



Review

Ten essentials for action-oriented and second order energy transitions, transformations and climate change research



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ABSTRACT

The most critical question for climate research is no longer about the problem, but about how to facilitate the transformative changes necessary to avoid catastrophic climate-induced change. Addressing this question, however, will require massive upscaling of research that can rapidly enhance learning about transformations. Ten essentials for guiding action-oriented transformation and energy research are therefore presented, framed in relation to second-order science. They include: (1) Focus on transformations to low-carbon, resilient living; (2) Focus on solution processes; (3) Focus on 'how to' practical knowledge; (4) Approach research as occurring from within the system being intervened; (5) Work with normative aspects; (6) Seek to transcend current thinking; (7) Take a multi-faceted approach to understand and shape change; (8) Acknowledge the value of alternative roles of researchers; (9) Encourage second-order experimentation; and (10) Be reflexive. Joint application of the essentials would create highly adaptive, reflexive, collaborative and impact-oriented research able to enhance capacity to respond to the climate challenge. At present, however, the practice of such approaches is limited and constrained by dominance of other approaches. For wider transformations to low carbon living and energy systems to occur, transformations will therefore also be needed in the way in which knowledge is produced and used.

1. Introduction

In a world with a changing climate significant societal change is inevitable. Keeping the world well below 2 °C rise in temperature relative to pre-industrial levels will require extensive and rapid social and technological transformations, including in the systems, structures, worldviews and beliefs underpinning climate change and other contemporary challenges [1,2]. This raises a critical question for humanity: how can rapid and transformational societal change be achieved to prevent dangerous levels of global warming? While science has so far excelled at understanding the climate problem and identifying technocentric solutions, it has so far largely failed to seriously engage with the critical question of how to make transformational change happen.

Addressing this and other related questions requires a diversity of approaches to knowledge production [3]. Importantly, many contemporary challenges have emerged through the success of science over the last 300 years, such as through technologies to extract and use fossil fuels that have led to human induced climate change. Thus, while science has clearly brought many benefits, it has also resulted in new challenges that require new ways of thinking to address them [3,4]. These approaches need to be able to take into account normative aspects, inequalities, politics and power, and work more directly across the interface of science and practice [4–6].

Many alternative forms of research that are more democratic, inclusive, action-oriented and integrate different forms of knowledge have emerged over the last three decades. This includes mode 2, transdisciplinarity, post-normal, participatory, sustainability science and action research [7–12]. As yet, however, there has been no integration of these insights specifically for researchers aiming to inform and facilitate the transformational changes necessary to address climate change and help achieve more sustainable societies. Further, while all

forms of research have value, effective responses to climate change require a much more direct and concerted effort towards learning from and through action [13].

This paper therefore presents 10 essentials we believe are important for researchers to achieve greater impact from their work in relation to energy transformation and climate change. The paper does not suggest that research that does not apply all of the essentials is not useful, and working towards applying any of these will add value. However, when applied as a collective, the essentials represent a considerable shift in the way research is conducted that will generate more significant impacts for addressing the climate challenge and legitimise the inclusion of a greater diversity of kinds of knowledge, perspectives, values, imaginations and approaches needed to facilitate transformations to a low-carbon, resilient world. Overall, while the emphasis is on climate change and transformation, the paper will be of wide relevance to any field of study that seeks to enhance societal outcomes.

The paper first explains the need for more action-oriented research and the concept of first and second-order science, which frames the rest of the paper. We then explain the 10 essentials, followed by a discussion about the challenge of encouraging greater attention to the kinds of research that will more effectively accelerate the learning needed to stimulate transformations in the context of climate change.

2. The need for greater attention to action-oriented transformation research

There is a growing emphasis on research agendas and programmes relating to understanding how to achieve deliberate societal transformations to avert the threat of climate change [1,14,15]. While there are many definitions [16], transformation is broadly a process leading to marked and qualitative change [17] and processes that lead to

Table 1
 Types of change (modified from Waddell ([18], p. 15)).

	Incremental	Reform	Transformation
Learning type	Single loop	Double loop	Triple loop
Core questions	<ul style="list-style-type: none"> How can we do more of the same? Are we doing things right? 	<ul style="list-style-type: none"> What are the rules and structures? What are the rewards? Who should do what? 	<ul style="list-style-type: none"> How do I make sense of this? What is our core purpose? How do we know what is best?
Purpose	To improve performance	To understand and change the system and its parts	To innovate and create previously unimagined possibilities
Power and relationships	Confirms existing rules	Opens rules up to revision	Opens issues to the creation of new ways of thinking and action
Core dynamic	Replication	Reorganization	Transcendence
Archetypal actions	Copying, duplicating, mimicking	Changing policy, adjusting, adapting	Visioning, experimenting, inventing

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