

Editorial

Driving Sustainability through Engineering Management and Systems Engineering

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The COVID-19 pandemic has highlighted the somewhat precarious nature of our lives, including the way we work and our lifestyles. It is clearly important that efforts continue to be directed towards remedying this situation; and thankfully the global rollout of vaccines is beginning to have a positive impact although there is of course still much to be done across the world [1]. In this context, however, the seemingly ever-present challenge of realizing sustainability across the triple bottom line of social, environmental, and economic development has not diminished [2–4]. If anything, it is now more pressing than ever that we work towards achieving the United Nations’ Sustainable Development Goals (SDGs) [5,6]. The challenges appear to be significant both in scale and complexity.

The burning of hydrocarbons continues apace, leading to climate change and the resulting negative consequences [7]. A reduction in carbon emissions [8] and decarbonization of industrial supply chains [9] is required along with concomitant adoption of renewable energy production, such as solar and wind power [10]. Despite advances in such areas, there remain various issues associated with the adoption of renewable forms of energy, such as solar power, including the low capacity factor, grid instability, and intermittency [11]. Furthermore, there is a need to ensure effective energy storage solutions are available to complement solar power provision [12], a need to understand the environmental risks of solar cells [13], and a need to move towards a circular economy use of photovoltaics [14].

The level of urbanization continues to increase along with the growing ecological footprint and decreasing biocapacity, which represent a major challenge to be addressed in many parts of the world [15]. Environmental pollution caused by high levels of industrial development has resulted in degradation of the quality of freshwater along with depletion of this finite resource [16]. There remain serious issues associated with alleviating the multi-dimensional nature of poverty in developing nations [17,18]. The list of challenges to sustainability goes on. Many of these societal challenges represent complex problems concerning technical, organisational, social, and political issues, where a paradigm shift is required in order to understand and engage with such issues [19]. Such a paradigm shift needs to be informed by an appropriate form of thinking and knowledge creation, including the capture, codification, and analysis of relevant data and information. In this regard and from an epistemological perspective, the disciplines of engineering management and systems engineering provide a viable and robust solution to help tackle the challenges of sustainable development and the broader needs for sustainability.

Engineering management involves the management of people and projects related to technological or engineering systems—this includes project management, engineering economy, and technology management, as well as the management and leadership of teams. The American Society for Engineering Management (ASEM) defines engineering management as “an art and science of planning, organizing, allocating resources, and directing and controlling activities that have a technological component” [20]. Engineering management is used across different industrial sectors as part of the management of engineering programmes and technology solutions [21]. With regard to research studies, the field of engineering management spans different areas, for instance, ecological



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engineering [22], operational design [23], safety engineering [24], and lean construction projects [25].

Systems engineering involves the design, integration, and management of complex systems over the full life cycle—this includes requirements capture, integrated system design, systems integration, as well as modelling and simulation. The International Council on Systems Engineering [26] defines systems engineering as “an interdisciplinary approach and means to enable the realization of successful systems. It focuses on holistically and concurrently understanding stakeholder needs; exploring opportunities; documenting requirements; and synthesizing, verifying, validating, and evolving solutions while considering the complete problem, from system concept exploration through system disposal”. Systems engineering is utilised in different applications and across different industrial settings to help in the design, development, and implementation of complex industrial and organisational systems [27]. With regard to research studies, the field of systems engineering spans different areas, for instance, chemical process systems engineering [28], satellite systems [29], vehicle system design [30], and renewable energy systems [31].

In addition to the theoretical underpinnings of both disciplines, they also provide a range of tools and techniques that can be employed to address complexity across technological, organizational, social, and political domains. Such tools and techniques include, for instance, project management, financial analysis, R&D management, operations management, requirements capture, engineering design and modelling, optimization methods, workflow analysis, and system dynamics. The disciplines of engineering management and systems engineering are therefore ideally suited to help tackle both the challenges and opportunities associated with realizing a sustainable future. Furthermore, engineering management and systems engineering implicitly enable multifaceted solutions informed by multidisciplinary approaches in order to provide the necessary knowledge and processes to underpin sustainability.

As mentioned, the goal of sustainable development presents many challenges. However, there are also various opportunities that are now becoming available. Indeed, the 4th Industrial Revolution, or Industry 4.0, is gathering pace across manufacturing [32–34] along with there being significant scope for adoption in other sectors, such as the energy and food sectors [35]. Innovation 4.0 can be regarded as a collection of different but related technologies that enable integration between physical and digital systems. The related technologies include cyber-physical systems; the industrial internet-of-things; artificial intelligence and machine learning; autonomous robots; big data and big data analytics; simulation; digital twins; virtual and augmented reality; cloud computing; cybersecurity; and additive manufacturing (3D-printing). Looking ahead, it is likely that adoption of 5G wireless technology for digital cellular networks along with much faster download speeds will help to power ahead adoption of Industry 4.0 technologies across new applications [36].

Not only are the technologies and corresponding new business processes from the Industry 4.0 paradigm positioned to support improvements in productivity as well as industrial competitiveness [37] but there are also tangible links to enabling energy sustainability, harmful emission reduction, and social welfare improvement [38]. While still an emerging area, there are already studies examining the link between Industry 4.0 and sustainability, including related aspects such as the circular economy, resource scarcity, lean production, energy problems, food production, process management and modelling, waste reduction, raw material reuse, and social aspects [39]. Furthermore, Industry 4.0 technologies have the capacity to improve the sustainability of supply chains [40] as well as support the adoption of sustainable business models [41].

Across this aforementioned context, this Special Issue in Sustainability draws on the theory and practical application of engineering management and systems engineering in order to drive sustainability. The contributions in the Special Issue address different perspectives and approaches that enable sustainability through leveraging the disciplines of engineering management and systems engineering. The scope of research studies includes measuring the sustainability of infrastructure projects [42]; sustainable project

selection [43]; assessing the impact of COVID-19 on the food and beverages manufacturing sector [44]; complexity theory in engineering management [45]; vehicle to grid technology for improved energy performance [46]; and development of a data centre industry towards a circular economy [47].

The contributions include the use of different research methodologies in order to investigate the underlying phenomenon of interest and this includes qualitative research via expert interviews [42]; quantitative modelling via the fuzzy analytic hierarchy process [43]; quantitative research via use of a survey instrument [44]; conceptual studies through analysis of extant literature [45]; engineering modelling based on machine learning [46]; and a mixed quantitative/qualitative method based on a survey instrument and semi-structured interviews [47]. The Special Issue also has international contributions representing a global coverage of the subject matter, including three articles from authors in the United Kingdom, one article from Italy, one article from the United States, and one article from South Africa.

The first contribution is by Mansell et al. [42] on “Delivering UN Sustainable Development Goals’ Impact on Infrastructure Projects: An Empirical Study of Senior Executives in the UK Construction Sector”. This research examined how the United Nations SDGs can be measured on infrastructure projects through a qualitative study involving interviews with 40 executives from the United Kingdom (UK) construction industry. Although the SDGs carry a certain level of complexity through there being 17 global goals along with 169 targets and 244 indicators, the study did however identify both the opportunities and challenges for measuring the SDGs in this application. This includes a recognition that measuring SDG performance should include a full project lifecycle perspective as well as an adequate understanding of the longer-term project outcomes and wider impacts generated by infrastructure projects. Moreover, there is merit in viewing infrastructure projects from a systems perspective in order to fully capture the wider impact, including the link to sustainability metrics. The results further indicate that while SDG measurement practices are embraced in principle, there remain difficulties in how they can be implemented. Nevertheless, there continues to be significant scope for those involved in the management of infrastructure projects to apply the findings of the study in order to translate the SDGs to the project level.

The second contribution is by Alyamani and Long [43] on “The Application of Fuzzy Analytic Hierarchy Process in Sustainable Project Selection”. This research investigated the process of sustainable project selection as part of enabling sustainable development through achievement of project goals. Since the process of sustainable project selection depends on a wide range of factors, there can be difficulties associated with the subjective judgments of experts involved in prioritizing project selection criteria as well as the resulting uncertainties associated with the subjective judgments by such experts. The study employed the fuzzy analytic hierarchy process (FAHP) as the mechanism to account for these uncertainties, where ‘expert opinions’ were gathered from the literature and translated into the necessary variables. Specifically, FAHP was used to rank five key sustainable project selection criteria identified by the study through calculating the relative weight of importance for each of the selection criteria. The results from the study identified that the most important criterion to consider during the process of sustainable project selection is project cost, followed by novelty and uncertainty as the second and third most important criteria, respectively.

The third contribution is by Telukdarie et al. [44] on “Analysis of the Impact of COVID-19 on the Food and Beverages Manufacturing Sector”. This research examined how the food and beverages manufacturing sector in South Africa can respond to the major challenges caused by the COVID-19 global pandemic. The study considered a number of different sources of information from the global literature as part of a knowledge classification process in order to formulate an expedited response by the food and beverages manufacturing sector. This enabled deployment of a survey instrument with 106 small and medium-sized enterprises (SMEs) engaged in the food and beverages manufacturing sector in South Africa. Following statistical analysis via use of Cronbach Alpha to test the reliability of

the data, the results identified that SMEs are under significant pressure caused by the pandemic. The results further revealed that the situation can be mitigated through a number of different measures, including social distancing, communication, facilities reconfiguration, and virtual working, which aligns well with international best practice. Additionally, the study pointed towards further mitigation measures being adopted beyond South Africa and globally, and this includes human resource and workforce adjustments as well as scope to leverage technology developments associated with the Industry 4.0 paradigm.

The fourth contribution is by Abatecola and Surace [45] on “Discussing the Use of Complexity Theory in Engineering Management: Implications for Sustainability”. This research explored through a conceptual lens the adoption of complexity theory (CT) in the field of engineering management as well as the resulting implications concerning sustainability. The current status of complexity research in EM was identified and discussed through review of 38 sources of relevant literature published in the journal, *IEEE Transactions on Engineering Management*, which provided a heuristic proxy as part of the conceptual study. The research identified that since the year 2000, CT in EM has been associated with a wide range of key themes in the field, namely, new product development, supply chain management, and project management. Moreover, the dataset included modelling and optimizing decision-making under uncertainty as a key theme related to CT in the EM literature. In terms of the link to the area of sustainability, the research identified that there is scope to apply the use of CT to this application in areas such as energy, health-care, and construction, which could be supported through harnessing complexity-based observations. The study also proposed that firms engaged in tackling sustainability issues would benefit from adopting structures and processes according to a complex adaptive system model.

The fifth contribution is by Scott et al. [46] on “Machine Learning Based Vehicle to Grid Strategy for Improving the Energy Performance of Public Buildings”. This research investigated vehicle-to-grid (V2G) technology as a way for carbon neutral buildings to accommodate situations involving unpredictable renewable sources. The study provides an effective V2G strategy, which was developed and implemented for an operational university campus. Furthermore, the study derived a machine learning algorithm in order to predict energy consumption and energy costs for the building on the university campus. This approach was based on a feed-forward neural network (FFNN) machine learning algorithm (MLA) that enabled prediction of the future energy demand for the building under investigation, where the input data was taken from 2013–2017 to predict output data for the years 2018 and 2019. The research focused on integrating V2G technology into the campus environment according to different scenarios and various demand levels, such as peak time and off-peak, and included modelling of net profits. The engineering modelling study revealed that the proposed V2G installation at the university campus is both economically and environmentally beneficial, thereby underpinning the case for sustainability of this technology solution.

The sixth contribution is by Andrews et al. [47] on “A Circular Economy for the Data Centre Industry: Using Design Methods to Address the Challenge of Whole System Sustainability in a Unique Industrial Sector”. This research explored how the data centre industry (DCI) can be transformed from a linear economic model to a circular economy system. As a major global industry, there are significant challenges for current practices in the DCI, which are becoming both environmentally and socially unsustainable. Therefore, a new approach to enable transformation to a circular economy model has been developed that is based on a whole systems perspective, design thinking, and the double diamond method, combined with people/stakeholder engagement throughout the project. A whole systems approach has benefits in terms of capturing how decisions are made and actions are taken at each stage in the life cycle, which can impact the sustainability of the remaining stages in the life cycle. The study collected quantitative data via an online survey along with deeper insights through qualitative research from semi-structured interviews. The findings revealed that the project under investigation is generating innovative outputs

(namely, designs, business models, and a digital tool), which can support the DCI to follow a circular economy trajectory.

The published research articles in the Special Issue are as follows:

1. Delivering UN Sustainable Development Goals' Impact on Infrastructure Projects: An Empirical Study of Senior Executives in the UK Construction Sector by Paul Mansell, Simon P. Philbin, and Efrosyni Konstantinou [42].
2. The Application of Fuzzy Analytic Hierarchy Process in Sustainable Project Selection by Rakan Alyamani and Suzanna Long [43].
3. Analysis of the Impact of COVID-19 on the Food and Beverages Manufacturing Sector by Arnesh Telukdarie, Megashnee Munsamy, and Popopo Mohlala [44].
4. Discussing the Use of Complexity Theory in Engineering Management: Implications for Sustainability by Gianpaolo Abatecola and Alberto Surace [45].
5. Machine Learning Based Vehicle to Grid Strategy for Improving the Energy Performance of Public Buildings by Connor Scott, Mominul Ahsan, and Alhussein Albarbar [46].
6. A Circular Economy for the Data Centre Industry: Using Design Methods to Address the Challenge of Whole System Sustainability in a Unique Industrial Sector by Deborah Andrews, Elizabeth J. Newton, Naeem Adibi, Julie Chenadec, and Katrin Bienge [47].

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