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The anatomy of change in urban infrastructure landscapes: cooking landscapes in Maputo, Mozambique

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ABSTRACT
Rapid urbanisation and global environmental transformations require rethinking the material and social configurations of cities. The concept of 'transitions' has gained traction to guide such processes of infrastructure change towards net-zero, resilient societies both in academic and policy conversations. In this paper, we examine what notions of change are deployed in these debates. Specifically, we argue that transition theory conceptualises change as triggered by intentional actions and innovations by emphasising the functional drivers leading change. While deliberate actions cause changes, not all change follows strategic intent. Instead, transitions also depend on contingent relations between social actors and material objects, which cannot always be planned or anticipated. The concept of 'urban infrastructure landscape' helps reveal the non-strategic aspects of transitions. The example of improved cookstoves in Maputo, Mozambique, demonstrates the change envisaged in current energy policy and the changes on the ground.

KEYWORDS
Urban infrastructure landscapes; energy landscapes; energy access; improved cookstoves

1. Introduction

Rapid urbanisation and climate change require the structural transformation of our societies (see, for example, IPCC, 2018). The question of 'change' has become increasingly central to debates on how cities will adapt their infrastructure to the challenges raised by a changing climate, whether this is to address vulnerabilities to climate risks or support low carbon economies (Bulkeley, Castán Broto, & Maassen, 2014; Hughes, Chu, & Mason, 2018). The need to enhance cities' sustainability and resilience requires just transformations (Elmqvist et al., 2019; Hughes & Hoffmann, 2020; Köhler, Geels, Kern, Onsongo, & Wieczorek, 2017; Wolfram, Frantzeskaki, & Maschmeyer, 2016) that put urban infrastructure are the heart of future processes of change (Carroli, 2018; Truffer, Störmer, Maurer, & Ruef, 2010). However, understanding the nature of the changes required and how to trigger such changes are no easy tasks.

The question of change is central to the literature on socio-technical transitions, which analyses the multiple pathways that enable socio-technical and socio-ecological transformations (Foxon, 2013; Rydin, Turcu, Guy, & Austin, 2013). Transitions are most often depicted as the coordination of alternatives for change, such as 'niche innovations,' with external pressures to

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transform the complex set of material and institutional arrangements that constitute a regime (e.g. Verbong & Geels, 2010). A key challenge for transition scholars is identifying the locus of agency, who can influence the transformation of a socio-technical regime and how (e.g. Duygan, Stauffacher, & Meylan, 2019). For example, transition management advocates reflexive governance to identify potential innovations alongside the drivers and barriers of change and the learning requirements to adjust action (for empirical examples, see: Grin, 2013; Halbe, Pahl-Wostl, A. Lange, & Velonis, 2015). This body of work emphasises the diversity of governance structures that enable cooperation across networks or loose coalitions of actors in shared strategic projects of change (Smith, Stirling, & Berkhout, 2005).

Because of its focus on strategic innovations and concrete acts of purposeful governance, transitions theory may overlook those mundane and everyday interactions with infrastructure that foster incremental changes in urban environments and that may also shape radical reconfigurations of infrastructure (Castán Broto 2019). For example, a key strategy to overcome gaps in electricity access in African cities and towns is the acquisition of solar energy technologies or diesel generators: how these are acquired may condition the adoption and development of unfamiliar technologies (Munro, 2020; Rateau & Jaglin, 2020). Strategic and mundane practices of innovation coexist, contribute to and hinder transition pathways in cities. In the example above, the accessibility of diesel generators reinforces the presence of fossil fuels in the urban environment. Mundane, everyday practices change urban infrastructures alongside policies, regulations, technological innovations, and broader political-economic processes.

In this paper, we examine the non-strategic aspects shaping urban socio-technical transitions in urban environments by reflecting on the conceptualisation of the socio-technical landscape. An in-depth analysis of the urban infrastructure landscape reveals urban change as a multi-layered, multi-scalar, and distributed process (Section 2). Section 3 explores how this concept can help us make sense of change occurring in Sub-Saharan African cities' energy infrastructure. The continent is undergoing rapid urban growth and infrastructure transformations while facing significant energy access gaps. Section 4 zooms in on the case of Maputo's socio-technical regime of cooking and how it coevolves with the urban infrastructure landscape. Section 5 concludes the paper with a reflection of the non-strategic aspects of socio-technical transitions.

2. Interrogating the relationship between landscape and change

Research on sustainability transitions has provided insights on the processes of infrastructure change at the local scale, whether linking those processes to large technological systems or examining the urban lives of technologies (e.g. Frantzeskaki, Castán Broto, Coenen, & Loorbach, 2017; Lawhon & Murphy, 2012). Transitions are multi-dimensional coevolutionary processes involving a multiplicity of actors with different interests and perspectives on what desirable trajectories of change might be (Köhler et al., 2017). There are three dominant approaches to socio-technical transitions. First, research on technological innovation system(s) (TIS) has focussed on innovations and their embeddedness in complex governance arrangements and multi-actors settings (e.g. Bergek et al., 2015). Second, historical analyses of transitions, such as the multi-level perspective (MLP), analyse the dynamics that challenge, destabilise, and change dominant regimes (e.g. Verbong & Geels, 2010). Third, scholars on transitions management (TM) take a pro-active stance to explain what can and should inform transitions, with the objective of informing policy processes (e.g. Frantzeskaki, Hölscher, Bach, & Avelino, 2018).

Empirical evidence on socio-technical transitions has revealed their messy nature and the extent to which they follow uncoordinated and simultaneous processes of change in-the-making (Moloney, Bosomworth et al. 2018). Transitions research has focussed on purposeful interventions, powerful actors, and innovations that can have a disruptive impact (e.g. Avelino, Grin et al. 2016). Scholarship on infrastructure change in cities has shown that power tends to be much distributed, rooted in policy processes and in everyday activities that maintain or change infrastructure configurations (e.g. Rutherford & Coutard, 2014; Silver 2014).

Socio-technical transitions perspectives define the landscape metaphorically as the external set of socio-cultural and economic trends that shapes dominant regimes but over which actors have little influence. An early influence on this literature was the work on the history of electricity networks by Thomas Hughes (Hughes, 1993). Hughes portrayed a wide range of innovators (inventors, engineers, financiers) as mediating the impact of contextual factors on technological development. In later work on socio-technical transitions, the diversity of potential innovators grew, and the concept of socio-technical change came to contain all those aspects over which such innovators have no influence or control. Hughes notion evolved into a metaphor that sees the landscape as a background that enables or constrains socio-technical transitions. For instance, Raven, Schot, and Berkhout (2012) define the landscape as an exogenous environment that innovation actors cannot influence.

Transitions thus result from the interaction of levels that operate at different times: the immediate time of experimentation, the medium time of a changing dominant regime, and the longer, less mutable time of the landscape (Raven et al., 2012). The landscape is all that which recedes from view: the flow of processes whose influence cannot be pinned into singular instances of change. Sometimes the landscape is used as a catch-all term that refers to an invisible exogenous environment in which everything is landscape.

In contrast, scholars of infrastructure landscapes situate infrastructures in the geographical context in which they operate. Infrastructure becomes entangled in a web of processes and flows that resist systemic description. Where is the landscape in this urban picture? Urban infrastructure landscapes emerge from a close relationship between urban infrastructure and spatial changes over time (Coutard & Rutherford, 2016; Monstadt & Schramm, 2015). Rutherford and Coutard (2014) highlight the heterogeneity of the 'mutually recursive change' that infrastructures and places undergo simultaneously, whether it happens suddenly or through planning, whether it is radical or incremental, whether it becomes chronic or punctual.

Urban infrastructure landscapes may appear as the physical manifestation of collective memory accumulation (Gandy, 2011). However, urban infrastructure landscapes can also transform and challenge past legacies. In his classic text, Tuan (1977; p. 197) reflected on the impulse to preserve landscapes as a hesitation to sacrifice the present for an unrealised future. He observed that '*all creative effort – including the making of an omelette – is preceded by destruction*'. The preservationist impulse has influenced studies of infrastructure landscapes, particularly those concerned with the external imposition of infrastructures onto local places and communities (Pasqualetti, 2011). Research has also shown that urban infrastructure landscapes are embedded in particular histories of colonial domination and exclusion (Graham & McFarlane, 2014; Monstadt & Schramm, 2015). For scholars looking at the postcolonial legacies of infrastructure and the enduring injustices they create and maintain, the question of landscape change is a normative one. This normative angle on infrastructure change connects critical analyses of infrastructural politics and urban transformations and transitions studies.

Urban infrastructure landscapes do not only change through long-term time processes that are difficult to apprehend. They also change in punctual, unexpected ways—through the imposition of large infrastructures or in mundane practices that reimagine the urban environment. Infrastructure landscapes are imagined as an amalgamation of material, resources, technologies, institutions, social practices, cultural beliefs, and affective attachments. They bring the urban together, forming links and connections between material and social processes, forming a connective tissue in which urban life unfolds (Castán Broto, 2019). Individuals' and groups' capacities to influence any of those landscape aspects will vary over time, but everyday practices of infrastructure access will always impact what changes are feasible and acceptable (Coutard & Rutherford, 2016; Rateau & Jaglin, 2020). Urban dwellers mobilise energy sources, including formal and informal connexions to the grid network (when they have access to it), back up diesel generators or solar home systems (when they can afford them), and firewood and charcoal for cooking. Within these complex configurations, change is everywhere and, also, nowhere. Landscapes include both the salient elements of infrastructure regimes (infrastructure networks, off-grid facilities, housing structures) described in transition theory and all the other non-salient elements that sustain and connect them (soils, wildlife, heritage, resource extraction) (Castán Broto, 2019).

From this perspective, what counts as 'change' is difficult to determine. Yet, the form of change and its relation to time directly links the abstract notion of landscape mobilised in theories of socio-technical transitions and the tangible landscapes we live within. The challenge is how change is approached, providing fragmented interpretations of what remains a complex phenomenon. For example, landscape ecology naturally emphasises the drivers of landscape change. Landscape emerges as a layered composition that brings multiple responses to geophysical, ecological, and cultural driving forces (Bürgi, Hersperger, & Schneeberger, 2005). Change is identified as an alteration that transforms landscapes' structure and function (Musacchio, Ozdenerol, Bryant, & Evans, 2005). In the context of sustainability transitions, landscapes relate to multi-dimensional chaotic processes, agglutinating multiple macro and micro political agendas. In this understanding, the landscape is the material manifestation of transitions in specific and generative territories. This perspective emphasises the components of change- its anatomy- rather than the functional drivers of change. The components of change shape the broader landscape elements that produce governance mechanisms, flows of materials, technologies and resources, and everyday practices (Castan Broto, 2019).

The above analysis suggests three elements constitutive of the anatomy of change in urban infrastructure:

- Strategic actions that impose change on the landscape, resulting, for example, in large-scale infrastructure, regeneration programs, or slum clearance programs (e.g. Doshi, 2019);
- Open-ended actions and minor shifts that people live through daily and result in organic changes, improvised material arrangements, and, sometimes, radical change (e.g. Ingold, 2010);
- Urban infrastructure imaginaries shaped from the constant adjustment of normative ideas of future cities, inspiring both strategic and open-ended actions (Bulkeley, Castán Broto, & Edwards, 2015).

This perspective complements transitions theories because it asks how to govern urban landscapes to reach the desired outcome and how those changes are lived and enacted daily. Urban infrastructure landscapes invite us to look at how mundane acts of living in the city contribute to stabilising governance mechanisms, resource flows, and social practices. Urban infrastructure landscapes are shaped by law and regulations, technological developments, and investments, as much as by the daily activities of multiple actors who maintain, operate, and use infrastructure at work, in their homes, or move through the city. The anatomy of change reveals that urban change is both something discrete and strategic, and something that is 'happening' and always in-the-making.

The anatomy of change in urban infrastructure landscapes requires methodologies to examine the non-functional, non-strategic aspects shaping socio-technical transitions. Landscapes foreground ethnographic and observational methods of study that enable to map unexpected connections that may also explain processes of urban change. This paper examines the elements of change in infrastructure landscapes, as described above (imaginaries, strategic intentions, and mundane changes), in the case of facilitating energy access in urban areas in Mozambique. The following section reviews dominant conceptions of change in discussions of energy access for cooking and transitions to clean energy technologies. Zooming in on how change is experienced on the ground, section 4 reveals the complex arrangement of strategic and improvisational projects that shape the infrastructure landscape of cooking in the city of Maputo.

3. Changing energy landscapes and the challenges of achieving clean energy access in African cities

This case study builds upon a long-term engagement with the energy landscapes of Maputo, Mozambique, since 2012. Initially, the research focussed on understanding change in urban energy landscapes from the perspective of informal settlement dwellers via walking methodologies and participatory workshops. Through these engagements, we became interested in a particular instance of deliberate change: the provision of improved cookstoves. To understand the significance of improved cookstoves in the energy landscapes and adapt existing technological designs to local conditions, we worked with local producers to update their templates. After the design work with local producers, we conducted eight semi-structured interviews with four NGO workers and four producers that explored different aspects of the improved cookstoves program and how they were changing the existing landscapes of cooking in Maputo.

The Sustainable Development Goal 7 calls to 'ensure access to affordable, reliable, sustainable and modern energy for all.' What that means is highly variable across different geographies. In urban areas, energy access relates to electricity networks and the structure of the built environment, the local markets for fuels, and the technologies available to provide different energy services, from communication to mobility. In that sense, energy access relates to a complex energy landscape of relationships extending across space, from electricity connections to the extraction of fuels above and below ground, and its impacts on the vegetation cover in the case of biofuels.

Cooking is a particularly intractable 'energy challenge' in the built environment. Cooking practices are difficult to change as they relate to multiple factors, including the social organisation of cooking in the household, the taste of food, or the role that different forms of cooking play in creating relations with other people in a given place. According to the Energy Sector Management Assistance Program's report on modern energy service delivery (ESMAP, 2020), energy access, particularly for cooking, depends on six contextual attributes: convenience, affordability, safety, fuel availability, exposure, and efficiency. This contextual and multi-dimensional understanding moves away from binary understandings of energy access that focus on a single measure, such as physical or financial access to energy. This understanding aligns with a perspective that situates energy access for cooking in an urban infrastructure landscape of material and ecological relations where culture and institutions mediate people's relationships to particular energy sources and technologies. The contextual attributes described in the ESMAP (2020) report help understand energy access for cooking as deeply embedded in urban infrastructure landscapes. If we analyse Maputo's energy landscape through these six contextual attributes, energy for cooking is embedded in complex urban socio-technical relations (see also Castán Broto, 2017, 2019):

- **Convenience** relates to the accessibility of fuels, shaped by the structure of local markets for fuels, the transport of fuels to and across the city, or the fuel distribution systems. In Maputo, charcoal is the primary source of energy for cooking. The charcoal chain is organised in depots in large markets from where the charcoal is distributed. Those who cannot afford to buy large sacks of charcoal depend on local vendors, most often women, who sell charcoal in portions that poorer families can afford;

- **Affordability** relates to the share of household budget spent on fuel. For example, in Maputo, affordability explains the combination of different fuels within a given household in the context of changing prices;
- **Safety** refers to possible injuries caused by cooking technologies (e.g. electrocution, fires, etc.). In Maputo, people regularly witness accidents around the cookstove;
- **Availability** relates to the extent to which users can access the fuel, including complex processes of distribution which in the case of charcoal also direct attention to deforestation and the exploitation of forest areas;
- **Exposure** to pollutants relates to both stove technologies and housing, for example, the dynamics of ventilation. In Maputo, cookstoves are produced locally, often by recycling materials such as wheel discs. Households are organised around a courtyard where cooking takes place;
- **Efficiency** of combustion depends on the cooking technologies and utensils available.

From the household to the city's forests, these attributes point towards the complex urban infrastructure landscape that shapes energy usage, access to energy, and cooking practices. However, the ESMAP multi-dimensional framework conceptualises a relatively linear pattern of change, whereby change is driven by households that cook with specific technologies and fuels, moving progressively through different tiers that configure a ladder structure.

In this model, Tier 0 refers to a situation where individuals have no energy access, while Tier 5 refers to a situation with the highest access level. The six contextual attributes shape households' positions across different tiers. The ESMAP framework adapts the energy ladder model to situate it in actually existing contexts of energy use. The energy ladder model has been a staple of energy access thought. Frequently associated with the work of Kirk Smith (e.g. 1987, see also Barnes & Floor, 1996), the energy ladder refers to the linear progression from polluting, low cost and inefficient fuels (e.g. dung, charcoal, fuelwood) to cleaner fuels such as electricity and gas as households' income and educational levels increases. Studies of energy use in urban environments have challenged this linear understanding of change. They point towards broader complexities that question energy access, showing how households combine multiple forms of energy to satisfy their everyday energy needs (Masera, Saatkamp, & Kammen, 2000), some of which are clean, some of which are not. Fuel stacking refers to this idea, as households combine multiple fuels in complex ways for different use (e.g. lighting, cooking, heating) that may depend on affordability, but also other factors, such as the availability of particular technologies (e.g. solar, improved cookstoves) (Bisaga & Parikh, 2018) and cultural preferences (Nansaior, Patanothai, Rambo, & Simaraks, 2011). A ladder model does not fully explain these diverse practices of energy use and bricolage processes, where people work with what they have at hand to satisfy their needs (Munro & Bartlett, 2019).

While the ESMAP framework can help improve people's lives by directing aid flows towards access to cooking technologies, an urban infrastructure landscape lens reveals a gap between the theoretical representation of cooking and the actual cooking practices. The most basic assumptions of this model imply rigid definitions that sit at odds with people's everyday lives. Take, for example, the household. What is a household? In Maputo, household sizes vary enormously. A previous survey (Castán Broto, Maria de Fátima, & Guibrunet) found a widely variable household structure that ranged from sole individuals to large groups of over 20 people living together. Local living practices are also highly variable, with neighbours or distant relatives sporadically sharing space and services—assumptions about the household also obscure alternatives that do not take the household as a locus. In Maputo, it is very common to eat food on the streets. Entrepreneurs prepare food in front of customers, whether it is maize or shrimps (Figure 1). Collective cooking practices have had an essential role in building resilience during the COVID19 pandemic. Examples from Lima to Bangkok explained how communal kitchens or collaborative cooking practices have allowed poorer communities to endure lockdown hardships

Figure 1. Cooking on the street in Maputo.

(Pinto, 2020). The idea that cooking could be a communal practice (or a public service) escapes theorisations of households' energy access, such as the energy ladder or the tiers approach.

The coexistence of clean or modern fuels with polluting, non-modern ones has been a pre-occupation in international development discourses. Fragmented cooking ecosystems prevent progression across the tiers. However, that complex and fragmented ecosystem is how people find themselves cooking and using energy. A complex and fragmented cooking ecosystem is not something to lament but to understand if we want to find out how things might change—or are already changing. The next section zooms in on the case of Maputo to understand the extent to which landscape thinking provides an alternative to the tier system.

4. Exploring dynamics of change in Maputo's cooking landscape

When it comes to cooking practices, energy transitions are considered as fuel use changes or changes in the appliances used. One standard transition narrative involves improving cookstoves, improving their performance and thermal efficiency while also reducing emissions from the combustion processes. However, the term 'improved' is loosely applied and entails numerous programs of appliance exchange with different technologies and modes of distribution (Ruiz-Mercado, Masera, Zamora, & Smith, 2011). Despite the claims about the potential of improved cookstoves programs and large investments from the donor community, they have shown limited success (Sesan, Clifford, Jewitt, & Ray, 2019). Looking at the limited success of improved cookstoves in Maputo from an infrastructure landscapes perspective can help understand how initiatives that focus on relatively narrow drivers of change (in this case, technological innovation) fail to account for the complex dynamics of energy transitions.

Different schemes have proliferated under the label of 'improved cookstoves' in Maputo. Some schemes have sought to challenge cooking practices completely. For example, in 2012, the company CleanStar distributed over 30 000 ethanol stoves in the larger Maputo area, but the ethanol supply collapsed at the same time as the company was restructuring (Mudombi et al., 2018). A company called NDZiLO now supplies ethanol to the owners of those stoves in Maputo. While many households benefitted from the program, it is unclear how this initiative will sustain itself. Indeed, NDZiLO is now dependent on South African imports, making ethanol a comparably more expensive fuel than charcoal for residents (Mudombi et al., 2018). Often improved cookstoves programs seek to change cooking practices and fuel use by creating business opportunities for cookstoves manufacturers and fuel suppliers. However, the change required for business success and uptake is massive. It implies creating and sustaining new fuel markets (in this case, ethanol) and making them attractive compared to other fuels (e.g. charcoal). Improved

Figure 2. Cooking on the Envirofit CH-2200 cookstove.

cookstoves programs' success is often evaluated based on users' adoption and use at the household level (Mudombi et al., 2018), which overlooks the broader landscape that shapes the impact of these solutions.

For instance, a landscape perspective reveals that cookstove technologies and the promotion of new fuels will affect local markets and value chains. It forces us to pay attention to the kind of local economies that can maintain a fuel change in the long term through affordable and reliable supply and the livelihoods that energy access programs might threaten. In Maputo, for example, the distribution of charcoal is intimately linked to micro-enterprises that play a retail function down the value chain, reselling fractions of charcoal in small quantities for lower-income users (Castán Broto, 2017). Women often lead these micro-enterprises. A local leader joked in a public meeting in 2016 that more than one lady has become rich by selling charcoal in this way.

Similarly, subsistence economies are linked to charcoal, as charcoal is perceived as a resource which can be mobilised on-demand in times of need. Charcoal thus is inserted into the local economy in various ways, becoming ubiquitous in informal settlements or *bairros populares* (which contrasts with its absence in the city's main district). NGOs working locally with communities see a significant opportunity to introduce improved cookstoves that use charcoal to support local economies while changing the devices to make the combustion process more efficient.

Energising Development—a global partnership to promote energy access led by donor countries Germany, the Netherlands, Norway, and Switzerland—has taken improved cookstoves as a central strategy for energy access in Mozambique (Loayza & Galimberti, 2017). With this support, an Italian NGO, Foundazione AVSI, facilitated the commercialisation of improved cookstoves through the generation and trade of Certified Emission Reductions (CERs) under the Clean Development Mechanism (Loayza & Galimberti, 2017). An intermediary consultancy called CarbonSink has facilitated the mobilisation of climate finance to support improved cookstove programs. The success of the program has generated the interest of diverse organisations, including intermediaries looking to broker access to financial markets via the new climate finance mechanisms, international NGOs seeking to capitalise on a new wave of improved cookstoves projects, and local NGOs long focussed on creating local network and capacity building. Programs such as Energising Development and organisations such as Foundazione AVSI have changed the local cultures of energy governance and changed Maputo's energy landscape.

AVSI estimates that they have distributed circa 30 000 cookstoves in Maputo (Galimberti, Personal Communication). Among residents of *bairros populares*, there is manifest interest in the cookstoves. Initially, AVSI distributed the Envirofit CH-2200 cookstoves, considered one of the world's most fuel-efficient charcoal cookstoves (Figure 2). The cookstoves were imported and distributed among families through a subsidised program. However, at the height of 15 cm, they did not entirely fit the habitation conditions in informal neighbourhoods. Locally produced cookstoves have a cast iron combustion chamber raised on legs, up to 60 cm. Most people use two-mouth cookstoves that allow cooking different dishes simultaneously, and many houses have a large cookstove to keep water hot during the day. The Envirofit forced cooks to bend and did not provide a more comfortable alternative than established cooking routines. Moreover, the Envirofit cookstove did not address daily cooking needs. Efficient technologies and easy access (through subsidies) are not enough to spur transitions towards cleaner cookstoves if new technologies do not match people's everyday cooking practices.

AVSI has a long experience working within communities and routinely follows up on the impact of their programmes. Local leaders noted the local capacities to make cookstoves and routinely spoke of the possibility of developing in-house technologies that could be cheaper and spread more rapidly through Maputo's markets. AVSI listened to these concerns and accepted that the cookstoves they had distributed did not respond to the cooking needs of the communities. Motivated by their observations, they moved to investigate other possibilities. The Kenya Ceramic Jinko cookstove provided an alternative. The cookstove consists of a metal cladding and a ceramic liner, perforated to collect ash at its base (Kinyanjui, Undated). The Jinko cookstove has two advantages. On the one hand, it uses local skills and materials and can be mass-produced on site. On the other hand, the Jinko cookstove fits better the cooking needs of people in Maputo. Local artisans have learned to produce the Jinko cookstove, allowing them to reuse skills that would otherwise not be valued (Figures 3 and 4).

For example, an artisan explained that he was thankful to use his ceramic skills—learned in his youth during an exchange program between Mozambique and the USSSR—to produce the liners for the cookstoves. In late 2018, we saw Jinko's cookstoves lined up in markets on our way to the cookstove workshop, but cookstove producers suggested that they did not sell many. In an interview, an AVSI representative explained that they could not produce them at sufficient speed.

We worked with an engineering team and local producers to make micro improvements to the Jinko cookstove and speed-up production. For example, the metallic cladding has two halves

Figure 3. Jinko cookstoves piled in a workshop.

that need to be connected by folding thinly cut slits. The team streamlined the design, reducing the number of slits. Still, the new design was not compatible with the local tools available to fold the metal sheets (other micro improvements, such as the ventilation system, were successful). The model of Jinko cookstove used by local producers was inserted in the network of skills available, and any micro improvements required careful consideration of local practices and the possibility of implementing specific designs (e.g. availability of local tools) (Figure 5). Changes in the urban infrastructure landscape are rooted in small experiments and constant adjustments between particular technologies or design ideas and local craftsmanship, skills, cooking preferences, and material available. Spurring transformative change in Maputo's cooking landscape requires the involvement of local manufacturers, the creation of sustainable manufacturing capacities, and the production of affordable cookstoves that respond to cooking practices and are embedded within broader systems of fuel usage (in this case local economies sustained through charcoal distribution).

Figure 4. Ceramic liners that make use of local skills.

Figure 5. A Jinko cookstove in use.

Table 1. Improved cookstove programs and the dynamics of change in Maputo's urban energy landscapes.

Changes in …	Strategic drivers of change	Unexpected, organic drivers of change	Changes in imaginaries and discourses
… energy governance	International NGOs diagnosed the challenge and have facilitated access to international climate finance.	NGOs and community organisations interested in the improved cookstove field have proliferated, and created new opportunities, linking existing communities with international finance opportunities.	Smaller, locally-based organisations have grown interested in a new field of climate action, while international NGOs have learned to appreciate and recognise local skills.
… material flows of energy	International NGOs have facilitated the distribution of cookstoves and have initiated diverse programs of capacity building.	Local producers are repurposing existing technologies and skills. There are visible signs of changes in local markets through the actions of cookstove sellers and buyers.	Improved cookstoves are becoming regular products in local markets, thus becoming marketable without subsidies.
… choreographies of energy use	Programs of distribution of cookstoves targeting individuals and households, for example, through economic incentives.	Residents are not adjusting to the new cookstoves. Instead, improved cookstoves are used in tandem with old ones.	New understandings of safety are spreading among residents, even though their acceptance of new cookstoves is constrained.

Our examination of the introduction of different cookstoves technologies in Maputo reveals that dropping a given technology (e.g. the Envirofit cookstove) in a place does not necessarily trigger landscape change. The fact that thousands of families received one is not evidence of change because those technologies do not significantly reconfigure other aspects of the energy landscape. Sometimes they rely on the creation of new markets (for ethanol) that are unsustainable. However, the Jinko cookstove provides a different story. The Jinko cookstove could be produced locally, enrolling local skills. It has aligned a wide range of organisations that can intervene in different aspects of the production process (from training producers to creating local markets and shifting the incentives for their distribution). These changes will likely have a durable impact on the urban infrastructure landscape.

A variety of changes in energy governance and shifting flows of cookstove technology are already noticeable in Maputo, but what is less pronounced and curtailed by the dynamics of the current pandemic is an apparent change in everyday practices energy use. Table 1 summarises the different aspects of Maputo's energy landscape that the cookstoves programs have transformed. The table analyses the different types of change outlined in section 2 in energy governance (e.g. distribution of ethanol cookstoves), the political economy of resource flows (e.g. surges in fuel prices), and the everyday practices of urban dwellers (e.g. the persistence of charcoal as fuel for cooking). In the columns, the table aims to identify whether those changes can be attributed to strategic projects of change, unexpected or improvised processes, or to changes in imaginaries and discourses.

The different changes highlighted in this table occur simultaneously. There is no necessary causal relationship between all those changes. For example, both the ethanol and Envirofit cookstoves had been available for some time in Maputo before the Jinko cookstoves emerged as a more suitable option. Protests against the Envirofit cookstove fostered an interest in local production skills. Still, those local production skills had been developed through a diversity of capacity-building processes targeting local manufacturers, which had nothing to do with cookstoves. One change may activate another but only through recursive forms of interaction. Over time, change understood in this way can transform urban infrastructure landscapes beyond recognition. The transformation requires understanding not only the drivers of those changes but also their anatomy.

5. Conclusion

Rather than bracketing socio-technical landscapes as exogenous to transitions, this paper suggests that they constitute those processes of change. Through the lens of cooking technologies, the example of changes in Maputo's energy landscape highlights how overlapping processes shape dynamics of change in non-linear ways. The close reading of the implementation dynamics of improved cookstove programs in Maputo allows us to identify three different components of landscape change, including strategic actions, ad-hoc spontaneous action, and new imaginaries. Transitions result from the concurrent deployment of new ideas of low carbon improvement, new finance flows, the deployment of existing and new skills, and the gradual adaptation of cooking practices.

How can a landscape perspective address urban energy challenges? Policy narratives such as the tier framework on access to modern cooking services reflect the complex set of variables that influence fuel use and thus, provide a persuasive account of the kind of actions that can help deliver the sustainable development goal 7. However, these policy frameworks are not entirely suited- nor is their aim- to the task of understanding the process of change as it unfolds at large scales, over whole communities and neighbourhoods. Socio-technical transition perspectives emphasise the role of innovators and institutions that can develop partnerships and collaborations to facilitate coordinated action over time. Even small-scale interventions such as niche innovations and bounded socio-technical experiments are strategic, directional projects whose intent is to activate change.

The landscape perspective can provide critical insights into energy policy narratives and transitions perspectives by pointing out unexpected interactions in urban environments. However, the landscape perspective speaks most deeply to the role of objects within a physical environment and how the daily interaction with those objects may help improve people's lives or their relationship with the environment. The landscape perspective situates the role of designers, architects, and planners within complex processes of change, by emphasising the potential of fostering changes by modifying a single object. Since design transforms the complex web that shapes its function and role of a single object—a humble cookstove—within the built environment, a landscape perspective foregrounds the potential of micro-interventions to cause broader reconfigurations, whether they are strategic or not.

The landscape perspective has broader implications for the literature on urban infrastructure, as it throws new light on the multiple interventions that shape urban environments through a range of makeshift, improvisation practices of infrastructure appropriation for everyday living. The landscape perspective calls for recognising those ad-hoc practices of place-making as an inherent part of the urban environment. An emphasis on urban infrastructure landscapes re-values human experience as a critical source of design innovations. The landscape perspective recognises the importance of purposeful attempts at bringing transitions, but it also demands us to pay attention to the ordinary as a means for change.

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