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Editorial

Special Issue "From COP 26 to COP 27: Contributions of Systems Approaches to Address the Challenges Ahead": An Editorial Commentary

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Abstract: This Special Issue focuses on proposing and analyzing systemic interdisciplinary approaches to support collaborative strategies and agreed-upon global sustainability policies toward addressing the challenges that lie ahead for our planet's future. The contributions target applications in system dynamics, systems thinking, discrete event simulation, agent-based modelling, and hybrid approaches and provide valuable qualitative and quantitative insights to guide the collaborative efforts of governments, institutions, organizations in general, and even the financial sector toward the next Conference of Parties (COP28).

Keywords: systems thinking; modelling; policymaking; sustainability; Conference of Parties

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1. Introduction

The motivation behind this Special Issue, "From COP 26 to COP 27: Contributions of Systems Approaches to Address the Challenges Ahead", is to be found in the need to recognize "how complex our world is", by focusing on exploring, analyzing, and proposing interdisciplinary systemic approaches to help shape commonly agreed-upon policies toward the achievement of the Conference of Parties [1] (COPs) goals, hence trying to help assess the effects of the measures taken and the progress made to prevent "dangerous" human interference with the environmental and climate systems.

In this context, it is worth noting that complexity is not an inscrutable concept. Rather, it is a definitive, strong, and widespread feature of the real world, where many variables of a different nature (e.g., economic, social, environmental, political, organizational, etc.) are interconnected. The resulting complexity requires that we perceive those variables as systems, seeking highly sensitive intervention points, that, when stimulated, can generate non-linear change that can lead to consequences for society, the environment, and the climate in both the short, medium, and long term (Ref. [2]). As a result, this complexity must be addressed by relying on robust methodologies based on the scientific method. In fact, the purpose of this Special Issue was to collect contributions based on—but not limited to—complex systems modelling and simulation techniques. The ultimate objective is to channel the learning from complex systems' dynamics [3] to inform effective decision making in the context of (i) decarbonization strategies, (ii) natural resources management, (iii) sustainable development, and (iv) sustainable practices in the economic and financial sectors, to name but a few.

In Section 2, we discuss the rationale and the content of the selected contributions. The closing remarks in Section 3 summarize the achievements of this Special Issue and how it could be helpful in shaping future investigations and policy.

2. Structure and Content of the Special Issue

Overall, seven papers were selected for this Special Issue: six original research papers and one review paper. From different angles, all the papers clearly investigated topics concerning the Conference of Parties' objectives, from the individual to the global level, going through a number of other intermediate levels (i.e., citizens/city, country, region, and global) and perspectives (energy efficiency, technologies, decision making, urban planning, and financial support to decarbonization).

Our commentary starts by examining the first contribution, which is transversal to the aforementioned levels and perspectives, entitled "Peaking Dynamics of the Production Cycle of a Nonrenewable Resource", which aims to model one of the most important variables involved in assessing the efficiency and convenience in the use of energy: Energy Return on Energy Invested (EROI). The definition of EROI recalls the same concept used in economics to assess the return on invested capital and aims to assess the net energy profitability of any energy extraction and transformation processes. The history of EROI has been empirically studied for a long time, and it is indissolubly linked to the concept of "peak oil", introduced by geophysicist M. King Hubbert [4]. The authors' efforts were targeted at providing an empirical perspective on EROI, in the context of energy transitions. In doing so, they defined, for the first time, a relationship between the peaking of the production curve of non-renewable energy vectors (like oil or other fossil as well as nuclear fuels) and EROI. The authors found that the peak of the resource extraction occurs at a time that is inversely proportional to the EROI of the process at the start of the extraction cycle. This means—rather counterintuitively—that systems that yield higher initial energy or economic gains tend to be exploited and depleted more quickly when considering the same amount of available resources. The authors' model is inspired by the classic Lotka–Volterra prey–predator dynamic model [5], with the main difference being the replacing of foxes (predator) and rabbits (prey) with humans and non-renewable resources. The model is not designed to provide precise forecasts on selected variables, but rather it is envisioned as a guiding experiment that can be used to determine some "rules of thumb" for understanding the peaking phenomenon in the exploitation of natural resources. This can be used to provide robust indication on the possible exploitation of energy resources in the longer-term future and hence help effective planning in the context of green energy transition and societal decarbonization on timelines that are concurrent with prevailing energy planning processes.

The strategic role of the EROI is further elucidated for renewable energy in the second paper, entitled "Examining the Potential of Marine Renewable Energy: A Net Energy Perspective". The paper seeks to find balance in the question of prioritizing reserve locations according to their profitability potential, while seeking to contain global warming. This research highlights the pivotal role of the EROI parameter in evaluating the viability of marine renewable energy technology and in determining the feasibility of future large-scale implementations of such technologies. The findings indicate that the average EROI for marine energy (including tidal, ocean currents, wave, offshore wind, as well as salinity gradient and thermal differentials) sets in at around 20, but these averages plunge to roughly 8 when offshore wind [6] is excluded from the analysis. The authors' assessment is predominantly based on technical considerations and did not include economic and legal limitations in its calculation. As a result, while still potentially feasible from an EROI perspective, these findings should be understood as a maximum limit for the potential net energy contribution of marine energy sources to the worldwide energy blend. This limitation, however, is somewhat attenuated by the vastness and accessibility of the marine resource.

Complementary to the previous study, the third paper, entitled "Renewable Electricity Transition: A Case for Evaluating Infrastructure Investments through Real Options Analysis in Brazil", addresses the problem of how to explore the financial barriers in investor behaviors that could impede the fast diffusion of low-carbon power technology in Brazil. The shift toward cleaner energy sources is essential for achieving climate objectives, and this article explores the uncertainty associated with future expectations of financial evaluation of renewable energy projects. The research employs real options analysis—a known risk modelling technique for capital budgeting [7] to obtain a financial evaluation model for renewable energy projects that incorporates the uncertainty in expected returns for the case of the Brazilian economy. This tool can be integrated into larger (heuristic) modeling frameworks (such as agent-based simulation) to gauge the effect of real options analysis on diverse markets and varying environmental and socio-political contexts. The results show that, by employing this approach, renewable energy projects can emerge as more financially appealing compared to those based on carbon-intensive energy sources. Beyond COP28, scheduled to take place in Dubai, the authors highlight that COP30 will be hosted in Brazil, and further development of this line of research may prove fruitful if proposed at those events.

The three papers reviewed so far were mainly focused on research topics dealing with the energy production side, but what about the actions to limit climate and environmental impacts on the consumption side?

The Guest Editors selected the following two papers to give some insight on this perspective. The first paper is entitled "Decarbonization Strategies in the United Arab Emirates (UAE) built environment: An Evidence-Based Analysis Using COP26 and COP27 Recommendations" [8]. The article seeks to offer a thorough examination of the decarbonization suggestions introduced in COP26 and COP27, with a specific focus on the built environment sector. In particular, this research presents a case study that highlights the decarbonization efforts incorporated into the newly constructed Social Environment Economic Institute Building in Dubai: the architectural planning embraced a systems thinking approach that enables the building to achieve net-zero status, thanks to merging strategies in managing energy, water, and waste management. The paper represents a successful example and calls for further investigations in this area [9,10], for instance, by applying the method to different countries that have different climate conditions, or buildings with different purposes rather than offices (e.g., residential).

In addition to decarbonizing buildings, sustainability in transport [11,12] is another pillar of the built environment. This is also proved by the outcome from COP26 through the launch of "Decarbonize Transport! A Call from Business Leaders for Climate Action and Collaboration with Governments". With the paper entitled "Systems Thinking and Group Concept Mapping for Classification of Marketing Techniques in Mobility Plans", the authors propose an innovative methodology to help policymakers in designing and implementing sustainable mobility plans. The study is motivated by the fact that urban planning involves a large number of stakeholders from different areas, and that reaching this broad audience may be challenging for policymakers. The study provides a hybrid approach with the purpose of (i) aiding policymakers in classifying marketing strategies to support the uptake of sustainable urban mobility plans, and (ii) understanding the effectiveness that such marketing techniques may have when moving citizens from old mobility means to more sustainable ones. This approach blends systems thinking with the adapted Group Concept Mapping [13]. The results show that Sustainable Urban Mobility Plans (SUMP) can be originated considering different geographical levels (local, region, national) and operating on different timescales. Interventions at different parts of the SUMP cycle require different marketing techniques to maximize the probabilities for success. For example, when policymakers strive for behavioral change in commuters, a combination of techniques with a focus on digital marketing and e-engagement applied in a wide timeframe seems to be the most successful strategy.

Renewable energy production, energy efficiency, building sector efficiency, and sustainable transport are also at the center of the decarbonization strategy of the European Union, both before and after the Green Deal [14]. In the sixth paper, entitled "Investigating European Union Decarbonization Strategies: Evaluating the Pathway to Carbon Neutrality by 2050", the authors make the point that the EU road toward net zero 2050 is still uncertain. Examining the National Energy and Climate Plans as well as the long-term strategy plans of every Member State, the authors show that "Member States have more clearly set the Green Deal targets than the actions to deliver against those targets. Actions, in terms of national's policies and funds administration, are still immature and partially addressed". In this regard, the implementation of new economic models and decision-making tools [15] are necessary to escape from this immaturity: a more frequent updating of those plans (now performed every 5 years), new tools which account for economic decoupling, and national carbon budget controls [16] will reinforce the Member States' commitment to decarbonization as well as to implement the COP26 "Glasgow Climate Pact" [17], which amends the Paris Agreement's requirement for reviewing Nationally Determined Contributions [18] every year.

As a final paper to complete this Special Issue's purpose, the Guest Editors selected the paper entitled "Climate and Energy Crises from the Perspective of the Intergovernmental Panel on Climate Change: Trade-Offs between Systemic Transition and Societal Collapse?". The Intergovernmental Panel on Climate Change (IPCC) is the United Nations institutional body for assessing the science that is related to climate change and monitoring the progress toward the Paris Agreement goal. The IPCC chaired sessions both in COP26 and in COP27 and represents the main reference for policymakers from all over the world to plan future international environmental policy. In this contribution, the author investigates the presence of some contradictory outputs from different working groups of the Assessment Report 6 of the IPCC [19]. These contradictions can lead to the risk of policymakers adopting the 2 °C target as a more achievable mitigation option in comparison to the safer 1.5 °C target, steering us away from a world where many self-reinforcing feedback loops can pass tipping points which can lead to cascading ecosystem collapse [20]. The author proposes a new conceptual model explaining that this controversial result can lead to a loss of collective momentum at the international level, weakening global progress toward the target and returning to recommendations influenced by the distinct strategies of individual nations and leading to failure in the IPCC worst-case scenario, which is conducive to the collapse of our current civilization [21]. To avoid this future, the author suggests a series of corresponding preventive measures (in terms of social actions, economic measures, and their linked policies) and strategies to attract funds for the essential investments worldwide, to speed up the phasing out of the current fossil-based socio-economic system while reducing inequality [22].

3. Closing Remarks

This Special Issue collated innovative research contributions to fulfil the Conference of Parties' mission on a longer-term basis. In particular, the SI contributions were selected under a wide perspective that spans from pure applied research to policy recommendations under the common thread of the Conference of Parties' objectives:

- A new mathematical model of the EROI parameter facilitates estimations of the profitability of energy (non-renewable and renewable) resources. However, this is an approximate approach; further studies are necessary to refine the model and further validate it.
- With regard to the state of the art, the most profitable marine renewable electricity production relies on wind offshore technology: further studies on the economic feasibility of the other technologies (tidal, salinity gradient, etc.) are necessary to fully consider their potential as suitable technologies for renewable energy production.

- Real options analysis can help in assessing the financial appeal of renewable technology versus fossil fuel-based energy production. Integrating this analysis into larger models would identify relevant progress to increase investment in the renewable energy sector.
- A case study in the UAE already shows that the built environment can achieve close-to-net-zero construction of large buildings used as offices, thus merging strategies to manage energy, water, and waste. This case study can be used as a benchmark for further investigations in other locations or in buildings with different purposes (e.g., residential).
- An innovative blended approach of systems thinking with adapted Group Concept Mapping is proposed to help policymakers to involve stakeholders in helping with urban mobility planning. The approach is promising (despite the limitations that are discussed by the authors), especially since at its core lies systems thinking and system dynamics, which are suitable methods to tackle complex problems in the face of uncertainty [23].
- The investigation on the decarbonization strategy of EU reveals substantial weaknesses, showing a high number of well-set targets followed by fewer or immature strategies to achieve them. Efforts in further monitoring of the energy and climate plans by 2030 and by 2050 are necessary to avoid a failure to meet Green Deal targets.
- Some controversial outputs have been highlighted in the IPCC AR6. This unclear message could bring about a loss of international synergy in pursuing the 1.5 °C target of the Paris Agreement. New efforts are necessary to improve the reporting process to avoid dispersions of cooperation, avoid a rise in international tension, and avoid the path toward the present civilization collapse.

To summarize, this Special Issue highlights the need to achieve a closer synergy between the scientific and policy-making communities—with complex systems modelling methods potentially serving as a suitable bridge between the two. While this research helps in shaping the dialogue toward the use of complex systems methods to better describe the interacting phenomena and influence policymaking toward a low-carbon and sustainable global economy, the authors feel that more work is clearly needed. We are now in the critical decade to achieve these targets, and we invite more research and investment at the interface between science and policy.

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