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SPECIAL FEATURE: EDITORIAL

Accelerating Actions for Leveraging a Climate-Neutral, Sustainable Society

Accelerating actions for leveraging a climate-neutral sustainable society

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Abstract

The establishment of the Leveraging a Climate-neutral Society–strategic Research Network (LCS–RNet) (then named the International Research Network for Low Carbon Societies) was proposed at the Group of Eight (G8) Environment Ministers' Meeting in 2008. Its 12th annual meeting in December 2021 focused on the discussion on how to transition into a just and sustainable society and how to reduce the risks associated with the transition. This requires comprehensive studies including on the concept of transition, pathways to net-zero societies and how to realise the pathways by collaborating with various stakeholders. This Special Feature provides new insights into sustainability science by linking the scientific knowledge with practical science for the transition through the exploration of studies presented at the annual meeting. Following the opening paper, "A challenge for sustainability science: can we halt climate change?", a wide range of topics were discussed, including practices for sustainable transformation in the Erasmus University, practices in industry, energy transition and international cooperation.

Keywords Climate emergency · Sustainable transition · Net-zero emissions · Innovation · International collaboration

Introduction

The severe impacts of climate change have already manifested across the world, and there are concerns about their future exacerbation. At the 21st Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC COP21) held in 2015, it was agreed to limit global warming to well below 2 °C, preferably to 1.5 °C, compared to pre-industrial levels (UNFCCC 2015). The IPCC Special Report on 1.5 °C (2018) showed the stark difference in projected impacts between a temperature increase of 1.5 °C and 2 °C. In response, many national and local governments have declared to achieve net-zero emissions.[1]

A total of 151 countries have expressed support for net-zero emissions in some form: six countries have already achieved this target, while 27 countries have included this in law, 51 countries in policy documents, eight countries have pledged, and 59 countries have proposed this target. Furthermore, 147 regions, 253 cities and 952 companies have also committed to net-zero emissions (Net Zero Tracker 2023).

However, according to the United Nations Environment Programme (UNEP) Gap Report (2023), under the current

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[1] The term "net zero" is sometimes used to refer to only CO_2, and sometimes includes all greenhouse gases, including those other than CO_2. When only CO_2 is targeted, it is sometimes referred to as "net-zero CO_2".

policy scenario and unconditional Nationally Determined Contribution (NDC) scenarios, greenhouse gas (GHG) emissions in 2030 are expected to exceed emissions in 2015. The predicted value for 2030 under the unconditional NDC scenario is 23 GtCO2e higher than the scenario that achieves the 1.5 °C target, necessitating the strengthening of urgent measures. Limiting global warming to 1.5 °C is no longer achievable through a step-by-step approach and requires a system-wide transformation.

The International Energy Agency (IEA) (2021) reports that, despite the current gap between the emission goals and the reality, there are still pathways to reach net-zero emissions by 2050. Although the remaining pathways are the most technically feasible, cost-effective and socially acceptable, they are extremely challenging, requiring all stakeholders—governments, businesses, investors and citizens—to take action this year and every year thereafter so that the goal does not slip out of reach.

Still, according to the IPCC (2022), strengthened near-term action beyond the NDCs can reduce and/or avoid long-term feasibility challenges of global modelled pathways that limit warming to 1.5 °C. The report also shows various 'enabling conditions' that enhance the feasibility of adaptation and mitigation options, including finance, technological innovation, strengthening policy instruments, institutional capacity, multi-level governance and changes in human behaviour and lifestyles. The challenge is how to make sure that these enabling conditions are realised. The report points out that the development pathways taken by countries at all stages of economic development impact GHG emissions and hence shape the greatly variable mitigation challenges and opportunities that countries and regions face.

Achieving a net-zero society requires a just and sustainable transition. Loorbach et al. (2017) point out that, from a transition perspective, sustainable development policies and programmes have focused too much on reducing unsustainability through optimisation of the current systems, thereby (unintentionally) adding to the lock-in of societal systems. Transition requires new ideas and technologies, which initially grow slowly, but may then 'take-off' in a phase of exponential growth as they emerge from a position of niche into mainstream diffusion. These dynamics arise from interactions between innovation (in technologies, companies and other organisations), markets, infrastructure and institutions, at multiple levels (IPCC 2022). Ensuring decent work and inclusive working conditions are also important issues for a just transition.

Such transitions are enabled by coherent sets of technological and social innovations. Stern and Valero (2021) argue that investing in and disseminating clean innovation not only helps achieve sustainable infrastructure and net-zero GHGs, but also improves productivity, encouraging investment in and dissemination of clean innovation. Without a strong and coordinated enabling package of policies, it is difficult to shift from dirty to clean technologies because of strong inertia and path dependence in innovation systems. They also point out that local decision-making and delivery mechanisms that utilise the latest innovations in public participation, such as citizens' assemblies, can help generate policies and projects for sustainable growth that are seen as fair and focused on local needs and perspectives. Recently, climate citizens' assemblies have been held in many places, especially in Europe. At the Citizens' Climate Assembly held in France in 2019–2020, the Climate and Resilience Act was enacted based on citizens' recommendations (Giraudet et al. 2022). Coherence in both technological and social innovations allow for a whole-of-society approach to decarbonisation.

A great deal of literature on making a transition to decarbonised societies has already been published. However, the challenge is how to turn theory into reality. Some challenges are, for example, identifying pathways to a climate-neutral society that can be implemented by both national and local governments; finding ways to revitalise new industries while minimising the negative impact of the transition; activating international cooperation; and financing for leveraging climate-neutral societies. The transition to a society includes not only energy issues, but also a wide range of areas such as land use and ecosystems.

This Special Feature focuses on research presented at the 12th Annual Meeting of the Leveraging a Climate-neutral Society–strategic Research Network (LCS–RNet) (LCS-RNet 2021a, b) with the theme, "Accelerating Actions for Leveraging a Climate-Neutral, Sustainable Society". Following an introduction on why we need a sustainable transition, this Editorial presents methodologies and examples related to the transition to a net-zero society.

Articles in this special feature

The articles vary from concepts to applications, showing why we need sustainable transitions and examples on how to tackle this. The papers of this special feature are divided into three categories. The first category focuses on sustainable transitions, the sustainable development goals (SDGs) and citizens' participation. Articles in the second category focus on industry, employment and the energy system, which include discussions on industrial clusters, job creation and energy systems to realise a decarbonised society. Articles in the third category focus on international collaboration, including explorations of international collaboration initiatives, international cooperation on green hydrogen and international cooperation on model development to support policymaking.

Sustainable transition, SDGs and citizens' participation

In the first group of articles, researchers discuss climate science and sustainable transitions, why sustainable transitions are necessary and what actions can be taken. They highlight through multi-country analyses and case studies, such as Bangladesh that, when planning and implementing actions, understanding the potential synergies and trade-offs between climate change policies and other SDGs is critical. Given the importance of a whole-of-society approach, recent work on climate citizens' assemblies demonstrate the need for public engagement in sustainable transitions.

Nishioka (2023) argues that the lagging global climate governance is contributing to the climate crisis. To implement the narrow pathways still available towards the 1.5 °C target as indicated by the natural sciences, the social sciences and humanities should focus strongly on promoting action and participation on the ground from the demand side, in addition to top-down policymaking and efforts from the supply side.

Loorbach and Wittmayer (2023) describe the research and design required for sustainability transitions. Taking the Erasmus University Rotterdam (EUR) in the Netherlands as an example, this paper illustrates the problems with the dominant (i.e., twentieth century) model of universities in the social sciences and explores the strategies that universities can develop to effectively support societal transitions.

Halsnæs et al. (2023) describe how to accelerate the transition in the context of sustainable development. Through a review of selected studies across regions, this paper draws out conclusions focusing on mitigation–SDG trade-offs, implications on costs and equity for different development contexts. The study recommends the ex-post analysis of detailed and place-based cases to document how synergies and trade-offs emerge and how these are addressed.

Mahmud and Roy (2023) present an evidence-based sustainability status analysis for the energy sector in Bangladesh. Using 38 context-specific indicators and data, a multidimensional hierarchical framework, principal component analysis and a composite sustainability index helped identify the strengths and weaknesses of the sustainability challenges to derive policy-relevant recommendations. Results show that Bangladesh is showing marginal progress towards sustainability of the energy sector with high potential for improvement. The article also identified data gaps, which, when addressed, may improve monitoring.

Meilland and Lecocq (2023) developed a new analysis of the SDGs framework by systematically mapping the national development priorities displayed by 121 countries in their long-term development documents with a visualisation tool. The tool and database may inform many development-related questions, enabling us to discuss the relevance and aimed universality of the 2030 Agenda in light of its connections with national development priorities.

Kainuma et al. (2023) review climate citizens' assemblies, which are meetings in which citizens selected randomly discuss and put together recommendations for use in national and subnational climate policies. Such climate assemblies have been held mainly in Europe since around 2019. This paper summarises their significance and discusses the challenges of implementation in Japan.

Mori and Yoshida (2023) discuss the Climate Citizens' Assembly Kawasaki (CCAK) held in mid-2021 in Kawasaki City, Japan, highlighting its achievements and the lessons learnt. They illustrate that CCAs can effectively be held in Japan, despite some procedural irregularities and technical difficulties encountered throughout the CCAK process.

Industry, employment and the energy system

For sustainable transitions, it is important to achieve net-zero emissions in industry, secure jobs and secure energy security. Here, industrial clusters, job creation and energy systems for realising a net-zero society are explored.

Rattle et al. (2023) discuss decarbonisation strategies in industry and the challenges of scaling out decarbonisation from industrial clusters to entire sectors. Drawing upon the UK as their case study, they provide initial analysis of the issues facing dispersed industrial sites on their path to decarbonisation and suggest a number of solutions to the challenges they face.

Hanna et al. (2023) review job creation, quality and skills as well as the net employment effects of decarbonisation in the energy sector. National studies largely agree that the most likely outcome over the next few decades is a modest net-positive creation of jobs and moderate economic growth.

Vaillant et al. (2023) used a statistical approach to explore how certain factors, such as the use of local resources and the establishment of energy interconnections, have caused similarities and differences in patterns and/or trajectories in the energy sectors of various countries. They demonstrate that OECD and BRICS countries have different attitudes towards contemporary transitions to renewable energy.

Kuriyama et al. (2023) developed six scenarios for 100% renewable energy in Japan's power sector and conducted electricity system simulations of least-cost security-constrained unit commitment (SCUC) and security-constrained economic dispatch (SCED) of generators with capacity constraints for high-voltage transmission lines. It will become important to secure long-term flexibility for energy storage in large quantities across seasons.

Rajbhandari et al. (2023) explore the economy-wide impacts of achieving net-zero GHG emissions by 2050 in Thailand. Results indicate that Thailand should put more effort into GHG mitigation measures to achieve peak emissions by 2025 and net-zero GHG emissions by 2050. Compared to baseline emissions or no climate action, the gross domestic product (GDP) loss was projected to be as high as 8.5% in 2050.

International collaboration

International collaboration is a pillar for building a suitable environment that can enable and sustain the growth of both mitigation and adaptation technologies. International cooperation enables innovative technology transfer and the development of new technologies such as green hydrogen and synthetic fuels. Meanwhile, international collaboration, through co-developing models to analyse climate policies such as nationally determined contributions (NDCs) and long-term strategies (LTSs), can pave the way for ambitious net-zero policies.

Capra and La Motta (2023) describe the Italian experience in participating in "Mission Innovation", an international collaboration initiative instituted at COP21 to foster research in energy technology. The paper proposes a set of recommendations to policymakers to set up a successful international innovation initiative.

The Middle East and North Africa (MENA) region are well positioned to generate renewable energy at low cost to produce green hydrogen and synthetic fuels. Yet, other factors are expected to play an equally important role for the development of the green hydrogen and synthetic fuel (export) sectors. Ersoy et al. (2023) assess the existing infrastructural and industrial conditions in Jordan, Morocco and Oman for the development of a green hydrogen and downstream synthetic fuel export sector.

Meanwhile, in the Asia–Pacific, the Asia–Pacific Integrated Model (AIM) team has been working with researchers and policymakers in Japan and other Asian countries to develop long-term strategies towards decarbonised societies. Hibino and Masui (2023) present the process of developing long-term strategies for several Asian countries based on their experiences to date and discuss challenges and solutions, including how to use the AIM models in the policymaking process.

The way forward

Global average temperatures have continued to rise even after the Paris Agreement was agreed (NASA 2023). The World Meteorological Organization (WMO) announced that there is a 66% probability that average temperature rise will exceed 1.5 °C in the next 5 years (WMO 2023). The IPCC assessed detailed mitigation options to limit the temperature rise to 1.5 °C in the 6th Assessment Report, and identified measures that can be taken to limit global temperature rise to 1.5 °C by 2100 (IPCC 2022). However, even if they are technically feasible, many challenges remain in terms of urban planning, lifestyle changes, budgets and so on.

LCS-RNet has provided science-based knowledge through the promotion of international cooperation, consensus-building research and the development of integrated evaluation models. To achieve net-zero emissions globally, national and local governments must implement policies toward net-zero emissions.

When formulating policies, one effective means is to use models to propose feasible solutions. LCS-RNet members not only develop models and scenarios for their own countries in the Global North, but also support researchers from the Global South to develop and improve their models based on the local data. To create a scenario, it is necessary to set many social and economic conditions as input assumptions, such as industrial structure, urban structure, lifestyle, transportation system and land use. Accordingly, it is necessary to estimate energy demand, renewable energy availability and the feasibility of introducing carbon capture, utilisation and storage (CCUS) and bioenergy with carbon capture and storage (BECCS). In some cases, a more detailed model (estimating hourly energy demand, etc.) may be required (Hibino and Masui 2023). Meanwhile, models that present future scenarios in an accessible way are also needed to communicate model results to policymakers and citizens. It is important for researchers to discuss what kind of society we are aiming towards in the future, what models and information we need to envision pathways to such a future and what actions we can take. This will lead to the development of more effective scenarios to support the transition to net-zero societies.

In recent years, the impacts of climate change have become increasingly severe, and the necessity of not only mitigation, but also adaptation has increased. The city of Gdansk in Poland suffered damage from flooding in 2016, and held an assembly to discuss measures with citizens to prevent future damage. As a result, they were able to quickly respond to the heavy rains that occurred in 2017. In this way, it is important to listen to the opinions of citizens and create an environment where citizens take the initiative in tackling global warming (Gazivoda 2017). Chilvers et al. (2023) point out that "it is necessary to better recognise and respond to diverse public engagements with energy, climate change and net zero." One of the themes for the future of LCS-RNet is to consider how best to conduct dialogue with citizens.

The IPCC Sixth Assessment Report's (2022) five shared socio-economic pathways (SSP1–SSP5) provide narratives

describing alternative socio-economic developments from the points of socio-economic challenges of mitigation and adaptation, and the future pathways to net-zero societies are quantified using various integrated assessment models (IAMs) (Riahi et al. 2017). SSP1 is the "Sustainability" pathway, on which there remains the possibility of achieving net-zero emissions by 2050. However, in SSP3, called the "Regional Rivalry" pathway, it would be almost impossible to achieve the 1.5 °C target. To realise a SSP1 world, there are many actions that need to be taken, including strengthening international cooperation, transforming industries, and changing lifestyles. By further accumulating science-based knowledge and facilitating discussions amongst actors based on the knowledge, LCS-RNet will contribute to the realisation of a decarbonised world.

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Declarations

Conflict of interest The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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