sustainability

Editorial

Systems Engineering for Sustainable Development Goals

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Sustainability is expanding the discipline and practice of systems engineering. The International Council on Systems Engineering (INCOSE) has foreseen the critical importance of addressing sustainability issues in their Systems Engineering Vision since 2007 [1,2]. As a concept, sustainability covers a broad range of issues ranging from the concern for rapidly depleting natural resources to the concern for the welfare of the earth's populations. Domains such as health care, transportation, natural resource management, social economics, and governance recognize the value of applying systems thinking and systems engineering practices to finding solutions that go beyond temporary Band-Aid solutions for symptoms and that instead address the root causes of these problems.

Traditionally, the discipline and practices of systems engineering are associated with solutions for technological systems and products. The term has been used since the late 1950s, and over the intervening decades, systems have been increasing in complexity. A realization that these practices, which have evolved to cope with technological complexity, are equally equipped to cope with political and society issues has gradually emerged [3]. Applying the concepts of systems thinking and systems engineering is both acceptable and expected [4]. Research applies these methods to various grand challenges and the UN Sustainability Development Goals (SDG) [5,6].

The 14 articles in this Special Issue are from researchers representing Brazil, Ireland, Germany, the Netherlands, Norway, Poland, Spain, and the USA. The contributions cover a range of industries. Of the articles in this Special Issue, four cover topics pertaining to the energy sector, three include work pertinent to the food, higher education, and regional planning sectors, respectively. Topics span sustainable business models, resilience and post-COVID recovery, models for working to achieve SDG targets, and one application of system dynamics to explore the peace nexus.

Seven of the contributors to this issue are young researchers who are also graduates of the NTNU industrial ecology program, the first such academic initiative of its kind, started in 1993 [7]. Systems engineering and industrial ecology both build on the strengths of interdisciplinary theory and practices [8]. This Special Issue of *Sustainability* features original papers by young and established researchers in systems engineering leading the advancement of this rapidly expanding discipline.

Addressing resilience in the energy sector, Neumann, van Erp, Steinhöfel, Sieckmann, and Kohl studied business model patterns for achieving corporate resilience. The identified patterns were analyzed and validated by expert interviews in the German electrical industry, confirming their usefulness in providing guidance for organizations to tackle industrial resilience by adapting their business models [9]. In the same sector, this time considering the oil and gas industry on the Norwegian continental shelf, Czachorowski also uses systems engineering to innovate business models for use in the exploration and production phases of a major operator. She applies morphological analysis to identify discrete components that can be applied in the industry as they "clean up their act" to address SDG targets [10]. Against the backdrop of energy transitions, Kirkels, Evers, and Muller contribute a position paper exploring the challenges facing systems engineering when it is applied to sociotechnical problems. They offer two approaches to address the

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limitations [11]. Muller also presents a case study of an energy transition in the Netherlands, applying roadmapping and conceptual modelling to support policy and decision makers who must cope with a large heterogeneous set of stakeholders. [12].

Agriculture, fisheries, and food waste in the hospitality arena provide examples of how applying methods from systems engineering can help formulate solutions to move the food sectors toward meeting SDG targets. Palmer, Burton, and Haskins propose a framework called MPAST: Mapping Problem Archetypes to Solutions for Transitions, then apply it to a Norwegian agricultural bioeconomy transition using data collected from a recent survey [13]. Building on research conducted around lost fishing gears and ghost fishing, Deshpande and Haskins apply a disciplined systems engineering process to examine ways to address the root causes of this problem. The study yields some interesting suggestions [14]. Finally, Buczacki, Gładysz, and Palmer propose a framework that is suitable for illustrating the dependencies between different micro actions and macro policies that impact the ability to meet SDG targets. They conclude that to resolve a pervasive issue, such as food waste, requires the concerted collaboration of consumers, businesses, and governing authorities [15].

Communities hoping to preserve their natural resources and regional planners also benefit from systems engineering research. Johansen, Aspen, Sparrevik and Æsøy developed a system-oriented sustainability scoring model that they apply to the port of Geiranger, Norway in an effort to balance the negative effects of cruise tourism [16]. A case study from a regional planning process in the Aalesund region in Norway was used by Aspen and Amundsen to demonstrate their participatory planning support system (PSS), derived using systems engineering methods, for integrating and operationalizing the SDGs [17].

Themes from industrial ecology inform two of the articles. The Capacity-building in Sustainability and Environmental Management model (the CapSEM-model), presents organizations a systemic way to transition to sustainability through the application of systemic methodologies that gradually help increase environmental and sustainability performance. Fet and Knudson map the SDGs onto the CapSEM model as an example of how they can be useful in the transition to sustainability [18]. A case of industrial symbiosis (IS) in Spain was analyzed by Ruiz-Puente and Jato-Espino. They concluded that the changes implemented in industrial parks resulted equated to contributions to nine SDGs and fourteen of their specific targets, proving the domino effect associated with the application of IS policies by governments and public entities [19].

In the domain of higher education, Lynch, Andersson, and Johansen address the potential for courses in entrepreneurship to establish a mindset in students toward a sustainable future. They assert that a systems perspective must be integrated into entrepreneurial education and suggest that merging systems thinking and entrepreneurship can be used to nudge students towards sustainability [20]. Yang and Cormican conducted a scoping study that analyzes extant evidence to uncover the contributions of systems engineering in advancing progress towards the SDGs. They conclude that systems engineering has been an active catalyst promoting the SDGs with the potential to encourage the transdisciplinary research necessary to achieve long-term transformational and sustainable change across sectors and disciplines [21].

The pièce de résistance is provided by Amadei, who addresses one of the quintessential SDG goals to promote peace. He examines the value proposition of adopting a systems approach to capture the linkages between the SDGs and peace sectors using basic system dynamics models to illustrate peace–development nexus dynamics [22].

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