studies and approaches, as well as possible solutions, the report reveals why engineering is crucial for sustainable development and why the role of engineers is vital in addressing basic human needs such as alleviating poverty, supplying clean water and energy, responding to natural disasters, constructing resilient infrastructure and bridging the development divide, among many other actions, leaving no one behind.

It is hoped that the report will serve as a reference for governments, engineering organizations, academia and educational institutions, and industry to forge global partnerships and catalyse collaboration in engineering so as to deliver on the SDGs.

It is essential
that more young people,
especially **girls**,
consider
engineering
as a career



'Since wars begin in the minds of men and women it is in the minds of men and women that the defences of peace must be constructed.'



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A new engineering report

Engineering is about the knowledge and practice of solving problems. Engineers as a profession play a vital role in addressing basic human needs, alleviating poverty, promoting secure and sustainable development, responding to emergency situations, reconstructing infrastructure, bridging the knowledge divide and promoting intercultural cooperation. They connect social needs with appropriate technological innovation and commercial applications. As such, engineering is a major driver for sustainable socio-economic development. It has contributed

to our ability to survive disasters and public health challenges, to secure food and water, to communicate and transport, and to innovate and create new products and services. Wherever there is a problem, there is a need for engineering solutions.

Why the need for a second UNESCO Engineering Report? It has been a decade since the first landmark report was published, which was widely recognized as one of the most important documents available on engineering, highlighting both the importance of the engineering profession and how engineers build a better world. It raised considerable public interest and became one of the most downloaded reports on UNESCO's website. While some fundamental features of the engineers' mission and responsibility remain, times have changed markedly in the ten years since its publication.

The 2030 Agenda for Sustainable Development presents a blueprint for action, and engineers are now at the forefront to deliver on the Sustainable Development Goals using their scientific knowledge and experience to turn innovative ideas into sustainability projects for the benefit of all. The unprecedented situation presented by the COVID-19 pandemic has revealed the interconnected nature of societies and how scientific innovations, through the effective implementation of engineering, can increase resilience. At the same time, technologies are fast evolving and offer promising perspectives, but they should also be assessed in view of the new risks presented from an ethical standpoint.

Ultimately, the engineering profession itself needs to be reshaped to address today's pressing issues and to promote a sense of global responsibility towards achieving the necessary innovations. This new report attempts to provide an all-important overview of the profession's new challenges as well as the cutting-edge innovations of some key technological areas of engineering.

Another key challenge is to raise awareness among governments and civil society of the important role of engineering for economic development and for advancing the 2030 Agenda. World Engineering Day for Sustainable Development is now celebrated annually on 4 March and provides an opportunity to mark the achievements of engineers and the contributions of engineering to making a better world.



Engineering and the UN Sustainable Development Goals (SDGs)

SDG 1



Engineering can address extreme urban poverty.
© Marlene Kanga

How engineering can make it happen

Engineering drives economic growth and alleviates poverty through basic infrastructure such as roads, railways and telecommunications. However, much engineering work remains to be done to develop technologies that improve access to basic services such as clean water and sanitation, reliable energy and clean cooking fuels. Large populations in low-income countries are demanding access to the latest technologies for communication, education and health. Frugal innovation enables the development of affordable and reliable technologies that are accessible to all.



SDG 2



Engineered mechanization of farming for food production in India. © Marlene Kanga

How engineering can make it happen

Agricultural, mechanical and chemical engineers have engineered mechanization for agriculture and food production, and increased productivity through the use of fertilizers and pesticides. Ongoing innovations by electronics and agricultural engineers include sensors for soil moisture and condition monitoring that optimize delivery of scarce water and fertilizers. Other innovations include robotics for the application of pesticides and fertilizers, weeding and planting, and communications technology for weather monitoring, forecasting and natural disaster warning, all of which are crucial to achieving global food security.



SDG 3



Artificial Intelligence camera vision for COVID-19 fever detection in crowds. © Marlene Kanga

How engineering can make it happen

Engineering has been crucial during the COVID-19 pandemic with advanced technologies deployed, for example, in the search for a vaccine, through advanced manufacturing processes, logistics and transportation systems, and in 3D-printing for personal protective equipment. Engineering has eradicated diseases such as typhoid and cholera through clean water and sanitation. Biomedical engineering has developed medical devices for limbs, and improvements have been made in hearing, heart health and brain functioning. Robotics, computer vision and Artificial Intelligence (AI) are revolutionizing diagnosis, detection and surgical procedures, and improving accessibility for low-income countries.



SDG 4

Young engineers learning about engineering and sustainable development. © WFEO

How engineering can make it happen

Engineers facilitate the delivery of education at primary, secondary and tertiary levels by employing new technologies, such as online learning tools and rapid communication systems. These improve accessibility and reduce costs for students. Wi-Fi is implemented in more than 40 billion devices worldwide, underpinning advances in education and enabling other applications. Software and telecommunication engineers are fast expanding access to the internet through low-cost satellites and other aerial devices to deliver information and services to remote and low-income communities.

4 QUALITY EDUCATION**SDG 5**

Women engineers working on high voltage electrical systems. © Chinese Society for Electrical Engineering

How engineering can make it happen

Ensuring women's access to technology and engineering will close many gender gaps, ensuring that women benefit from and participate in the technology revolution, which is critical to achieving the SDGs. Diversity of thought is vital for innovation and the development of solutions that reflect community standards, values and aspirations. New technologies developed by engineers are increasingly empowering female users in work and entrepreneurship, including mobile communications and the internet, which facilitate women's access to banking and financial and information services.

5 GENDER EQUALITY**SDG 6**

Advanced engineering technologies using laser scanning for monitoring the Cahora Bassa Dam, Mozambique, one of the largest dams in the world.

© Antonio Berberan, Eliane Portela and João Boavida

How engineering can make it happen

Civil and environmental engineers have saved millions of lives through clean water and sewage treatment systems, eradicating waterborne diseases like cholera and typhoid. Every day, electrical and mechanical engineers ensure reliable system operations. Innovations in water treatment and recycling ensure clean water for all, even in arid zones. Despite these advances, more than 1 billion people still lack access to clean water and 2 billion have no access to basic sanitation. Urgent action, including by engineers, is required to address this challenge.

6 CLEAN WATER AND SANITATION

SDG 7

7 AFFORDABLE AND CLEAN ENERGY



How engineering can make it happen

Engineering has been essential for the generation and supply of electricity, which is vital for economic growth and better living standards. Yet nearly 1 billion people, predominantly in sub-Saharan Africa and South Asia, still lack access to a reliable source of electricity, the provision of which is a key task for engineers. Electrical, mechanical and environmental engineers have been central to the development of low-cost, zero carbon, renewable energy solutions, including wind, solar, wave and geothermal energy, making energy accessible in remote regions, while mitigating the impacts of climate change.

Engineers are essential for designing, building and maintaining power infrastructure. © Chinese Society for Electrical Engineering

SDG 8

8 DECENT WORK AND ECONOMIC GROWTH



How engineering can make it happen

Engineering is now recognized as an essential enabler of economic growth, evidenced by the positive relationship between economic growth and the number of engineers in a country. Roads, railways, airports, telecommunications, and the supply of water and electricity are essential infrastructure underpinning all economies. This infrastructure is designed, developed and maintained by civil, mechanical, electrical and environmental engineers. Engineers are also responsible for such basic amenities as clean water, energy and housing, enabling citizens to maintain healthy and therefore productive lives, and to engage in decent work.

Transport engineering is essential for economic growth and for sustainable cities. © Marlene Kanga

SDG 9

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE



How engineering can make it happen

A modern economy cannot exist without engineering. Engineers design, build and maintain infrastructure. Roads, ports, railways, communications, water supply and energy systems are the work of civil, mechanical and electrical engineers. Industry needs engineers in sectors such as mining, petroleum, chemicals and food processing, and all manufacturing is underpinned by mechanical, electrical, chemical and environmental engineers. Engineering innovations in AI, robotics, cloud computing and big data will drive future economic growth and employment.

Students developing innovations in chemical process engineering. © Technische Hochschule Georg Agricola (THGA)

SDG 10



Engineering generates work and incomes.
© Ingénieurs et Scientifiques de France

How engineering can make it happen

Through sustainable infrastructure and new technologies and innovations, engineers and engineering create jobs and opportunities, enabling access to housing, food, health and a decent living, all of which are crucial to reducing inequalities. Ensuring access to low-cost communications and mobile phones, information and education, medical diagnostics and treatment, especially in low-income countries, is also essential to addressing basic needs. Technologies that empower women to increase their participation in the workforce and that address chronic gender-based economic inequalities are being developed by engineers.

10 REDUCED INEQUALITIES



SDG 11



Engineering infrastructure, such as this underground metro tunnel, is essential for sustainable development. © Mr Pung Chun Nok, Hong Kong Institution of Engineers

How engineering can make it happen

Civil, structural, electrical, mechanical, environmental, software and telecommunications engineers are contributing to safe, inclusive and resilient cities, facilitating access to affordable housing and public transport, clean air, water and energy, as well as the protection of natural and cultural heritage assets and greater resilience against natural disasters. Advanced engineering technologies are used in energy and resource efficient buildings, smart city lighting, efficient transportation systems, renewable energy sources, integrated water resource management, geospatial engineering, Building Information Modelling and data analytics, making cities more livable and sustainable.

11 SUSTAINABLE CITIES AND COMMUNITIES



SDG 12



Biogas from treated sewage used to generate electricity at North Head Wastewater Treatment Plant, Sydney, Australia. © Marlene Kanga

How engineering can make it happen

Mining, civil, mechanical, electrical and environmental engineers play critical roles in managing the Earth's resources efficiently through processing essential minerals, generating energy from renewable resources, using water resources sustainably, supporting agricultural production and managing biodiversity. Engineering innovations support resource management and responsible consumption through the 'circular economy' where outputs and products can become inputs into other processes and products. Innovations to recycle or reuse waste materials, including plastics, are being developed by materials and chemical engineers.

12 RESPONSIBLE CONSUMPTION AND PRODUCTION



SDG 13

13 CLIMATE ACTION



The impacts of climate change, caused intense bush fires and smoke haze over Sydney, January 2020.
© Marlene Kanga

How engineering can make it happen

Engineering enables climate change action. Engineered renewable energy sources with zero carbon emissions include hydroelectric, solar, wind and wave power, with green hydrogen facilitating energy storage at low cost. Resilient infrastructure addresses the escalating impacts of natural disasters including cyclones and floods. Greenhouse gas reductions through carbon capture, the transformation of waste bio-solids into energy, and timber building from rapid growth forests are other established actions. Other fast-evolving technologies to absorb carbon dioxide include the chemical processing of carbon from air to re-use as chemical feedstock and the use of low carbon building materials for housing.

SDG 14

14 LIFE BELOW WATER



Engineering is needed to protect against rising sea levels and increasing beach erosion in coastal communities. © Marlene Kanga

How engineering can make it happen

Engineers have a vital role in preserving and protecting oceans and seas, and the life within them. Marine engineers are working with scientists and other engineering disciplines to address the degradation of fisheries, the pollution of oceans and the use of resources, including wave energy. Engineers are addressing solutions such as plastic pollution in oceans and managing ocean assets such as the Great Barrier Reef that are threatened by the impacts of climate change.

SDG 15

15 LIFE ON LAND



Geo-engineering innovation is essential for discovering and protecting the Earth's resources.
© Technische Hochschule Georg Agricola (THGA)

How engineering can make it happen

Environmental engineers are managing biodiversity through the responsible use of forestry resources and the preservation of habitats. Innovative technologies map the Earth's surface to provide geospatial information for agricultural monitoring and infrastructure design, and to predict natural disasters like earthquakes. These technologies are assisting Indigenous and disadvantaged groups to enhance their capacity to map, analyse and negotiate for sustainable development while protecting natural forests. Sensor and drone technologies can map forests and identify diminishing animal populations. DNA sequencing and microchips are used to track endangered species.

Engineering has always transformed the world for the better. It is as relevant and urgent as ever, and more engineers with the right skills are needed

1



The foremost problem facing the world today is how to reconcile human development with preserving the planet. In this context, engineering has a central role to play in ‘Engineering a more sustainable world’, as described in Chapter 1. This chapter outlines the key role of engineering and engineers in advancing each of the 17 Sustainable Development Goals (SDGs). It reflects on how engineers have transformed our world for millennia, from the invention of the first stone tools and simple devices, such as the pulley and lever in ancient times, to the development of the steam engine that led to the First Industrial Revolution, and the remarkable changes that are happening now at the dawn of the Fourth Industrial Revolution, including the application of advanced Artificial Intelligence (AI) and biomedical engineering technology to improve people’s lives and production processes.

Chapter 1 also highlights the gaps between current engineering capacity and the requirements for achieving the SDGs, as well as calls for closer collaboration between governments, industry, education and research institutes, civil society and the engineering community, to ensure that more engineers have the right skills to respond to the call for a more sustainable world. Demand for engineers around the world is high, whether in developed countries in the fields of high technology, software, AI and telecommunications, or in developing countries that also require basic infrastructure, transport systems, and energy and water supply networks. It is also crucial that engineering education meets the current and future needs of employers, especially to keep pace with rapidly changing technologies and the emergence of new disciplines. Government, engineering educators and professional engineering institutions need to work together to ensure that the standards of engineering education address the SDGs, and that more young people, especially girls, consider engineering as a career.

Engineering itself needs to transform to become more innovative, inclusive, cooperative and responsible

2



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The essence of sustainability is to leave no one behind. Engineers therefore need to reassess their professional practice and social standards in order to provide 'Equal opportunities for all' – the subject of Chapter 2 – which are fundamental to solving the problems of unsustainability and to transforming our world for the better.

Chapter 2 presents the importance of diversity and inclusiveness in engineering so as to ensure that sufficient numbers of engineers representing different viewpoints and backgrounds are attracted to the profession. A diverse engineering workforce can more effectively address the SDGs by providing creative solutions that are relevant and inclusive, and avoid bias and discrimination, while at the same time leaving no one behind. This chapter provides a comprehensive look at this issue with an emphasis on women and young engineers.

Thanks to the joint efforts of engineering organizations, governments and educational institutions, among others, significant progress has been achieved, but the process remains imbalanced. Much more needs to be done to further improve diversity and inclusiveness in the engineering profession, which requires a more interdisciplinary approach and a more inclusive mindset. The engineering community must strengthen its collaboration with multiple sectors of society to address the SDG challenges in a more balanced and holistic way, while ensuring that progress made against one goal is simultaneously balanced with respect to the others.

Engineering innovations are crucial to achieving the Sustainable Development Goals

3



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While the range of engineering innovations is vast, Chapter 3 provides some selected areas of engineering that show how innovation associated with emerging technologies can address key challenges and help achieve the SDGs. Areas of work include the COVID-19 pandemic, clean water and sanitation, as well as issues related to hydraulic engineering, climate emergencies and natural disasters, clean energy and mining engineering, and leveraging emerging technologies such as big data, AI and smart cities for sustainable development. These engineering solutions do not solely concern technological means, they are also linked to ethical codes, norms and standards to ensure that engineering practices are conducted responsibly. It is also worth noting that UNESCO's Engineering Programme and Category 1 and 2 Centres under the auspices of UNESCO, such as ICEE,¹ ISTIC,² UCPBL³ and others, play a particularly vital role in promoting engineering innovations for the SDGs.

Engineering to combat COVID-19 and improve healthcare

Engineers are actively engaged in the fight against COVID-19 through the use of advanced technologies, which include diagnostic and therapeutic medical devices, information and communication technologies (ICTs), Internet of Medical Things (IoMT), AI, robotics and additive manufacturing. These efforts have hastened the ability to quickly and accurately detect viral infection and have made available a number of complex life support devices, such as ventilators, and imaging and monitoring devices, as well as efficient isolation, contact tracing and the analysis of big data, which offers timely assistance within the healthcare ecosystem.

¹ International Centre of Engineering Education, Tsinghua University, China.

² The International Science, Technology and Innovation Centre, Malaysia.

³ The UICEE Centre for Problem-Based Learning, Aalborg University, Denmark.

Many biomedical engineers are presently focused on mitigating the pandemic. However, the overall aim is to improve healthcare and achieve the SDGs by implementing technological advances to help the swift diagnosis, treatment and rehabilitation of patients, while achieving greater accuracy at lower cost for the well-being of all.

Water engineering for sustainable development

Water, as a prerequisite for life, assumes a special focus in terms of sustainable development. Global water problems, including droughts and floods, pollution caused by natural and anthropogenic-driven events such as extreme rains, rising sea and river levels, bushfires and untreated domestic and industrial effluents, are key challenges globally which require adequate and efficient management in order to meet the growing demand for clean water.

The close relationship between human health and the well-being of communities with access to clean water is a determining factor for the economic and social development of society. Despite the fact that the right to safe and clean drinking water and sanitation was recognized as a human right by the United Nations in 2010, there are still major challenges to ensuring full implementation, especially in less developed countries. Today, clean water has gained unprecedented focus in public policy in an effort to contain the spread of COVID-19. Historically, civil and environmental engineers have played a prominent role

in the design and construction of large infrastructure projects that provided clean water and adequate sanitation systems. Significant progress in water and environmental engineering in past decades has led to the development of new and more efficient water technologies, such as advanced oxidation, adsorption, reverse osmosis, and nano- and ultra-membrane filtration used to remove priority substances in advanced water treatment. In addition, innovations in engineering disciplines, such as aerospace, satellite, electronic and computer engineering, and remote-sensing technologies, have contributed to identifying trends in the water cycle that are of paramount importance for the comprehensive assessment of quantitative and qualitative water-related impacts of climate change.

The hydrological changes induced by climate change will present challenges for the sustainable management of water resources. Such resources are already under severe pressure in many regions of the world, and these challenges will further aggravate the situation in regions already experiencing water stress and will generate water stress in regions where water resources are still abundant today. The science of hydrology provides practical knowledge and information about the fluxes, transport and management of water, which are inextricably linked to engineering applications. In the four decades after 1930, the development of hydrological science as a separate field of scientific inquiry coincided with an enormous increase in engineered water infrastructure development. Furthermore, the rapid increase in hydro-infrastructure development triggered engineering applications across the globe, meaning that hydrology and engineering essentially developed in tandem.

Engineering for climate emergencies and disaster risk reduction

The design, construction and management of infrastructure must be adapted to address climate-related challenges and to support the implementation of adaptive or remedial actions. The updating of national codes, standards and guidelines, and enhanced climate services provide the pathway for engineers to address risks to infrastructure associated with the changing climate.

Countries can identify, understand and manage climate change risks by prioritizing adaptation planning and actions, including by implementing operational and maintenance procedures that extend the life of infrastructures at critical risk of failure. UNESCO plays a vital role in building a global culture of resilience, operating at the interface between natural and social sciences, education, culture and communication, and assisting countries in capacity-building for disaster management and climate risk.



Engineering for clean and affordable energy

Sustainable energy is essential to address the challenges posed by climate change and sustainable development. Energy is inextricably linked to transitions in our societies and economies, whether in terms of lifestyle, food or transport, and it is also at the heart of the transformation of production systems that includes the development of low carbon energy sources. In this regard, the COVID-19 pandemic has placed a spotlight on the importance of inclusive and resilient energy systems.

Sustainable mining technologies for the future

Mining can contribute positively to the realization of the 17 SDGs, but to achieve this, the industry has to re-invent itself. During the past 30 years, a wide variety of visions, objectives, methods, technologies, processes and other measures have been developed to improve the application of sustainable mining activities.



Big data, Artificial Intelligence and smart cities

The availability of large amounts of heterogeneous data from multiple sources has grown in an exponential manner, making it imperative to formulate strategies and develop processes and algorithms, such as AI, to efficiently analyse large datasets, opening up new opportunities for researchers, engineers and entrepreneurs across a wide variety of domains. Big data systems incorporate multiple evolving technologies and skillsets that include domain knowledge, data analysis, statistical knowledge



and advanced data visualization skills. The transformative potential of big data in healthcare, public sector administration, retail, manufacturing and daily life has been widely accepted.

For engineers, the outcomes of big data analytics will be especially relevant in domains such as predictive and preventive maintenance, and in product and structural design, among other areas, leading to more efficient project management and greater cost effectiveness in the context of sustainable development. However, the tremendous potential of big data can only be unleashed by relevant AI technologies. These constitute the core of the Fourth Industrial Revolution, impacting all aspects of economic and social development, from advanced manufacturing, energy supply, transportation, healthcare, education and agriculture to different kinds of commerce, social services and household functions. AI and big data can empower engineering for SDGs, but there are also negative consequences in terms of privacy and security, among other things. It is therefore the responsibility of engineers to exercise responsible conduct when dealing with AI and big data for the benefit of all people and the planet.

Big data and AI should work in tandem to help build more resilient communities and cities around the world, which face the daunting challenges of growing congestion, worsening air quality, insufficient availability of water, lack of proper waste disposal and management, public health concerns, increased crime rates, and so on. The application of smart technologies is changing the nature and economics of the infrastructure required to deal with these urban challenges. This also opens up enormous opportunities for future engineers and technologists to create new ideas to implement cost-effective applications in the broad and comprehensive development of cities, while improving the quality of urban life. The United Nations *Global Sustainable Development Report 2019* also identifies urban development as an essential entry point for the integrated implementation of the SDGs.

Engineering education and capacity-building as the key to enabling engineering to achieve the SDGs

4



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Despite the social and economic importance of engineers, there is increasing concern that declining enrolment in engineering studies will have consequences for future development. The UNESCO Engineering Initiative is addressing this concern through its partnerships with professional engineering societies such as WFEO, and those with an educational focus, as well as industries and civil societies to promote ‘Engineering education and capacity-building’, the subject of Chapter 4. This chapter sets out the need to build a global standards framework. It explains how capacity-building in engineering is a continuous process, starting in school, proceeding through higher learning with formal programmes, and then continuing through the entire professional career of an engineer, technologist or technician through the lens of lifelong professional development in order to keep pace with the rapid growth in knowledge and attendant skills.

Training engineers for the implementation of the SDGs requires not only new competencies, including creative learning and thinking, complex problem-solving, interdisciplinary and international cooperation, and a code of ethics, it also demands a change in engineering education itself. It necessitates a shift from today’s academic, technical, knowledge-focused path to a

much broader interdisciplinary approach to learning, and from a teacher-centric focus to one that is more student-centred and problem-based. It will require building a structured approach, with its related quality assurance and accreditation, in order to promote lifelong learning and professional development.

Periodic reviews of graduates’ attributes and professional competencies involving multiple stakeholders will help guide engineering education to meet the changing demands of sustainable development, while a global system of accreditation is needed to help ensure sufficient numbers of high-quality engineers are trained to carry out engineering practices to implement the SDGs – and to help engineers work across national boundaries. Continual professional development can play a fundamental role in adapting engineers to technological innovations and new working methods that better fulfil the engineer’s commitment to society. In this regard, professional certification systems are of paramount importance, recognizing engineering qualifications and professional competences worldwide by establishing a set of minimum requirements of knowledge, skills and competences for the engineering profession of the future.

Fostering engineering development in the regions

5



Guided by the 2030 Agenda for Sustainable Development, engineers worldwide have taken great strides to promote the SDGs and to enhance engineering capacity towards their achievement. Chapter 5, 'Regional trends in engineering' provides an overview of how interregional cooperation has facilitated progress towards achieving the SDGs, and analyses the trends of engineering development within the different regional contexts. It demonstrates how engineering is indeed an enabler for regional development.

However, significant gaps remain between the progress made and the targets set by the 2030 Agenda to which UN Member States have committed. Looking at these gaps, it is evident that one prominent cause is lack of engineering capacity, as well as international, interdisciplinary and intersectoral cooperation for engineering development, among many others.

The world must overcome a large number of challenges if it is to meet the SDGs by 2030, the most serious of which concerns the imbalance in development between the different regions. This situation emphasizes the need for greater global partnership in building engineering capacity, especially in developing countries. This report recognizes the challenges to achieve equitable engineering development worldwide across different regions, and highlights the importance of interregional partnership, as stated in the 2030 Agenda for Sustainable Development, in order to enhance 'North-South, South-South and triangular regional and international cooperation on access to science, technology and innovation', 'knowledge sharing on mutually agreed terms, including through improved coordination among existing mechanisms', and 'international support for implementing effective and targeted capacity building in developing countries to support national plans to implement all sustainable development goals'.

Conclusion

As COVID-19 continues to spread across the world, the pandemic has revealed the multi-faceted contribution of engineering, and has brought to light the fault lines of inequalities around the world, chief among them the gaping and glaring scientific, engineering and digital divide between countries, which is particularly detrimental to youth.

It is in this regard that this report can serve as a reference point for Member States. Through its international and intergovernmental scientific programmes, networks of Centres and Chairs, its partnerships with various non-governmental organizations, multinational corporations and engineering educational institutions across the world in different disciplines, UNESCO fosters interdisciplinary and international partnerships in engineering, which is key to accelerating the delivery of the SDGs.

No single discipline on its own can present a solution to achieving the SDGs because all the goals 'are integrated and indivisible and balance the three dimensions of sustainable development: the economic, social and environmental', as pointed out in the 2030 Agenda. A new paradigm for engineering is thus urgently needed; one that goes beyond the traditional division of disciplines and is inter- and multidisciplinary in its approach, enabling engineering to address such highly complex issues as climate change. Furthermore, engineers need to understand and shoulder social responsibility by building a more sustainable, resilient and equitable world for all people, leaving no one behind. Engineers must think in a way that carefully considers social impacts, while being attentive to environmental impacts, so as to reboot the health of our shared nature and planet, and make engineering a true enabler, equalizer and accelerator to deliver on the SDGs.



Recommendations

Each chapter of the report concludes with a set of actionable recommendations that can be implemented by governments, educational institutions, engineering organizations, civil society or the private sector, with the up-to-date expertise of the engineering and scientific community. Some of the key recommendations are outlined below.

Understanding the role of engineering and engineers in achieving the SDGs

1. Government, engineering educators, industry and professional engineering institutions need to promote greater understanding of the crucial role played by engineers and engineering in creating a more sustainable world.

Equal opportunities and diversity

2. Governments and policy-makers should take urgent action to encourage more young people, especially girls, to consider engineering as a career in order to address the shortfall in the number of engineers, and to ensure the diversity of thought and inclusive participation necessary to achieving the SDGs.
3. The engineering sector as a whole should embrace the 'leave no one behind' ethos of the SDGs and ensure that technological solutions address current inequalities.

Water as a global and strategic sustainability issue

4. Anticipated global water challenges related to the impacts of increasing water pollution and climate change need to be addressed, while benefiting from advances in science, technology and innovation in areas such as hydro-environmental models, decision support systems, microelectronics, nanotechnology, fine chemicals, biotechnology and information technology.
5. The social and environmental relevance of clean water and the holistic nature of the 2030 Agenda for Sustainable Development demand an integrated and systematic approach when dealing with the specificities of each of the 17 SDGs, all of which require intensive interdisciplinary analysis and multi-sectoral expertise for their implementation.

6. Engineered and nature-based infrastructure needs to be combined with water management approaches involving stakeholder engagement and bottom-up climate adaptation. Engineers need to be trained in recent advances in hydrology, intertwined with externalities such as technology and societal needs, in order to develop approaches for the implementation of SDGs and other water-related goals.

Climate change awareness and resilience

7. Countries can identify, understand and manage climate-change risks by prioritizing adaptation planning and actions, including implementing operational and maintenance procedures that extend the life of infrastructures that: i) are at critical risk of failure; ii) service a high level of demand; iii) are reaching the end of their life cycle; or iv) exceed the risk tolerance level and require significant investment to refurbish or replace.
8. Special attention should be given to developing vulnerable countries in building their capacities to deliver climate resilient infrastructures, by updating their national codes, standards and guidelines, and building capacity in their climate services, engineering and delivery capabilities. Public and private funding is needed for investment in engineering activities for disaster risk prevention and reduction, through structural and non-structural measures in order to foster resilience. Cooperation coupled with engineering research should be sought to identify and provide innovative solutions, including those that are nature based.

Natural resources and sustainable energy

9. In order to help achieve the SDGs, it is essential to develop sustainable and resilient energy systems. Policies and developments in this area must be based on rigorous facts and avoid preconceptions. To achieve these objectives, all energy options are open, depending on the national context. It is important to use simple and transparent economic criteria such as the cost per tonne of CO₂ avoided.
10. Suitable technologies to achieve sustainability in mining should be implemented and developed.

Data, AI and smart cities

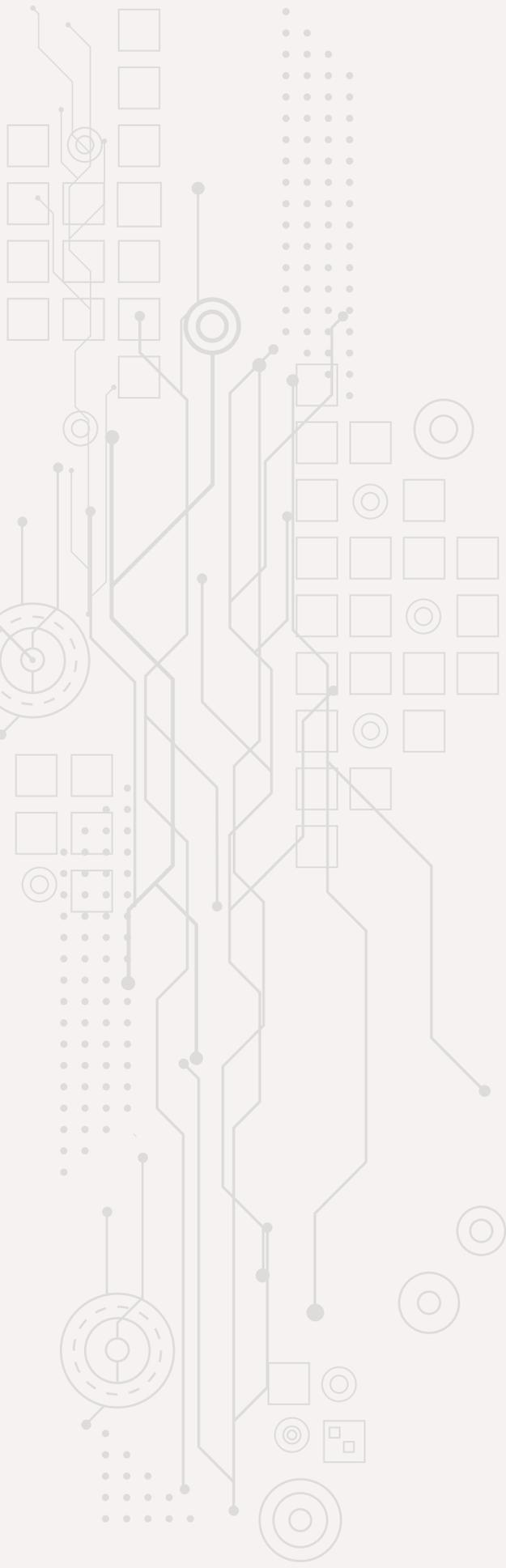
11. Governments and data owners need to make data findable, accessible, interoperable and reusable in an ethical way. Rules and standards need to be developed based on global consensus to enable efficient data sharing and data exchange.
12. Security and privacy of data have increased in relevance and must be part of the design process at all stages of the big data paradigm. International and interdisciplinary cooperation should be in place between academic institutions, universities and industry, as well as civil society, to advance AI innovation and applications for the implementation of the SDGs. Governments and civil society should promote international dialogue to reach global consensus on AI governance, and to adopt global principles, guidelines and standards for the responsible conduct of AI.
13. Smart engineering technologies and applications change the nature and economics of infrastructure. With the new generation of transport and healthcare facilities, disaster resilient infrastructure and low-carbon sources of energy, smart cities could be vehicles of purpose-driven innovation and test-beds for new applications and solutions.

Engineering education and capacity-building for the SDGs

14. Government, engineering educators, industry and professional engineering institutions need to collaborate to fund and support strategies, in order to increase the number of engineers, to introduce an internationally harmonized approach for graduate attributes in engineering, and to promote ongoing professional competencies so as to ensure the high quality of engineers to achieve the SDGs. These benchmarks need to be recognized across the world and should form the basis of national engineering education systems to train engineers with the right skills.
15. Improving and strengthening STEM education in school is the foundation of higher engineering education and lifelong learning. Furthermore, the topic of 'sustainability' needs to be included in the curriculum for all education establishments, from schools and universities to engineering departments and professional training bodies.
16. Governments should increase their focus on interdisciplinary curricula, sustainable development and professional competencies, combining them with funding models that support these needs. National accreditation criteria should be formulated and accompanied by incentives and rewards for institutions meeting these requirements.
17. Studies should focus on interdisciplinary and complex problem-solving using student-centred, problem-based approaches and online learning.
18. Engineering institutions, industries and academia should cooperate to develop and implement an engineering professional certification system for the promotion of continuing professional development and the recognition of engineering qualifications and professional competences worldwide.

Regional engineering cooperation

19. There is a need to strengthen all types of interregional, regional and sub-regional cooperation for engineering capacity-building in alignment with sustainable development, including an emphasis on the engineering dimension across all SDGs, as well as inclusive standards, the mobility of engineers and the articulation of the engineering-education nexus to address imbalances in engineering capacity and economic development in the various regions of the world.
20. Engineering is a highly diversified sector in both educational and professional settings. A common approach is therefore needed to harmonize definitions and data recording, which should also reflect diversity trends in the engineering sector. Government institutions and engineering organizations should reinforce their cooperation to further harmonize the profession's standards of data collection and study.



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