Decentralized energy futures: pathways and lockins towards emerging new logics of energysystem organization

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(1) Introduction: a forward-looking approach to lock-ins in transition pathways

- Lock-ins play an important role in sustainability transitions. Focus has been on lock-ins in unsustainable system constellations (incumbents) and how these lock-ins can be overcome to allow for systemic change
- Yet, lock-ins can also play a role in the transition process once incumbent lock-ins have been overcome and new system configurations have emerged
- The focus of this paper is on such potential lock-ins of emerging new system configurations



Aim and research question

- Aim: Explore potential lock-ins on the pathways towards alternative, emerging configurations of decentralized energy systems
- **RQ:** Which lock-ins can emerge on the pathways towards decentralized configurations of the energy system and what can we learn from this case for the analysis of lock-in risks in sustainability transitions?
- Contribution: The sustainability assessment of future system configurations
- Long-term ambition: Develop a methodology for a forward-looking pathway analysis to identify lock-in risks

(2) Methodology



Literature review of lock-ins in transition processes (Scopus)



Regular online discussions among researchers and experts in the ISGAN Smart Grid Transitions working group



Case – four ideal-type configurations of decentralized energy systems developed in Wieczorek et al (2022)



Empirical examples of decentralization to develop further insights, representing different ideal-type configurations

(3) Lock-in concept and its use in studies of sustainability transitions

Positive feedbacks or increasing returns to the adoption of a given technology, institution, or practice/ behavior – self-reinforcing mechanisms that tend to maintain status quo

Incumbent technologies, institutions, practices, and the sociotechnical systems they are part of, therefore "have a distinct advantage over new entrants ... [simply] because they are more widely used and diffused" (Klitkou et al., 2015)

Lock-in processes are a key source of **path dependency** of complex systems





Typology of lock-in mechanisms

Lock-in category	Lock-in types (selected)	Lock-in category	Lock-in types (selected)
Material	Economies of scale and scope Technological learning effects Technological interrelatedness Spatial interdependencies	Behavioural	Individual decision-making Self-reinforcing social practices Risk avoidance
Institutional	Collective action Institutional learning effects Network externalities (social)	Discursive	Unchallenged ideas Cooptation of alternative ideas Incumbent's agency reg. dominant ideas

Sources: Arthur (1994), Klitkou et al. (2015), Unruh (2000), Foxon (2002), Gottschamer and Zhang (2020), Simoens et al (2022a/b), Kotolainen et al (2019), Seto et al. (2016)

Forward-looking analysis (of lock-ins)

- Studies with a forward-looking perspective that investigate bridging technologies and how they can reinforce lock-ins in incumbent systems rather than facilitate the development of a new system
 - Focus on newly emerging lock-ins from the incumbent system that result from the double-edged nature of some technologies – e.g., gas is intermediate tech
- We go one step further: Not focus on new carbon lock-ins in the transition process, but on lock-ins that result from the development of the new system configuration itself
- Forward- and backward-looking analysis of lock-ins in transition processes: Forward-looking analysis needs to find ways to discover potential lock-ins that do not exist yet

Case: Forms of decentralization logic in the energy system

Value orientation Service orientation	Individual values	Collective values
Outward services System services, system oriented Full support to the system	<i>Individual-Outward:</i> System-oriented prosumers and consumers	Collective-Outward: System-oriented energy communities
Inward services Self-services oriented Selective support to the system	<i>Individual-Inward:</i> Self-service oriented prosumers and consumers	Collective-Inward: Self-service oriented energy communities

Source: Wieczorek et al (2022)



(4) Decentralization example: Material lock-in in the inward-looking configurations

- Lock-ins in inward-looking configurations may emerge because these configurations, by definition, each focus on small parts of the energy system while the energy transition is about the whole energy system
- Individual investment decisions that are not in line with overall RES expansion targets can lead to RES underinvestment
 - Well-endowed regions develop renewables only for their own demand
 - Home-owners develop PV only for self-consumption and do not use the entire rooftop space
- Such investments are typically difficult to revise for some time due to technological lock-ins (creating sunk costs). As a result, at a system level, there can be a lock-in in a certain RES development pathway.





Technological interrelatedness lock-in in collective outwardlooking configuration

Solrød Biogas in Zealand, Denmark

Capacity limitations of pipes supplying gas generator with biogas from nearby biogas plant prevents increasing size of new generator, despite increased availability of biogas, in turn reducing profitability and supply of green electricity to the grid

(5) Conclusions and next steps

- Sustainability transitions are not just about destabilizing the incumbent system and replacing it with a well-defined alternative
- There is **uncertainty** about how transition pathways will unfold, what the new system should/will look like, and whether a new system meets sustainability requirements. Lock-ins play a major role here.
- Hence: How can potential lock-in effects be detected and evaluated?
 - Even in where things move in the right direction, lock-ins can be an issue detecting them is not just about **direction** of a (sustainable) pathway, but also about **speed** and the **target level** that can be reached
 - More difficult to evaluate than in the case of incumbent lock-ins



Next steps

- Refining the understanding of potential lock-ins to be able to identify them ex-ante in transition processes, as part of a sustainability assessment of potential future system configurations
- Once potential lock-ins have been identified, the next step is to develop governance strategies with the objective to avoid:
 - Lock-ins in one configuration that make it difficult to switch to another, more sustainable pathway
 - Lock-ins that undermine a pathway to a specific configuration, so that it "gets stuck on the way" and fails to reach its full sustainability potential



Thank you for listening!

