Editorial
Integrated and Sustainable Net Zero Implementation: The Role of Engineering Management for Sustainability

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As COP28 drew to a close in Dubai, United Arab Emirates, the key message was that climate action is urgent so the promises made in previous conferences can become a reality. Reports, videos, and social media posts related to COP28 were encouraging, immediate, and meaningful actions with higher ambition and significant results to curb emissions and avoid the 1.5 °C temperature increase scenario. Another word is also in the discussion, however, attracting much less attention: that is *integration*. In other words, this very challenging climate action will require transitioning to greener energy systems, redesigning production and consumption systems, rethinking the role of traditional industries in our economies, and last, but not less important, reflecting upon our societal priorities and aspirations. For this, all stakeholders of a society are needed. And these integration efforts for sustainable behavior are not only needed at the governmental level, but also, on the regional, group, and individual levels [Brem and Puente, 2020].

This editorial discusses how important an integrated approach is in this moment as we are challenged by "polycrises" and how crisis innovation [Viardot et al., 2023] can help here. Without integration, one can solve one crisis but unleash a series of unintended consequences, aggravate crises in socio-economic domains, or simply transfer impacts from one area of our biosphere to another [Alamino and Nunes, 2023]. In addition, crisis innovation can have many faces: societal, funding, financial, political, strategic, and organizational crisis, or crisis in the context of digitalization and transformation [Brem et al., 2023].

First, the direction of travel with greener energy systems is to quickly phase out fossil fuels. This should be welcome, and the required speed of change is possibly one of the highest barriers to overcome. Burning fossil fuels are the primary reason for poor urban air quality and climate change. Because the oil and gas industry have a high level of technological maturity, the cost structure remains globally competitive (without accounting environmental externalities). Products' applications are also wide because oil and gas are easily stored and transported through an infrastructure fully embedded in many cities. Its long existence, over 100 years old, led to the domination of various essential aspects of life,

such as heating houses, powering road, air, and sea transportation, as well as generating electricity. Fears over energy and mobility poverty, if the change is too quick, are present in every discussion. On the other hand, the political lobby of oil and gas companies, or low investment (and, therefore, slow technological progress) in alternative forms of energy, can delay the transition in such a way that a much higher cost for adaptation will replace the cost of mitigation actions. A balance—or better—a reconciliation between energy cost and human needs is necessary here. As in other moments of crisis, notably the COVID-19 pandemic, an adequate safety net and government policies are required so as to avoid a situation where we prevent an ecological crisis but then create a socio-economic one.

Second, assuming the phasing out of fossil fuels is not quick enough, yet, however, unlikely, some companies are still committed or forced to climate action and targets. Those companies will have to review their consumption and production activities and strategies. Educational campaigns, taxes, regulations, and social activism tend to be in place to reduce the demand for undesirable or superfluous economic activities in times of crises. Thus, organizations will have to rethink their supply chains. Engineering teams will have to redesign products and processes. Traditional industries may need to relocate or repurpose their production systems. Recent or even occasional innovators may become serious players in well-established markets as we are seeing, in the case of electric vehicles [de Paulo, 2020], where Tesla and BYD are dominating the global markets.

Nevertheless, when the private sector is late in taking their responsibility with future generations, what we have been witnessing lately is the complete ban of products and services due to environmental issues. From petrol and diesel cars to short-haul flights, from coal-fired power stations to residential gas boilers, traditional industries are having to reinvent themselves. Formulation of a sustainability strategy is absolutely crucial [Nunes et al., 2023a] to reach complex goals, such as Net Zero. Their success, however, will depend a lot on the quality of strategy implementation as seen in previous experiences of business transformation [Ferreira et al., 2022].

The new rule to stay in the business game is not only to reduce negative socio-environmental impacts but also to become more "essential," i.e., to address essential human needs [Nunes et al., 2023b]. In truth, the debate about economic development (focused on quality/robustness of an economy) versus economic growth (focused on size of the economy) is an old one. Nevertheless, how to make decisions and encourage the "right" or the best economic activities to grow is still a challenge in a world disillusioned with laissez-faire economic policies.

If the first point is about "optimal speed" and the second about "right" type of growth that is needed, the final one refers to the politics of climate action. How will it impact global trade? What kind of jobs will the green economy provide? Will countries and companies fall into traps of carbon tunneling and neglect other important ecological factors, such as waste management, land and biodiversity protection, and water conservation? Firms and engineers will note that in this transition period, intradimensional tradeoffs will become more prominent. Recently, the toy company Lego Group discontinued the plan to make bricks from recycled plastic bottles under the reason that it would have a higher carbon intensity than virgin plastic [Bartholomew, 2023]. Quality and cost issues were also mentioned. Well, recycling and use of recyclable materials are ways to reduce the volume of materials eventually dumped in landfills. Recycling, which is the last resort in the waste hierarchy, is an activity where CO_2 emissions are not desired but are justified to minimize plastic pollution. What are the other environmental tradeoffs we may have in the green energy transition?

Integrated solutions to the phasing out of fossil fuels will not come easy, mainly due to its high level of urgency. Many technological transitions were slow, unplanned, or even evolutionary rather than revolutionary, e.g., sail to engine vessels; horses to cars, etc. Some technological transitions had governments playing a major role not only in infrastructure investment but also in supporting the development of advanced innovation capabilities of domestic firms [Qiu et al., 2022]. High speed is not necessarily good for integration. Thus, in the spirit of sharing questions that both academics and practitioners of IEEE Engineering Management Review (EMR) can reflect upon, we suggested the following.

a) Is there an "optimum" integration level for phasing out fossil fuels? If yes, how does it look like?
b) How should the nonessential economic activities be treated in the process of phasing out?
c) What role can the fossil fuel industry play in the future? What alternative tracks can oil and gas companies play in the green energy future?
d) Where mitigation alone cannot deliver results, what are the key technologies to climate adaptation? How can managers adapt such key technologies into their strategy?
e) How can we reconcile Net Zero urgency and deliver carbon reduction sustainably respecting human needs, particularly in developing countries?
f) How can we ensure that sustainability goals related to water, land, biodiversity, and other

SDGs are also protected when environmental and sustainability policies are predominantly focused on climate action?

g) How do we deliver a different kind of management education that better prepare leaders for the future during this green energy transition?

Ways out to solve this problem exist, but are unfortunately complicated and resource intensive. With the advent of artificial intelligence (AI), especially with generative AI, new chances emerge to tackle issues of net zero implementation, but not without risks and challenges. This was also already a topic of EMR recently [Brem, 2023], and there are articles included in this issue of EMR, e.g., on engineers' perspectives on the use of generative AI tools in the workplace, on AI-driven decision making, on AI retail analytics, or on the AI revolution in new-product development. So, the topic of AI in engineering management has not only arrived, but has apparently come to stay.

There is no doubt that companies and their managers will play a key role in all related activities here. As indicated in the last editorial of EMR already [Lemmetty and Brem, 2023]. This issue of IEEE EMR also covers further articles related to the above-mentioned topics. For instance, you will find articles on sustainable construction, fast fashion supply chain management, or resilience management.

Beyond the special focus on the role of engineering management for sustainability, you will also find many other interesting articles, including topics like soccer, technology management, digital supply chains, and strategic management. Hopefully, they will relate and add value to your daily managerial practice. In any case, we hope you will enjoy the reading. We are always open for feedback and suggestions.

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