

Policy mixes for sustainability transitions must embrace system dynamics

Citation for published version (APA):

Alkemade, F., & de Coninck, H. (2021). Policy mixes for sustainability transitions must embrace system dynamics. *Environmental Innovation and Societal Transitions*, 41, 24-26.
<https://doi.org/10.1016/j.eist.2021.10.014>

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DOI:

[10.1016/j.eist.2021.10.014](https://doi.org/10.1016/j.eist.2021.10.014)

Document status and date:

Published: 01/12/2021

Document Version:

Publisher's PDF, also known as Version of Record (includes final page, issue and volume numbers)

Please check the document version of this publication:

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
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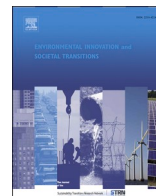
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Environmental Innovation and Societal Transitions

journal homepage: www.elsevier.com/locate/eist

Policy mixes for sustainability transitions must embrace system dynamics

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ARTICLE INFO

Editor: Dr. J.C. van den Bergh

Keywords:

Social tipping dynamics
Policy impact
System dynamics

ABSTRACT

Increasing the policy impact of sustainability transitions research requires a focus on the interactions and feedbacks within *and* between systems. More specifically, it requires insights into how dynamics can accelerate sustainability transitions and make them self-reinforcing. Existing approaches that focus on dynamics lack a social-science perspective, often leading to an over-estimation of policy leverage. Sustainability transitions scholars are uniquely positioned to address this research gap. This requires the following steps: (1) The identification of those intervention points that set in motion reinforcing feedbacks or reduce negative interactions, (2) Using a systems perspective to understand how trade-offs between different processes can be reduced and co-benefits stimulated, and (3) Gathering empirical insights from the sustainability transitions research on how policy can trigger self-reinforcing dynamics.

1. Viewpoint

The IPCC in its 2018 Special Report on limiting warming to 1.5C acknowledges that systems transitions need to increase in spread, scale and speed (de Coninck et al., 2018). Identifying the policy levers to do so requires a high-level view of sustainability transitions and a multi-systems approach (Köhler et al., 2019; Rosenbloom, 2020). While sustainability transitions scholars are increasingly studying the different types of interactions that link sociotechnical transitions in different domains and on different scales through concepts such as multi-scalarity, functional, and structural couplings (Binz and Truffer, 2017; Mörner and Binz, 2021), their engagement with policy remains limited (an exception is EEA (2019), which highlights the importance of the science-policy interface). Other sustainability research fields have succeeded in making such a policy link. For instance, socio-ecological and complexity studies identify social tipping points that can accelerate transitions (Otto et al., 2020; Roberts et al., 2018) and argue for their use (Mercure et al., 2021; Sharpe and Lenton, 2021).

These interesting and hopeful studies all consider how dynamics can accelerate sustainability transitions and make them self-reinforcing. What they lack is a social-science perspective; they are based on a natural-science perspective on tipping point-thinking, which omits the complexity of social processes, thus leading to an overestimation of policy leverage. We argue that the sustainability transitions field has much to offer to identify policy leverage points and for this should embrace the field of system dynamics (Meadows, 2008). More specifically, it is uniquely positioned to contribute to a much-needed dynamic approach to transitions policy.

An example of self-reinforcing feedback loops are social tipping points. We speak of social tipping dynamics in the context of low

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<https://doi.org/10.1016/j.eist.2021.10.014>

Received 23 July 2021; Received in revised form 14 October 2021; Accepted 18 October 2021

Available online 29 October 2021

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carbon transitions when a small change or intervention in the socio-economic system has a large effect on emission reductions (Milkoreit et al., 2018). Analogous to climate and biological tipping points, social tipping dynamics could provide effective and efficient points for intervention when a small, well-timed intervention initiates larger-scale changes. Tipping points are usually unintended, rather than planned, and systematic evidence on the interventions that trigger tipping dynamics in sustainability transitions is missing. Yet, unleashing intentional positive societal feedback loops may be the only chance we have at preventing the worst of climate change and biodiversity loss through accelerating system transitions. It is therefore key to understand reinforcing feedbacks in systems transitions. However, the wide range of social factors and the complex interaction of these factors with broader socio-technical systems have so far prevented a systematic understanding of social tipping dynamics. This presents a critical knowledge gap.

If an understanding of tipping dynamics can be presented in such a way that policymakers are not only aware of but also able to act upon the insights, it could provide the theoretical support for policy studies that call for a focus on effectiveness and adaptability rather than on economic efficiency (Alkemade et al., 2009; Rosenbloom et al., 2020; Sharpe and Lenton, 2021). To address this knowledge gap, we need to move beyond understanding of feedbacks within socio-technical systems to research that enhances our understanding of the impacts of interactions between the different systems and sectors in a dynamic way. When these interdependencies are aligned and reinforce one another, social tipping dynamics and fast transitions may result. Observed social tipping dynamics typically result from the interdependencies and interactions between several social processes with developments in technology and policy (Otto et al., 2020). When these interdependencies do not align, barriers to the transition arise (Kern et al., 2019; Negro et al., 2012; Rogge and Reichardt, 2016). For this, timing matters. Lovell and Foxon (2021) call attention to ‘branching points’ in which a groundswell can resolve a ‘transition bottleneck’ by making use of a decision window (Geels et al., 2020). For instance, if the timing is aligned, the electricity transition can also speed up the decarbonization of mobility through electrification. The same goes for the development of offshore wind and the electrification of industry in the Netherlands. More compact housing and collective mobility can facilitate the transition to climate neutrality, but they need to be enhanced jointly.

Identifying such interventions starts from insights into the interactions between different complex, non-linear processes. Although non-linear dynamics are at the core of innovation studies and transitions studies, the different types of interactions and feedbacks are typically studied qualitatively and in isolation (Chilvers et al., 2021; Edmondson et al., 2019; Gillard et al., 2016; Roberts et al., 2018; Rosenbloom et al., 2019). In short, the transitions literature is rife in suggestions that timing and non-linearity matter, and it has provided detailed empirical insights on the effects of such interactions on individual socio-technical transitions. The next step is to systematically map these interactions and feedbacks to be able to evaluate their policy leverage. The ability to foster social tipping dynamics crucially requires a step beyond the identification of tipping points to the identification of interventions, along with an actor or a group of actors that can make the intervention(s).

Summarizing, increasing the policy impact of sustainability transitions research through a focus on the interactions and feedbacks within and between systems requires the following steps: (1) Understanding feedback processes and their effects starting from the identification of those intervention points that set in motion reinforcing feedbacks or reduce negative interactions, (2) Using a systems perspective to understand how trade-offs between different processes can be reduced and co-benefits stimulated (Peñasco et al., 2021), and (3) Gathering empirical insights from the social sciences on how policy can trigger a tipping point, and ensure that tipping dynamics scale up and reduce attractiveness of unsustainable alternatives. This should be embedded in the work on policy feedbacks and policy mixes for sustainability and requires closer collaboration with the environmental and climate sciences.

Declaration of Competing Interest

The authors declare that they have no competing interests.

References

- Alkemade, F., Frenken, K., Hekkert, M.P., Schwoon, M., 2009. A complex systems methodology to transition management. *J. Evol. Econ.* 19 (4), 527–543. <https://doi.org/10.1007/s00191-009-0144-x>. Scopus.
- Binz, C., Truffer, B., 2017. Global innovation systems—A conceptual framework for innovation dynamics in transnational contexts. *Res. Policy* 46 (7), 1284–1298. <https://doi.org/10.1016/j.respol.2017.05.012>.
- Chilvers, J., Bellamy, R., Pallett, H., Hargreaves, T., 2021. A systemic approach to mapping participation with low-carbon energy transitions. *Nat. Energy* 6 (3), 250–259. <https://doi.org/10.1038/s41560-020-00762-w>.
- de Coninck, H., Revi, A., Babiker, M., Bertoldi, P., Buckenridge, M., Cartwright, A., Dong, W., Ford, J., Fuss, S., Hourcade, J.-C., Ley, D., Mechler, R., Newman, P., Revokatova, A., Schultz, S., Steg, L., & Sugiyama, T. (2018) Strengthening and Implementing the Global Response. In: In Masson-Delmotte, V., Zhai, P., Pörtner, H.-O., Roberts, D., Skea, J., Shukla, P.R., Pirani, A., Moufouma-Okia, W., Péan, C., Pidcock, R., Connors, S., Matthews, J.B.R., Chen, Y., Zhou, X., Gomis, M.I., Lonnoy, E., Maycock, T., Tignor, M. & Waterfield, T. (Eds.) *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty*. In Press.
- EEA, 2019. Sustainability transitions: policy and practice. EEA: Copenhagen, Denmark. ISBN: 978-92-9480-086-2: <https://www.eea.europa.eu/publications/sustainability-transitions-policy-and-practice>.
- Edmondson, D.L., Kern, F., Rogge, K.S., 2019. The co-evolution of policy mixes and socio-technical systems: towards a conceptual framework of policy mix feedback in sustainability transitions. *Res. Policy* 48 (10), 103555. <https://doi.org/10.1016/j.respol.2018.03.010>.
- Geels, F.W., McMeekin, A., Pfluger, B., 2020. Socio-technical scenarios as a methodological tool to explore social and political feasibility in low-carbon transitions: bridging computer models and the multi-level perspective in UK electricity generation (2010–2050). *Technol. Forecast Soc. Change* 151, 119258. <https://doi.org/10.1016/j.techfore.2018.04.001>.
- Gillard, R., Gouldson, A., Paavola, J., Alstine, J.V., 2016. Transformational responses to climate change: beyond a systems perspective of social change in mitigation and adaptation. *WIREs Clim. Change* 7 (2), 251–265. <https://doi.org/10.1002/wcc.384>.
- Kern, F., Rogge, K.S., Howlett, M., 2019. Policy mixes for sustainability transitions: new approaches and insights through bridging innovation and policy studies. *Res. Policy* 48 (10), 103832. <https://doi.org/10.1016/j.respol.2019.103832>.

- Köhler, J., Geels, F.W., Kern, F., Markard, J., Onsongo, E., Wieczorek, A., Alkemade, F., Avelino, F., Bergek, A., Boons, F., Fünfschilling, L., Hess, D., Holtz, G., Hyysalo, S., Jenkins, K., Kivimaa, P., Martiskainen, M., McMeekin, A., Mühlemeier, M.S., ..., Wells, P., 2019. An agenda for sustainability transitions research: state of the art and future directions. *Environ. Innov. Soc. Transit.* 31, 1–32. <https://doi.org/10.1016/j.eist.2019.01.004>. Scopus.
- Meadows, 2008. *Thinking in systems: A primer*. Chelsea green publishing.
- Mercure, J.-F., Sharpe, S., Vinales, J.E., Ives, M., Grubb, M., Lam, A., Drummond, P., Pollitt, H., Knobloch, F., Nijse, F.J.M.M., 2021. Risk-opportunity analysis for transformative policy design and appraisal. *Glob. Environ. Change*, 102359. <https://doi.org/10.1016/j.gloenvcha.2021.102359>.
- Milkoreit, M., Hodbod, J., Baggio, J., Benessaiah, K., Calderón-Contreras, R., Donges, J.F., Mathias, J.-D., Rocha, J.C., Schoon, M., Werners, S.E., 2018. Defining tipping points for social-ecological systems scholarship—An interdisciplinary literature review. *Environ. Res. Lett.* 13 (3), 033005 <https://doi.org/10.1088/1748-9326/aaaa75>.
- Miörner, J., Binz, C., 2021. Towards a multi-scalar perspective on transition trajectories. *Environ. Innovat. Soc. Transit.* 40, 172–188. <https://doi.org/10.1016/j.eist.2021.06.004>.
- Negro, S.O., Alkemade, F., Hekkert, M.P., 2012. Why does renewable energy diffuse so slowly? A review of innovation system problems. *Renew. Sustain. Energy Rev.* 16 (6), 3836–3846. <https://doi.org/10.1016/j.rser.2012.03.043>. Scopus.
- Otto, I.M., Donges, J.F., Cremades, R., Bhowmik, A., Hewitt, R.J., Lucht, W., Rockström, J., Allerberger, F., McCaffrey, M., Doe, S.S.P., Lenferna, A., Morán, N., Vuuren, D.P.van, Schellnhuber, H.J., 2020. Social tipping dynamics for stabilizing Earth's climate by 2050. *Proc. Nat. Acad. Sci.* 117 (5), 2354–2365. <https://doi.org/10.1073/pnas.1900577117>.
- Peñasco, C., Anadón, L.D., Verdolini, E., 2021. Systematic review of the outcomes and trade-offs of ten types of decarbonization policy instruments. *Nat. Clim. Chang.* 1–9. <https://doi.org/10.1038/s41558-020-00971-x>.
- Roberts, C., Geels, F.W., Lockwood, M., Newell, P., Schmitz, H., Turnheim, B., Jordan, A., 2018. The politics of accelerating low-carbon transitions: towards a new research agenda. *Energy Res. Soc. Sci.* 44, 304–311. <https://doi.org/10.1016/j.erss.2018.06.001>.
- Rogge, K.S., Reichardt, K., 2016. Policy mixes for sustainability transitions: an extended concept and framework for analysis. *Res. Policy* 45 (8), 1620–1635. <https://doi.org/10.1016/j.respol.2016.04.004>.
- Rosenbloom, D., 2020. Engaging with multi-system interactions in sustainability transitions: a comment on the transitions research agenda. *Environ. Innovat. Soc. Transit.* 34, 336–340. <https://doi.org/10.1016/j.eist.2019.10.003>.
- Rosenbloom, D., Markard, J., Geels, F.W., Fuenfschilling, L., 2020. Opinion: why carbon pricing is not sufficient to mitigate climate change—And how “sustainability transition policy” can help. *Proc. Nat. Acad. Sci.* 117 (16), 8664–8668. <https://doi.org/10.1073/pnas.2004093117>.
- Rosenbloom, D., Meadowcroft, J., Cashore, B., 2019. Stability and climate policy? Harnessing insights on path dependence, policy feedback, and transition pathways. *Energy Res. Soc. Sci.* 50, 168–178. <https://doi.org/10.1016/j.erss.2018.12.009>.
- Sharpe, S., Lenton, T.M., 2021. Upward-scaling tipping cascades to meet climate goals: plausible grounds for hope. *Clim. Policy* 1–13. <https://doi.org/10.1080/14693062.2020.1870097>.