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Financialisation, scaling and the role of finance for 'just' urban sustainability transitions – the possibilities and limits of renewable energy interventions in cities

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Abstract

There is an increasing focus in research and policy on cities as sites where low carbon transition can and should be driven (Barber 2017; Coenen et al. 2012). This paper contributes to the emerging field of urban sustainability transitions (Frantzeskaki et al. 2017; Hodson et al. 2017) by examining how the scaling up of decarbonisation is achieved across space, beyond local niche experimentation. This paper identifies a critical limitation of existing multilevel frameworks which recognise non-linearities and multiplicity of pathways, but maintain an a-spatial diffusion or aggregation model of scaling (Geels and Johnson 2018; Geels et al. 2018). To address this gap, the paper analyses financial relations underpinning urban renewable energy interventions in order to illuminate spatial difference in scaling processes. Drawing on empirical cases across national contexts, the paper defines four 'financial rules' through which to understand the spatial and scalar boundaries of urban sustainability interventions. These financial rules have distinct implications for the possibilities and limits of 'just' transition in cities.

1. Introduction

There is an increasing focus in research and policy on cities as sites of low carbon transition (Frantzeskaki et al., 2017). Some even argue that cities are their principle drivers (Barber 2017). These developments reflect the accelerating growth of urban populations and consequent energy and resource consumption contributing to greenhouse gas (GHG) emissions and climate change. At the same time, we can witness widespread mobilisation of urban actors around climate change mitigation objectives and deployment of low-carbon solutions facilitated by a proliferation of global city networks such as C40.

Sociotechnical systems approaches to sustainability transitions, understood as complex and multidimensional transformations of systems of consumption and production required to meet environmental goals over the long term (Geels and Schot 2010), have in recent years started to recognise the role of cities. This responds in part to geographical approaches to transitions which critique a-spatial or implicitly national-level accounts for their lack of attention to place and scale and the differentiated spatial contexts across which transitions unfold (Coenen et al. 2012; Hansen and Coenen 2015). Earlier framings positioned cities as subject to national transitions; unless the sociotechnical regime in question comprised of an aggregation of local system, such as public transport networks, cities were not considered in explaining or governing transitions (Geels 2010).

More recent work on urban sustainability transitions recognises cities as social and political arenas characterised by experimental, multilevel governance. Now, cities are acknowledged both as advantageous 'seedbeds' for niche-level innovations, as a nexus of multiple regime configurations, as sites of contestation, deliberation and political struggle, and as typical manifestations of the uneven realisation of sustainability outcomes in place (Hodson et al. 2013; Hodson et al. 2017; Frantzeskaki et al. 2017). In this context, whether and how cities are achieving meaningful change towards low carbon systems of provision, however, remains unclear. This raises questions as to how *scaling up* of decarbonisation is achieved across space, beyond niche-level experimentation, and the role of urban actors in facilitating, driving, or mediating those processes in the city.

The multilevel framing of transition processes across the niche, regime and landscape, broadly assumes a 'diffusion' or 'aggregation' model of scaling (Geels and Deuten 2006). While sustainability transitions frameworks continue to draw on critiques, recognising, for instance, debates around 'place and geography' of transitions (Geels et al. 2018: 27) opportunities for localised enquiry are framed around emergence; 'why' low carbon innovations emerge in certain locations more than others, more quickly or slowly, and the role of local context, noting the multiplicity of social, institutional and material elements constituting niche innovations. However, it falls short in asking *how* transitions occur across space beyond these emergent niches. 'Scaling' and 'scalability' of niches continues to be understood as an a-spatial 'diffusion' process through which niche systems grow in size and uptake (Geels and Johnson 2018: 139). Niches are understood to 'spread' through circulation of knowledge, resources, artefacts, between locations, which then facilitate replication of the niche innovation elsewhere (Geels and Johnson 2018: 141). While this framing acknowledges 'non-linearities' or setbacks, and the multiplicity of pathways to diffusion, these are (still) not understood spatially. That is, difference does not represent spatial 'unevenness' as much as hurdles overcome towards an end point or state of a system, generally aggregated at the national scale. This constitutes a critical gap in the understanding of system reconfiguration *across* space and at different scales. Urban interventions in renewable energy development, for example, are contributing to expanding uptake of renewable technologies in the city, an increasing share of alternative energy system ownership structures, but are also supporting new renewable energy generation outside of the city. Therefore, research is required to not only understand the context within which system reconfiguration occurs in cities (Hodson et al. 2017). Equally it needs to identify and account for the spatial distribution of urban renewable energy development at a more granular level within the city and beyond. It should acknowledge the entities and built forms included and excluded from these interventions, the costs and benefits associated with these models and for whom, and how these interventions add up to meaningful decarbonisation of energy systems.

This paper contributes to this gap by analysing the financial relations underpinning urban renewable energy interventions. The research question guiding the analysis is how does finance shape scaling processes in the reconfiguration of energy systems in cities towards decarbonisation, and with what effects on the distribution of costs and benefits for urban dwellers? Finance is noted in many transitions studies with regards to the overall importance of capital investment, government subsidies and technology prices among others. While, more specifically, finance constitutes both sunk investment in incumbent energy regimes and a necessary element of new infrastructure development (Bridge et al. 2013; Castree and Christophers 2015) there is little knowledge of how financial flows condition the spatial distribution of renewable energy generation and use and its variegated impacts on urban dwellers.

Underpinning this analysis is the concept of financialisation, broadly defined as "the increasing dominance of financial actors, markets, practices, measurements and narratives, at various scales, resulting in a structural transformation of economies, firms (including financial institutions), states and households" (Aalbers 2017: 544). Financialisation is found to contribute to decision-making driven by shareholder value generation, short-term profit seeking and risk management; global systems of capital accumulation through local value extraction in, for example, urban property and infrastructure investment by geographically distant investors (Knuth 2016; Pryke and Allen 2018); disciplining of individuals and organisations around financial logics and profit seeking to the detriment of social policy goals (Mader 2015; Wainwright and Manville 2017); individual economic security increasingly exposed to the performance of financial markets (Mertens 2017; Spies-Butcher and Bryant 2017); and the individualisation of responsibility as a substitute for state-based welfare services provision (Dowling 2017). Sourcing project finance for urban renewable energy programs, and capturing (financial) benefits from those schemes, occurs within this broader system of capital accumulation and risk, providing differentiated opportunities for alternative systems and uneven spatial and socio-economic outcomes.

The paper proceeds as follows: section 2 reviews existing literature on the role of business models (BMs) in sustainability transitions which begin to account for financial value in energy transitions. Section 3 reviews how research on financialisation in (urban) built environments conceives of multiscalar financial flows and contributes to a better understanding of scaling in transitions. Based on ongoing empirical studies of renewable energy interventions in cities, Section 4 establishes four 'financial rules' which illuminate uneven scaling processes of urban sustainability transitions across space. Section 5 concludes with reflections on the MLP and the possibilities and limits of 'just' transitions in cities.

2. Transitions and value: niche innovation, niche-regime translation and landscape conditions

As mentioned above, finance is involved in both sunk capital investment in incumbent fossil fuel energy infrastructures, and required investment in new renewable energy systems. While there is a tendency to focus on (innovative) renewable energy technologies as fundamental artefacts in sustainability transitions in energy systems, recent studies have underscored that uptake of technological innovations in market societies do not occur without mediation by business models (BMs) – frameworks by which the *value* of the technology (or product, service) is defined, created and captured and systems through which stakeholders are enrolled in its production, use or exchange (Bolton and Hannon 2016; Bidmon and Knab 2018; Sarasini and Linder 2017; Wainstein and Bumpus 2016; Tongur and Engwall 2014). Here, stakeholders are more narrowly understood as users/customers and suppliers, which is a limitation this work in the context of transitions. BMs for the uptake of renewable energy technologies are positioned in competition with and challenged by incumbent energy regimes. A potentially disruptive role of BMs is identified due to the ways BMs "connect multiple actors, mediate between the production and the consumption side of business and support the introduction of novel technologies into the market" (Bidmon and Knab 2018: 903). While this work maintains a diffusion model of scaling, it nonetheless goes some way towards illuminating the role of finance in transitions by considering the work of BMs and, by extension, the importance of value creation and capture in technological innovation and uptake. It also speaks to the gap in understanding niche-level emergence and regime change by highlighting the multilevel interactions characterising BMs (Wainstein and Bumpus 2016: 574). This section will review the role of BMs in (energy) transitions identified in recent research, before turning to financialisation.

Employing the MLP, Bidmon and Knab (2018) identify three distinct roles for BMs in sociotechnical transitions. Firstly, mainstream BMs constitute a sociotechnical regime. This role relates to their function as 'industry recipes', in other words how an organisation meets customer needs and at what cost in a sector. Interconnections between stakeholders through these dominant BMs are said to have a stabilising and reinforcing effect at multiple scales and thus a barrier to innovation, particularly in resisting threats to revenue streams. For example, incumbent energy utilities generally sell units of energy from large-scale, centralised (fossil fuel-based) energy generation and unidirectional supply via network infrastructures. Secondly, BMs act as important intermediaries between technological niches and sociotechnical regimes. BMs function as 'devices' or 'vehicles' to commercialise technology through market entry (Bidmon and Knab 2018: 906; Bolton and Hannon 2016). In this role, BMs work to articulate value (for customers, as well as revenue generation), legitimise technology and build social networks and learning between stakeholders. Thus, BMs are considered critical facilitators and drivers of transition from niche technology to regime uptake. For example, leasing models for rooftop solar PV minimise upfront cost barriers of the technology and responsibility for operating and maintaining the system. A company provides and installs the system, while the household buys the solar electricity generated at a lower cost compared with electricity supply from the grid, thus (in theory) reducing their overall energy costs. Lastly, BMs can be innovative at the niche level by redefining means of value creation and capture, and may be influenced by customer demands or new legislation ('landscape pressures') (Bidmon and Knab 2018: 910; Wainstein and Bumpus 2016). A key example of this is the Energy Services Company (ESCo) model which provides energy *services* rather than units of energy supply, typically characterised by energy efficiency measures (Bolton and Hannon 2016). Innovative BMs are considered more stable than technological innovations due to the ways BMs inherently involve stakeholder networks across production and consumption and resourcing, and the articulation of specific guiding visions.

Studies of emerging BMs for renewable energy deployment highlight the ways in which BM structures differentiate interventions in built form actor roles, and implications for niche-regime relations. Bolton and Hannon's (2016) study of ESCo models in the UK notes how value definition has spatial implications in the distribution of energy interventions in the built environment; for one ESCo, a broad objective of sustainable development in the locality was sought through the provision or trial of low carbon and decentralised technologies. A second ESCo aimed to reduce energy bills through combined heat and power (CHP) and district heating (DH), and subsequently prioritised specific buildings with large heat energy demand over others. This resulted in more fragmented infrastructure development (Bolton and Hannon 2016: 1738). In terms of actor roles, grassroot initiatives promoting local ownership of distributed solar technologies in the US are found to be increasingly displaced by better funded and supported corporate models for distributed solar development (Hess 2013). Moreover, Wainstein and Bumpus (2016) suggest that feedback between innovative (niche-level) BMs and incumbent (regime-level) BMs in Germany has resulted in an acceleration of sociotechnical transition where incumbent utilities have responded by restructuring their own BMs to maintain their revenue streams and position in the market. This review has demonstrated the ways in which (financial) value, articulated through BMs, constitutes an important element in both the stabilisation and disruption of sociotechnical regimes, and how this can have uneven impacts in practice.

3. Understanding uneven transitions – insights from financialisation

Financialisation literature illustrates the ways in which financial mechanisms differentiate value and generate multiscalar financial flows. This work goes some way towards an understanding of spatial difference generated through financial decisions of infrastructure development. As such, this work provides a way of better understanding the socio-spatial implications of financial flows in sustainability transitions. While macro level finance conditions have been noted by transitions scholars in regard to the financial-economic crisis and its influence on low carbon technology investment (Geels 2013), financialisation literature draws down to the micro level of multiscalar financial relations and thus better accounts for implications of space, place and agency.

In the urban built environment, increasing global investment in property and infrastructure has resulted in a geographical shift and detachment of investment decision-making from local to global. Globalised investment flows are directed by non-local property valuations, involve speculation on future profits in particular places, and preference predictable returns (with knock on effects such as the displacement of less affluent populations as values in these places may increase) (Fainstein 2016). At the building scale, sustainability retrofits of commercial buildings corresponding with green certification, illustrated by a case study of San Francisco, generate added 'green value' beyond qualitative sustainability credentials (Knuth 2016). In addition to new green value streams in the form of operation cost savings via energy efficiency measures, green certification is seen to secure a premium valuation for commercial properties. In terms of infrastructure investment, a study of a San Diego desalination illustrates the complexity of translocal financial flows in which future revenue from water sold to residents in the region was leveraged by developers to secure private finance from geographically diverse sources (Pryke and Allen 2018). A water purchase agreement with San Diego County Water Authority constructed a unit price for water that would generate sufficient income for repayment of the debt and interest, resulting in an average US$80 increase in household water bills projected for 16 years. This case is a notable example of the ways in which global capital extracts value through infrastructure investment from the locality, via local water users, mediated by private and state actors.

As one of its key tenets, financialisation works to discipline subjects around financial logics, particularly through profit-seeking motives of investors. At the level of individuals, microfinance offerings in the global South are an extreme example of this disciplining by (global) capital. Disadvantaged communities are given access to credit as a means of 'financial inclusion' with the aim of empowering individuals to increase their wealth through entrepreneurial activities, such as the establishment of small businesses selling goods (Mader 2015). Borrowers are subsequently enrolled in weekly repayment schedules at extremely high interest rates – maintained in the name of 'financial sustainability' and indicative of investor perceptions of risk – which are enforced through close observation and reporting. From an organisation perspective, a study of housing associations in the UK examines the effect of bond financing, increasingly employed to maintain and expand housing portfolios for vulnerable and low-income tenants in the absence of government funding (Wainwright and Manville 2017). Bond finance involves an issuer (in this case a housing association) borrowing a large sum of capital from an investor for a fixed term (as a bond), which is then repaid with interest at a fixed rate. The study finds that even though bond holders have a passive investor role – unlike shareholders who have voting rights and can thus influence organisation operations – housing associations are nevertheless influenced by the need to meet investment return. For instance, in order to attract bond investors, housing associations are compensating for lower market prices of certain housing assets by paying higher yields. While bond investment can increase available units for low-income residents by filling a critical funding gap, this disciplining of the organisation around investment returns increases the associations' financial risk exposure. It also threatens to impact expenditure on repairs or staff, or management of riskier tenant applications, ultimately undermining the provision of affordable housing.

The permeation of finance into everyday life increasingly transfers risk onto individuals who are more exposed to global market fluctuations. Household mortgages exemplify this relationship of risk exposure, where the resale of mortgage debt by banks as securities connects households to global markets. In Australia, "household debt has increased from 33 per cent of disposable income in 1991 to 188 per cent in 2017" (Conley 2018: 41) according to the Reserve Bank of Australia. Mortgage debt continues to support the inflation of housing prices in Australia, which in turn affect state and local government budgets as a source of taxation revenue. Relatedly, the ways in which private home ownership (enabled by debt) is framed by governments as a source of wealth marks the individualisation of responsibility for personal welfare (Mertens 2017; Spies-Butcher and Bryant 2017). Increasing demand for household credit is identified by Prasad (2012) as a "credit/welfare state trade-off" or substitute for public provision of social security. The effect of this is a transfer of risk to individuals in debt who are subject to interest rate variations and global market trends.

This substitution of public services is also found in the funding and delivery of social policy outcomes via private finance and non-governmental organisations which is of particular interest and relevance for this study. Social impact bonds, first developed by the British Government, are illustrative of a 'regressive redistribution' (Dowling 2017) of funds. This funding mechanism involves a government contract with a non-governmental organisation to provide services against outcome criteria related, for example, to unemployment, health, or crime. Once the required outcomes are met, the state pays the organisation ('Payment by Results') according to estimated cost savings such as cheaper delivery of services, and avoided future costs (using counterfactuals). However, these payments are sourced through private sector bond finance; as a result, cost savings achieved through outsourcing do not flow back into the public budget, but are transferred to the private sector in the form of interest payments (between 15-30%) (Dowling 2017: 298). Private investors may seek to fund higher yielding projects to the detriment of other social needs, or indirectly incentivise cost-cutting measures, meaning private investors are afforded a considerable level of agency in social policy delivery. Moreover, measures taken by investors to minimise risk of an unsuccessful project – which include staggering funding, replacing service providers, or withdrawing funds – shifts the burden of risk onto contracted parties, and those in receipt of social services.

While this is a brief and ranging review of the state of the art on financialisation, this section aims to illustrate key overarching themes and how they relate to space and scale. Despite these critiques, there are nonetheless openings in existing work that point to the possibilities of finance being leveraged and mediated for public benefit. The role of government is important in this respect; state intervention creates opportunities for equitable policy and redistribution (Fainstein 2016; Ward 2017). For example, decoupling of land and property in Singapore supports affordable housing provision by reducing the cost of units bought and sold, while increased land values are channelled to the public sector (Fainstein 2016: 1507). Indeed, local governments are found to be taking on new financial roles by brokering low carbon product purchases for residents, providing loans for the upfront cost of residential solar PV, investing in energy efficient products, and leveraging procurement processes for renewable energy supply, to realise decarbonisation objectives (Hadfield and Cook 2018). Income-contingent loans for higher education also represent a more egalitarian financial model; setting an income threshold under which repayments are not required facilitates access to education regardless of present income or assets (Spies-Butcher and Bryant 2017). In this way, financial mechanisms can be structured for public purposes rather than private financial gain.

4. The role of finance in (urban) sustainability transitions – a preliminary framework

Sustainability transitions studies on BMs and value creation for renewable energy technologies highlighted the role of BMs in innovation, niche-regime translation of innovative technologies, and stabilising sociotechnical regimes. The above review of financialisation literature deepens our understanding of the ways in which financial relations are established across scales through local investment; extract (local) value for the benefit of often globally dispersed entities; redistribute and individualise (financial) risk and exposure to global markets; while also illuminating the possibilities for finance to be leveraged and mediated for public benefit through careful structuring, and with a likely role for (local) government. Drawing on these insights, this paper proposes a series of distinct 'financial rules' which contribute to the structuring of sociotechnical transitions and which relate to and inform the central 'rules' guiding the MLP. 'Financial rules' create openings or favourable conditions for urban renewable energy interventions as well as limits, and which have distinct social and spatial consequences in cities. These financial rules are drawn from ongoing empirical studies of urban renewable energy interventions in different national contexts – including household solar PV schemes, community-owned commercial-scale renewable energy developments, and collaborative offsite renewable electricity procurement models. The findings of this research comprise four overlapping principles: 1) financial flows are subject to *hard temporal boundaries;* 2) investment is characterised by *uneven spatial and scalar boundaries* through which capital is fixed in local renewable energy developments; 3) *cost, profit logic, and risk perceptions* correspond with spatial differentiation of value generated by different technologies in different locations; and 4) *energy system cost structures* differentiate grid energy supply costs and savings for distributed renewable energy generation while generating cross-subsidisation of fixed network charges and green schemes. Each of these financial rules are detailed in turn below.

4.1 The hard temporal boundaries of financial flows

Financial flows in the context of urban renewable energy development are subject to hard temporal boundaries characterised by (pending) expiry of government subsidies; time-constrained funding sources; existing energy contract terms; limited energy market price forecasting and assumptions of continuity.

Government subsidies for renewable energy uptake – such as feed-in tariffs (FiTs) for distributed solar electricity exported to the grid, and national renewable energy targets mandated through certificate trading (Hadfield and Cook 2018) – aim to incentivise renewable technology uptake. They also have limited lifespans and their expiry have implications for ongoing scaling up of renewable energy technologies. For example, the UK Government's planned phase-out of FiTs generated a rush of project developments and applications among community energy groups seeking to benefit from the subsidy (see also Geels et al. 2016). Likewise, changing FiT rates in the state of Victoria, Australia, have influenced projected electricity cost savings for households installing rooftop solar PV systems; reduced rates have created challenges for local governments replicating initial pilot schemes with fewer residents being recruited.

Funding sources also present distinct time constraints. A community energy cooperative in South West England, for example, raises funds for solar PV installations on community buildings and large-scale renewable energy generation from multiple sources, including individual shareholdings (equity), bonds, grants, and bank loans. Bond offers may secure an amount of capital for three years, after which point the funds must be returned to investors. This means that the cooperative continues to refinance projects over time. In addition to this recirculation of capital through the cooperative, interest payments to shareholders, bond holders and lenders require periodic outward flows of capital to be managed.

Existing energy contract terms, particularly for corporate electricity procurement, create challenges for aligning with alternative (renewable) electricity suppliers. This is the case for local governments interested in alternative procurement options such as group renewable power purchase agreements (PPAs). End dates of current electricity procurement contracts among Victorian local governments (generally three or four years in length) vary among providers (Victorian Greenhouse Alliances 2017). This mismatch limits the potential for aggregating local government end-users in a group procurement contract, and creates added risk in the case of construction delays for new renewable energy developments. These temporal constraints may complicate or inhibit establishment of new procurement models and thus encourage the stability of incumbent procurement processes.

For corporate energy customers, *future electricity prices* represent a significant budget risk. In Victoria, the wholesale electricity market is characterised by considerable price volatility; between November 2015 and November 2016, for instance, electricity prices increased by 65% (Victorian Greenhouse Alliances 2017: 9). These price fluctuations are in part influenced by coal plant closures. This volatility is translated as a risk for budgeted electricity expenditure; as such, a long-term PPA with a renewable energy developer is represented as a containment of this risk by establishing 'price certainty' for participating entities. At the same time, future electricity prices are only estimated up to three years (AER 2018). This means that the 'price certainty' of a 10-year contract is achieved at the risk of unknown price changes in the future (including stabilisation or decline). Relatedly, assumptions of continuity underpin long term capital loans for household solar PV. For instance, a bank loan scheme for solar PV among pensioner households (an alternative to a local government loan mechanism provided via property tax levies) takes the form of a personal loan, rather than an additional charge alongside property taxes (rates). As a result, the financial risk associated with the loan is returned to the individual (as opposed to the rates charge mechanism, which ties the debt to the property). This model hence assumes a continuity of residence in place (i.e. at the property where the solar PV has been installed) and ability to pay over the 10-year term (relevant to the age of participating pensioners).

4.2 The uneven spatial and scalar boundaries of investment

Spatial and scalar boundaries of local renewable energy investment are characterised by government budget allocations; the limits of local funding sources; the size of investment; identification of beneficiaries; and extra-local spill overs of capital exchange.

Due to the geographically bounded nature of local government jurisdictions, implementation of local renewable energy schemes is subject to *varying budget allocations that are unevenly distributed* within and beyond the city. For example, a local government loan scheme for solar PV established by a Melbourne council was initially funded through the council's cash reserves, and has since been repeated and expanded on that basis. While a coordinated pilot was established to enable further uptake of the scheme among over 20 urban, peri-urban and rural local governments across Victoria, few opted to trial the council loan model due to cost, lack of available cash reserves, and resistance to taking on debt.

The *limits of local funding* relative to the scaling potential of urban renewable energy developments are illustrated by the expansion of crowdfunded community-owned initiatives in the UK. The community energy cooperative mentioned above (4.1), for example, facilitates community-owned renewable energy generation (commercial and large-scale) within Greater Bristol. However, the community members enrolled as investors are defined largely on a virtual basis, rather than being geographically bounded. While there is some concentration in the South West of England, shareholders are located across the UK. Moreover, share purchases are supplemented by bond offers, grants (municipal and charitable trusts) and loans (bank and social investment).

For renewable energy investment*, capital must be fixed to sufficiently scaled developments*. Urban stakeholders, such as local governments, face limited funding avenues despite the presence of large funds such as the Clean Energy Finance Corporation (CEFC) in the Australian context. The CEFC provides a minimum of AUD$10 million for single grants, while local governments generally do not have project portfolios of this scale. Community energy cooperatives are found to draw on diverse sources of finance as a pragmatic means through which to pool funds for multiple renewable energy installations. For urban energy consumers, aggregated models such as group PPAs allow (local) end users to engage directly with utility-scale projects. In a Melbourne-based project, multiple corporate end users collaborated in order to establish sufficient energy demand and thus purchasing power to support the wind farm's construction. The purchase agreement for a third of the wind farm's capacity was leveraged as guaranteed future income to secure bank finance for the development. This mechanism had a further scaling effect of supporting generation above the consortium's total demand. However, the aggregation of customers across sectors nonetheless had the temporal effect of complicating and delaying the tender development (City of Melbourne 2017).

At the same time, *local organisations can mediate a range of financial investments*. For example, a local government network organisation established a shared services model in order to roll out a solar PV program (mentioned above, this section) across multiple local government areas while leveraging centralised administration, implementation and monitoring of the program (MEFL 2016). Similarly, a community energy cooperative in South West England allows share purchases from as little as £50 as part of their ethos of "fairness"; that is, setting shareholder criteria such that most citizens would have the capacity to participate. Moreover, the expertise and coordination supporting and managing the cooperative's fund raises is notably centralised; Mongoose Energy, an asset manager and key partner, now manages up to two-thirds of community energy assets in England and Wales.

Identifying beneficiaries of schemes like the solar PV program for pensioner households established in Melbourne, is a limiting factor in respect to the spatial distribution and expansion of solar PV through this mechanism. Homeowner pensioners are considered ideal candidates; they are likely to have high daytime energy use, are identifiable as recipients of the Municipal Rates Concession, have sufficient numbers, and receive a co-benefit (such as improved health) (MEFL 2016). This means that for a scheme with the core aim of minimising vulnerability to heatwaves, tied to the impact of rising electricity prices, upfront cost barriers of solar PV, and lack of access to finance, the parameters of 'vulnerability', and the potential for addressing market and financial exclusion, are narrowly defined.

Extra-local spill overs of capital exchange can be identified in localised projects subject to GHG emissions accounting. For instance, a number of local governments participating in a renewable PPA pilot project in Melbourne opted to procure 100% of their electricity supply, alongside equivalent purchases of LGCs (large-scale generation certificates) in order to claim the emissions reductions. Because of the national Renewable Energy Target obligations, 20% of LGCs purchased from the renewable energy generator must be surrendered to the regulator. For the purpose of meeting carbon neutrality criteria, some councils opted to purchase the additional 20% of certificates via the international carbon offset market – as a cheaper option compared with (local) LGCs. Likewise, the solar PV loan scheme for pensioner households in Melbourne involved national subsidies in the form of certificates (allocated to the system equivalent to estimated output) which are traded under the Small-scale Renewable Energy Scheme (SRES) (Hadfield and Cook 2018). These subsidies contribute to the financial viability of the scheme. However, because these certificates are surrendered, the council is unable to claim GHG emissions reductions as a result of the scheme.

4.3 Cost, profit logic, and risk perception

Costs, profits and perceived risks correspond with uneven spatialities of value generated by different technologies in different locations, integrated in different urban forms.

An often-cited element among urban stakeholders is *political (in)stability* and its effect on *investor (un)certainty* (see also Geels et al. 2016). General uncertainty around the maintenance, alteration or repeal of renewable energy policies (including subsidies, targets, and procurement) is exacerbated in settings characterised by bipartisan politics around climate and energy (like Australia). This makes it difficult for stakeholders to project the viability of developments in the short term and to make decisions on investments.

The cost of a household solar PV installation is influenced by a number of *material factors which generate additional costs*, including switchboard upgrades, roof access (including additional charges for tiled roofs), cabling, how the system is mounted to the roof (whether it requires additional structures for optimal orientation, or more complex siting on a small roof space/around a skylight), and managing the presence of asbestos (which is more common in older homes). Available roof space, unobstructed by shading from trees or adjacent buildings, also determines households to be included, and excluded, in schemes like Solar Savers.

Renewable energy technology selection generates divergent spatialities of value. While onsite 'behind-the-meter' renewable energy generation (e.g. rooftop solar PV) generates immediate cost savings by by-passing the grid, a Victorian local government survey finds that "a council's usable roof space is unlikely to meet its total electricity demand" (Victorian Greenhouse Alliances 2017: 20). This material reality reinforces the value of larger-scale renewable energy development outside of urban boundaries, thus continuing extra-local relations between local consumers and distant energy supply. Moreover, there are inherent spatial trade-offs associated with price and climate; large-scale solar generates more electricity at a more competitive price in Queensland, for instance, while large-scale wind power generates more electricity at a more competitive price in Victoria. As such, urban stakeholders privileging cost savings in electricity supply may opt for an agreement with a generator outside of the locality, at the expense of localised circulation of financial benefit.

Conversely, a solar PV loan program established in Adelaide emphasises a focus on the local in their choice of solar provider, a South Australian company based in Adelaide. In turn, the distribution of funds through payment for services, products and (indirectly) employment, was deliberately localised. Moreover, the solar PV panels are manufactured within the state, contributing to an improved 'carbon footprint' (Adelaide City Council 2018). Definition of 'local' can also be reframed at a regional level in terms of local economic development; the co-benefits identified by urban stakeholders involved in a PPA with a regional wind farm, for example, included job creation in construction and ongoing operation and management.

Local renewable energy initiatives also exhibit a *redefinition of values* associated with land use, property, and privileging of environmental outcomes over profit. Firstly, certain commercial-scale solar PV developments in southern Sweden and South West England were established through the revaluing of landfills and unused pieces of land between motorways as productive sites for solar arrays. Secondly, for a local government loan scheme for solar PV targeted to residential property landlords in Adelaide, Melbourne, the promotion of the scheme is reframed as a means of generating increased market value of the property, as well as being more attractive to tenants and reducing risk of vacancy. This reframing aims to moderate the perception of a ‘split incentive’, where the landlord is repaying the cost of the solar PV system while the tenant benefits from reduced electricity costs. Lastly, for a solar cooperative in Helsingborg, Sweden, investment in a solar array was supported not on the basis of financial return, but the value of local generation in proximity to demand. It also frames the development as an opportunity to increase renewable energy generation as a future substitute for nuclear pending decommissioning. This is nonetheless supported by the expertise of the founding organisation, a municipally-owned utility in the region, and generous national government subsidies (30% of total development cost).

4.4 Energy system cost structures and the redistribution of wealth

Ownership structures distribute, dilute and extract local value. For local government schemes, councils draw on municipal tax revenue while redistributing the benefit of the scheme within the municipality. Conversely, renewable energy installations supported by community energy cooperatives represent complicated ownership structures and diverse sources of benefit. Because the cooperative owns the solar PV installations on community buildings, it receives FiTs for electricity exported to the grid. While the cooperative leverages the central government subsidy as a revenue stream, community building occupants still benefit from electricity bill savings, contingent on solar electricity used during the day as a substitute for grid-supplied electricity.

Furthermore, as mentioned above (4.1), non-local investors in community energy developments (including share and bond holders, banks and other investment firms) necessarily extract local value in the form of interest payments, representing outward flows of capital (the ‘cost’ of various finance sources). There are inherent trade-offs involved in non-local shareholders supporting local schemes while benefiting from annual dividends. At the same time, the cooperative’s renewable energy assets generate added local value in the creation of a community fund through which local grants are provided for energy-related services. While these funds are generated by excess profits, they are necessarily diluted by interest payments made by the cooperative noted above.

Ownership of the distribution network in Australia is geographically allocated to monopoly distribution businesses. As a result, solar PV grid connection costs are spatially differentiated according to the geographic area of the distribution company’s operation, ranging between around AUD$80 to AUD$300 in Melbourne. Multiple distribution businesses may operate within a single municipality (DELWP 2018). Consumers thus lack agency in their relationship with the grid operator.

The relationship between renewable energy interventions and grid energy prices is a key determinant of local value capture. For household solar PV schemes targeting low-income residents, the construction of ‘avoided costs’ between grid electricity prices and the cost of a solar PV system and its outputs via modelling establishes value for residents in the form of bill savings. Bill savings are nonetheless limited within the low-income resident segment; those with low overall consumption are generally excluded, while the modelling also implies that households can use a sufficient portion of electricity generated during the day (when the system is generating most electricity). This represents a restriction of benefit distribution to higher (daytime) energy consumers.

In Sweden, there is limited investment in new generation assets, particularly decentralised systems at the urban scale, due to the predominance of renewable energy supply from hydroelectricity generation in the north, as well as regional large-scale wind power and district heating networks (in addition to nuclear generation). The increased proportion of wind energy in the market has led to decreasing electricity costs, while Sweden is a net-exporter of energy. These broader network conditions mean that new grid-connected renewable generation is not considered financially viable, while there is less incentive for distributed generation as a cost-saving (and emissions reduction) measure.

Cross-subsidisation is determined by the energy system design and government green schemes. Centralised national or state-based renewable energy targets and feed-in tariffs tend to be funded through charges spread across all consumers' electricity bills relative to electricity consumption from the grid. Households with rooftop solar PV in the state of Victoria, for example, currently receive a FiT of 11.3 cents/kWh. Community energy cooperatives in the UK have also benefited from FiTs similarly funded through a national-scale tax. This is problematic for the continued uptake of distributed renewable energy generation because, as more and more households purchase solar PV, reducing their electricity consumption from the grid, remaining households bear additional costs of the subsidy (Grover and Daniels 2017; Nelson et al. 2011). This results in a disproportionate impact for residents unlikely to be able to invest in solar, such as renters, young people and other low-income groups. These mechanisms compound existing cross-subsidisation in the electricity networks, where distribution infrastructure upgrades required to meet peak demand are costed across the network – rather than being spread among residents according to their level of consumption.

These financial rules explain, in part, niche-regime relations in urban sustainability transitions and the uneven ways in which scaling of transitions occur in place and across space. Table 1 below provides a summary of these findings.

Table 1: Summary of findings

'Financial rules' in urban sustainability transitions	Corresponding themes
1. Hard temporal boundaries of financial flows	*- expiry of government subsidies - time-constrained funding sources - existing energy contract terms - limited price forecasting - assumptions of continuity*
2. Uneven spatial and scalar boundaries of investment	*- (uneven) budget allocations - limits of local funding - fixing capital with sufficiently scaled developments - local mediation of financial investment - identification of beneficiaries - extra-local spill overs of capital exchange*
3. Cost, profit logic and risk perception	*- investor (un)certainty and political (in)stability - material costs of rooftop solar - renewable energy technology selection - 'local' economic development - redefining values*

4. Energy system cost structures and the redistribution of wealth	*- ownership structures and the distribution, dilution or extraction of local value* *- relationship between renewable energy interventions and grid energy prices* *- cross-subsidisation in energy system design*

5. Conclusions

Financialisation provides the conceptual tools with which to uncover the socio-spatial implications of financial flows and thus move beyond existing conceptions of BM value definition as a disruption and diffusion agent, or global financial systems as landscape pressures for renewable energy investment. This paper extends this analysis by establishing a preliminary conceptualisation of the role of finance in (urban) sustainability transitions. Drawing on ongoing empirical research of urban renewable energy interventions in different national contexts, the paper establishes four 'financial rules' with which to conceptualise the role of finance in urban sustainability transitions: 1) financial flows are subject to *hard temporal boundaries;* 2) investment is characterised by *uneven spatial and scalar boundaries* through which capital is fixed in local renewable energy developments; 3) *cost, profit logic, and risk perceptions* correspond with spatial differentiation of value generated by different technologies in different locations; and 4) *energy system cost structures* differentiate grid energy supply costs and savings for distributed renewable energy generation while generating cross-subsidisation of fixed network charges and green schemes.

Recognising that the MLP approach to sustainability transitions is underpinned by rules seeking to explain relations between niches, regimes and landscape conditions, this paper contributes to this work by deepening understandings of niche-regime processes with attention to space and scale – a critical gap that remains in accounts of urban transitions. The financial rules outlined in this paper, illustrated by urban renewable energy interventions, demonstrate that scaling processes cannot simply be understood in terms of diffusion and aggregation. The ways in which finance is fixed through renewable energy developments are determined by multiple temporal and scalar boundaries, and are spatially differentiated through value definition and energy system design. Non-linearities, hurdles, and differences in sustainability transition processes are very much embedded in place and, rather than representing general setbacks, are indicative of spatial and scalar limits. Ultimately, this work begins to address the question of *how* transitions occur across space beyond emergent (local) niches in cities.

Attention to financial relations illuminate patterns of exclusion and local value extraction, with important implications for the possibilities and limits of a just transition. Urban renewable energy interventions often rely on and reinforce capitalist relations of profit generation through, for example, distribution of dividends for shareholdings in renewable energy developments. At the same time, neoliberal profit maximisation is disrupted through community funds, and community solar schemes established on the basis of local environmental value. The analysis also points towards material and spatial constraints related to the size, function and integration requirements of particular technologies. While local government loan programs seek to redress urban dwellers' relationship to an otherwise inaccessible solar PV market, patterns of exclusion remain due to electricity bill savings being restricted to those able to shift their energy consumption to daylight hours. Moreover, as more and more households take up such programs for small-scale solar PV, cross-subsidisation between consumers through state and nation-based FiTs is compounded, disproportionately impacting segments of the population unable to invest in solar. These findings underscore the ongoing risks in urban sustainability transitions interventions of reinforcing urban inequalities.

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