International Sustainability Transitions Conference (IST'24)

June 17 to 19, Oslo

TYPOLOGY OF PATHWAYS FOR DECARBONIZATION

Nuno Bento[1,*], Tiago Alves[1], Ricardo Ribeiro[2], Margarida Fontes[3]

[1] DINÂMIA'CET–Iscte, Portugal,

[2] INESC-ID & Iscte, Portugal

[3] LNEG, Portugal

* corresponding author: nuno.bento@iscte-iul.pt

Abstract

Addressing the urgent climate change requires a clear knowledge of the options available, as well as an understanding of the possible strategies to reduce carbon emissions. Identifying realistic pathways for decarbonization is crucial to inform agents' decisions about the relevant measures (Turnheim & Nykvist, 2018), with unawareness of these pathways often delaying climate action (Bergek et al, 2023).

This paper seeks to identify, categorize, and analyze decarbonization pathways from the scientific literature, uncovering cross-cutting dimensions, interconnections, and regional trends for enhanced decision-making and accelerated change.

The research builds on a growing literature that considers transitions as phenomena occurring at multiple (micro, meso, macro) levels (Geels, 2007), involving technology systems in interaction (Markard & Truffer, 2008; Andersen & Geels, 2023) and innovations with transformative effects on related systems and sectors (Fontes et al., 2021). The paper also draws on energy and climate studies that have advanced the understanding about the type of knowledge needed for climate change (Callaghan et al, 2020), as well as of strategies for decarbonization such as energy efficiency, decarbonization of electricity, and electrification of uses (Sachs et al., 2017). However, this typology misses important challenges in decarbonization such as shifts in behaviors, food, and agriculture.

We suggest that a large-scale, agnostic (non-biased), systematic review of the literature can reveal the complex landscape of decarbonization strategies. The study applies Artificial Intelligence (AI) techniques to review over 1 million articles from Scopus and WoS. Cutting-edge techniques like Latent Dirichlet Allocation (LDA) and BERTopic are employed for pathway identification and dimension analysis respectively (Grootendorst, 2022). Additional citation network analysis validates the revealed typology of decarbonization pathways.

The resulting typology identifies six primary decarbonization pathways (see Fig.1) as well as five transversal dimensions (energy services, economics, planning,

infrastructure, and transition). Regional analysis reveals distinct priorities among key global players (US, EU, China, Japan). Advanced analysis finds frequent overlaps between the decarbonization pathways and associated scientific requirements that can support real-world implementation. Decarbonization requires a systematic change that goes beyond the focus on transitions in the energy sector, an important lesson for future research. The findings also advocate for a tailored approach to decarbonization strategy implementation, offering a framework for policymakers and other stakeholders.

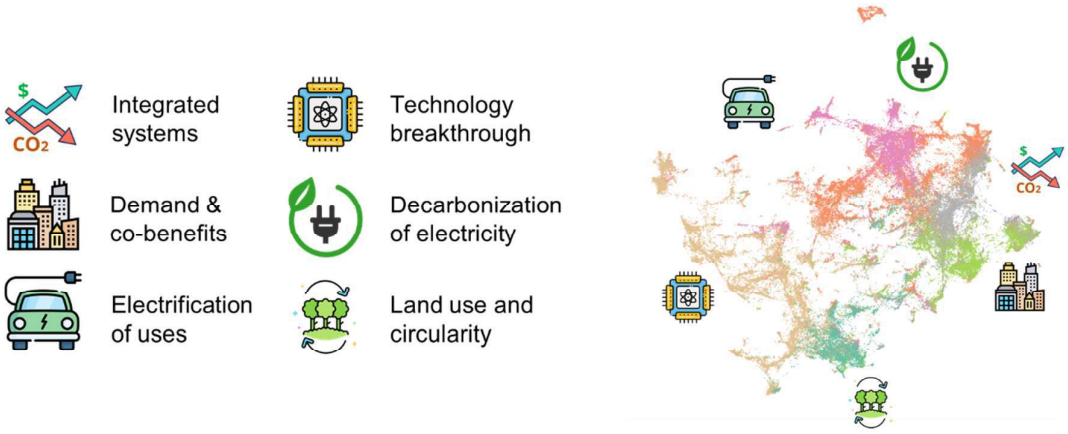

Fig 1 Literature map and revealed decarbonization pathways

Keywords: socio-technical systems, decarbonization pathways, artificial intelligence.

Track 1: Accelerating sustainability transitions (sub-category: acceleration challenges)

Alternatively: Track 3: Exploring multi-system dynamics (al. new frameworks; new approaches); Track 9: Overcoming methodological challenges (al. development of integrated transition pathways)

References

Andersen, A. D., & Geels, F. W. (2023). Multi-system dynamics and the speed of net-zero transitions: Identifying causal processes related to technologies, actors, and institutions. Energy Research & Social Science, 102, 103178.

Bergek, A., Hellsmark, H., & Karltorp, K. (2023). Directionality challenges for transformative innovation policy: lessons from implementing climate goals in the process industry. Industry and Innovation, 1-30.

Callaghan, M.W., Minx, J.C., Forster, P.M. (2020). A topography of climate change research. Nature Climate Change 10, 118–123.

Fontes M., Bento N., Andersen A.D. (2021), "Unleashing the transformative potential of innovations," Environmental Innovation and Societal Transitions 40, 207-221

Geels, F. W., & Schot, J. (2007). Typology of sociotechnical transition pathways. Research policy, 36(3), 399-417.

Grootendorst, M., 2022. BERTopic: Neural topic modeling with a class-based TF-IDF procedure. arXiv:2203.05794.

Markard, J., & Truffer, B. (2008). Technological innovation systems and the multi-level perspective: Towards an integrated framework. Research policy, 37(4), 596-615.

Sachs, J.D., Schmidt-Traub, G., Mazzucato, M., Messner, D., Nakicenovic, N., Rockstrom, J., 2019. Six Transformations to achieve the Sustainable Development Goals. Nature Sustainability 2, 805–814.

Turnheim, B., & Nykvist, B. (2019). Opening up the feasibility of sustainability transitions pathways (STPs): Representations, potentials, and conditions. Research Policy, 48(3), 775-788.