Assembling for Sustainable Urban Energy Transition: UK Institutional Property Owners' Consideration on Deploying Solar Panels on Buildings

PhD Thesis

Department of Real Estate and Planning, Henley Business School

Dexter Du

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Declaration

I confirm that this is my own work and the use of all material from other sources has been properly and fully acknowledged.

Dexter Junju Du[a]

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[a] ORCID ID: https://orcid.org/0000-0001-7895-964X

Abstract

Against the background of climate change, achieving sustainable urban energy transition is claimed to be urgent. Deploying building-applied solar panels can contribute to reducing carbon emission in cities. Since many buildings in the UK cities are owned by institutions, this study enquiries into the consideration of these institutional property owners over solar panel deployment on their buildings. Literature suggests that such consideration is likely to, firstly, engage a wider range of actors than solely the property owners, and secondly, concern specific situations of particular cases. Assemblage theory is adopted to define and analyse this study's main interest in the assemblage of institutional property owners' deployment of building-applied solar panels. A local level focus helps methodologically match the likely case specificity while at the same time manage the scope of empirical fieldwork consisting of in-depth interviews. Nottingham in the UK appears to be a place of best-practice which can enable both a focused scope and sufficient data availability for the fieldwork. The relational perspectives of institutional property ownership help engage the variant interactions among heterogeneous human and non-human actors in the assemblage of institutional property owners' deployment of solar panels on buildings. Under such assemblage understanding, solar panel deployment progresses through contingent processes, and outcomes emerge from such progression. Institutional property owners' consideration can be conceptualised as the virtual space of possibilities. In such virtual space, heterogeneous elements throughout social-material processes are virtually assembled. The empirical data suggest that only the highly cost-effective projects are likely to be territorialised to the degree of enabling the assemblage to empirically emerge. Payback period and scale of projects are important coding components that reinforce cost-effectiveness as territorialisation. The assemblage of institutional property owners' deployment of building-applied solar panels often emerges together with other assemblages of assemblages, such as holistic programmes of building retrofit.

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BREEAM: Building Research Establishment Environment Assessment Method

CSR: Corporate Social Responsibility

EPC: Energy Performance Certificate

EPRA: European Public Real Estate Association

EPRA sBPR: Best Practice Recommendations for Sustainability Reporting

ESG: Environmental, Social and Governance

ESOS: Energy Savings Opportunity Scheme

FiT: Feed-in Tariff

GRESB: Global Real Estate Sustainability Benchmark

MEES: Minimum Energy Efficiency Standard

UoR: University of Reading, UK

SECR: Streamlined Energy and Carbon Reporting

TCFD: Task Force on Climate-related Financial Disclosure

UNPRI: United Nations Principles for Responsible Investment

Chapter I: Introduction

The theorisation of sustainability energy transition calls for fundamental decarbonisation of society (Rutherford & Courtard, 2014; Sovacool & Hess, 2017), in which decentralising energy generation into cities plays a key role (Rydin et al., 2013). Building-applied solar panels representing a mainstream on-site energy generation technology have been widely adopted in the UK since 2010, thanks to the financial incentives offered by various policy schemes such as Feed-in Tariff (Keirstead, 2007). Property owners among the many relevant partners play an important role in leading the action of deploying solar panels on buildings (Weatherall et al., 2018). Accordingly, property ownership provides an interesting perspective of studying the challenges of increasing solar panel deployment on buildings (Bright & Weatherall, 2017). Furthermore, in line with some existing research (Heywood, 2008), this study is interested in the importance of institutional property owners, which are defined broadly as all the organisations and non-individual bodies that hold real properties.

In the UK, institutional property owners can play a significant role in promoting sustainable energy transition, for example, by taking up solar panels on the many buildings they hold in cities (Dixon, 2009). There has been research about domestic property owners' deployment of solar panels on their houses (Sarralde et al., 2015; Bulkeley et al., 2016; Westacott & Candelise, 2016; McKenna et al., 2018). However, due to the several aspects of differences between domestic and institutional property owners, this study's focus on institutional property owners will contribute further to the existing literature. Therefore, this thesis raises the research question: what is considered by institutional property owners regarding deploying solar panels on their buildings?

1.1 Sustainability Energy Transition and Cities

As sustainability has become a common topic, there seems increasing degree of consensus that a certain kind of energy transition is needed (Rohracher & Spath, 2014; Sovacool & Hess, 2017; Geels et al., 2018). The local level and the role of cities are conceived of as a helpful focus to demonstrate the link between tangible action and global transition (Rutherford & Coutard, 2014). Cities are recognised as the source of both problems and solutions (Bulkeley, 2013). On the one hand, cities with the large amount of urban energy demand reinforce the need to generate energy centrally and transmit it over long distance. Such long-distance energy transmission causes a large amount of energy loss during the transmission journey. On the other hand, urban actions are directly linked to the large amount of carbon emission from cities, for which individual cities become impactful units of change towards global transition. Fundamental change must be reflected beyond either only reducing carbon footprint of energy generation (e.g. renewable energy farms) or reducing energy consumption (e.g. passive building ventilation). Therefore, energy decentralisation or renewable energy microgeneration is considered helpful for sustainable energy transition. Such transition would be able to remove the heavy reliance on long-distance energy transmission from large-scale energy generation sites from afar (Rydin et al., 2013; Rutherford & Coutard, 2014).

Regarding the widely used term of ‘sustainability’, the fundamental interest is whether and how human society has a long-term future given the way society operates itself (e.g. capitalism and crises) and interacts with environment (e.g. limit of mining) (Allmendinger, 2017). Against the background of climate change, the dependence on fossil fuel of current development is widely criticised because of, among other reasons, the large amount of carbon emission. Therefore, low-carbon energy transition is called for urgently (Rydin et al., 2013; Rutherford & Coutard, 2014). If large-scale carbon emission reduction is not taken urgently, the recent and

current pace of the emission is already impeding the target of limiting the increase of global average temperature within 2 degrees Celcius (Eames et al., 2013; Dixon, 2018). Regarding the specific concern of emission from buildings in the UK, reducing carbon emission coupled with building retrofit and renovation is becoming more and more common practice (Sayce et al., 2007). However, some authors argue that the current piece-meal approach (building-by-building or house-by-house) is unable to meet the emission reduction target set by the current policy in the UK (Eames et al., 2013; Dixon, 2018). Moreover, it seems unlikely to accelerate the progress as major refurbishment to a building does not happen frequently (Sayce et al., 2007; van de Wetering & Wyatt, 2011). The piece-meal kind of change is not considered transformative, for which potential transition demands changes with more significant effect (Geels et al., 2018; Shaw et al., 2018).

Transition as large-scale and long-term change is complex societal processes that require interdependence of individual actions, including not only individuals' actions but also collective effort engaging organisations and authorities (Mason & Whitehead, 2012). In the case of solar energy, for example, a large number of organisations are involved in the process of adopting solar energy in the UK (Keirstead, 2007). These include the central government (Office of Gas and Electricity Market), solar panel companies, installation contractors, distribution network operators, electricity suppliers, as well as households and institutional property owners (Keirstead, 2007). More specifically, increasing adoption of decentralised solar electricity requires actions from all parts of the electricity system, including electricity generation, consumption, as well as distribution (McMeekin et al., 2019).

The large temporal and spatial scale of transition requires linkages to tangible scale of operations. A stream of research considers cities as the promising link between concrete actions

locally and energy transition nationally or globally (Hodson & Marvin, 2009; Raven et al., 2012; Rutherford & Coutard, 2014). Cities are key sites of energy consumption and carbon emission, for which changes in urban built environment are reasonably important for low-carbon society (Bulkeley, 2013). The discussion about low-carbon transition must concern not only generating renewable energy (e.g. solar farms) but also the penetration of such energy into urban practice (e.g. building-applied solar panels) (Roberts et al., 2019). Given the impact of cities on carbon emission, it is helpful to focus on urban areas in empirical investigation under the broader interest in low-carbon energy transition.

The highlight of urban areas is not meant to overlook the fact that urban setting is embedded in wider networks of actors and longer chains of actions. Local actions can very much be determined at the transnational level. For example, international firms operate branches locally, but the local operations are highly influenced by the firms' central strategies concerning global competition (Bulkeley, 2013). Moreover, there is an issue of energy loss and waste during the transmission of energy between its local consumption and centralised generation. Intensive consumption of energy in cities is supported by transmitting energy whose procurement and generation is concentrated from afar, for example, at corporates' national headquarters and large power plants (Rutherford & Coutard, 2014). The long-distance separation of energy generation and consumption is an obstacle to low-carbon energy transition. Firstly, there is a large amount of energy loss during transmission, due to the length of the transmission distance. Secondly, the consumers may be unaware of the carbon footprint of the energy generation that is supported by their consumption (Shove & Walker, 2014; Bulkeley et al., 2016; McMeekin et al., 2019). In other words, not every customer consciously procures their energy from renewable sources, and it may be difficult for customers to access or verify relevant information regarding their energy sources. These issues can be prevented by decentralisation of energy

generation, or microgeneration, which is to generate renewable energy at the site where it is consumed (i.e. mostly cities) (Rydin et al., 2013; Rutherford & Coutard, 2014). Energy decentralisation is well represented by, for example, solar electricity, which sees small-scale of generation (i.e. panel installation) spread across the built environment (e.g. neighbourhoods and buildings) (Callaghan & Williams, 2014).

1.2 Building-Applied Solar Photovoltaics and the UK Feed-in Tariff

Microgeneration of energy, such as building-applied photovoltaics and community wind turbines, is getting increasing policy attention (Keirstead, 2007). There have been increasing projects and initiatives emerging to address energy provision locally (Rydin et al., 2013; Callaghan & Williams, 2014; Coles et al., 2016). The different features of these energy projects, depending on the nature of the specific energy sources (e.g. solar, wind, and biomass), require research to investigate specific settings of social relations accordingly. For examples, interest groups for solar energy are different from the groups for wind or biomass. Existing research scoping across various types of energy initiatives suggests further research investigating with larger degree of specificity (Rydin et al., 2013).

In the context of energy decentralisation in the UK, building-applied photovoltaics (PV), which can generate electricity from sunlight, provides opportunities for policies to financially incentivise its deployment. Solar PV generates electricity through receiving photons from the daylight, which still works in a cloudy or winter day despite lower productivity than a sunny day. It is possible to feed electricity from individual PV system into the utility infrastructure, based on which the financial logic of Feed-in Tariff is developed. Feed-in Tariff (FiT) concerns not only solar panels but also other technologies for on-site renewable energy generation, but solar panel installation has been a major component under this policy scheme.

The essence of Feed-in Tariff is to pay the owners of an on-site generation system for the electricity it generates and feeds back into the utility grid (often measured in kilowatt). The self-consumption of solar electricity generated from the PV systems is free of charge, which makes savings from utility bills. The details in the Feed-in Tariff payment rates structure vary from country to country, and this research focuses on the UK context. Before the UK FiT was officially introduced in 2010, the technology of solar photovoltaics had been practiced and developed in the UK since the 1970s (Keirstead, 2007; Smith et al., 2014; McMeekin et al., 2019). The UK FiT was open for registrations from 2010 until 2019[1]. The registration of PV installation under the UK FiT provides data to allow for further analysis about the uptake of solar photovoltaics in the UK (Balta-Ozkan, 2015; Snape, 2016; Westacott & Candelise, 2016). A further scheme called Smart Export Guarantee (SEG) was launched in 2020[2] to replace FiT in supporting energy microgeneration such as the adoption of building-applied solar PV. By the time of this study, it is still too early to discuss SEG. However, FiT has had undoubtfully significant impact on solar panel deployment in the UK. National statistics has shown an exponential increase of solar panel installation after the 2010 Feed-in Tariff (Cherrington et al., 2013; Muhammad-Sukki et al., 2013; Smith et al., 2014).

Feed-in Tariff had an explicit attempt to subsidise building-applied photovoltaics, and designed limit for eligible system size to prevent the subsidy from being absorbed by ground-mounted solar farms (Smith et al., 2014). The UK FiT subsidy was mostly available for systems with a generation capacity that was smaller than 50 kilowatt (Smith et al., 2014). This eligibility concern focused on the scale of the solar panel system while it discriminated little among

[1] News article accessible in September 2021 at: https://www.evoenergy.co.uk/blog/20314/feed-in-tariff-to-end-april-2019/

[2] Policy brief accessible in September 2021 at: https://www.ofgem.gov.uk/environmental-programmes/smart-export-guarantee-seg/about-smart-export-guarantee-seg

various size of buildings or various kinds of property owners. For example, a large organisation would be eligible to apply for Feed-in Tariff to install a (relatively) small solar panel system to a large size building.

Feed-in Tariff and the decreasing price of solar panels have helped reduce the upfront cost of installation, which used to be considered as a major barrier to solar panel deployment (Gooding et al., 2013; Candelise, 2015; Lockwood, 2016). Solar panel deployment has several market segments including domestic (on residential properties), non-domestic (on public and commercial buildings) and ground-mounted (solar-farms, "industrial scale" or "utility scale" projects). However, the UK Feed-in Tariff has mainly targeted the domestic sector, which then also dominates the focus of academic publications (Westacott & Candelise, 2016). As mentioned earlier, depending on the scale of the solar panel systems, applications from the non-domestic sector, such as office buildings, retail buildings, and public buildings (e.g. schools and hospitals), could also satisfy the eligibility of the Feed-in Tariff.

In addition to Feed-in Tariff concerning on-site renewable energy specifically, there are other background policies that take a broader scope and intend to encourage the property market to take up sustainability agenda. Locally in the UK, there are now local planning policies requiring any new development projects to have on-site renewable energy generation, and subsidies for installing these technologies are also appearing (Wilson, 2009; Rydin et al., 2013). Upon granting planning permissions, local authorities require every new build project to contain certain extent of on-site renewable generation, for instance, minimum 10 percent of the building's energy need satisfied by on-site renewable generation (Rydin, 2012). As common practice in the UK, there are measurement schemes such as BREEAM and EPC with which the buildings' features and performance concerning sustainability can be assessed and certificated

for each building specifically (Sayce et al., 2007). There are also UK regulations such as MEES[3], SECR[4], and Building Regulations and Energy Act 2011 that urge improvement for the buildings with very poor energy performance (Patrick et al., 2018). Moreover, there are global benchmarks such as GRESB[5] and EPRA-sBPR[6] that specify the top tier practice of building energy performance.

These above schemes and tools provide a context that gives concrete meanings to the uptake of sustainability agenda among the property market. However, they do not guarantee extra actions, since most functional buildings would already have an acceptable level of energy performance even without the pressure from these schemes. In other words, many buildings are just fine without doing much extra work of incorporating sustainable features such as installing solar panels. Compared to Feed-in Tariff, these other regulations and schemes focus on buildings instead of energy systems. By encouraging buildings to achieve high energy performance, these regulations are expected to deliver positive impact on increasing solar panel deployment on buildings. For instance, the EPC scheme rates buildings' energy performance by points, and a building can score the points by taking various measures such as installing solar panels, installing LED lighting, installing efficient water boiler, and so on. Solar panel deployment can contribute positively to a building's EPC rating, but a building may as well score high under the EPC rating by taking other relevant measures while not installing any solar panels.

[3] Minimum Energy Efficiency Standard.
[4] Streamlined Energy and Carbon Reporting.
[5] Global Real Estate Sustainability Benchmark.
[6] European Public Real Estate Association-Sustainability Best Practice Recommendations.

1.3 Property Owners' Role in Solar Panel Deployment

Currently, solar panels on buildings are usually installed on rooftop or outside external walls.[7] When decision-making power over this space such as rooftop concerns multiple parties such as different occupants, the installation of solar panels on buildings requires collective actions (Bright & Weatherall, 2017). Recognising this issue, Roberts and colleagues (2019) propose models in which groups of solar panels may be specifically connected to individual apartment units. In this way the common space of rooftop may be divided into many plots of individually owned building space. In practice, the city of Perth (Australia) experimented such projects of individualising solar panels in a couple of apartment buildings, for example, Square One Apartment[8]. However, the approach of individualising rooftop space seems rare.

In the UK, property ownership has also been the focus of some studies relevant to the deployment of solar panels on buildings. Weatherall and colleagues (2018) are interested in energy upgrades of multi-owned properties. By energy upgrades, they include a range of actions that can improve energy performance of buildings, and explicitly state 'installation of renewable electricity generation (principally solar photovoltaics (PV))' as an example (Weatherall et al., 2018, p.1642). By multi-owned properties, they refer to what Bright and Weatherall (2017) introduce as 'buildings with privately owned flats in them' (p.203). This definition is also studied by Appleby (2018) who terms it multi-residential property. In this context, Weatherall and colleagues (2018) argue that the current legal definition of property ownership is a hurdle to energy upgrades in multi-owned properties. They suggest that further

[7] A recent BRE report (2016) offers a useful introductory account about solar panel deployment on non-domestic premises in the UK. *Solar PV on Commercial Buildings: a Guide for Owners and Developers*, report by BRE National Solar Centre, accessible in September 2021 at: http://www.bre.co.uk/filelibrary/nsc/Documents%20Library/NSC%20Publications/123160-NSC-Solar-Roofs-Good-Practice-Guide-WEB.pdf

[8] Project brief accessible in September 2021 at: http://www.squareoneliving.com/sustain.htm

issues of lacking incentive and collective effort are underlain and reinforced by the right and power that property law assigns to the various owners. The building owners as the freeholders have the power to undertake energy upgrades, but they have little incentive to do so. The flat owners as the leaseholders have no legal obligation to act collectively to facilitate the energy upgrades of their buildings. Weatherall and colleagues (2018) argue that some sense of collective responsibility is missing among the leaseholders, which they then argue is a gap or flaw in the legal definition of property right.

The above research has a clear legal focus. Property ownership can be a complex concept if many of the legal details are to be specified (Carr, 2011; Gardner & MacKenzie, 2015; Bryson et al., 2017). In general, property ownership concerns a bundle of legal rights that various parties share in different ways. For example, as mentioned above, freehold owners hold the basic ownership for principally an indefinite period of time. Meanwhile, freehold owners can lease substantial amount of property ownership to leasehold owners who hold many legal rights over the leased property for a period of time specified by the lease agreement. As mentioned earlier (Roberts et al., 2019), this legal sense of property ownership is relevant to the concern of deploying solar panels.

Bright and Weatherall (2017) study the lease documents of multi-owned properties in the UK. They find that the hurdles to building energy upgrades are already indicated in the leases. In the example of deploying rooftop solar panels, problems or disputes may stem from the vague terms included in the leases, such as ‘improvement’ or ‘repair’. Mostly, the leases may define the responsibility and financial deals between freeholders and leaseholders in terms of building improvement or repair in general, instead of addressing solar panel installation specifically. Moreover, there is no ‘standard’ lease, so it varies from lease to lease what is meant or included

by improvement or repair. It is also likely that these terms are so vaguely defined in the lease that the lease document itself cannot offer any clear reference about how solar panel installation would be addressed (Bright & Weatherall, 2017).

Although property owners mostly take the responsibility of deploying solar panels (Weatherall et al., 2018; Roberts et al., 2019), it involves much technical and social consideration that requires consultation of many other actors (Hudson, 2007; Rydin, 2012; Bright et al., 2019). For example, installation companies must be consulted for a basic survey of the roof condition. Many of these companies also provide further services to advise system design and installation plan with optimum outcome. Moreover, installation of solar PV systems beyond certain capacity is required to seek permission from electricity distribution network operators (Bulkeley et al., 2016; McMeekin et al., 2019). As for rented buildings, benefit and cost of installing solar panels must be negotiated between landlords and tenants (Roberts et al., 2019). Therefore, deploying solar panels on buildings is faced with potentially complex social relations and networks. While acknowledging such complex context, the focus on property owners' role can be a useful approach to investigating the topic of solar panel deployment on buildings. This focus is not meant to neglect the roles of the many other actors, which can also be studied through the property owners and their relations with the other actors.

1.4 Institutional Property Owners

Institutional property owner is a central term in this study. By institutional property owners, this study refers to the institutions that own properties. Under the concern of this research focus, there is no further discrimination of different types, sectors, or categories of institutions. In this sense, all the non-individual property owners are considered as institutional property owners in this study. More specific examples of institutional property owners in the UK include local councils, universities, housing associations, private companies and so on (Adams et al., 2001;

Dixon, 2009). The local councils hold and manage many public buildings and social housing properties in their local areas. Most universities in the UK possess and operate their own buildings and campuses. As for housing associations, they are mostly considered as public-sector social housing providers. However, some of them are not-for-profit organisations, while some others are commercial companies that also belong to the private sector (Morrison, 2017).

Moreover, private companies' property ownership also presents different manners. Some companies are categorised as institutional (property) investors, whose core business is to invest in properties and lease them to others. Here, the term of 'institutional' is also used to distinguish from 'individual' investors. Institutional investors often neither occupy nor manage their properties themselves. In contrast, there are also private companies, whose core business is not trading or managing properties, choosing to acquire and own properties to facilitate their core business activities. These companies are often also the occupiers of their own properties, for example, retail companies occupying their own store buildings. There are also private companies whose core business is property investment, but their scale is often much smaller than any typical institutional investors. Moreover, there is another kind of institutional property investors, who invest in properties as part of their diversified investment profile. Insurance companies and pension funds are examples of this group of investors. Their engagement with the specific property investment project, such as occupancy and management, varies from project to project. The above categories are not definitive, and more categories can be defined based on further differences among institutions (McAllister, 2020). Being aware of the possible nuances among different institutions, this study takes a broad definition of 'institutional property owners' covering all the organisations and non-individuals that process real properties.

The proposition of a broad definition of institutional properties owners here is that all these institutions could to some degree be put in a shared context, because of the common ground they have. For example, they are all institutions that need to deal with the real assets they own as property portfolios. They are likely to hold multiple properties located at various locations (forming a property portfolio). Moreover, they may have similar institutional processes and organisational structures through which actions concerning their buildings are determined. This proposition is seconded by Heywood (2018) who focuses on corporate real estate defined as 'real estate used by 'for-profit' or 'not-for-profit' and private and public sectors – essentially, all organisations' (p.229). While also acknowledging the differences among organisations, Heywood (2018) justifies the broad scope of organisations because the need to meet the strategic objectives of managing corporate real estate is consistent, and there are common principles. Some literature suggests that, between the public and private sectors, there is a convergence of approaches to corporate real estate management (White, 2011; Morrison, 2017). This convergence of management approaches between the public and private sectors could demonstrate the common ground among various kinds of institutional property owners. Therefore, the research question of this study accepts that there is common ground based on which the various institutional property owners could be drawn together for research purposes.

Previous usage of institutional property owner can be found in some literature (Guy et al., 2002; Jones et al., 2017). However, both of these articles put institutional property owners at a background position while focusing on institutional property portfolios (Jones et al., 2017), or independent developers (Guy et al., 2002). Similar with the above literature, this study uses the term of institutions to mean organisations such as firms, public bodies and other agencies. This is considered by an old yet extended review of institutions in British property research (Ball,

1998) as a casual yet acceptable approach of interpreting the term, as compared to using the term to refer to the general sense of rules, norms, regimes, and so on.

In the UK, a large number of properties in cities are owned by a relatively small number of the institutional property owners, which hence play a significant role in the issue of solar panel deployment on buildings. Despite a broad definition of institutional property owner, the number of such institutions is much smaller than the total number of buildings. Therefore, it is possible that institutional property owners might only possess a small proportion of the existing properties, and hence the potential impact of their deployment of building-applied solar panels could be limited. However, some existing literature suggests otherwise. Adam and colleagues (2001) found that more than 90 percent of properties in the re-development sites across four UK cities were owned by institutions. Dixon (2009) suggested that financial institutions, owner-occupier companies (retail), and the government were the main groups of property owners in the commercial sector in the UK. Regarding the residential sector, Dixon (2009) referenced English Housing Survey to suggest that about two-thirds were owned by individuals and couples, and about one-third was owned by companies and organisations. Some other reports from University of Cambridge[9], and Property Investment Forum[10] also suggested that institutional property owners formed the majority group of owners in the commercial property market in the UK. More than one-third of the property owners were institutions such as financial firms, pension funds and insurance companies.

[9] Overview of the research project accessible in September 2021 at: https://www.cam.ac.uk/research/news/who-owns-the-city#:~:text=The%20City's%20'functional%20specialisation'%20with,financial%20and%20business%20services%20firms;
Report accessible in September 2021 at: https://www.landecon.cam.ac.uk/news/new-who-owns-the-city-report-shows-foreign-ownership-of-city-of-london-offices-passes-50

[10] Report accessible in September 2021 at: https://www.ipf.org.uk/resourceLibrary/the-size---structure-of-the-uk-property-market---year-end-2018-update--december-2019--full-report-.html

1.5 Research Question

The previous sections together help introduce the overall research question of this study: what is considered by institutional property owners regarding deploying solar panels on their buildings? There seem normative motivation and financial incentive for deploying solar panels on buildings, as introduced in the previous sections. However, recognising such motivation and incentive may differ from how these motivation and incentive as well as other potential factors are drawn into consideration from the specific perspective of institutional property owners. It is unknown how the many factors suggested by literature are interpreted by institutional property owners. How would institutional property owners think about and weigh up the many factors to reach a decision? How would they explain and justify such decisions? The question is about the consideration of the many factors instead of the factors per se. Such consideration may have certain subjective point of view depending on specific contexts. This study's research question aims at clarifying such consideration by institutional property owners.

This study takes a broad definition of institutional property owners, including any kind of non-individual owners, such as government, local authorities, housing associations, universities, institutional real estate investors, private companies (e.g. retail and logistics), and so on. As these many kinds of institutions are arguably different in many ways, this research question then may be quickly resolved into several separate and more specific questions. For example, what are considered by local councils? What are considered by universities? What are considered by institutional investors? What are considered by retail companies? The list will go on. As discussed earlier, literature suggests increasing degree of convergence between public and private sectors in their approach to managing property portfolios (White, 2011; Morrison, 2017). Would the different kinds of institutional property owners consider the same principles in terms of deploying solar panels on their buildings? Although the many kinds of

institutions are different in many ways, to what extent this matters to the specific topic of solar panel deployment on their buildings? This study is more interested in keeping such discussion open rather than restricting the scope a priori. After all, there is literature suggesting the possibility of common principles shared by many kinds of institutional property owners in terms of dealing with their properties (Heywood, 2008).

There is exiting research about individual households' adoption of solar panels (Sarralde et al., 2015; Bulkeley et al., 2016; Westacott & Candelise, 2016; McKenna et al., 2018). However, the research focusing on individual households would not address certain issues that are particularly relevant to institutional property owners. For example, institutional property owners oftentimes possess many buildings in their property portfolios (Heywood, 2018), for which deploying solar panels on one building may be considered in relation to the other buildings in the portfolio. Moreover, many buildings held by institutional property owners are unlikely to be occupied by the building owners (Adams et al., 2001; 2002), which would result in further issues of bearing cost and sharing benefit of installing solar panels. Thirdly, many institutional property owners manage buildings whose physical features significantly differ from domestic houses, such as size, height, and roof structure (Dixon, 2009), which may concern the deployment of solar panels. Due to these aspects that differ institutional property owners from individual owners, it is helpful to raise the research question focusing on institutional property owners' consideration.

1.6 Thesis Structure

Against the current background of climate change, immediate actions of cutting carbon emission are urgently needed, so as to limit the global average temperature increase within 2 degrees Celsius (Geels et al., 2018; Grove-Smith et al., 2018; Wilkinson et al., 2018). Cities are major sites of carbon emission (Bulkeley, 2013), for which mitigating emission particularly

from urban environment makes great impact, for example, reducing emission from each building due to its electricity consumption. In addition, the urgency of such mitigation has rendered gradual, accumulative, or building-by-building retrofit inadequate, for which larger-scale actions or wider-coverage thinking is called for (Eames et al., 2013).

In the UK, institutional property owners with their property portfolios containing many buildings and covering multiple cities play an important role in emission mitigation from buildings, and the broader interest in sustainable real estate (Wilkinson et al., 2018). Examples of institutional property owners include local councils, housing associations, publicly listed companies, private companies, universities, and so on. It is these institutional property owners that anchor the investigation of this research which then attempts to contribute knowledge to making sustainable urban environment.

This thesis contextualises the case of deploying building-applied solar panels by institutional property owners in the academic discussion of assemblage and emergence. This study's research question about the institutional property owners' consideration on solar panel deployment will help investigate into the complex processes from which certain reality emerges. The area of Nottingham in the UK is selected to be the geographical focus of such empirical investigation that consists of in-depth semi-structured interviews with respondents from institutional property owners holding properties in Nottingham. The research is designed into a qualitative study in social science. The design follows the general steps including problematising social phenomena, contextualising the research question, theorising sociological processes, investigating empirical cases, discussing evidence, and drawing conclusions. Further articulation of the research design is only meaningful after the specific

context and theory are explained. Therefore, more details of the research design will be seen in the later chapter about methodology.

In the following chapters, Chapter II Literature Review will discuss literature that may be suggesting possible answers and propositions to the research question. The scope of the literature review will go from generally relevant literature towards relevant research projects that are similar to the project that this study is aiming at. Chapter III Theory will discuss the theoretical insights of assemblage theory, while also drawing upon references of Actor-Network Theory. This theoretical discussion will help theorise the research question and relate the concepts of the theory to the specific topic and enquires of this study. Chapter IV Methodology intends to apply the lessons learned from the previous chapters of literature review and theory to this thesis' research design. Details of research methods, such as the geographical focus of Nottingham and the semi-structured interviews, will be further explained. Analytic strategies will also be explained in this chapter before presenting the analysis in the next chapter. Chapter V Finding and Analysis will focus on the empirical evidence. Direct quotes from the field work and additional evidence will be presented, and analysis will be followed up right after the relevant empirical evidence. In other words, finding and analysis are intertwined rather than being divided in separate sections. Chapter VI Conclusion will review the main points discussed throughout the thesis, and propose the knowledge claims that this thesis is confident to contribute to the academic community.

Chapter II: Literature Review

There is existing research about deploying solar panels on buildings (Mah et al., 2018; Roberts et al., 2019), which suggests many issues that may be considered by institutional property owners. The general concern of cost-benefit analysis can receive various impacts from specific issues related to institutional property owners, such as tenants occupation, lack of data, limited amount of rooftop space, and so on. Useful lessons can also be drawn from research about social networks and partners' collaborations that are involved in on-site energy generation projects in cities (Rydin, 2012; Rydin et al., 2013; Coles et al., 2016). Such projects are common contexts and relevant opportunities in which building-applied solar panel deployment can be included. Being aware of the possible relevant issues and actors, Rydin's case study (2016) demonstrates that real estate investment and markets can further influence how the many issues and possible partnerships would be considered in various ways. Moreover, several other case studies suggest the importance of specific projects and particular material conditions in shaping institutional property owners' case-specific considerations (Hudson, 2007; Rydin et al., 2013; Bright et al., 2019).

2.1 Difficulties in Deploying Solar Panels on Buildings

Despite the positive contribution to sustainability by deploying building-applied solar panels, there are difficulties and obstacles in realising such deployment. The concerns on finance and space availability can be manifested in different ways and reinforced by various situations (Mah et al., 2018; Roberts et al., 2019). After all, solar panels are devices that come with a cost, including not only the price of the panels but also the fees involved in the installation. Working out a financially robust solution is a practical prerequisite of deploying solar panels. Such robustness may be crucial for institutional property owners whose capital spending is likely to

be collectively examined for approval by certain committee or board members. Despite the normative presumption related to environmental sustainability as introduced in the previous chapter, the practical issue of finance may turn out more fundamental in empirical reality. In other words, although buildings 'should' have solar panels due to the urgent need to reduce carbon emission, this may not be materialised due to the difficulties in financing such deployment (Mah et al., 2018). This section provides an overview of the known problems that may discourage the uptake of solar panels by institutional property owners.[11]

Generally, high upfront cost and hence long payback period underlie the financial difficulty in deploying solar panels on buildings (Mah et al., 2018). Currently, technical basis of solar panels is either solar photovoltaics (solar PV) or solar thermal, while the former is more widely used. Financial logic of deploying solar panels is the same for both these technological sub-types. Solar panels can provide 'free'[12] energy (either electricity in the case of PV or heat in the case of solar thermal), which reduces energy purchase from the utility grid. Therefore, the consequential saving from the reduction of power purchase from the grid becomes the financial gain of solar panel deployment. This saving accumulates day by day, and at certain point the financial gain of solar panels is expected to exceed the upfront cost of installing them. After this payback point, solar panels may continue functioning and generating the financial gain. As will be discussed below, there are other variables that may lead to high upfront cost and long payback period, which would lead to financial hurdles to potential deployment.

[11] There is existing literature reviewing the barriers to solar panel deployment specifically (Roberts et al., 2019) or barriers to building energy upgrading broadly (Weatherall et al., 2018). A common approach is to classify barriers into several categories, such as economic, organisational/governance, behavioural, technical, and so on. The focus of this section is not to rehearse or comment on any 'comprehensive list' of these barriers or their classification. Instead, based on learning from the existing literature, this section intends to discuss the issues that are relevant to the research question and its development in this study.

[12] Solar energy itself is free, but installing solar panels is not free. Therefore, it is up to interpretation whether or to what extent the energy generated by solar panels is free.

In the wider context of sustainable real estate, installing solar panels is among the many actions that may contribute to reducing carbon emission from and to improving energy performance of buildings. There are also many available technologies besides solar panels. Therefore, there is some degree of competition in terms of capital spending by the property owners (Roberts et al., 2019). For example, installing LED lighting may be prioritised over solar panels due to shorter payback. Replacing old gas boilers may also be prioritised depending on the urgency of the replacement. Therefore, to find a desirable solution of installing solar panels may require quite an amount of time, financial and intellectual input, which may not be always available among institutional property owners. Moreover, such desirable solution may require not only a bit of roof space but require a particular kind of ideal situation such as large south-facing flat roof, which may not be available in the property portfolio (Roberts et al., 2019). Therefore, knowledge accessibility is recognised as a potential issue (Roberts et al., 2019). Institutional property owners may lack adequate knowledge about not only solar panel technology but also energy performance of their buildings. There may also be difficulties in seeking such knowledge from external sources such as consultants and building energy performance assessors. Consultancy fees and similar charge for accessing relevant knowledge can also discourage institutional property owners to investigate further in order to progress towards solar panel deployment. It is worth further studying how this issue is addressed by institutional property owners.

Regarding building-applied solar panels, the high turnover of property ownership is recognised as an issue that may worsen financial difficulty (Roberts et al., 2019). While currently solar panel deployment often requires around 8 years[13] to pay back its upfront investment, many

[13] Payback period depends on subsidies and electricity price, which change quickly. The estimation of payback period about 8 years is based on literature (e.g. Cherrington et al., 2013; Roberts et al., 2019) and practitioners'

buildings may not be held by the same owner for such a length of period (Axon et al., 2012). For example, many commercial buildings may be traded in frequent buy-and-sell circles. In this case, many institutional property owners do not expect to benefit financially from deploying solar panels. This contradicts against the simplified view that solar panels immediately generate financial gain because of free solar energy. This simplified view overlooks the concern on installation cost. However, it is questionable whether waiting for the solar panels to pay back is the only way to capture the financial gain. Could the deal of trading properties be sensitive to solar panel deployment so that the financial gain is shared by the previous and current property owners? Further study is needed to elaborate this aspect.

For institutional property owners that do not occupy the properties, the financial gain of installing solar panels is far from straightforward. A widely known issue is split incentive[14] (Ambrose, 2015; Howarth & Roberts, 2018; Roberts et al., 2019)[15]. As the financial benefit of solar panels comes from savings in electricity bills, it is the building occupiers who also pay for the electricity bills that straightforwardly benefits from solar panels. Property owners who do not occupy the buildings may require other incentive points to help with installing solar panels, such as the increase of property value due to solar panel deployment (Weatherall et al., 2018). Different parties may consider potential deployment with different incentives, but

advice (e.g. EvoEnergy website content, accessible in September 2021 at: https://www.evoenergy.co.uk/technology/solar-panels-faq/).

[14] Castellazzi, L., Bertoldi, P. & Economidou, M. (2017). *Overcoming the Split Incentive Barrier in the Building Sector*. European Commission report: accessible in September 2021 at: https://publications.europa.eu/en/publication-detail/-/publication/ae5716d7-fb39-11e7-b8f5-01aa75ed71a1/language-en

[15] Throughout this thesis, only academic publications are referenced in the academic style as well as listed in the reference list at the end. These include articles published in academic journals and academically written books. All the other sources of references are noted by footnotes. These other sources also include reports about research projects, and official government papers, which some audience may consider as academic publications. Such arrangement is not meant to discriminate 'academic' from 'non-academic', but to keep the clarity and consistency of the reference list. All kinds of reliable literature are appreciated as important references where they prove relevant.

predominantly the most incentive stems from direct and clear financial benefit.[16] Moreover, the consumption pattern of the building occupiers has direct impact on how much benefit could be made through savings of the bills, and the property owners may have little influence on occupiers' behaviour in energy consumption. The property owners may not even have access to the data or information about the electricity consumption pattern of their buildings (Janda et al., 2014; Weatherall et al., 2018). This adds complexity in the split incentive issue, which, as Sayce and colleagues (2007) argue, may turn into the lack of incentive rather than simply split incentive.

Building rooftop space may have been used or reserved for other purposes, such as green roof, water tanks, and emergency space, which limit the available space for installing solar panels (Munkhammar et al., 2015; Mah et al., 2018; Roberts et al., 2019). This lack of rooftop space may be particularly relevant to the cities where the ratio of roof space against the total energy demand of the building tends to be small (Sarralde et al., 2015; Adam et al., 2016; Roberts et al., 2019). However, the existing literature lacks further clarification about how much space is needed to encourage solar panel deployment. Does it have to be the whole roof, or more than half of the roof? Do the solar panels have to supply electricity for the whole building? Or a whole section of the utility such as lighting? Is there any 'rule of thumb' adopted by institutional property owners? A possible consideration behind may be the 'potential economies of scale with large PV systems' (Roberts et al., 2019, p.96). Due to this consideration, adequate roof space is required to accommodate solar panel systems that are large enough to enable economy of scale. Otherwise, it is not economically viable to deploy

[16] Report by Department of Energy and Climate Change (2012), *The Energy Efficiency Strategy: the Energy Efficiency Opportunity in the UK*. Accessible in September 2021 at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/65602/6927-energy-efficiency-strategy--the-energy-efficiency.pdf

small systems of solar panels. However, such assumption alone seems to contradict the rapid increase of (small-scale) domestic deployment (Bulkeley et al., 2016; McKenna et al., 2018). Further understanding or evidence is needed about this factor of roof space availability in solar panel deployment.

There are other issues related to the physical aspects of tall buildings. For example, certain mounting racks may damage the roof and result in leakage. Other mounting racks may exceed the weight that the roof structure can bear. Finding solutions to these issues is technically possible, but it will increase the cost of installation and maintenance (Roberts et al., 2019). Therefore, the height of the building plays a role linking solar panel deployment to the financial consideration, which indicates reluctance of deployment particularly in cities. The tall buildings in cities also result in the issue of shading, which reduces the productivity of solar panels (Rydin, 2012). Moreover, as orientation is considered an important factor in solar panels' productivity, the urban setting may limit the possible orientation options that the buildings can provide for solar panels. This orientation issue is particularly relevant for façade installation (Yun & Steemers, 2009). The above issues may reduce the productivity of solar panels, but it is uncertain how such reduction would be perceived by various institutional property owners. For example, how important is the reduction of productivity? Can such reduction be accepted as compared to not installing any solar panel at all?

2.2 Social Context of On-site Energy Generation Projects

As mentioned previously, solar panel deployment is embedded in the broader issue of on-site renewable energy generation or microgeneration of energy. Cities are sites of intense energy consumption, and the supply of this energy can be operated in different geographical patterns. Relatively speaking, this can lead to centralised or decentralised governance of energy supply (Rydin et al., 2013). Energy can be generated in large-scale power plants and transmitted to the

sites of its consumption. In this case there are a very small number of generation sites that support a large number of consumers covering a large geographical area. However, energy can also be generated in small-scale plants which only intend to supply for their surrounding local areas. In this case there are many generation sites situated close to their consumers, and the need of energy transmission is limited. In the example of building-applied solar photovoltaics, energy is generated and consumed within the same building. Therefore, energy generation is operated in a micro scale and at the same site of its consumption. Acknowledging the link between solar panel deployment and on-site energy generation is to enable this study to learn useful lessons from literature that has not emphasised solar panels as much as this study does.

Building-applied solar panel system is an example of the many kinds of technologies that render microgeneration of energy in cities feasible. Coles and colleagues (2016) gather energy projects taking place in a local area in London and analyse the social networks linked by these projects and their related partners. The authors intend to use 'community energy projects' to define their focus and empirical search, but the concept is not used to identify empirical projects. The empirical projects are identified through the database of planning permissions issued by the local planning authority. In other words, their sample consists of energy-related projects that gain planning permissions in that local area. However, it is worth noting here that not all the projects that apply solar panels to buildings need to apply for planning permission. What is made very clear by Coles and colleagues (2016) is that most of the projects involve multiple actors' collaboration. Similar approach but more detailed analysis is found in the single case study of an office development in London (Rydin, 2012). This development project also involves multiple elements in micro-generating energy, including, solar thermal panels, solar photovoltaics panels, biomass and so on. Rydin (2012) demonstrates that a wide range of actors must be effectively engaged to achieve such a development project which renders energy

microgeneration possible. The lesson taken from the above literature to this study is that the decision-making role of institutional property owners should be reflected cautiously, and the institutional property owners are unlikely to be the sole decision-maker.

Linked to the multiple partners involved in energy microgeneration projects, Coles and colleagues (2016) find complex variance of interests that drive those projects. In many projects, the central actors are not residents, local activists or energy firms. Even energy generation itself becomes only a by-product of other project activities, such as waste and water management. These 'other' project activities are interested by the main promoters that neither focus on energy as the core business nor particularly concern the local area where the projects are located. These projects are driven by their promoters 'from a distance', in the sense of both governance and geography. This finding is worth bearing in mind while studying the role of institutional property owners in their deployment of solar panels. Is generating electricity the main goal of the project? Are there other project intentions and activities to which deploying solar panels is an addition? Moreover, how much do the local context and the particular property matter in the institutional property owners' decisions to take up solar panels?

Another study by Rydin and colleagues (2013) takes a more comprehensive approach to gathering empirical projects. They consult a wide range of sources and organisations to identify urban energy projects in the UK. Their focus is on collective actions on urban energy system, for which their sample excludes either individual and private behaviour by a single household or projects located outside of towns and cities. Their sample (Rydin et al., 2013) overlaps with the interest in institutional property owners by this study. They suggest the role of property owners in providing roof space for installing solar panels (Rydin et al., 2013). The role of property owners in deploying solar panels may be specified further as the role of providing

roof space. Moreover, the follow-up study in 2019 (Rydin & Turcu, 2019) suggests that the ability to finance themselves is a key factor in the survival of the studied energy projects. It also indicates that the deployment of solar panels is closely related to the financial considerations in many examples, but it is unclear how this financial issue is considered by the institutional property owners. Are institutional property owners expected to solve the financial issues? Are they seeking financial solutions from other actors? Or do they rather passively wait for financial opportunities to emerge from somewhere?

The same sample (Rydin et al., 2013) is used by Devine-Wright and Wiersma (2013) to select nine cases for further investigation. Their case-studies research (Devine-Wright & Wiersma, 2013) is complementary to the above social network analysis by Coles and colleagues (2016). While Coles and colleagues (2016) find that urban energy projects can be driven by actors from afar, Devine-Wright and Wiersma (2013) suggest that certain degree of localisation also exists. Many partners in the projects have local appearance, being local residents' groups, local councils or business that has office located in the local area. This spatial proximity is helpful for building social relations and trust for collaborating in the projects. Therefore, whether local partners can be found could potentially factor in institutional property owners' considerations on initiating energy projects such as installing solar panels on their buildings.

2.3 Sustainability Agenda in Property Sectors

Useful insights are also found in Rydin's research (2016) about the uptake of sustainability agenda in the commercial property sector in the UK. Rydin asks how improving the environmental sustainability of properties is considered in the commercial property market, concerning both property owners and tenants, both solar panel deployment and other solutions. Therefore, assuming that deploying solar panels is symbolic of taking up sustainability agenda, Rydin's question (2016) is very similar with the question that this study intends to ask, i.e. how

do institutional property owners consider deploying solar panels on their buildings? Moreover, the commercial property sector as targeted by Rydin (2016) is an important part of institutional property owners' portfolios. Rydin finds difference between the prime (mostly new development) and non-prime (mostly existing or 'older' stocks) sectors. The prime sector is more interested in the uptake of sustainability agenda than the non-prime sector. Rydin's (2016) definition of prime and non-prime concerns the difference in institutional investors' interest. The prime sector buildings are equipped with the 'latest and newest' features (Rydin, 2016, p.749), for which their likelihood of generating high investment return attracts institutional investors' interest. Prime sector buildings are not defined as new buildings, but in practice they are likely to be new buildings developed for the purpose of attracting institutional investment. A non-prime sector building is 'not only older but is typically owned by wealthy individuals and small local businesses', and institutional investors are relatively less interested in the non-prime sector (Rydin, 2016, p.751). Similarly, the definition indicates that non-prime buildings are likely to be existing stocks.

This study has a broader interest in institutional property owners and their properties, compared to Rydin's (2016) focus on institutional investors and commercial properties. However, relevant insights can be inferred from Rydin's study (2016). As Rydin (2016) concludes, it is more likely to take up sustainability agenda in the prime sector than the non-prime sector. It then leads to more possibility or opportunities to deploy solar panels in new development projects than on existing buildings. Specific to the deployment of solar panels, institutional property owners may have less interest in doing so on their existing buildings as compared to their new development projects. This potential lack of interest may have significantly negative impact on the overall deployment of solar panels because the existing buildings form a large proportion of the many buildings held by institutional property owners.

Rydin (2016) adopts a sociological framework and suggests that the market is continuously being made and maintained by heterogeneous actors. The market is not a static given. Rather, it is made of dynamic processes. 'If sustainability is to influence commercial property markets, this framework suggests that there will need to be a differentiated object of exchange that is the focus of calculative devices altering prevailing modalities of valuation and where tools play a performative role in altering practices.' (Rydin, 2016, p.753) The essential interest of the market is to create value and capture profit through exchanging tradable objects. The property market has developed its tools to calculate values as well as attach the value to certain objects of exchange, such as buildings, physical space, and property right. The uptake of sustainability agenda will depend on the extent to which it can translates itself into object of exchange that is compatible to the calculative tools of the property market. The stimulation of new actions will then depend on the difference between the sustainable object of exchange and the business-as-usual object of exchange. Moreover, as Rydin (2016) finds, the stories are different in the prime and non-prime sectors.

The prime commercial property sector is interested in long-term certainty. Property owners aim at securing leases with reputable tenants over a time span of 10 to 25 years (Rydin, 2016). This stable long-term rental income can rationalise the upfront actions of incorporating sustainability features. Neither the owners nor the tenants would want unpredictable refurbishment obligations in the future. Aiming at best energy performance, instead of simply meeting the current MEES requirement, renders the properties and their long leases future-proof of risks in this particular perspective. The problem of split incentive gets addressed from the beginning, as tenants can expect savings from future utility bills and landlords can negotiate

for higher rent[17]. Therefore, if long lease is considered as the prevalent object of exchange in the prime sector, sustainability aligns with this object. The more explicit example of this alignment is the practice of green leases[18] (Rydin, 2016). Moreover, the calculation of property value takes account of reducing future risk and hence is willing to accept lower yield. This then can justify the upfront investment in deploying sustainability features. With these considerations on object of exchange and value calculation, Rydin (2006) explains why uptake of sustainability agenda encounters less difficulties in the prime sector. The reasoning is transferrable to the topic of solar panel deployment in new buildings. Regarding the specific issue of deploying solar panels by institutional property owners, many possible aspects of considerations are likely to align with each other in the cases of new buildings. For example, the upfront cost is less a problem compared to the long-term rental benefit as anticipated at the point of lease renewal. Both the tenants and the landlords are incentivised to install solar panels from the beginning.

In contrast, in the non-prime commercial property sectors, the average lease length is about 5 years (Rydin, 2016). Building-applied solar photovoltaics, as an example of building sustainability features, usually requires more than 10 years to pay back the upfront investment (Gooding et al., 2013). Sustainability agenda does not fit into the time horizon of the object of exchange in the non-prime market. Tenants in this sector heed rent level, lease length, and break clause much more than sustainable building features. As for rent level, the comparison with similar buildings within the local area factors more significantly in the calculation than sustainability of one particular building. Improving energy performance for certain building

[17] Tenants can immediately benefit from energy performance improvement through lower utility bills. But landlords cannot immediately adjust rent in the middle of the rental term. Landlords tend to consider improving the building condition only at the point of rent renewal.
[18] See Bright & Dixie (2014) and Sayce et al. (2009) for more about green lease per se.

would have little impact on the rent of even that very building itself. Therefore, Rydin (2016) finds that the obligations involving EPC and MEES are unable to attract much interest or attention in the non-prime sector, let alone the best practice benchmarks.

As non-prime properties comprise a large proportion of the built environment and the portfolio held by many institutional property owners, Rydin's finding (2016) does concur with the previously reviewed difficulties in deploying solar panels in cities. It concurs with the issues suggested by other literature (Roberts, et al., 2019) regarding solar panel deployment on buildings, such as high turnover of property ownership and tenancy. This suggests that the consideration of solar panel deployment by institutional property owners may be closely related to the consideration of property value. In other words, institutional property owners are likely to consider how solar panel deployment would influence the value of the property or the future income that can be generated by the buildings. Such value is considered in comparison to how much benefit or utility bill savings that can be generated by the solar panels themselves. The former (i.e. property value) may be a more important concern than the latter (i.e. solar panels' productivity), although the former is less directly related to the solar panels' outcome than the latter.

2.4 Case Specificity

After reviewing the context relevant to solar panel deployment in the UK, this section reviews a few specific case studies which can be taken as examples illustrating how solar panels get deployed on institutionally owned buildings. In addition to academic studies, some recent cases of practice, for example, in London, the South Bank Tower[19], the 20 Fenchurch building[20], and

[19] Project brief accessible in September 2021 at: https://www.evoenergy.co.uk/case-studies/south-bank-tower/
[20] Project brief accessible in September 2021 at: https://www.evoenergy.co.uk/case-studies/fenchurch-street/

the Mercury Shopping Mall[21], can be taken to indicate the possibility of taking up solar panels on institutionally-owned non-domestic buildings.

The first case is Rydin's (2012) study about a development project of an office building in London. Rydin's main point is to use Actor-Network Theory (ANT) to study planning processes. It shows how various actors across different levels of governance are linked through the planning regulations and city plans as intermediaries, and planning consent as the obligatory passage point. Many actors, including investors, developers, contractors, planners, and politicians, are concerned about this development with slightly different foci of interest. Solar PV is one of the perspectives that enrols these interests in the project and consolidates the project's realisation. As an example of prime commercial property development (Rydin, 2016), sustainability is concerned from the beginning. Particularly, one of the three energy strategies of this development is to provide on-site renewable energy through the combination of roof solar PV panels, solar thermal panels, and a biomass boiler. These technologies are commissioned to supply 15-20 percent of the building's energy demand as well as reduce carbon dioxide emission by 10 percent (Rydin, 2012). These technologies need to adjust themselves to the other elements of this project, including the building form, the system design, the architect, the engineer, the developer, and the calculation of modelling their output. If the modelling fails to generate a convincing output, the realisation of the whole development project could be vitally compromised. The deployment of solar PV in this case is considered within a suite of action plans to achieve sustainability credentials and to meet planning regulations. This case study illustrates the previously-reviewed policy context in which solar

[21] Project brief accessible in September 2021 at: http://copy-syzygyrenewables.smartlittlewebsite.com/projects/mercury-mall-romford

panel deployment may be considered in relation to the local regulations and assessment schemes regarding buildings' energy performance and sustainability rating.

Hudson (2007) offers a case of an owner-occupied historical office building in Manchester[22]. The building takes up vertical solar PV cladding. The driver of this deployment is the combination of two concurrent issues of the building. Firstly, the building's old mosaic cladding has deteriorated into serious concerns to the surrounding buildings and people. Action of repair is undoubtedly needed. Secondly, the institutional owner of the building has strong commitment to its social responsibility and is willing to respond to the overall concern of environmental sustainability and building energy efficiency. Therefore, the photovoltaic cladding becomes the win-win solution to the above two issues. Moreover, PV cladding is also cheaper and more feasible than the other two options of repairing the cladding. Due to the process of planning consent, a number of other organisations are involved in the decision making of this scheme. Generally, the local authority and other governmental bodies are in favour of this scheme, as it can be a positive demonstration in the region which welcomes promotion of the uptake of photovoltaic technology. Aesthetic concern is also a significant concern due to the visibility of the scheme, but the aesthetic feature of the building itself helps to address this issue. The main aesthetic value of the building is 'its overall massing and elemental form' (Hudson, 2007, p.58), so the specific material on the surface would not significantly compromise this primary aesthetic importance. More detailed design of the scheme has to engage a range of external experts to well address the countering opinions. Overall, the case shows that the deployment of this solar PV scheme is deeply embedded in the particular context of this building (Hudson, 2007). Solar panel deployment may be considered

[22] There is another similar and earlier case in the UK (Bahaj, 2000), but Hudson's case (2007) is adequately insightful here.

in the frame of wider projects addressing many aspects of a building, as compared to being considered as an individual action. The various interest groups involved in the wider projects can also influence the consideration on solar panels depending on how solar panel deployment would contribute to satisfying their interests in the projects.

Bright and colleagues (2019) provide a case study about five residential building blocks in Oxford. In this case, energy upgrade is proposed to ensure the living condition of the buildings would meet the Decent Home Standards. The main owner of the building blocks is the Oxford City Council, but some flats in the blocks are sold with long lease under the Right to Buy scheme. The occupiers of the blocks are mainly social housing renters, with some owner-occupying leaseholders as well as private renters from the investing leaseholders. The main concern of the energy upgrade is about the heating condition of the building, which lends to wall insulation and window frame renewal as the main work. Some solar PV panels are installed on one building's 'south-facing elevation' (p.165). The main issue of this project is about the share of the cost among the occupiers. The project is faced with significant increase of cost compared to its initial budget. Some of the work is for individual flat, but some other work such as solar PV benefits occupiers collectively. The mixture of tenure with both short-term renters and long-term leaseholders renders the cost issue even more complex. This case study (Bright et al., 2019) does not detail the part of solar PV, but it is clear that the deployment of solar PV is considered within the overall building refurbishment proposal. The case shows the impact of complex property ownership on the finance of building-applied actions such as installing solar panels.

The case studies show that the consideration of deploying solar panels is highly contingent on the specificity of individual cases. This raises questions about how research could enquire

about solar panel deployment among institutional property owners who hold many different buildings which are potentially also scattered across different local places. To what extent the instances such as what the case studies illustrate take place in the institutional property owners' portfolios? Are there any strategies by institutional property owners to engender opportunities of deploying solar panels among their buildings? Or do institutional property owners only rather passively wait for the opportunities and deal with the specific buildings that happen to encounter the opportunities? Further research is needed in addition to the existing literature as reviewed.

Chapter III Theory

Assemblage theory provides the useful theoretical framework underpinned by thorough conceptual construct (DeLanda, 2016). Such framework will be used to address the complexity related to institutional property owners' considerations regarding deploying solar panels on their buildings. Broadly speaking, the current theoretical literature with an interesting socio-material approach to analysing research questions involving technologies convinces this study of the appropriateness of adopting such theoretical framework in its analysis. Specifically, this study recognises the promising potential of the thorough conceptual construct offered by DeLanda's theorisation of assemblage (2016). This conceptual construct will help substantiate and guide the analysis concept by concept, as will be shown throughout the later part of this thesis. This sense of clear guidance in theorical analysis underlies the initial motivation of using assemblage theory in this study's analysis.

The general theoretical review will define the assemblage of institutional property owners' deployment of solar panels on their buildings. Within such assemblage, relevant relations and the extent of their exteriority form the basis where potential emergent properties may emerge. The potential of deploying solar panels on buildings is conceptualised as such emergent property existing in equal ontological status with the relevant actors, relations, and interactions. Territorialisation and coding can potentially help articulate the assemblage of institutional property owners' deployment of solar panels with further depth and clarity. Institutional property owners' consideration is theorised as the virtual space of possibilities, and such theorisation enables the application of the theoretical concepts to the empirical research of this study. Finally, emergent causality offers the qualitative approach that is able to describe and analyse the empirical matter and its theoretical reflection.

3.1 Assemblage Theory

> *'What is an assemblage? It is a multiplicity which is made up of many heterogeneous terms and which establishes liaisons, relations between them, across ages, sexes and reigns -- different natures. Thus, the assemblage's only unity is that of a co-functioning: it is a symbiosis, a 'sympathy'. It is never filiations which are important, but alliances, alloys; these are not successions, lines of descent, but contagions, epidemics, the wind.' (Deleuze and Guattari, Anti-Oedipus, p.42, quoted in DeLanda, 2016, p.1)*

The theoretical discussion is centred around assemblage theory (DeLanda, 2016). The above definition of assemblage will be unfolded and articulated in this chapter step by step following the conceptual construct offered by DeLanda (2016). Specific to this study, the focal assemblage is defined as the assemblage of institutional property owners' deployment of solar panels on their buildings.[23] This assemblage concerns the multiplicity of heterogenous terms related around institutional property owners' deployment of solar panels on their buildings. The centre of such assemblage is placed at institutional property owners. Similarly central, material components of this assemblage are anchored around institutionally owned buildings and building-applied solar panels. As reviewed in previous chapters, many other heterogenous terms are relevant to such assemblage. Property investors, occupiers, facility managers, local authorities, energy experts, and project contractors are often concerned and can be liaised in various conditions of collaboration. Specific building components such as rooftop, common space, and façade may at certain point start playing different roles that co-function to support solar panel deployment. In line with solar panels, relevant relations can also relate other types of building-applied technology that can improve buildings' energy performance, such as LED lighting, water boiler, wind turbines, and so on. Moreover, Feed-in Tariff, local plans, building

[23] This study's focal assemblage is defined as the assemblage of institutional property owner' deployment of solar panels on their buildings. The central focus of this study's research question is institutional property owners' consideration on solar panel deployment on their buildings.

regulations, and energy performance assessment schemes are highly possible components related in this assemblage. This assemblage defined in this study will be articulated further with DeLanda's (2016) conceptual construct, before which assemblage thinking and DeLanda's assemblage theory will be introduced first.

The fundamental proposition of assemblage thinking is that the social or the urban is underlain by complex and dynamic processes and relations linking various actors and objects together (Farías, 2011). To understand certain material phenomenon, such as the uptake of solar panels by institutional property owners, research must enquiry into these processes and relations and investigate what is relevant based on empirical evidence. Assemblage theory does not have the answer, but it suggests that answers should be found through tracing the social relations, listening to the actors, and paying attention to (non-human) objects. Assemblage theory (DeLanda, 2016), and the closely related Actor-Network Theory (ANT) (Latour, 2005), are adopted to explain the emergence, stabilisation, and mobilisation of certain (social) phenomenon. Examples seen in literature include the region of South East England (Allen & Cochrane, 2007), local sustainability agendas (Rutland & Aylett, 2008; Temenos & McCann, 2012; Hope, 2021), international network of assisted reproduction (Müller & Schurr, 2016), and large-scale unexpected event (e.g. American blackout) (J. Bennett, 2005). The epistemology of assemblage theory emphasises the relational ontology of entities, for which analysis of social phenomenon must not exclude any possible relevant relations or entities due to analysts' arbitrary choice (Farías, 2011).

Assemblage thinking has been adopted in various disciplines. Its seminal articulation was done by the French philosophers Gilles Deleuze and Félix Guattari (Brenner et al., 2011; Müller, 2015). Assemblage, as the term itself suggests, 'assembles' heterogeneous elements to form

certain kind of social and spatial ‘assemblage’ (Wise, 2011). It emphasises the relational view of the world, which suggests thinking of reality through studying and understanding the possible relations among multiple elements (Baker & McGuirk, 2017). Anderson and McFarlane (2011) suggest that ‘deploying the term assemblage enables us to remain deliberately open as to the form of the unity, its durability, the types of relations and the human and non-human elements involved’ (p.124). This guides research to not only always attend to relations, but also be wary of overlooking the less obvious relations such as the relations to muted agencies (Karrholm, 2016). Research design must be open to discover what is possibly assembled in the empirical world, instead of being fixed at what researchers find relevant a priori (Farías, 2011).

Assemblage analysis incorporates a dynamic view. Assemblage is at the same time the process of assembling and the outcome of relations (Lancione, 2013; Baker & McGuirk, 2017; Buchanan, 2017). Not only is the assemblage assembled through the relations, but also the relations, with the multiple parties that are related, are deliberately assembled. Assemblage thinking rejects the binary split between process and substance. In contrast, process and substance are interrelated and interdependent, for which relevance is suggested empirically. The relevance of certain process is suggested by the substance context where the process is embedded, and meanwhile the relevance of certain substance is suggested by the process where the substance is involved. For example, the process of tenants’ turnover may play a key role in institutional property owners’ deployment of solar panels (Roberts et al., 2019). The substantial conditions of buildings may become fundamental driving concern under which deploying solar panels can be part of the solution (Hudson, 2007; Bright et al., 2019). As an example, McGuirk and colleagues (2016) use urban regeneration to illustrate the dynamic view of assemblage thinking. Thinking of cities as the assemblages of heterogeneous elements may indicate a static

view, as if ‘the’ assemblage is settled. This indication is in contrast with the dynamic view of assemblage thinking. ‘Repositioning the city as processually produced and always becoming, assemblage thinking reanimates the urban.’ (McGuirk et al., 2016, p.130). More broadly than the urban, as Latour articulates (2005), grand (academic) notions, such as 'society', 'context', 'structure', 'framework', and 'scale', are not set in stone by analysts once and for all. Instead, they are constantly being assembled, modified, and maintained by the many actors in the empirical world through their ‘labours of assembling’ (Baker & McGuirk, 2017, p.431). They are the actors' own achievement, not any analysts' decisions.

3.2 DeLanda’s Theorisation on Assemblage

The challenge of assemblage theory is to articulate an abstract account which suggests the fundamental role of empirical variance. If process and substance are meaningful in their empirical contexts, what is the justification for any abstract theory hovering above any particular context? This question is somewhat ignored by most of the empirical studies claiming to adopt the theoretical framework of assemblage. Authors may provide a brief overview or small discussion about assemblage, which would usefully bring forward the relational view, the dynamics of process, and the active role of substance. Then they may use certain empirical cases to illustrate how these general theoretical viewpoints help understand and analyse those cases. It becomes a double-edged sword. On the one hand, assemblage becomes this apt theory widely adopted in various empirical issues and academic disciplines. On the other hand, the ‘apt’ theory may be left being too abstract and encountering difficulty in developing further than a few points of epistemological inspiration. Consequently, in most of the studies, there is a certain degree of disconnect between the theorical reflection and the empirical analysis. This study addresses this disconnect issue by reflecting on the research question through the conceptual construct offered in a specific version of assemblage theory

articulated by DeLanda (2016). This approach enables this study to construct the theoretical framework concept by concept, as compared to only giving a general overview of the theory. This conceptual construct will then be integrated also concept by concept into this study's empirical analysis. Before studying DeLanda's theorisation on assemblage in detail, some overall observation of his approach would be helpful.

Recent extended work closely focusing on assemblage is done in DeLanda (2016) which is titled 'assemblage theory'. While various authors have engaged the concept of assemblage that is seen in the writing by Deleuze and Guattari, which is considered to form a line of 'assemblage thinking', DeLanda (2016) is explicit about the intention to articulate it into a theory. This explicit intention may indicate why DeLanda (2016), firstly, dives into great philosophical depth, and secondly, also theorises several supportive concepts, such as emergent properties, extrinsic relations, and so on. He takes assemblage as a fundamental framework to understanding and explaining a variety of (meta-)phenomena, including the human history, economy and social structure, evolution of language, scientific practice, and events like wars (DeLanda, 2016).

DaLanda's work (2016) also concentrates so much into directly discussing and developing the insights by Deleuze and Guattari, that almost only their own writing is fully engaged. Works by other authors who have directly discussed Deleuze and Guattari is also touched upon, but discussion with further or more indirect link is ignored. One manifestation of this concentration is the lack of any explicit reference to Actor-Network Theory, such as the works by the leading authors widely known as Bruno Latour, Michel Callon and John Law. This absence of reference is somewhat surprising, considering the close mutual relevance between assemblage

and ANT.[24] However, it seems acceptable among the peer scholars, as Wise (2011) takes the same approach, and Buchanan (2017) explicitly argues for such approach closely focusing on the original ideas by Deleuze and Guattari. It may depend on to what extent the writing intends to focus on discussing Deleuzian philosophy, to what extent it intends to advance assemblage thinking, and in what way these two intentions are fused.

After all, DeLanda's extended reflection (2016) is still recognised as a significant contribution to assemblage theory. This study will engage ANT (Latour, 2005) where it is helpful for supporting the theoretical articulation, but this overall articulation will mainly focus on DeLanda's assemblage theory (2016). The choice of focusing on assemblage theory is due to several reasons specifically related to this study's research question, but not the outcome of comparing assemblage theory to ANT. As mentioned above, general comparison between assemblage and ANT has been discussed in detail by some literature (Müller, 2015; Müller & Schurr, 2016). This study considers DeLanda's assemblage theory suitable for the analysis, and this is not based on how much 'more' suitable it is than ANT would be. Firstly, several concepts from DeLanda's assemblage theory, such as relation of exteriority, space of possibilities, and assemblage of assemblages, are insightful for reflecting on this study's research question, which will be shown when these concepts are discussed later. Secondly, this study is interested in taking this opportunity to reflect on DeLanda's (2016) recent attempt of theorising assemblage, and to relate it to the other authors' contribution to assemblage thinking, which, as argued above, is missing from DeLanda's own account (2016). Thirdly, this study aims at a

[24] Detailed comparison between assemblage and ANT can be found in Müller (2015) as well as Müller & Schurr (2016), which acknowledge and analyse the close mutual relevance of these two theories. However, as expressed through other channels, DeLanda strongly disagrees with Latour, and claims fundamental difference between his theoretical view and Latour's. It is beyond the concern of this thesis to further criticise DeLanda's approach of referencing or to comment on DeLanda's critique of ANT. See an online lecture by DeLanda, accessible in September 2021 at: https://www.youtube.com/watch?v=1xJwZcpDnoY

contribution of connecting DeLanda's (2016) philosophical articulation to the conceptual insights of emergent causality as offered in the wider context of assemblage thinking (J. Bennett, 2005; Bender, 2009; Buchanan, 2017).

The following content will anchor itself around DeLanda's assemblage theory (2016)[25], meanwhile relevant works about ANT and from other authors will also be engaged to help the clarification and reflection. As assemblage thinking has been adopted by a wide range of literature (Brenner et al., 2011), it would be irrelevant to try to theorise a coherent account based on comprehensively reviewing all this literature. Buchanan (2017) argues that the reflection and development of assemblage should stay closely loyal to the original ideas by Deleuze and Guattari, and hence criticises many assemblage accounts of losing the philosophical origin and becoming misleading. Whereas McFarlane (2011) welcomes the diversity of views, and argues against the attempt to 'legislate' one particular version of assemblage. DeLanda's work (2016) can be taken as a useful base point in this debate, which helps navigate the way through with a healthy balance between being adamant and conservative in thinking and getting lost in this broad and abstract discussion.

3.3 Relations of Exteriority

The relation of exteriority is a foundational concept to start unpacking DeLanda's philosophical articulation of assemblage (2016). It is contrasted against the relation of interiority[26].

> *'Some relations, such as that between parents and their offspring, or those between brothers and sisters, define the very identity of the terms that they relate. One can only be a father if one is related genealogically to a son or a daughter, and vice versa, so that the identity of*

[25] DeLanda also published earlier attempts (2002; 2006) of developing assemblage theory, the gist of which has been kept and developed in the later version (2016).

[26] DeLanda (2016) claims that 'intrinsic' and 'extrinsic' would be better word choices than 'interiority' and 'exteriority', but DeLanda does not abandon the latter. Intrinsic relation means the same as the relation of interiority, and extrinsic relation means the same as the relation of exteriority (DeLanda, 2016).

> *the role of father, or of that of son or daughter, cannot exist outside their mutual relation. Traditionally, these relations are designated as relations of interiority. On the other hand, when two groups of people related by descent enter into a political alliance, this relation does not define their identity but connects them in exteriority. It is a relation established between the two groups, like the air that exists between them transmitting influences that connect them but do not constitute them.' (DeLanda, 2016, p.2)*

These two types of relations correspond to what Deleuze and Guattari term the relations linked by filiation (interiority) or alliance (exteriority) (DeLanda, 2016).

The relation of interiority and the relation of exteriority are not divided by their nature once and for all, which may be implied by the examples of the father-son relation and the political alliance relation. The difference is in the extent to which the relation is internalised into the identity of terms that they relate. For example, 'persons are socialised as they grow up in families and attend schools, and after they have internalised the values of their societies their obedience to traditional regulations and cultural values can be taken for granted' (DeLanda, 2016, p.14). In this example, social and cultural relations become the relations of interiority as similar to family relations. This kind of society then becomes stable and homogeneous, and the persons and relations are totalised. These persons become what DeLanda (2016) terms 'mere epiphenomena' or what Latour (2005) terms 'placeholders'. This kind of seamless totality is not assemblage. This kind of social relations become more of relations of interiority rather than relations of exteriority.

The relation of exteriority respects heterogeneity, while the relation of interiority tends to fuse the related components into a homogeneous whole (DeLanda, 2016). The relation of exteriority is looser than that of interiority. There are less obligations coded in the relation of exteriority, and hence terms in relation can break apart and plug into other relations (Swanton, 2013; Briassoulis, 2017). It is more difficult to predict or dictate the behaviour of the components

linked by the relation of exteriority (Anderson et al., 2012). There are more possibilities, and hence higher potential of heterogeneity. As mentioned above, heterogeneity is an essential feature of assemblages. This sense of looseness is not just a matter of extent. Rather, it is the fundamental basis that engenders assemblage, which is a qualitatively distinct kind of ontology. The relation of exteriority allows for great space of possibilities, so its impact expands further than the relation itself. Due to the exteriority, the overall heterogeneity is exponentially larger than or qualitatively different from the diversity of relations themselves. A number of relations of exteriority would already be able to engender a great deal of possibilities. That being said, as DeLanda (2016) claims, the 'majority of relations in the world are extrinsic' (p.2). Therefore, the relation of exteriority provides a theoretical starting point to understand the world as highly complex heterogeneity, which, by this very starting nature, would reject being simplified, modelled, or reduced (Law, 2002). This concept helps apply the relational view of the socio-material reality, and it opens up the scope in which a wide range of relations can be acknowledged and studied in terms of a focused object, such as a building (Rose et al., 2010; Edensor, 2011; Jacobs et al., 2017).

The exteriority of relations may offer the foundation of understanding why deploying building-applied solar panels goes beyond simply acknowledging the incentives and issues of doing so, as reviewed in the previous chapters. The relations among the many elements, such as solar panels, buildings, property owners, tenants, and so on, can have variation and lead to various outcomes. Institutional property owners' consideration of solar panel deployment on their buildings is able to demonstrate how the nature of these extrinsic relations has further impact on the complex processes. Therefore, the reality of solar panel deployment cannot be clearly 'read off' or 'deduced' from the many related elements without analysing how these elements are related or considered by important actors such as institutional property owners.

3.4 Emergent Properties

Emergent property is a twin concept in line with relation of exteriority, which together function to block both micro- and macro-reductionism (DeLanda, 2016). This is related to the context of agency and structure (Berger & Luckmann, 1966; Giddens, 1986). DeLanda (2016) uses micro-reductionism to mean that agents have ultimate autonomy, and hence there is no such thing as structure. In other words, society can be reduced to the micro-level, where many rational decision-makers determine wider outcomes. In comparison, macro-reductionism means that structure has determinant effect on agents' behaviours. In other words, society can be reduced to the macro-level, where such ontology as structure is believed to exist and cause social outcomes. Micro- and macro-reductionism are the two extremes of determinism that rejects the complexity of society (Anderson et al., 2012). They try to reduce social complexity to simple determinant relations. In the context of agency and structure, they are also termed intentionalism and structuralism (Allmendinger, 2017).

Both extremes of determinism, together with the dualism of choosing either this extreme or that extreme, are rejected by recent scholars. Well-known attempts to fuse or resolve such dualism include Anthony Giddens' structuration, Roy Bhaskar's critical realism, and Bob Jessop's strategic relational approach (Allmendinger, 2017). What these attempts have in common is the claim that agency and structure are interdependent. Agents have a certain degree of autonomy, while they are also framed by existing structure. Structure has systematic influence, but it cannot completely override the autonomy of agents. Neither simply determines the other. Agency is altering structure while at the same time structure is governing agency. These are complex, simultaneous, intersecting, mutual and circular processes.

DeLanda (2016) agrees with the rejection of dualism between intentionalism and structuralism, which he terms micro- and macro-reductionism. Therefore, emergent property is

conceptualised to block micro-reductionism, and relation of exteriority can block macro-reductionism.

> *'The very first step in this task is to devise a means to block micro-reductionism, a step usually achieved by the concept of emergent properties, the properties of a whole caused by the interactions between its parts. If a social whole has novel properties that emerge from interactions between people, its reduction to a mere aggregate of many rational decision-makers or many phenomenological experiences is effectively blocked. But this leaves open the possibility of macro-reductionism, as when one rejects the rational actors of micro-economics in favour of society as a whole, a society that fully determines the nature of its members. Blocking macro-reductionism demands a second concept, the concept of relations of exteriority between parts. Unlike wholes in which 'being part of this whole' is a defining characteristic of the parts, that is, wholes in which the parts cannot subsist independently of the relations they have with each other (relations of interiority), we need to conceive of emergent wholes in which the parts retain their autonomy, so that they can be detached from one whole and plugged into another one, entering into new interactions.' (DeLanda, 2016, p.9-10)*

For example, given a small town or a neighbourhood in a city, DeLanda (2016) suggests that an emergent property could be the degree to which the members are linked to each other. Some may be friends or colleagues. Some may attend the same gym class or socialising group. Some may regularly let their kids play together in the same playground somewhere in the neighbourhood. If the density of this linkage is high, which means many members know many of the rest of the members, words of mouth may travel fast, and personal reputation could be informally yet firmly stored in the community. While certain personal reputation is shared among a group of community members, it may affect the feeling or life of the person. To this person, it does not matter whether it is this group of members or that group of members that share this reputation, it feels as though the community as a whole has stored this reputation.

This is the kind of emergent properties of a community or a social whole, which is not reducible to specific members. DeLanda (2016) refers to ‘this type of irreducible social whole produced by relations of exteriority, a whole that does not totalise its parts’ as ‘assemblages’ (p.11). The term ‘social’ can be used to designate ‘what is already assembled together’, but it cannot make ‘any superfluous assumption about the nature of what is assembled’ (Latour, 2005, p.1). It is an emergent whole that comes from the interactions among the individuals. The whole is not the simple sum of the individuals, and the potential effect of the whole cannot substitute the effects of each individual (J. Bennett, 2010). The emergent properties of the assemblage differ from any properties of the individual element of the assemblage (Kurtz et al., 2021).

> *'Significantly, the elements of an assemblage have properties, but these do not determine the outcome of processes of assemblage. Rather, it is the relation between elements of the assemblage that lead to the emergence of something greater than the assembled parts.' (Kurtz et al., 2021, p.303)*

The potential of deploying solar panels may emerge from the many issues drawn together by institutional property owners’ consideration. Compared to this theoretical view, the reasons or causes of solar panel deployment is not to be reduced to specific individual factors such as Feed-in Tariff. Instead, it may be an emergent property based on the specific manners in which the many elements interact among each other. Such interaction may be traced through institutional property owners’ consideration which then is the virtual site where the many extrinsically related elements interact to support further emergent properties. Based on this theoretical concept, institutional property owners’ consideration on deploying solar panels on their buildings is an important virtual space to observe the dynamics of relevant assemblages. Therefore, this study’s research question finds substantial theoretical grounding in this reflection of assemblage theory so far.

3.5 Ontological Plane

Emergent properties are emergent, and they cannot become transcendent. They are contingent to the interactions among components of the whole. They are constantly produced by these interactions, which means 'if the interactions cease to take place the emergent properties cease to exist' (DeLanda, 2016, p.12). This emergence then responds to the notion of 'relation of exteriority', which is the kind of relations that can be broken apart without breaking the identity or nature of the related components. In other words, interactions based on the relation of exteriority may cease to take place at any moment.

> *'Philosophically, this double determination is important: wholes emerge in a bottom-up way, depending causally on their components, but they have a top-down influence on them. The upward causality is necessary to make emergent properties immanent: an assemblage's properties may be irreducible to its parts but that does not make them transcendent, since they would cease to exist if the parts stopped interacting with another. The downward causality is needed to account for the fact that most assemblages are composed of parts that come into existence after the whole has emerged.' (DeLanda, 2016, p.21)*

Overall, 'assemblage focuses on how causality emerges through the nondeterministic enactment of practices of worldmaking' (Anderson et al., 2012, p.181).

To support the concept of emergent properties, DeLanda (2016) brings about a philosophical concept called 'ontological plane'. Since emergent properties are produced by the interactions among assembled components, and they cease to exist once the interactions cease to take place, the emergent properties, the assembled components, and the assemblage are on the same ontological plane. Despite the wording of 'upward' or 'downward' in the above quote, DeLanda (2016) could not emphasise more that emergent properties are not transcendent over the components. Assemblage does not intend to build another hierarchy similar to that related to agency and structure. The components, the relations (of exteriority), the emergent properties,

and the assemblage are ontologically equal. This agrees with what Latour (2005) terms 'flattened topology', which conceptualises the social world as flat as possible.

Being ontologically equal on the same ontological plane means that emergent properties and the components can influence each other mutually. This concurs with the modified conceptualisation of agency and structure as mentioned earlier, which suggests that agency is altering structure while at the same time structure is governing agency.

> *'But in the majority of cases the component parts come into being when a whole has already constituted itself and has begun to use its own emergent capacities to constrain and enable its parts: most people are born into communities that predate their birth, and most new government agencies are born in the context of an already functioning central government. Nevertheless, the ontological requirement of immanence forces us to conceive of the identity of a community or of a central government as being continuously produced by the day-to-day interactions between its parts. So we need to include in a realist ontology not only the processes that produce the identity of a given social whole when it is born, but also the processes that maintain its identity through time. And we must also include the downward causal influence that wholes, once constituted, can exert on their parts.' (DeLanda, 2016, p.18)*

However, it must be kept in mind that this mutual influence happens on the same ontological plane.

> *'Assemblages have a fully contingent historical identity, and each of them is therefore an individual entity: an individual person, an individual community, an individual organisation, an individual city. Because the ontological status of all assemblages is the same, entities operating at different scales can directly interact with one another, individual to individual, a possibility that does not exist in a hierarchical ontology, like that composed of genera, species, and individuals.' (DeLanda, 2016, p.20)*

The (flat) ontological plane is also important for maintaining the heterogeneity of assemblage. Assemblage is heterogeneous in at least two dimensions. The first one is to include not only

human but also non-human components (Briassoulis, 2017). There is an emphasis on materials, in line with persons. The second is the acknowledgement of 'assemblage of assemblages'. 'Assemblages can become component parts of larger assemblages' (DeLanda, 2016, p.20). For instance, a community can be considered as an assemblage, and this community can form alliance with other communities to become a larger assemblage (of communities). The second point must be firmly put in the context of the ontological plane. By stating 'larger' or 'smaller' assemblages, it is not to indicate any kind of hierarchical order. Instead, all assemblages are equal individuals on the same ontological plane. Therefore, 'assemblage exist as part of populations: populations of persons, pluralities of communities, multiplicities of organisations, collectivities of urban centres' (DeLanda, 2016, p.21). The flat ontological plane and the heterogeneity of assemblage are closely intertwined concepts. This is also a strong link between assemblage and Actor-Network Theory, the latter of which is famously vocal about non-human actors. Moreover, as Latour (2005) points out, the most important element in ANT is the hyphen between the word 'actor' and 'network'. An actor is a network, and a network is also an actor (Callon, 1986).

On the same ontological plane, the emergent potential of deploying solar panels has to be constantly and mutually reinforced by the interaction of the many relevant elements. Since institutional property owners' consideration is argued to be the virtual space where such interaction takes place, their consideration of deploying solar panels and the potential of doing so could reinforce each other. In other words, institutional property owners may consider deploying solar panels even when the potential of doing so has not been firmly established. The process of establishing the potential of deploying solar panels may encourage institutional property owners to consider it further. This potential cannot be taken for granted. Instead, it

emerges from the interaction of many relevant elements, and this interaction can virtually take place in institutional property owners' consideration.

Under this theoretical frame, institutional property owners' consideration plays a proactive role in continuous processes. This then adds a temporal dimension to the research question of this study, which also aligns with the processual perspective that has been emphasised by literature (McGuirk et al., 2016). Instead of waiting for the potential of deploying solar panels to appear externally, and only then starting to consider doing so, institutional property owners may constantly consider the relevant elements among which the potential emerges internally and gradually. Moreover, theorising institutional property owners' consideration as the virtual space allows for the observation of assemblages of assemblages. There may be many assemblages plugging into each other as to be observed in this virtual site.

3.6 Assemblage: Territorialisation and Coding

The concept of assemblage is already presenting itself in the process of conceptualising relations of exteriority and emergent properties, as indicated in the writing of the previous sections. What is also appearing is the conceptualisation of the 'social whole'.

> *'Deleuze and Guattari distinguish between different kinds of social wholes: strata and assemblages. … A tightly knit community, with its capacity to police its members and punish violations of local norms, would also be a stratum. But an alliance of several communities, such as those involved in a social justice movement, would be considered an assemblage. So we face the problem of whether to treat the 'social field' as a stratum or as an assemblage.' (DeLanda, 2016, p.18)*

DeLanda (2016) does not suggest demarcating between stratum and assemblage with drawing a clear line. What he suggests is, firstly, to introduce the notion of parameter which can accommodate continuous change, and secondly, to tolerate a broad and ontological sense of assemblage together with a strict sense of assemblage. To begin with, the social wholes,

including both the stratum kind and the assemblage kind, are all considered assemblages. One sense is the strict sense of assemblage that is compared to the instances where the relation of exteriority becomes internalised, and the emergent property becomes prerequisite[27]. The other sense is the broad sense of assemblage as the ontological nature of social whole. By doing so, DeLanda (2016) seems attempting to avoid creating another set of boundaries, orders, and hierarchies that assemblage theory attacks in the first place.

> *'A different problem is that distinguishing between different kinds of wholes involves ontological commitments that go beyond individual entities. In particular, with the exception of conventionally defined types (like the types of pieces in a chess game), natural kinds are equivalent to essences. As we have already suggested, avoiding this danger involves using a single term, 'assemblage', but building into it parameters that can have different settings at different times: for some settings the social whole will be a stratum, for other settings an assemblage (in the original sense).' (DeLanda, 2016, p.18)*

Besides the difference between the strict sense of assemblage and the broad sense of assemblage, the notion of parameters is also used to describe the characteristics and the degree of their variation within the strict sense of assemblage. The two parameters that DeLanda (2016) highlights are (the degree of) territorialisation and coding.

> *'Territorialisation refers not only to the determination of the spatial boundaries of a whole – as in the territory of a community, city, or nation-state – but also to the degree to which an assemblage's component parts are drawn from a homogeneous repertoire, or the degree to which an assemblage homogenises its own components. ... Coding refers to the role played by special expressive components in an assemblage in fixing the identity of a whole.' (DeLanda, 2016, p.22)*

[27] As will be mentioned in the following quote, 'essence' is what DeLanda (2016) uses to describe the alternative (or 'an' alternative?) of the emergent property. While emergent properties emerge from the interactions of many components, essence exists independently by its own. Moreover, essence must be respected by the other non-essential components. Therefore, essence is prerequisite. It exists regardless of whether other things take place or cease to take place.

DeLanda (2016) uses the example of a conversation to illustrate the conceptualisation of assemblage and the parameters of territorialisation and coding. ‘Some of these social encounters, like ordinary conversations, are sufficiently ritualised that they themselves may be treated as assemblages.’ (DeLanda, 2016, p.27) To treat a conversation as an assemblage must accepts its heterogeneity from the beginning, which then involves not only the persons in the dialogue but also the material components. The material components may include ‘the physical bodies assembled in space, close enough to hear each other and correctly oriented towards one another, as well as the expenditure of attention needed to keep the conversation going and the labour involved in repairing breaches of etiquette or recovering from embarrassing events’ (DeLanda, 2016, p.27). Technology may change the material components needed in this assemblage, but technology itself also becomes one of the material components (Wise, 2011).

The principle is that these material components must not be overlooked in the course of understanding assemblage. They are no less important than human components, although they tend to be less visible than the humans, especially in a common manner of understanding reality. Latour (2005) illustrates this very similar point with a very similar example: the interaction between a lecturer and the students in a lecture theatre. In order to make this interaction effective, the physical environment is no less important than the lecturer and the students. For instance, the windows and doors that block the unpleasant wind and disturbing noise from the outside.

Regarding DeLanda’s example of a conversation, territorialisation ‘is performed by social conventions giving a conversation well-defined borders in space and time’ (DeLanda, 2016, p.28). Territorialisation does not necessarily be spatial, but it often has a strong spatial aspect (Wise, 2011). In this case, the spatial boundaries ‘are clearly defined by the physical

requirement of co-presence and by the fact that once the participants ratify each other as legitimate interactors, they can exclude passers-by from intruding into the conversation' (DeLanda, 2016, p.29). Besides the spatial boundaries, conversations also 'have a temporal structure defined by rules like turn-taking, as well as by ritual means of initiating and terminating an encounter' (DeLanda, 2016, p.28-9). Therefore, de-territorialisation may take place spatially, for example, through technology that allows conversation at a distance. This may also take place in aspatial manners by any element that takes the participants' attention away from the subject of the conversation, 'such as embarrassing revelations or humiliating comments' (DeLanda, 2016, p.29).

Coding refers to the expressive components that 'speak' for the identity of the assemblage as a whole. In the example of a conversation, 'the most obvious expressive component of this assemblage may be the flow of words itself' (DeLanda, 2016, p.28). Moreover, there are other components that 'express' without relying on language. 'Every participant in a conversation is expressing his or her persona through facial gesture, posture, dress, choice of subject matter, the deployment of (or failure to deploy) poise and tact, and so on. These components express in a non-linguistic way the image that every participant wants to project to others.' (DeLanda, 2016, p.28)

DeLanda's (2016) two parameters of an assemblage seem highly co-related to each other. It is easier to imagine assemblages that are highly territorialised and coded, than highly territorialised yet de-coded, or highly coded yet de-territorialised. Moreover, the two parameters seem also interdependent. Coding to some degree relies on territorialisation. Coding is about expressing the identity of an assemblage that emerges from and is strengthened by territorialisation. Coding can also reinforce territorialisation. The expressive components with

clear and convincing messages may make other components comply and start expressing the same messages, which process itself could be considered as part of territorialisation. This mutual interdependence is indicated in DeLanda's example of cities and nations.

> *'The cities that became national capitals also played an important expressive role, the best example of which is the style of urban design that became fashionable in Europe after the Thirty Years War. … National capital also played a territorialising role, homogenising and exporting to the provinces a variety of cultural materials, from a standard language and currency, to legal codes and medical and educational standards.' (DeLanda, 2016, pp.36-7)*

This interdependence, however, results in the difficulty in clarifying the difference between the two parameters. As mentioned above, common empirical examples seem both territorialised and coded, or both de-territorialised and de-coded.

> *'Regional capitals like Paris, Vienna, or Madrid attracted migrants from throughout the region they dominated, and over a few centuries they slowly distilled a unique regional culture, giving them a well-defined identity. In this sense, these cities were highly coded. Maritime gateways like Venice, Genoa, Lisbon, or Amsterdam, on the other hand, never acquired a sharp cultural identity since they mixed and matched elements from the variety of alien cultures with which they came into regular contact, making their identity less coded.' (DeLanda, 2016, p.44)*

In these examples, it seems more difficult and less important to articulate how territorialisation differs from coding. If they are (always) both territorialised and coded, or both de-territorialised and de-coded, are they really two parameters, or are they two (of the many) sides of one parameter? Among other authors, territorialisation seems better-received and more often discussed than coding (Alliez & Goffey, 2011; McFarlane, 2011; Wise, 2011; Müller, 2015; Baker & McGuirk, 2017; Briassoulis, 2017; Buchanan, 2017; Bender, 2019; Kinkaid, 2020). Without the extended length of articulation as DeLanda (2016) yet generally concurring with

DeLanda, these other authors take territorialisation to mean stabilisation of elements and connections.

The research question of this study has indicated a certain extent of spatial dimension, as the interest is mainly on the building-applied solar panels deployment, mostly installed on the roof of buildings. Aspatial sense of territorialisation is also possible, such as a conventional or widely-adopted mentality of considering solar panel deployment in which a certain set of elements are configured in certain standardised manner. Aspatial territorialisation may be more difficult to discern than spatial territorialisation. Coding as the expressive components of assemblages may also play the role of 'expressing' certain assemblage and the sense of its territorialisation. For instance, if certain measures are very often used or referred to by institutional property owners while they consider solar panel deployment, these measures may be expressing certain kind of territorialised assemblage. Meanwhile, the high likelihood of keeping using these measures in considering solar panel deployment becomes part of the coding process that maintain and reinforce the territorialisation accordingly.

3.7 Conceptual Representation of Assemblage: Space of Possibilities

A major addition to the development of assemblage theory, as comparing DeLanda's later work (2016) to the earlier work (2006), seems the conceptualisation of a diagram of assemblage. This diagram has not been visualised into any graphic diagram. Sendra (2018) offers an attempt to graphically represent assemblage, which is to map out actors, strategies, and their relationships. Sendra's graphic diagrams are rather snapshots, as 'photographs of what has happened up to the time of writing' (Sendra, 2018, p.740), and each diagram specifically refers to a particular project.[28] However, DeLanda's call (2016) for diagram of assemblage is much

[28] Sendra (2018) compares several empirical projects, and 'up to the time of writing' is repeatedly emphasised throughout the account.

more abstract and dynamic, with ability to stretch over space and time. DeLanda (2016) describes how such a diagram may look like, and it is something similar to an intensity map. An example of the intensity map is a map of the atmosphere showing the different level of pressure, which may be colour-coded from red (high) to green (low). Such a map shows not only the spatial dimension of reality but also the intensity of atmosphere at various spatial points.

A diagram of assemblage may look like an intensity map because of several reasons that align with DeLanda's (2016) theorisation of assemblage. First of all, it must demonstrate the degree of heterogeneity and the multiple dimensions. It may look flat but it cannot be simplified or overlook the many dimensions that assemblage has. Secondly, it shows the dynamics of assemblage, and the possible dynamic changes corresponding to the several parameters. It shows the gradual changes in each parameter, and at certain point there may be threshold change from one status to another, such as from assemblage to stratum. Thirdly, it should be able to depict emergence from interaction, similar to air pressure emerges from how air molecules interact in certain space during certain point in time.

Diagram in this context is a philosophical concept, which again, can be traced back to Deleuze.

> *' … assemblages are characterized by what Deleuze refers to as a diagram … that would structure the space of possibilities associated with the assemblage' (DeLanda, 2006, p.30)*

DeLanda (2002; 2016) also articulates the difference between 'virtual' and 'actual'. The virtual is what is possible, while among the many possibilities, the actual are those possibilities that are realised. Therefore, the space of possibilities has all the virtual.

> *'A possibility space is the diagram of an assemblage that not only outlines what an assemblage is, but also the multitudes of what an assemblage might be. That is, the*

> *assemblage as it is actualised is laid alongside all the other virtual forms that are potentially real given the components available.' (Kurtz et al., 2021, p.303)*

Assemblage then emerges from the dynamics of moving back and forth between virtual and actual. During this emergence, certain elements are assembled and re-assembled, or in DeLanda's terms (2016) territorialised, de-territorialised, and re-territorialised. Once this temporal dimension, or the ontology of being 'processually produced' (McGuirk et al., 2016, p.130) is attended, the association of certain elements and the process of associating are inseparable. The process that leads to certain outcome is as important as the outcome itself. On the level of philosophical discussion, the process and the outcome have equal ontological status, although Buchanan (2017) seems to emphasise the process over the outcome.

> *'We have to stop thinking of the concept of the assemblage as a way of describing a thing or situation and instead see it for what it was always intended to be: a way of analysing a thing or situation. … the assemblage is a virtual entity with actual effects.' (Buchanan, 2017, p.473)*

The concepts of diagram and space of possibilities then argue one step further. Not only is the process as important as its outcome, but the 'virtual' that is not actualised during this process also deserves being ontologically acknowledged. Both the 'virtual' and the 'actual' must be equally considered ontological 'real' (Rao, 2020). This aligns with DeLanda's (2016) articulation of parameters, as territorialisation and coding, whose variance of degrees points to variant status of assemblages. Some assemblages may be more territorialised than some others (Briassoulis, 2017), and the difference is about intensity but not category (DeLanda, 2002). Therefore, if it is possible to imagine assemblage that is extremely de-territorialised, that is then the space of possibilities. In this space of possibilities, nothing is territorialised, and hence all the 'virtual' is equally (un-)actualised.

> *'This means that diagrams have an abstract structure in which the expressive and the material are not differentiated, a differentiation that emerges only when the material are not divergently actualized in concrete assemblages. One way of thinking about the status of diagrams is, therefore, as the product of a full deterritorialization of a concrete assemblage, since it is the opposite process (territorialization or actualization) that differentiates the material from the expressive.' (DeLanda, 2006, p.126)*

Institutional property owners' consideration could be theorised as the virtual site that may represent the space of possibilities. In this virtual space, institutional property owners can draw together the many elements relevant to solar panel deployment on their buildings. The consideration, as defined by this study's research question, is the weighing up of opportunities and issues, incentives and obstacles, as well as benefit and cost. The observation of this virtual space can reveal important information in addition to the statistical fact of the actual deployment. This virtual space is vital to discern the potential assemblages, emergence, and actualisation. In addition, investigating institutional property owners' consideration can also facilitate the virtual travel of tracing processes across space and time.

3.8 Emergent Causality

Emergent causality conceptualises the useful way of understanding causality in the reality of assemblages.

> *'The implication of assemblage thinking is that causality is located not in a pre-given sovereign agent, but in interactive processes of assembly through which causality operates as a non-linear process.' (Anderson et al., 2012, p.180)*

This is a highly relevant concept to social research that intends to 'explain' and answer questions of 'why'. Instead of assuming the simplified model of 'A causes B', and hence focusing on defining 'B' and identifying 'A', emergent causality argues for a highly different framework. First of all, the cause is unlikely to be one particular entity, as implied by 'A'. More

often than not, there are multiple and variant connections and instances that eventually lead to certain consequences (Baker & McGuirk, 2017). Therefore, instead of 'A causes B', emergent causality favours the narrative of 'one thing leads to another'. Secondly, the consequence also may not be one particular entity, as implied by 'B'. 'Consequence' may be defined by certain initiatives, such as social research. However, such 'consequence' may be only a snapshot in the continuous connections and processes of assemblages. One particular snapshot may be led to by many other snapshots, and at the same time may further stimulate many other snapshots. Each snapshot is ontologically equal to another, and hence there is no definite divide between causes and consequences. One can be the consequence in certain connection while becoming the cause in another connection. It is only the particular instance of giving interpretation such as social research that defines some as consequences and some others as causes.

> *'... assemblage thinking refutes the reduction of causality to the binary poles of disorder and randomness on the one hand and cause-and-effect on the other. Instead it is concerned with how specific agential intra-actions articulate assemblages. Rather than attributing causality to humans and non-humans, assemblage focuses on how causality emerges through the nondeterministic enactment of practices of worldmaking.' (Anderson et al., 2012, p.181)*

As Anderson and colleagues (2012) argue, the recognition of emergent causality does not mean the abandoning of pursuing causal explanation. Rather, it warns two potential pitfalls in the research of any causal explanation. Firstly, small things are trivial. In contrast, small things matter. In the narrative of 'one thing leads to another', there are many small instances that are able to alter the direction of change at the connection where these small instances are connected. Overall, these many small altering instances lead to certain reality, so defined as 'consequence'. However, there is no such thing as the 'overall cause' of the overall consequence. Each small instance is uniquely important and cannot be substituted by certain macro-level force.

Therefore, the second pitfall, especially tricky for social scientists (Latour, 2005), is to turn to a small number of 'grand notions' as the 'set menu options' to look for 'the' overall cause. This then often overlooks a much larger number of small instances, which, as argued above, are more capable of explaining and responding to enquires. Since causality emerges from assembling and re-assembling, causal explanation should be based on evidently traced processes. It is through tracing processes that useful evidence may be found to support causal explanation (A. Bennett, 2010; Bennett & Checkel, 2015). As McFarlane (2011) claims, the conceptualisation of causality needs to embrace randomness in emergence rather than fixating to linearity.

> *'This is a conception of causality that seeks to depart with linearity and to make room for novelty and randomness in emergence. Here, randomness may emerge from multiple sources, such as the volatility of initial conditions, unexpected changes in external environments or the chance relations that emerge as differential properties of existing parts are brought into the assemblage.' (McFarlane, 2011, p.384)*

However, it is a challenge to think about how causality could embrace randomness, since these two concepts seem contradictory in nature. If there is a causal link, then it is not random. If it seems random, it is probably due to the unawareness of the causation behind. Again, as also quoted earlier above (Anderson et al., 2012), assemblage strives to find the balance between these seemingly contradictory concepts, and to offer alternative to the binary frame of thinking as either predetermined or random (Wise, 2011).

> *'An assemblage is not a set of predetermined parts (such as the pieces of a plastic model aeroplane) that are then put together in order or into an already-conceived structure (the model aeroplane). Nor is an assemblage a random collection of things, since there is a sense that an assemblage is a whole of some sort that expresses some identity and claims a territory. An assemblage is a becoming that brings elements together.' (Wise, 2011, p.91)*

As Bridge (2021) words this, actions and parts are distributed but not random, and hence the emergent assemblage is co-constituted but not predetermined.

> *'Action is distributed away from human subjects and their reflexivity and into networks of actants or assemblages, in which the driving force is affect in the form of distributed desire (or 'will'). Affect may emanate from human bodies but is more a product of the co-constitutive properties of the emerging assemblage itself.' (Bridge, 2021, p.418)*

J. Bennett (2005) applies assemblage to analysing the American blackout in 2003, which provides an exemplar case in which emergent causality helps explain the consequence. In this account, J. Bennett acknowledges various ‘events’ and adopts the narrative of ‘one leads to another’.

> *'What seems to have happened on August 14 was that several initially unrelated generator withdrawals in Ohio and Michigan caused the electron flow pattern to change over the transmission lines, which led—after a series of events, including a brush fire that burned out a transmission line and several tree-wire encounters—to a successive overloading of other lines and a vortex of “disconnects.” One generating plant after another separated from the grid, placing more and more stress on the remaining participants. Within a one-minute period, “twenty generators (loaded to 2174 MW) tripped off line along Lake Erie.”' (J. Bennett, 2005, p.449)*

Buchanan (2017) offers a similar narrative in which infrastructure in general is used as an example.

> *'Infrastructure good and bad is the product of countless small decisions by many thousands of people over many decades. Those decisions, however well intentioned and well thought through, are not made in a vacuum. Of necessity, they are made in a context defined by a set of constraints to do with cost, existing infrastructure, topography, trade agreements, and countless other factors too numerous to even attempt to tabulate here, that ultimately blurs the line between the intended and the unintended, the fated and the accidental. The result is a curious state of affairs that is neither the product of deliberate, conscious design, nor the*

> *product of a sequence of random, ad hoc experiments, but somehow a combination of the two. It is, in this sense, a highly unstable object that requires a supple ontology to describe it.' (Buchanan, 2017, p.463)*

To account for emergent causality more empirically and specifically, Latour (2005) argues that 'describing' is no less important than 'explaining'. Empirical cases studies (Rydin & Tate, 2016) can demonstrate that it is through truthfully describing the matter at hand that the explanation of the issue may emerge. It is in the process of description that more and more relevant consideration, elements and actors may be discovered. Farías (2011) considers assemblage as 'self-contained processes of heterogeneous associations calling for a positive description of their becoming, not external explanations' (p.369). Bender (2009) auges that in some context, such as historical urban studies, to explain is to describe, for which 'an empirically grounded narrative that includes multiple causal elements becomes an explanation' (p.315). There seems a lack of clarity in terms of what 'description' is meant by each author, as it may mean description of empirical phenomena, description of interpretation, description of process, and so on (Tonkiss, 2011; Kinkaid, 2020). Overall, in this debate scholars are calling for a narrative or description that is able to align with emergent causality and assemblage ontology, similar with DeLanda's (2016) call for a (conceptual) diagram of assemblage as discussed in the previous section. Empirically, Latour (2005) argues that it should be nothing more mysterious than 'a very practical world-building enterprise that consists in connecting entities with other entities' (p.103).

As a critique alongside, Bender (2009) warns about the dilemma of ethics and politics that is implied by the theoretical viewpoint of emergent causality.

> *'What is the relation of causality and responsibility? If the whole actor-network produces the action, whether a war or a new life-saving medical intervention, is there individual*

> *responsibility (or credit) anywhere? According to the core idea of ANT, no one entity in the chain can be a sufficient explanation for any action. The action is the result not of the action of any one individual person or thing, but rather of the dynamic actor-network. Is every action overdetermined? This apparent leveling of responsibility in an actor-network analysis of causation worries me, for it seems to remove ethics and politics from social analysis.' (Bender, 2009, p.305)*

What Bender (2009) recognises is a double-edged sword. On the one hand, if causality only emerges from the assemblage of a large number of heterogeneous elements, any individual objection in the chain of causation can prevent particular actions. This chimes with the inertia of status-quo from which interventions for change struggle to see any substantial outcomes. On the other hand, if every small connection in the chain of causation matters, then there is potentially a large number of intervening points where actions may be taken to facilitate the emergence of certain desirable consequences (Bender, 2009).

While Bender (2009) worries about the potential lack or removal of ethics, Baker and McGuirk (2017) seem to suggest that embracing uncertainty is the very ethics that research needs to have. As it is argued that social science research itself is an active element in the assemblage of what is studied, there may be the danger of settling particular framework or viewpoint by the research outcomes (Latour, 2005; Baker & McGuirk, 2017). On the one hand, ethical analysis would not simply aim at reporting and accepting what it is (Li, 2007; Greenhough, 2012). On the other hand, it is a challenge how analysis could embrace the empirical contingency and uncertainty while at the same time ‘seeking to avoid the imposition of rigid explanatory frameworks’ (Baker & McGuirk, 2017, p.432).

Emergent causality offers the approach to describing assemblage as well as to analysing narratives from which assemblage may be identified, which provides a useful link between assemblage theory and qualitative research methodology. Through verbal discussion and

qualitative analysis, assemblages and the previously discussed theoretical concepts may be recognised, described, and analysed. In this study, institutional property owners' consideration over solar panel deployment on their buildings is theorised as the virtual space of possibilities. Further field work will search for evidence of relevant relations and the extent of their exteriority. The potential of deploying solar panels may be understood as emergent properties, maintained through the constant and dynamic processes of interactions among relevant elements. Possible territorialisation, in both spatial and aspatial sense, could be analysed together with identifying expressive coding components that encourage the stabilisation of certain elements and particular manners of their relations. These theoretical steps will then lead to the articulation of relevant assemblages that can help further understand institutional property owners' consideration on deploying solar panels on their buildings.

In summary, this chapter has shown the first-stage application of DeLanda's (2016) assemblage theory to this study. As initially anticipated, the thorough conceptual construct offered by this theory has given clear guidance in applying the theoretical insights to the empirical issue raised by this research question. Specific aspects of the research question have been related to each concept offered by the theoretical framework, as articulated in each section in this chapter. The conceptual construct carries such solid theoretical logic which then enables philosophical depth in reflecting on the research question. In this way, the theorical framework has been systematically applied to this study so far. This will help further integrate the theoretical concepts with the empirical data, as will be shown in the following chapters.

Chapter IV: Methodology

This research design aims at a qualitative exploratory study whose main data collection is done through semi-structured in-depth interviews with respondents representing the targeted institutional property owners, in accordance with the research question. The local focus of Nottingham in the UK is adopted to manage the scope of empirical field work while in the meantime safeguarding the potential availability of primary data. In addition, relevant information is also sought through other methods such as internet searching and report reading. Process-tracing is taken as the specific method to explore the available data (A. Bennett, 2010; Bennett & Checkel, 2015). Analytic strategies align with the general methodology to balance the multiple relevant subjects in the topic, to trace specific instances and concrete examples in the empirical process, and to explore the rationale and considerations behind the matters of fact. The computer-assisted software NVivo proves useful for applying such analysis in this study.

4.1 Qualitative Research Design

Qualitative methodology is chosen in this study to address the research question of what is considered by institutional property owners regarding deploying solar panels on their buildings. In other words, why and how institutional property owners reach the decision of (not) adopting solar panels on their buildings? As informed by the assemblage theory that is articulated in the previous chapter, the investigation of this question may need to touch upon complex processes and connections that assemble reality into what it is. Some authors (Winchester & Rofe, 2016; Yin, 2018) argue that generally qualitative methodology is suitable for research questions about ‘why’ and ‘how’. This view may exclude the suitability of quantitative methods too easily, but it to some degree supports the decision to use qualitative methodology for this study. Moreover, it is the nature of process and reasoning that determines the adoption of qualitative

methodology. The intention of the investigation is to reveal the many processes in which decisions are made, or the intention of making certain decision is translated through variant components all of which contribute to the decision-making process. Qualitative methodology with the style of telling stories about what has happened is preferred by this study, instead of trying to quantify the process. As also suggested by assemblage theory and Actor-Network Theory, data collection must truthfully follow the traces of empirical processes anchored by concrete instances (J. Bennett, 2005; Latour, 2005). As will be outlined in the later sections, this study uses the design of prompt interview questions to apply the analytic strategy of tracing connections virtually. Compared to physically following actors and events in person (Temenos and McCann, 2012), the semi-structured interviews help this study to re-visit the traces and connections among the actors and occasions through the respondents' story-telling.

The specific empirical research has a local level focus on Nottingham in the UK. The choice of Nottingham will be articulated later, while the concern here is on some general issues of the local level scope of empirical work in the study. As suggested by the theory chapter previously, a concrete case in its specific context is needed to advance the investigation. Processes and substance are empirically embedded in their specific social and material contexts, for which concrete cases are required to provide meaningful evidence for any potential knowledge claims. Moreover, acknowledging the complex processes behind what appears on the surface means that presumption may be already over-generalised before any further investigation starts. What appears the same or similar on the surface may be underlain by distinct processes underneath, which is termed methodologically as 'equifinality' (George & Bennett, 2005).

Regarding this study specifically, institutional property owners' consideration over applying solar panels on their buildings may vary from one specific building to another. The case

specificity as learnt earlier from reviewing literature can support such possibility (Hudson, 2007; Rydin et al., 2013; Bright et al., 2019). If the investigation ignores the possible differences and tries to cover all the buildings located across different places in the UK, it may be overwhelmed by possibly vast amount of data that does not lead to any meaningful conclusions. This study takes a cautious step to use a local focus to limit the scope of empirical search within a manageable range. This may lead to further evidence about whether the coverage of scope can be enlarged regarding the specific issue of solar panel deployment on buildings. For example, if data relevant to the deployment of solar panels in this local area is highly unique and is only possible to be found in this particular local environment, the research design covering all the places and ignoring their differences may be highly problematic. In contrast, if relevant data predominantly points to wider factors beyond the local, such as national policies, international influences, or sustainability discourse in general, widening the scope to cover larger geographical area in the UK may be viable. At this stage, this study decides to take the cautious step of focusing on one local area.

4.2 Nottingham, UK

The focus of Nottingham is chosen in this study because preliminary finding suggests that it could be a ‘best-practice case’ that may provide adequate available data that is still missing in other places (Yin, 2018). Nottingham has been a frontrunner in the practice of pursuing urban sustainability (Gooding et al., 2013). Nottingham is the earliest to implement district heating system which is still running today. It has a reputable tram system which contributes to low-carbon transportation. Recently, Nottingham has been recognised to also lead the way in terms

of deploying solar panels specifically. The media positively reported the examples of Nottingham local areas where a vast number of solar panels have been deployed on houses.[29]

> *'Recently released Department of Energy and Climate Change figures show that per number of households, Nottingham has the most solar rooftops.'*[30]

This achievement is also confirmed by the local authority's policy papers.

> *'As of March 2019, over 6,200 solar PV installations had been deployed across the city, covering 4.5% of domestic properties, with an installed capacity of 21MW. Moving forward, Nottingham will continue to increase its local renewable generation, with a particular focus on solar Photo Voltaic (PV) combined with energy storage.'*[31]

Literature also has recognised Nottingham to have achieved a high rate of rooftop solar panel deployment (Gooding et al., 2013).

Moreover, the Nottingham local authority has confidently declared 'an ambition to become the first carbon neutral city in the UK by 2028'[32]. This is intended to be a city-wide ambition which needs support across the city.

> *'We've had sign up already from both universities to help meet the wider target, and a number of key businesses are really gathering around this movement. … As this is a city-wide target and not just for the council, it is really important to get the net-zero mindset across the entire city.' (Wayne Bexton, Head of Energy Services, Nottingham City Council)*[33]

[29] News article accessible in September 2021 at: http://nottingham.remourban.eu/news/nottingham-is-tops-for-solar-rooftops.kl
[30] News article accessible in September 2021 at: http://nottingham.remourban.eu/news/nottingham-is-tops-for-solar-rooftops.kl
[31] *Carbon Neutral Nottingham: 2020-2028 Draft Plan* (p.31), accessible in September 2021 at: https://data.climateemergency.uk/media/data/plans/nottingham-city-council-54c9ac2.pdf
[32] *Carbon Neutral Nottingham: 2020-2028 Draft Plan* (p.2), accessible in September 2021 at: https://data.climateemergency.uk/media/data/plans/nottingham-city-council-54c9ac2.pdf
[33] News article published in December 2019, accessible in September 2021 at: https://www.edie.net/library/Net-zero-cities--Nottingham-s-mission-to-be-carbon-neutral-by-2028/6953

Specifically regarding solar panel deployment, the city council's plan reiterates this city-wide coverage, although more concrete details seem still too early to say.

> *'Engage and collaborate with the private sector to improve the energy efficiency of privately owned buildings' (p.28) … 'Solar PV programme on City Council owned estate and on properties across the city ' (p.31)*[34]

Therefore, regarding the purpose of managing the empirical work with a local focus, Nottingham appears to be the most likely to provide positive data for this study to reflect on. For example, there is a good chance of encountering concrete examples in which solar panels have been recently deployed by institutional property owners. Although the research question is about what processes are going on concerning institutional property owners' deployment of solar panels on buildings, no evidence guarantees that there is any process that is indeed going on. Therefore, there is the likelihood that further investigation would not find significant amount of positive data in certain institutions. In those situations, perhaps solar panels simply have not been considered to such a degree to support the investigation intended by this study. The choice of a 'best-practice case' would be able to reduce (but not eliminate) such likelihood of lacking adequate positive data. Nottingham becomes a geographical focus from which locally focused investigation helps increase the chance of seeking substantial examples and concrete details in data collection.

4.3 Semi-structured Interviews

Semi-structured interviews will be the method to seek and collect empirical data. The investigation aims at conversation and discussion with respondents who can inform about what is considered and what process exists in their institutions. The method of interview is suitable

[34] *Carbon Neutral Nottingham: 2020-2028 Draft Plan*, accessible in September 2021 at: https://data.climateemergency.uk/media/data/plans/nottingham-city-council-54c9ac2.pdf

in this study to ‘explore’ (instead of simply collecting) data that has not been presented or formalised into other channels, such as reports and statistics (Sim et al., 2018). For example, one institutional property owner may publish the figure specifying how many solar panels have been installed, and the report may also identify the buildings where they are installed. The research interview would then investigate what had happened that led to those installation, what would be considered for any other installation, who would be involved and what resources would be needed. Answers to these further questions are seldom found in the desk-top research about the targeted institutions.

Semi-structured interviews provide flexibility that allows the respondents to articulate the issue. Through dialogues in the interviews, respondents are encouraged to articulate what they consider important for the questions being asked. They can also discuss the relevance of certain questions to the general topic of the discussion. As will be unfolded further in the next section, the design of the interview guide contains several themes, primary questions, and secondary prompts that will be used to organise and encourage the flow of the discussion (Dunn, 2016). However, the respondents will not be tied rigidly to such design, and it is their questioning of the pre-designed questions that may reveal critical misassumptions taken by the research. For example, the flow of the respondents’ storytelling may override the pre-determined order of the primary questions by the researchers.

This study also keeps aware of the critical links and balance between the unit of data collection and the unit of analysis (Yin, 2018). The unit of data collection will mostly be individual persons speaking for their institutions. The institutions are the units of analysis. The main interest is in the consideration by the institutional property owners at the institutional level, rather than the personal view by the individual respondents regardless of which institutions

they represent. These two levels of considerations and views may be difficult to be completely separated, and in many cases mutual influences are reasonably expected. For example, since the staff of a sustainability team are hired to lead the sustainable practice of certain institutional property owner, the personal views of these staff would be expected to influence what is considered at the institutional level. The interviews will emphasise the importance of the unit of analysis, and the unit of data collection is to serve for this emphasis. Because the unit of analysis is institutional property owners, the main goal of data collection is to identify the suitable respondents to inform the processes in their institutions. The suitability of interview respondents is enhanced by desk-top research and email correspondence with targeted institutions before the interviews. The success of such identification would mean that each institution can be adequately represented by one respondent. Most of the respondents (13/16) have been able to adequately substantiate their discussion with concrete examples and details. Interviewing multiple persons from the same institution could also be helpful, but it is not considered compulsory. When multiple respondents are available for interviews regarding one same institution, the purpose of interviewing these multiple respondents is mainly to help trace processes and clarify instances, but not to counter opinions of different individual respondents. Three of the 13 institutions were informed by two respondents each.

Nottingham is claimed as a ‘case’ during the interviews so as to encourage respondents to discuss any potential local level concerns particular attached to this area. For example, instead of simply learning about the considerations by each institutional property owner, the links (if any) between their considerations and the context of Nottingham will also be investigated. As these links may not exist or may not be obvious to either the respondents themselves or to the researchers, it could be ‘leading questions’ to ask about the links directly. The questions will

stay closely faithful to the narrative and clues provided by the respondents.[35] It is in these narratives and clues that unknown links may appear and become explicit subject of the discussion. This scenario supports the suitability of semi-structured interviews for this exploratory qualitative methodology.

Potential respondents for interviews were identified through desk-top research. The first round of desk-top research was to identify the institutional property owners that held properties in Nottingham. A few institutions were obvious targets, such as the local council and the two universities. Literature reading[36] and learning about the history of Nottingham suggested some more targets, such as Boots and Intu Shopping Centres[37]. UK HM Land Registry provides service to identify the owners of properties. However, this service is not free of charge, and the database is not publicly accessible.[38] Dixon (2009) used some alternative sources of data to address the lack of direct comprehensive data of property ownership, for example, Investment Property Forum (IPF), companies' reports, and so on. This study followed Dixon's (2009) approach to identify more targets in addition to the few mentioned above.

[35] This point also concerns the analytic strategy which will be articulated further in section 4.8.
[36] For example, Prof. David Adams had studied regeneration of a city centre site in Nottingham, which extensively discussed the issue of property ownership. This research resulted in several articles in which Adams was the leading author.
[37] Unfortunately, Intu went into Administration later due to the impact of Covid-19 restriction in the UK. The initial conversation with potential Intu respondents simply no longer received any reply since certain point.
[38] According to a recent government report (2021), even the UK government and local authorities still lack easy access to good-quality and up-to-date data about properties and their landlords. "It is currently a highly resource intensive task to identify properties which are potentially non-compliant, including confirming the landlord details to enable enforcement action to be taken against them. The 'identification of properties which are potentially non-compliant' means understanding which properties have an EPC below an E, or which properties do not have an EPC but should. Local authorities require access to good quality and up-to-date data, which is currently either not easy to access, or often not available. Local authorities also require the in-house ability to analyse and cross match datasets. Local authorities have found it difficult to free up the required time and resource to begin this process." (p.14 in *The Non-Domestic Private Rented Sector Minimum Energy Efficiency Standards* published by Department for Business, Energy and Industrial Strategy, accessible in September 2021 at:
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/970192/non-domestic-prs-mees-epc-b-future-trajectory-implementation.pdf)

Two lists of institutions were used to identify more targets, including the 'real estate companies' listed in London Stock Exchange[39], and registered social housing providers listed by the UK government[40]. Each institution on these two lists was checked online to verify whether they own properties in Nottingham. Information about their property portfolio was often mentioned on their institutions' website or annual reports. Moreover, Henley Business School at the University of Reading granted access to CoStar UK database, which generated a list of property owners whose properties were located in Nottingham. The CoStar list was also checked one item by another to verify the suitability of each institution.

At the end, this process resulted in a list of over one hundred target institutions. This list covered a range of different types of institutions, which aligns with this study's broad definition of institutional property owner. The listed institutional property owners possess various types of buildings in various locations, which is in accordance with the research question that does not intend to focus on any particular property sector or type of buildings. Therefore, using Nottingham as a local focus is able to serve the sampling coverage in accordance with the research question. Meanwhile, it also helps the empirical search to identify those institutional property owners that are likely to have substantially considered deploying solar panels on their buildings and possibly also have concrete instances where this is already done. Additionally, the snow-balling technique was also used in each interview to ask respondents to recommend further interviews. This technique helped in recruiting a few respondents, but overall it did not turn out fruitful in this study. As also mentioned earlier, snow-balling was mainly intended to

[39] Accessible in September 2021 at: https://uk.investing.com/indices/ftse-supersector-real-estat-components
[40] Accessible in September 2021 at: https://www.gov.uk/government/publications/current-registered-providers-of-social-housing

help trace connections and reveal processes, but not seeking to counter opinions of several individual respondents.

In the second round, each institution on the targeted list was studied on the desk-top basis. This round further investigated other possibly relevant information, such as their sustainability strategy, their projects on renewable energy, their projects on increasing energy performance of their buildings, and so on. This desk-top research also intended to identify contact information of some specific individual persons that could be a favourable respondent, such as the portfolio manager. However, many institutions did not reveal contact information of specific staff. In addition, the website of LinkedIn was used to facilitate this identification process. In the end, the identifiable individuals were contacted directly about the research enquiry. Otherwise, the enquiry was sent to the general contact channel of the institutions to seek further response. Institutions and individuals giving no response in two weeks were contacted again, and this was repeated at least twice and up to four times.[41]

4.4 Design of Interview Protocol

The interview protocol is structured by several primary questions, and the protocol will semi-structure the actual interviews. [42] The first primary question concerns the 'case' of Nottingham. It asks the respondents to reflect on what they know about Nottingham that may be interesting regarding the specific topic of solar panel deployment. The second primary question then asks the respondents to focus on the property and portfolio by their own institutions. This will touch upon the respondents' specific roles, their institutions' concern on building energy performance, and what they know about their institutions' properties and those in Nottingham. The third

[41] Due to the Covid-19 situation in the UK, during which the empirical work of this research was conducted, many potential measures to encourage response and increase response rate were strictly limited or prohibited.
[42] See Appendix A

primary question asks respondents to focus on solar panels and give examples of projects in which solar panels are installed on their institutions' properties. The specific examples, whether they are located in Nottingham or not, will be used to investigate the specific processes in which solar panels are considered by the respondents' institutions. There are multiple prompt questions under each primary question.[43] These prompts are used to explore and specify possibly useful connections, for example, how do you think about it, why do you believe so, where do you learn about it, where did it happen, and through what channels the various parts are drawn together?

The order of the primary questions was initially designed as from introducing the respondents' roles and their institutions, to possible examples of installing solar panels on buildings, and finally to the thoughts about Nottingham. This initial order went from the general consideration to specific instances. However, placing the primary question about Nottingham at the end turned out risky in terms of time management. The respondents might have little to say about Nottingham. Nottingham was only one of but not the exclusive reasons why the respondents were targeted. In addition, as discussed before, it was not certain that institutional property owners would have unique local considerations concerning each city where their properties were located. This was the risk that this study tried to avoid by choosing Nottingham as a best-practice case at the first place, but the risk itself could not be completely eliminated. In this 'unwanted' scenario, it would do little avail to try to budget about 20 minutes for the question about Nottingham by rushing through the previous primary questions about which the respondents may have more interesting stories to tell. Moreover, it turned out that it was the respondents that brought about Nottingham at the beginning of the interview while they were

[43] The design of the prompts also concerns the analytic strategy, which will be outlined in a later section.

given the opportunity to ask questions about this study. They were curious about the reasons why Nottingham was chosen and claimed as the case in this study. Therefore, the conversation might naturally flow into discussing Nottingham at that beginning point instead of waiting to the last part.

The whole interview protocol was attached to the research ethics application that was put through the ethics reviewing process at the University of Reading. This reviewing approved the application which concerned not only the design of the questions, but also the design of the data collection process, the interview manners, and the issues such as data protection, confidentiality, and research consent (Dowling, 2016). The approval also approved specific documents, such as the consent form, the research information sheet, and the data protection information sheet, which were used in the data collection process.[44] Moreover, a pilot interview with this protocol was conducted with the Head of Estates (Ms. J. Pich) and Energy and Sustainability Manager (Mr. D. Fernbank) at the University of Reading. The pilot interview supported the initial order of the primary questions as the respondents discussed several points about the specific local contexts of Reading and Wokingham, which would be equivalent to the Nottingham context in this case study.

The first-hand data comes from 15 semi-structured in-depth interviews on video calls or phone calls depending on the respondents' preference (Covid-19 restriction) during March 2020 to April 2021. These interviews have involved 16 respondents representing 13 out of 108 institutional property owners that have been contacted (6 declined to participate, and 89 gave no response). Most interviews were one-to-one between the researcher and the respondent, except one interview that simultaneously involved two respondents from the same institution.

[44] See Appendix B; Appendix C

Each institution was discussed by one respondent, except three institutions that were discussed by two individual respondents. Most respondents' job roles could be classified as 'portfolio managers' (8) and 'in-house energy managers' (3) as designed in the interview protocol[45]. Specific examples of job titles include portfolio manager, director of estates, and asset manager. Some respondents (4) were from their institutions' 'sustainability team' whose responsibility or purpose would concern both portfolio management and energy management. Specific examples of job titles include head of sustainability, head of ESG (Environmental, Social, and Governance), and carbon reduction manager. One respondent could be classified as an 'external energy manager' as designed in the interview protocol, and unfortunately zero respondent classified as 'policy makers' came in touch. Due to the respondents' concern on confidentiality, this thesis does not automatically specify the respondents' job roles upon each quotation of data.

Related to this study's broad definition of institutional property owners, detailed sub-categories of institutions are irrelevant to the analysis of the first-hand data in this study. The institutional property owners are noted as 'public institution', 'private company' or 'institutional investor' when the respondents are quoted in this thesis. Same as also introduced in the introduction chapter, institutional investors typically conduct real estate investment as their core business which then takes rent as main income and may have routine concern on purchasing and disposing properties. Private companies possess real estate mainly to facilitate their core business which has little to do with real estate, for example, retail companies. Private companies here also include private real estate investment companies which conduct similar

[45] See Appendix A

business to, yet are usually in much smaller scale than institutional investors.[46] Among the 13 institutions represented by the respondents who participated in this study's interviews, 3 are noted as public institution, 2 as private companies, and 8 as institutional investors. Among the 108 institutions targeted by this study's field work, 8 are recognised as public institutions, 21 as private companies, and 79 as institutional investors. As shown from desk-top research, most of the participating as well as targeted institutions hold properties that are located across many places in the UK, for which their consideration on solar panel deployment on their buildings may apply to many buildings and places. This study's local focus on Nottingham could potentially have wider implication to the whole of the UK.

As mentioned earlier, measures to increase response rate were limited by the Covid-19 situation in the UK, which might have led to the potential bias of only getting response from 'good-practice' institutions. These institutions might be more likely to discuss the topic of solar panel deployment because they had already done some relevant projects, as expected in scenario 1 in the interview protocol. 14 out of the 15 interviews belong to this scenario 1. Meanwhile, the institutions fitting into scenario 3 might not be interested in responding to this study's interview requests. However, because discussing concrete instances where building-applied solar panels have been deployed is highly appreciated by the research design of this study, such potential bias is tolerable in this study. The design of scenario 3 in the interview protocol is to prepare for the situation where exploring and identifying positively relevant empirical data would be highly difficult. The lack of encountering scenario 3 does not undermine the design of the interview protocol or the design of method of this study. Moreover, one institution participating in the interview did not deploy any solar panels on their buildings despite conducting some

[46] Among the respondents who participated in the interviews for this study, there was only one that represented a private real estate investment company.

other projects to improve the buildings' energy performance, as expected in scenario 2 in the interview protocol. There was also another respondent generally holding hesitant opinion of directly involving their institution in any project of solar panel deployment on their buildings. In the overall data analysis, the data from these two interviews was able to counterbalance any possible 'good-practice' bias as mentioned above.

The interviews were about 60 minutes long, and they were all transcribed into text and coded with NVivo[47]. The transcription was initially done completely verbatim. However, the verbatim transcript was considered unnecessary during the reviewing of the transcription and initial coding process. Therefore, the transcripts were re-processed with correcting grammar errors and omitting some spoken phrases such as 'you know' where they significantly disturb reading. All the quotations from these transcripts were presented to their respondents accordingly, and the respondents confirmed their consent to using these quotations in this thesis.

The extent of the interviews being a 'representative sample' of the population is taken cautiously, in terms of either the respondents as individual persons or the institutions they work for (Stratford & Bradshaw, 2016). They are more like a few useful 'windows' to look into the processes that are still unknown to the researchers. Regarding the adequacy of data, Guest and colleagues (2006) reflect on 60 interviews in their research project and suggest that 6 interviews have been able to provide most of the data, and 12 interviews can reach an extent of data saturation. In other words, instead of conducting all the 60 interviews, conducting 6 to 12 would have been almost equally adequate (Guest et al., 2006). Their approach was to observe and document the analytic codes that were informed or used in their transcripts. They observed how many new codes were added along with the process of adding transcripts in such observation,

[47] More about the strategies of analysis and the usage of NVivo in coding are included in the methodology chapter.

and until how many transcripts all the codes informed by the total 60 transcripts were already seen. As implied in their article (Guest et al., 2006), the order of adding transcripts was largely in accordance with the order in which the interviews had been conducted. They concluded that once the number of transcripts reached 6 or more, the codes in this smaller group of transcripts were already as adequate as the whole of the 60 transcripts. This meant that after the first 6 interviews, further increasing the number of interviews had little impact on the number of codes that could be informed by the whole data collection work.

The above approach of examining data saturation was also applied by Hennink and colleagues in their study (2017), which concluded that nine out of 25 transcripts could already achieve data saturation. Moreover, Hennink and colleagues (2017) also tested the possible effect from the actual order in which the interview had been conducted. In addition to adding transcripts in the order of the actual interviews, Hennink and colleagues (2017) also randomised the order of the transcripts and applied the same examination in the randomised order. They found that the order of the transcripts, whether it was in accordance with the actual order of the interviews or randomised order, did not affect their conclusion of the point where data saturation was achieved (i.e. 9 transcripts).

The above examination approach can also be utilised during the process of data collection and analysis to signpost data saturation. For example, Guest and colleagues (2006) could have also used their approach to decide in advance that 6 to 12 interviews were adequate, before more interviews or all of their 60 interviews were done. As suggested by Francis and colleagues (2010), this could be done by integrating data analysis along with the process of data collection. They suggest two concepts in relation to this approach, which are initial analysis sample and stopping criterion. Initial analysis sample is the minimum number of interviews that are needed

to initiate data analysis. Stopping criterion is the number of additional interviews that are needed to apply the examination of data saturation. For example, initial analysis sample as 10 and stopping criterion as 3 mean that the study team would conduct at least 13 interviews. After that, the team would compare the latest 3 interviews with the first 10 interviews to test whether data saturation is achieved. If not, the team would conduct another 3 interviews, and conduct similar comparation between the latest 3 interviews and the first 13 interviews. Interviewing would continue along with the testing of data saturation after every additional stopping criterion, until data saturation is achieved. In this way, researchers could continuously examine the extent of data saturation and realise the point of data saturation in an efficient way (Francis et al., 2010).

Towards the end of the field work in this study, a sense of data saturation had started to appear. There was not any significant amount of new information raised or new issues discussed in the later interviews as compared to the previous interviews. An overall examination of the interview transcripts was conducted following the approach suggested by the above literature (Guest et al., 2006; Francis et al., 2010; Hennink et al., 2017). The first 13 interview transcripts from this study were compared to the other 2 transcripts, regarding the data-driven codes[48] that emerged. Following the approach by Hennink and colleagues (2017), the order of the transcripts in this study was also randomised to re-apply the above comparison. The comparison in either order did not find any significant difference among codes from the two

[48] More details about coding data will be presented in the later section about analytic strategy. Because data-driven codes are grounded in empirical data, they are the most relevant to the examination of data saturation. Theory-driven codes could also be relevant to such examination if these codes are new concepts that are to be developed from the empirical data, as in the approach of grounded theory. In comparison, theory-driven codes derived from existing theory are relatively less dependent on specific empirical data. Therefore, these codes are not the main concern of data saturation in specific empirical study. As suggested by Hennink and colleagues (2017), given the suitability of interviews, the very first interview transcript could already allow the researchers to apply all the theory-driven codes in their study.

sub-groups of the transcripts, i.e. between the first 13 transcripts and the additional 2 transcripts. Had this examination adjusted the size of the sub-groups of transcripts, for instance comparing 10 transcripts to an additional 1 or 2 transcripts from the rest, the threshold of data saturation in this study might be specified more accurately. However, specifying such threshold is not the main concern at this stage in this study. The essential purpose of such examination is to confirm that the 15 interviews from this study have been able to provide data saturation in terms of its research question and analysis. Therefore, empirical data collection of this study is considered adequate, although it has undergone some negative impact from the Covid-19 situation in the UK.

4.5 Ethics

Data collection and research interviews were conducted in compliance with the principles approved by the University of Reading Ethics Committee, for example, confidentiality, privacy, respectful interaction, and freedom of participation and withdrawal. Ethical issues were clearly outlined in the approved consent form[49] and information sheets[50] that were sent to the respondents before they agreed to participate in the research. Key points such as audio-recording the interview were highlighted in the email to which the consent form and information sheets were attached. The respondents were asked to give digital signature (Covid-19 restriction, working from home) to the consent form and return the signed form before the interview. The returned forms were then timely forwarded to the UoR Ethics Committee. At the beginning and end of each interview, the respondents were encouraged again to raise any questions and clarification about the ethical issues. The respondents were also informed at the end of the interview that they would be contacted again about how the data would be used, for

[49] See Appendix C
[50] See Appendix B

example, confirming quotations that would be included in the writing of the thesis. All the quotations used in this thesis have been confirmed by the respondents accordingly.

4.6 Analytic Strategy

This section outlines the analytic strategy, since analysis already to some degree takes place during the research design and data collection process. The analytic strategy would have already influenced the design of the interview protocol. For example, the analytic strategy influences what kind of follow-up prompts would be asked in addition to primary interview questions. In qualitative and exploratory interviews, data is (co-)generated through the discussion between the respondents and the researchers. Even if the researchers restrain themselves from imposing too much influence or leading 'wanted' response, a certain degree of influence is inevitable.

There are three principles in the analytic strategy of this study. Firstly, there are a few anchors of focus in this study that need to be well-balanced. These include institutional property ownership, Nottingham as the local focus, and solar panel deployment on buildings. This study intends to focus on the intersections of these components. However, discussion about each component individually is also treated patiently and strategically until any possible intersection is found. Consequently, knowledge advance in each of these components individually would also be conceived of as finding and contribution of this study.

Secondly, the empirical processes are traced through concrete and specific instances (Latour, 2005; Bennett & Checkel, 2015). The analysis does not want to impose any a priori 'frame' of understanding or 'structure' of causality. As discussed in the previous chapter, an important theoretical proposition of this study is causality being emergent instead of pre-defined. This analytic principle is to stay specific, detailed, and focused, for example, asking respondents for

specific examples and description of concrete occasions. Meanwhile, this is not to forget the first principle and not to over-discuss details of one single component that may seem rather irrelevant to the intersection of the multiple components. Virtually tracing connections through respondents' verbal account is an alternative to physically following actors across places and time. Examples of such connection-tracing questions include: how did you know, who brought it up, in what occasion did it take place, do you remember when was it, and so on. Moreover, as will be explained soon, a technique of tagging connections is applied to ensure that tracing connections underlies data analysis in this study. Following actors physically would have been a more rigorous method to apply assemblage theory in empirical research field work, but as acknowledged by Temenos and McCann (2012), such method is oftentimes unfeasible. It was unfeasible for this study's field work that took place during the Covid-19 situation in the UK.

Thirdly, the subject of discussion (and analysis) is more about the matters of concern than the matters of fact (Latour, 2004). For example, it matters more to this study to hear the respondents outlining what is considered and what process takes place in terms of installing or not installing solar panels, rather than, for instance, how many panels are installed or how many should it be. After all, many institutional property owners publish the factual information in their annual reports. Moreover, most respondents claim to be not an expert in solar technology. What they know about is how this technology is involved in the processes, and what else is also involved together. The targeted data is about what the respondents 'think about' solar technology rather than what the technology accurately is. It is about what has happened and what is likely to happen, rather than what should happen. Therefore, again, this principle is kept in mind in conjunction with the other two principles. Additionally, while addressing the matters of concern, it is also the ethical concern to not indicate any moral judgement to the respondents' views and their institutions' work so far (Sim et al., 2018).

The analysis is facilitated by computer-assisted software NVivo. In NVivo, small segments of the interview transcripts are tagged with various labels in the first stage of the analysis. This work of tagging labels can also be done without NVivo. However, the strength of NVivo is that it allows for further analytic actions concerning those tagged segments. For example, segments tagged with the same label yet in different transcript documents can be quickly fetched and composed into one piece of text for a convenient read. In this composed text, the source transcript of each segment is clearly informed, so that it is also convenient to relate to the specific context of each interview. In this way, NVivo transforms the many long documents of interview transcripts into clearly labelled pieces of information, and it allows for further analytic actions to these pieces of information.

In this study, the first stage of the analysis tagged segments of the transcripts as connections of two entities. For example, ‘landlord and tenant’, ‘building and solar panel’, ‘property manager and solar panels’, ‘portfolio manager and investors’, and so on. One segment may concern connections among more than two entities, but it is impossible to break down this segment into smaller segments. In this case, this segment can be tagged with more than one labels. This stage of analysis aligned with the analytic strategy of tracing connections as well as the advantage of NVivo. Firstly, this stage concentrated on identifying concrete connections among specific entities, instead of already a priori imposing theoretical or thematic concepts onto what respondents said in their own words. This stage of analysis stayed close to the empirical data itself. Secondly, this stage allowed for a significant size difference between each tagged small segment and the long transcript document it belonged to. This size difference was the basis of further analytic actions which would not be possible if the long documents of transcripts were only changed into similarly long documents of certain theme-related content.

The further stage of the analysis then composed theme-related or concept-related content based on the segments of information that was tagged in the first stage. NVivo assisted this work effectively. Several tags could be assigned under another newly created tag. For example, several segments of information could be further tagged under a theme. Similarly, it is also possible to construct the many tags into certain structure relating those tags with certain theoretical or conceptual logic. All the content related to those tags could always be conveniently reviewed during these further analytic processes. For instance, after certain structure of tags was created, all the content drawn together under this structure could be quickly composed into a piece of text for analytic reading. As mentioned above, NVivo's assistance of transforming long transcript documents into small segments of information became the useful basis of many further and experimenting analytic actions. Moreover, any of this analytic action was firmly based on the concrete traces of connections found in the empirical data.

While listening to the respondents about how solar panel deployment is considered in the empirical processes, a few themes or main points of concern are frequently mentioned. These include the regulation, the potential payback, the difference between new and existing buildings, and the economy of scale. Another theme exhibited through the analysis of the empirical data is the contingency of involving solar panels in the process of respondents' daily practice. The reflection on these themes facilitated the creation of data-driven codes. The analysis of the data-driven codes was then related to the theory-driven codes generated through the learning of assemblage theory as presented in the previous chapter. As suggested by DeCuir-Gundy and colleagues (2011), data-driven codes are developed directly from raw data, which is a process of assigning thematical labels to the raw text such as phrases, sentences and

paragraphs. In comparison, theory-driven codes are developed from theoretical concepts, so they are largely independent from specific raw data (DeCuir-Gunby et al., 2011).

The codebook[51] consisting of both data-driven and theory-driven codes assisted this study to conduct analysis that closely connected its primary data and the theory learning. The analysis is conducted under both the data-drive themes and the theory-driven concepts. Overall, the analysis is structured in accordance with the conceptual construct articulated by assemblage theory, for which the sections in the following Finding and Analysis chapter corresponds with the sections in the previous Theory chapter. The analysis related to data-driven themes is organised under the overall analysis structure related to the theory. The data-driven themes are to some degree signposted through the section titles in the Finding and Analysis chapter, but these themes are not individually highlighted in order to ensure the clarity of the overall analysis structure concerning the theory. In this way, the analysis strategy is able to weave the theory and the data together.

While applying the analytic strategies to the analysis process, the interview transcripts were processed through several analytical steps in this study, including tagging connections, coding data segments with data-driven codes, and coding themes with theory-driven codes. There steps were conducted reflexively. For example, the coding process might recognise the importance of certain entity under a particular code (either data-driven or theory driven). All the other entities related to this entity could be traced again through the connection-tracing tags. In this

[51] See Appendix D for the codebook of this study. The codebook includes both the data-driven thematical codes and the theory-driven conceptual codes. As outlined earlier, the first stage of analysis as tagging segments of connections is also part of the coding process, and the operation of this first stage in terms of using NVivo is essentially the same as the further stages. However, since those segments tags are largely still as raw as the primary data itself, they are not listed in the codebook.

way the potential importance of those other entities and relations could be further reflected, and the thoroughness of coding and the depth of analysis would be further enhanced.

Chapter V Finding and Analysis

The finding and the analysis of data are presented in accordance with the conceptual construct offered by the theoretical framework of assemblage theory (DeLanda, 2016). This chapter mainly involves the primary data that is collected first-hand from the empirical field work of this study. Some additional data from second-hand sources is included where it is relevant, and the sources are noted upon those points. To begin with, the relational perspectives of property ownership help acknowledge the various elements and actors that are relevant to institutional property owners' consideration of deploying solar panels on their buildings. The primary data shows a high degree of contingency in the relations and interactions among the various relevant elements and actors. Such contingency is recognised as a demonstration of the degree of exteriority of the relations. Previously theorised as the emergent properties of assemblages, the potential of deploying building-applied solar panels by institutional property owners can be further specified by this study's primary data as the emergent sustainability drivers.

The data shows little evidence of any spatial territorialisation of assemblage towards the local focus of Nottingham in the UK. In comparison, the analysis of the data argues for aspatial territorialisation towards cost-effectiveness of relevant projects that involve solar panel deployment on institutionally owned buildings. Payback period and the scale of such projects are found as the main coding components for the aspatial territorialisation of assemblage towards cost-effectiveness. Therefore, the previously defined assemblage of institutional property owners' deployment of solar panels on their buildings is often embedded in the assemblages of cost-effective projects. In other words, the assemblage of cost-effective project could demonstrate the concept of the assemblage of assemblages.

Institutional property owners' consideration is important virtual space of possibilities where the assemblage of solar panel deployment as well as other relevant assemblages of assemblages are virtually assembled. The example of Nottingham City Council's EnergieSprong Programme shows potential to substantiate the emergence of the assemblage of assemblages as well as spatial territorialisation in the local area of Nottingham. However, further empirical research will be needed to support such substantiation. Overall, theorising institutional property owners' consideration on deploying solar panels on their buildings as the virtual space of possibilities helps applying assemblage theory and the conceptual construct to data analysis. Such theorisation also helps apply the methodology of process-tracing in a virtual manner to explore the qualitative data of this study, which then demonstrates emergent causality throughout the relevant processes (J. Bennett, 2005; Bender, 2009; Buchanan, 2017).

5.1 Relational Perspectives of Property Ownership

Property ownership is a complex legal issue (Gardner & MacKenzie, 2015), for which identifying the 'real' or 'singular' property owner is impossible or irrelevant in many situations. The deployment of solar panels on buildings has been concerned by the complexity of property ownership. Moreover, this study of solar panel deployment offers further articulation of this complexity, which goes further beyond the legal sense. This section will unfold this complexity in several perspectives. Firstly, the rather widely acknowledged perspective concerns ownership and occupation. The second perspective concerns ownership and management. Thirdly, there is a perspective concerning owning the buildings' day-to-day operation. The final part will argue for an implicit yet important perspective concerning owning the building in the materialism and assemblage sense. The data will show that all the 'owners' in all these perspectives are all vitally important for the deployment of solar panels.

The occupiers are not necessarily the owners of the buildings, which is reasonably common among institutionally owned properties. As literature (Adams et al., 2001; Dixon, 2009) shows that a large number of buildings are owned by a relatively small number of institutions in the UK, many of these buildings would be occupied by the tenants instead of the owners. In the many cases where the owners and the occupiers are different parties, it is the owners that are commonly expected to make decisions and take actions in terms of installing solar panels. This aligns with the initial presumption held by this study. In the UK context, it is common practice that the property owners commission the installation of solar panels and then possess the panels system as part of the property.

> *'In the UK I think it's more landlord investments. So it's more direct ownership of the solar panels.' (Respondent#14212, institutional investor)*

There are also cases where occupation and ownership belong to the same party. This study has encountered institutional property owners whose business requires a large number of branches to conduct their business locally. Instead of renting the many branch venues, some of these institutions decide to take the ownership of the venues by purchasing the buildings or developing them from scratch. In these cases, the occupiers are the owners of these (owner-occupied) buildings. The overlap of the occupation and ownership arguably gives the owners a large degree of control over the buildings, for which the deployment of solar panels is reasonably more determined by the owners.

> *'I think we have at the moment 75 operational stores. I think all except one, we build from scratch. So we actually design the solar panels in where we can at that point in time.' (Respondent#16726, private company)*

Therefore, the institutional property owners have a degree of autonomy in deploying solar panels on their buildings. This then reminds the research question of this study: what is

considered by institutional property owners regarding deploying solar panels on their buildings? As discussed previously, some literature has suggested some general issues that may impede solar panel deployment (Mah et al., 2018; Roberts et al., 2019). These issues will be embedded in the relations around institutional property ownership, and the relational perspectives of property ownership will help re-explore these issues with further depth. With the help of the empirical data, this study argues that property ownership is a helpful perspective that not only well integrates the existing knowledge but also offers some further understanding of the research question. This then requires broader scope as well as deeper philosophy of understanding property ownership, which will be discussed below.

In many cases the ownership and the management of the buildings are separated, and the owners outsource the management of their buildings to professional asset managers. Specifically, properties are purchased and owned collectively by a group of investors whose identities could be very diverse, ranging from individuals to institutions, from within to outside of the real estate industry. The investors can continue investing in the properties they hold, such as improving their conditions, in order to enhance investment return. The third-party managers or managing institutions combine the investors' investment and their expertise in property management to help the buildings to generate investment return. The investors may also seek the managers' advice regarding what buildings to purchase or what kind of new development to fund. These managers could be considered as the investors' employees serving the investors' real assets as well as serving the investors' interest in investing in the real estate business. These managers do not claim the ownership of the assets, but they do take the role of making specific decisions and taking actions concerning the assets. There are occasions and channels that facilitate the communication between the managers and the owners so that the managers stand the owners in good stead.

> *'And also [name of respondent's institution][52] does not own the properties. The properties are owned by the investors. All we are doing is managing those properties on behalf of the investors. So [name of respondent's institution] is the landlord in name, because we are making decisions, or we are advising our investors. But ultimately [name of respondent's institution] doesn't own any single asset. We are just managing them for our investors.' (Respondent#14212, institutional investor)*[53]

Although the presented data above mostly refers to institutional investors, it is not unreasonable for other kinds of institutional property owners to separate the legal sense of property ownership from the managerial party of the property. Property management may require expertise that the owners of the property title do not necessarily have (Heywood, 2018; Miller & Pogue, 2018). However, it may be counter-intuitive, because in a conventional sense taking ownership of something means taking control of it. In this case the managers play the owners' role in the conventional sense, but they are not the owner in the legal sense. What the owners own exactly is the legal title, which is a bunch of legal rights that are stated in a document (Gardner & MacKenzie, 2015; Bryson et al., 2017), whereas the control of material changes to the property is largely owned by the managers. Therefore, although the claiming of ownership has suggested the degree of the owners' autonomy in deploying solar panels, the practice of management indicates that the managers are more likely to act as the agency of such material change to the buildings. The managers seem more suitable to be asked the questions about deploying solar panels than the owners, which aligns with this empirical field work in which many respondents representing institutional property owners have been in the managers'

[52] Square brackets are used in the quotation to insert general terms in replacement of the words that may be used to detect the identity of the respondents, such as names of their institutions and names of their institutions' business partners.

[53] Opinion seconded explicitly also by Respondent#14420 (institutional investor), and Respondent#18116 (institutional investor).

positions.[54] This inconvenience resulted from the nuance between the legal sense and the conventional sense is evidenced in a montage of one respondent's sentences which all touch upon this issue.

> *'So obviously it's not our portfolio, we are managing it on behalf of a range of investors and pension funds. ...[55] So we are not the owner, but we are a proxy for the owner. So you're as close as you'll get to the actual owner. ... So we are the closest proxy, if you like, to an owner, within the various funds. ... So I mean us, as a landlord in that sense. ... So we are the landlord. ... So landlord, I mean owner, basically. And you know, everything that goes with that.' (Respondent#1847, institutional investor)*

However, there are exceptions. While in the above examples the legal ownership belongs to the investors rather than the managers, this study has also encountered situations in which the legal ownership belongs to the manager rather than the investors. In this situation, the investors lend money to the property owners to manage their own buildings or purchase new buildings. The property owners take the loan from the investors using the real properties as the collateral. The investors claim return from such loan, and they do not claim the ownership of the buildings given the loan is repaid as expected. Through the terms of the loan, the investors can also influence the property owners regarding how the buildings would be managed. For example, the investors may specify the improvement of the building's energy performance expected in a few years' time if the property owner would want to continue or renew the loan upon that

[54] In this context of in-depth reflection on institutional property ownership, many respondents of this study are not exactly institutional property owners. However, as expected and hence designed in this study's research method, these respondents with various roles are identified as highly suitable informants to represent institutional property owners in the issue of solar panel deployment. Moreover, the empirical data also has turned out approving such expectation. Therefore, as a note of clarity, the in-depth reflection on the different roles concerning the complexity of institutional property ownership does not undermine the research design of this study.

[55] Ellipsis marks are used in quoting data throughout this thesis. Respondents sometimes discussed one specific issue throughout various time points during the interview. Or while the respondents were talking, there might be small verbal responses from the researcher to assure the respondents that their talk was getting heeded, which was reasonably necessary in the situations of phone and video interviews. In these cases, when it is considered useful, the scattered content is composed into one quotation on the condition that such composition is not misleading. The ellipsis mark is used in this kind of quotations to mark the omission of irrelevant content in between relevant points.

point. In this situation, the property ownership and management are held by the same party, as compared to the situation discussed above.

> *'We enclose stipulations in terms of the environmental performance, the ESG performance, on making decisions whether we would loan against that company. We find out what they are doing. And also phrasing ESG targets within their clauses for taking that loan. So for a 5 year period, we would expect to see improvement in energy performance, carbon reduction commitment.' (Respondent#18116, institutional investor)*

More specifically, in this example below, the owner institution manages its property on its own. This owner takes investment from other parties, which may potentially result in the transfer of property ownership to the investing parties. However, this owner voices the precaution against this potential transfer of the property ownership. On the one hand, the property owners aim at managing and improving the buildings to satisfy the terms upon which the loan could be gained to enable such improvement. On the other hand, the property owners want to safeguard their property ownership by not taking actions that may exceed their financial ability to repay the loan.

> *'I have my own investors that invested with me. Even though I don't owe money to the bank, I still owe my partners' money. That is the money that needs to be paid off. Obviously until that paid-off, you know, I keep making improvement (to the building), but then it makes you quite unwilling to take on any extra debt or loan from banks, unless you absolutely need to, and to take the whole building as collateral.' (Respondent#20613, private company)*

One consequence of this precaution, as shown throughout the interview instead of in this particular quote, is that installing solar panels does not belong to the kind of improvement that warrants the 'absolutely-needed' extra debt or loan.[56]

[56] The cost of installing solar panels will be further discussed in section 5.5.

In summary, the nuance of understanding property ownership, such as in a legal sense and in a conventional sense, has been evidently explicit in the discussion of deploying solar panels on buildings. The understanding of institutional property ownership is relevant to the understanding of institutional property owners' deployment of solar panels on their buildings. The ownership arrangements can be understood as the variant forms of relations between owners and buildings, and this owner-building relation is where the additional relation with solar panels would be 'plugged in' (DeLanda, 2016). There also has been some indication so far that such owner-building relation exhibits some degree of exteriority, for which ownership does not define or fix the nature of owners or buildings in any singular or universal way. In addition, the relational perspectives will continue offering further depth to this analysis, which are arguably also relevant despite being less explicit in the words of the respondents.

Buildings are not simple static objects. In contrast, they are intertwined in ongoing processes. Similar to living trees, buildings have their input and output that happen at any moment throughout time. They take in electricity, water, heat, light, optical fibre signal, posted mails, as well as people and whatever these people carry in and out of the buildings. They produce functional space which supports additional outcomes flowing out of this space, including activities and their impact and productivity, flows of information and finance, as well as sewage, solid waste, and (carbon) emission. This way of understanding buildings as ongoing processes questions the (static) concept of ownership. As the saying goes, parents do not own their children, in what sense property owners may or may not own their buildings, and hence claiming the decision-making power over deploying solar panels on the buildings? In the following respondent's words, taking control of this ongoing process is beyond the legal or managerial sense of ownership, as discussed previously. Moreover, the lack of control would limit the autonomy of those sense of owners in installing solar panels.

'We can install solar panels and LED light, etc. etc. more easily than it's a single building with one tenant in it where it's a long lease, it's ten or fifteen years, and we basically, we have very limited control. So the control is the key point here. Not necessarily ownership.' (Respondent#1847, institutional investor)

However, as mentioned before, taking ownership can be interpreted as taking control. Therefore, an additional sense of property ownership is arguably useful, which is the ownership of the ongoing operating processes, as the ability of and accessibility to taking control of these processes. As empirical example shows, this additional sense of ownership is also vital to the success of installing solar panels on buildings.

'One of the problems that I recall is, they (external party that proposed solar panel installation)[57] haven't really considered the fact that we didn't occupy the building. There was this disconnect between, you know, our clients own the building, we manage it, but we have an occupier, and it's largely dependent on what the occupier's needs are, and what their consumption patterns are, and how much they will take, how much will go to the grid, and so on so forth.' (Respondent#26119, institutional investor)

Regarding the particular issue of installing solar panels, the occupiers or tenants become indispensable 'owners'. To align with understanding buildings as not static objects but ongoing processes, solar panel deployment is not simply about putting some black panels on the roof of a building. In contrast, it is about involving the buildings' operating processes with the processes of consuming on-site solar electricity. As also hinted earlier, it is about relations being 'plugged into' each other (DeLanda, 2016). Clearly stated by a respondent, it is the tenants that take 'ownership' of these processes. The tenants choose the energy suppliers for the energy consumption from the building as well as from the tenants' business or activities using that building. They decide whether or to what extent renewable energy is adopted. The

[57] When additional clarification is needed because a quotation is taken out of the context of the conversation, this clarification is made in round brackets.

building owners, in contrast, are usually unable to step in and intervene the energy processes involved in their buildings, if such control is given to the tenants through tenancy agreement. Reflecting on a point discussed previously, in the UK it is mostly the property owners that take the initiative to deploy solar panels. However, in the many cases where the building processes are controlled by the tenants, the property owners feel unable to take such initiative.

> *'Because the vast majority of buildings are single occupier sites, the tenants or occupiers will have complete control over whether they use renewable energy or sustainable sources for their energy. So that isn't something that we can really control, just because it's all down to the tenants.' (Respondent#23219, institutional investor)*

Furthermore, not only is the process down to the tenants, but also the data about this process is held by the tenants. The tenants also have no obligation to respond to the property owners' enquiry for the data about the ongoing process of the buildings, such as the energy consumption data. The contractual relationship between the tenants and the energy suppliers does not have to involve the property owners, who then have no contractual right to investigate the consumption data through energy bills. This makes the so-called landlord a frustrated 'lord' who ironically has no substantial power to command in the matters such as deploying solar panels. Continuing the reflection of a previous point, the landlords not only are unable to fully take the initiative of deploying solar panels, but also have little access to the data in order to simply pre-assess whether such initiative is worth taking. The following respondent (#1847, institutional investor) suggests that certain kind of technological solution in terms of data access is needed, so that property owners can have the first-step information to consider solar panel deployment. The current lack of such solution is a real challenge to the whole industry regarding the intention to improve the buildings' energy performance.

> *'When it's an occupier (who holds the contract with the energy suppliers), we don't have that contractual relationship. And the actual fact that the occupier has no legal duty to provide us the data, so we have to just ask nicely. And even if we get the data, it might not be complete, or it might change. We don't know why because we don't know what the occupier is actually doing.' (Respondent#1847, institutional investor)*[58]

The above finding debunks the superficial impression that deploying solar panels on buildings is to simply put the panels on the buildings. In contrast, it requires substantial knowledge and data about the processes in which each specific building is operated day-to-day. For institutional property owners who have hundreds of different buildings in their portfolios, it becomes questionable whether these owners could ever possibly make portfolio-wide decisions or actions of deploying solar panels, even if they have the intention. Similar to property ownership, the ownership of property portfolios may involve even further complexity for which the ownership or control cannot be simply taken by any singular or central party (J. Bennett, 2005). As shown so far, various parties take control of various processes in which buildings are involved. Solar panel deployment needs support from all of those parties throughout those processes. Regarding institutional property owners and their property portfolios consisting of many different buildings, the decision-making power is distributed across a large number of diverse actors and their relations.

The environmental matters such as solar panel deployment offers an opportunity to reveal the dynamic complexity of property ownership. The ownership of the operating process is interpreted as possible sources of liability and burden. Therefore, to avoid that kind of liability, the ownership of the operating process could be deliberately excluded from the sense of ownership interpreted by the landlord. While giving away the accountability of dealing with

[58] Opinion seconded explicitly also by Respondent#14420 (institutional investor), and Respondent#23219 (institutional investor).

liability in the operating processes, the owners also give away their autonomy of intervening in these processes, which then results in difficulties in enacting solar panel deployment. In the literature (Mah et al., 2018; Roberts et al., 2019), such difficulty is touched upon under the difficulty of 'governance issue'. Deploying solar panels on many buildings requires collective effort involving various parties, but governing such collective engagement is faced with many obstacles, challenges, and dilemmas. However, what is missing from the existing literature, as argued here, is that this issue is not simply unfortunate incidents or due to the lack of governing skills. In contrast, it is to a large degree the consequence of institutional property owners' intentional and rational decisions concerning something else (i.e. avoiding liability of building operation). To avoid liability in the early stage of the process leads to the later difficulty of enacting solar panel deployment. This missing insight chimes with the theoretical perspective, as Bender (2009) claims that action is over-determined, and Latour (2005) claims that action is over-taken. To certain extent, the action of (not) deploying solar panels has been over-determined in the institutional property owners' strategies of (not) dealing with liabilities of operating their own buildings.

As discussed before, many cases separate property ownership from property management since the investors as the property owners employ third-party institutions to manage the property. Furthermore, the following respondent suggests a further degree of separation regarding the property management. The property managers focus on managing the investment return from the properties, while the management of the properties' operation processes is largely passed on to the occupiers. For instance, this separation is operated through the lease agreement known as full repair and insurance (FRI). Under FRI agreement, the occupiers are given substantial accountability of operating the buildings, and the property managers strategically supervise the

buildings conditions. The property managers would not (be able to) intervene as long as there is no significant alteration to the buildings.

> *'The reason we are able to carry out the business with minimal staff is because each building doesn't require very hands-on property management because the tenant is in control of all the utilities bills and the phone lines, and so if there is a problem they are able to deal directly with the supplier.' (Respondent#23219, institutional investor)*[59]

As also suggested by literature (Bright & Dixie, 2014; Bright & Weatherall, 2017), the leases are often unclear about the responsibility of many actions such as installing solar panels. Such actions need further communication and collaboration between the landlords and the tenants. However, as previously suggested by the respondent (#1847, institutional investor), the communication between the landlords and the tenants is still considered as a real challenge that to a large degree prevents the landlords from acting more proactively.

Institutions undergo complex processes to make decisions over the properties. The decision-making involves many people with different roles and responsibilities as well as many factors stemming from different considerations. From any single or outside point of view that is unaware of the complexity attached to institutional property ownership, such decisions may appear irrational. Moreover, the decision may also seem irrational although the decision emerges from processes during which each sub-decision linking the process to the next step is made rationally in each sub-situation. The way in which institutions decide to operate their property ownership may lead to certain rational decisions which then result in later difficulties in deploying solar panels. The causal relevance of related elements and considerations are spread across time and space, for which understanding the outcome becomes difficult to any outside observers. The complexity of this emergent causality also engenders great challenge to

[59] Opinion seconded explicitly also by Respondent#18116 (institutional investor).

any intention or policy-making that demands a clear, single, and certain direction of trajectory from situations that are full of dynamics, complexity, and contingency.

Meanwhile, there is also recognition that the ownership of the operating process needs to be more integrated in the concept of property ownership. Some institutional property owners intend to consider the management their buildings more comprehensively, so that they are able to respond or take initiatives based on thorough understanding the whole building. The drawback of passing on substantial responsibility to the occupiers, as discussed before, is being recognised by those institutional property owners. The balance between strategically managing the property portfolios for investment return and specifically taking care of individual buildings may start to be re-considered in practice.

> *'There has been a shift in the industry in terms of the perception of this issue. So previously, the landlord's view was they were responsible for the energy supply, the performance of the building, only where they provide the services. … But that starts to shift where we are now considering the whole building irrespective of occupation. So we are now starting to capture tenant data so we can understand the whole building.' (Respondent#1847, institutional investor)*

In summary, the ownership of the operating processes is a vital perspective of property ownership. This sense of ownership has not been explicitly termed so in the empirical data, and it may seem going too far to suggest that tenants and occupiers are also owners of the buildings. However, it is made clear that tenants and occupiers have been holding some important control over the matter of deploying solar panels. The rather narrow and explicit sense of property ownership may be blocking the recognition of important actors and relations in this matter, and hence blocking the involvement of them in ongoing analysis, discussion, and actions. This realisation encourages this thesis to continue questioning the concept of property ownership,

and suggest an even more implicit sense of property ownership, which is also critical to the deployment of solar panels on buildings.

Buildings do not come into being out of thin air. In contrast, most buildings are built amidst many already established elements that all significantly shape the process of the building being built and hence the outcome of what is built. These established elements involve not only materials and technologies that enable certain space, functionality, and structure, but also regulations, economy, and culture that legitimise these processes and outcomes. This thesis terms it assembling process of buildings, which goes beyond the process of construction. Construction is only one part of the assembling process that also involves much conceptualisation and negotiation which would already limit what goes into construction. The assembling process includes the processes of investors envisioning ideas, designers visualising concepts, architects drawing plans, developers calculating values, constructors examining feasibility, and in some cases even end-users experiencing the forthcoming space.[60] Moreover, these actions and processes do not take place in silos, and there is likely to be much negotiation and compromise among them. Tracing the assembling processes in their full spectrum would help recognise the agencies of power throughout time and space. Accordingly, this requires empirical research to pay great attention to a massive amount of qualitative translation (Latour, 2005). Detailed case studies, such as Rydin (2012) as reviewed previously, can illustrate the causality through such complex connections and processes. The scope of this study is not designed to cover the whole assembling processes of buildings in detail, but the link between such assembling process and the concern of deploying solar panels will soon be the focus of

[60] Marc Kushner, 'Why the buildings of the future will be shaped by … you', TED Talk accessible in September 2021 at:
https://www.ted.com/talks/marc_kushner_why_the_buildings_of_the_future_will_be_shaped_by_you/up-next?language=so#t-3777

data analysis. Some evidence is also found to indicate the influences from various actors to the assembling of the building, which then may indirectly influence the possibility of deploying solar panels. The following respondent briefly described a small part during the assembling process of a building, where possible impact from other actors was addressed through negotiation and feedback loops.

> *'It could very well be that the feedback is, oh yes this is nice but it's too big, in which case we go back to the architect, you know, we provide alternatives this and this. Or it says yes, but it's a bit ugly looking at it from this side, so we may say okay what if we paint it in a different colour.' (Respondent#16726, private company)*

This process may be simply defined as the development phase of a building, in addition to its construction phase, as a common divide in practice (Sayce et al., 2007). However, compared to such division, a broadened understanding of the assembling process is more helpful in reflecting on the research question of institutional property owners' considerations on deploying solar panels on their buildings. This broadened understanding of a building's lifespan continues questioning the concept of property ownership. The decisions concerning many features of the building could be 'owned' by various parties other than the current property owner, and such 'ownership' would have been taken earlier than the building is actually built.

More specific to the deployment of solar panels on buildings, the assembling process of a building may be excluded from the interpretation of property ownership, but at the same time it is considered relevant to the deploying of solar panels. Referring back to a quote earlier (Respondent#1847, institutional investor), the key point is the control, not necessarily the ownership. What is different here is that the control is not in the operating process as discussed in the previously, but in the assembling process in this case. As explained by the following

respondent (#141025, institutional investor), the institutional property owners take ownership of the buildings only when many aspects of the buildings have been settled during the assembling process of the buildings. In other words, the institutional property owners allow the control of the assembling process to be taken by other parties, such as the developers and the constructors. This transfer of controlling power is claimed as highly relevant to solar panel deployment. To a certain degree, the institutional property owners let the partners of assembling the buildings to consider solar panel deployment. Since those partners are trusted to consider certain features (e.g. solar panels) to enhance the potential of highly-rated building energy performance, it may not be re-considered by the institutional property owners themselves.

> *'We would forward fund the development through the development phase. … We eventually, ultimately pay last payment, that is the day we take ownership. … Often, often, photovoltaic cells are installed at the time of development. And they are not installed retrospectively. So it's very rare that you would see a retrospective fit of photovoltaics cells on any of our buildings. They tend to be developed, put in at construction.' (Respondent#141025, institutional investor)*[61]

As discussed previously, the accountability of deploying solar panels is shared among the institutional property owners, the property managers, and the building occupiers. The controlling power is split from the owners towards the occupiers, in a rather unclear manner. Meanwhile, the data here indicates that such split also stretches along the assembling processes of the buildings, from the owners towards the developers and constructors.

Other respondents may not explicitly claim such clear-cut demarcation between real estate development and property ownership. Institutional property owners can strategically consider

[61] Opinion seconded explicitly also by Respondent#122023 (public institution).

solar panel deployment from the beginning, and specify such intention while drawing collaboration with their partners to develop new buildings. The accountability of deploying solar panels is then shared through such collaboration.

> *'We declare publicly, we specify that we will install a 50kwh (solar) system on every new store. So where we build a store from scratch, we tell our construction company this is what we want. And we will, you know, we will accept that cost within that commission. … I think for the last two to three years, anything that would have been built the last, let's say two, three, four years, would have got the 50kwh installation on it as default.' (Respondent#16726, private company)*

For example, while being asked why several specific buildings were chosen from the whole property portfolio for solar panel installation, the following respondent mentioned the convenience of involving solar panel installation in the assembling processes.

> *'Well they are just brand new buildings, so you had the opportunity to include solar in the design. You have, you know, the opportunity to create them with renewable energy sources. So that would be why, given the opportunity to provide renewable energy as part of the build. … They can design them in from the start, which is so much easier.' (Respondent#21519, institutional investor)*

Regardless of particular examples, it seems a common perception that solar panel deployment is more likely among new builds because of the convenient opportunities to intervene during the assembling process. In this way, institutional property owners' deployment of solar panels still exemplifies the building-by-building or only-in-construction approach that literature has criticised for being inadequate in mitigating climate change (Sayce et al., 2007; Eames et al., 2013).

> *'I mean if you build a new building, then you probably integrate it on the new building at the same process of planning.' (Respondent#111315, public institution)*[62]

Moreover, the assembling processes settle down many of the buildings' aspects which happen to be key considerations of solar panel deployment, for example, location, orientation, and structural capacity of carrying weight on the roof.

> *'Sometimes we will go with this analysis to look at all the roof space we had at [name of respondent's institution] at the time. And that considered, yeah, roof shape, orientation, obviously the structure of the roof, and whether it's structurally sound to put panels on … We have to consider the age of the roof and whether by putting solar panels on it, it would cause problems later on them, like if we got to do any renovation works and things like that.' (Respondent#122023, public institution)*[63]

Once these aspects have been assembled in certain ways, they could become major obstacles for the property owners to considering installing solar panels afterwards. These aspects are highly difficult to modify once they are settled. Therefore, to consider solar panel deployment after the assembling process, these aspects would draw themselves in as powerful and persistent agencies of the assembling processes that have not included solar panels. As the impact from the assembling processes, these aspects tend to resist modifications to themselves, and hence further resist other actions such as installing solar panels. For example, many buildings' roof simply would not be able to bear the weight of the solar panels if the panels are to cover most of the roof space.[64] Another example is building height, as explained by the respondent below. Those physical aspects of buildings make it difficult to re-intervene the assembling process or to re-assemble solar panels and buildings.

[62] Opinion seconded explicitly also by Respondent#20613 (private company).
[63] Opinion seconded explicitly also by Respondent#26119 (institutional investor).
[64] The potential of using most of the roof space to deploy solar panels is another concern in institutional property owners' consideration of solar panel deployment. This concern relates to cost-effectiveness and the economy of scale, which will be discussed later.

> *'And the main issue is because we are such a tall building (7 floors with double-height ceilings), the main problem with that is its maintenance. Because in order to just get scaffolding up to the roof where you may be able to have it, you are looking at a very very large cost. So every time something happens with them, you are looking at a very very expensive cost. And due to that, it's just not realistic. ' (Respondent#20613, private company)*[65]

As many buildings were built while solar panel technology was still not well developed, those many buildings were assembled in ways that were not (ideally) suitable for deploying solar panels.[66] To certain extent, the action of (not) deploying solar panels has been over-determined during the assembling process. Therefore, taking some ownership of the assembling process becomes a vital advantage of deploying solar panels on buildings.

> *'But if when we built our stores from scratch, from new, we make sure that the roof can support solar panels, because we have to factoring the weight of them, and the fact that people need to be able to access them, so maintenance.' (Respondent#16726, private company)*

The relations and actors presented so far are to some degree already documented in literature (Sayce et al., 2007). However, discussing them through rethinking the concept of property ownership is not simply serving some old wine by new bottles. The existing literature is more general about sustainable real estate and green technology (Sayce et al., 2007; Wilkinson et al., 2018). This study then finds that the specific example of solar panel technology, which arguably has been well advanced in recent years, still reflects the exact problem suggested by existing literature (Sayce et al., 2007). Moreover, thinking of buildings with concerns over their assembling processes, questions the conception of singular clear-cut ownership. It may be more helpful to think of many owners taking various degree of property ownership in different ways,

[65] Opinion seconded explicitly also by Respondent#14212 (institutional investor), and Respondent#23219 (institutional investor).
[66] The concern over 'ideal suitability' of a building to deploy solar panels will be discussed in section 5.5 and 5.6.

across different temporal and spatial dimensions. This way of thinking then conceives of solar panel deployment as part of the assemblage, which may or may not be assembled throughout the process, or actualised from the virtual space of possibilities (DeLanda, 2016).

As acknowledged at the beginning of this thesis, this study chooses to take a broad definition of institutional property owners, which tolerates potential differences among many kinds of such institutions. The finding of this study so far confirms that there is not much difference among those many kinds of institutional property owners regarding deploying solar panels on their buildings. They may tend to be categorised into different groups, such as public institutions, private companies, and institutional investors, but this does not necessarily mean they are categorically different in every way. As an example, the evidence presented so far suggests that solar panel deployment is an area where they share the same kind of principles in their considerations.

5.2 Contingency of Interaction

The empirical data suggests that the deployment of solar panels on buildings is often a process in which one opportunity may lead to another, one kind of resource may lead to further effort, or one particular person may strike a conversation that kicks start further consideration. There is not any particular role that holds the responsibility of, or pledges commitment to solar panel deployment. The deployment is contingently emergent rather than centrally determined, as discussed previously in the theoretical reflection (J. Bennett, 2005; Bender, 2009). The realisation of solar panel deployment is dependent on particular interaction on the basis of many actors and relations. There is no single actor being able to determine or guarantee those particular interaction to take place across various actors, places, and time points. As outlined below, the outcome of solar panel deployment may emerge over a long period of process rather than being fully determined early on.

As a common practice among many institutional property owners, they may start the process with a desk-top analysis of their buildings. They could use Google Maps or similar tools to generally assess the relevant physical features of the buildings, such as the size of roof, the orientation, the potential shading, and so on. The results of such preliminary assessment would be able to roughly estimate the generation capacity of solar panels systems if installed. The results would be stored as potential information that waits until it becomes relevant to progress upon certain opportunities. For example, combined with the overview of future building refurbishment or lease events across many buildings, the results of the above preliminary assessment could suggest specific buildings on which the option of deploying solar panels is worth further investigation. Further feasibility studies could then be arranged for those specific buildings. It could take a long time period to conduct the preliminary assessment, as well as feasibility studies if with potential. The progress of this process also depends on the availability of various actors whose skills and expertise are required at certain points, as well as the accessibility of other information such as building occupiers' energy consumption data as discussed previously.

> *'It's, you know, it's baby steps at the end of the day. It's a process. Can't do everything at once, so you know, it's just a bit of inside intelligence (preliminary assessment of building conditions and roof features), just to help stimulate action. ... It might be dismissed at that stage, it might not. So it's process, it's process driven.' (Respondent#26119, institutional investor)*

The idea of installing solar panels may stem from a range of situations, get passed on, or get dismissed also by a range of roles. It has a high degree of contingency. It could come from the interest of particular managers. The particular managers may be intrigued by the Feed-in Tariff rate at certain time, as the FiT rate has been changing over time (Smith et al., 2014). They may also adapt to the investors' interest which could be influenced by the extent of exposure of

solar panel technology to real estate investment. They may be looking for certain opportunities or certain options such as solar panel deployment in order to respond to the sustainability concerns in regulations and property markets. They may also learn from the experience of their colleagues and friends who have managed projects of solar panel deployment on buildings.

> *'I think it was just interested by one of the fund managers. … There is one case where from the feasibility perspective it is probably going to be the biggest landlord funded solar installation in the UK. But the fund manager didn't want to do it. They didn't want to spend the money. They didn't want to spend it on that. … But funny enough, he is now changing his mind, and now doing it after two years.' (Respondent#1847, institutional investor)*

It could be proposed by other people or external parties. There are many consultancy or technology companies that are willing to act proactively to encourage and convince institutional property owners to collaborate with them. Those potential partners may also use similar tools and processes to preliminarily assess buildings' potential of deploying solar panels, as discussed earlier. Institutional property owners may receive requests from those external parties to discuss solar panel deployment on their buildings. Institutional property owners then may follow such contingent cues to proceed with the proposals, but they may as well decline the requests. Moreover, as discussed earlier, the attitude of institutional property owners may also change over time.

> *'I reckon maybe six or seven years ago, there were a couple of consultants that knocked on my door with solar panel opportunities, and I remember, there was two sites that they did illustration for me. … Now it never came to anything, because I think, you know I said at the start, depends on the ambition of our clients, and our clients felt this was just a little bit too early. … It's (solar panel installation) got there eventually which takes a few years.' (Respondent#26119, institutional investor)*[67]

[67] Opinion seconded explicitly also by Respondent#21519 (institutional investor).

It could be brought up by a curious research enquiry (in this case with very little impact of potential changes).

> *'I can admit to you that solar panels, you know, until you wrote it (an email of research enquiry), have not crossed my mind. ... Well I have never put any thought into solar panels, to be honest, because the cost of doing that would be so large.' (Respondent#20613, private company)*

It could be requested by the tenants. Many tenants of institutionally-owned properties are institutional tenants. These tenant institutions also have their sustainability concerns and targets, which would often concern the energy performance of the sites and buildings occupied by their business and operations. As mentioned previously, the tenants may also be intrigued by the financial benefits of solar panel deployment, especially when they pay for the utility bills of the buildings they occupy.

> *'Say for example … that one with solar panels installed on the roof, the idea is actually driven by the tenant. … So in that case the tenant is pushing the asset manager to find a solution to invest solar panels on the roof. … So it's a real mix of the tenant, the asset manager, the property manager, the fund manager. It could be either suggesting ideas or proposing investments, but ultimately it's the fund manager that will sign it off.' (Respondent#14212, institutional investor)*[68]

At the end of the above quote, the respondent explicitly describes the situation where many people or positions may be initiating the idea of considering installing solar panels. It is also mentioned that the fund manager would ultimately sign off the proposal. However, it must be clarified that this is not to say that the fund manager is the one that makes this decision. Rather, the decision is made collectively, and it emerges from an assemblage of many positions and parties. Signing-off can be considered as a physical action that increases the visibility of the

[68] Opinion seconded explicitly also by Respondent#26119 (institutional investor), and Respondent#18116 (institutional investor).

fund manager's share in this collective decision-making, but it should not be seen as the only crown of power. There would have been nothing for the fund manager to sign off had the idea and discussion not been assembled across various actors. As the same respondent illustrates, proposing the idea is no less important than signing it off. As also discussed previously, specific managers' particular interest may stimulate further conversations and actions. It is the collective efforts of these many actors over the process that push progress towards the emergence of the outcome.

> *'But it can go both ways…. The fund manager might say to the asset manager, I want you to look at, the opportunity, you know, is there a possibility to install solar panels on this property or not. But then it could work the other way around. … The asset manager is proposing to the fund manager, we could do solar panels here. So it completely depends on the motivations of a fund manager or an asset manager. But they can work both ways.' (Respondent#14212, institutional investor)*

To clarify, fund managers oversee many buildings, oftentimes a portfolio, while retaining less specific information about each building. Asset managers look after a smaller number of buildings than a whole portfolio, for which asset managers can keep track of more specificities of each of these buildings. Fund managers and asset managers work together regularly.

> *'So there's a constant working relationship between the asset manager and fund manager. So, you know, we (fund managers) speak with them (asset managers), at least once a week if not more than once a week, catching up about the asset. … The asset manager is always updating the fund manager on things that happen with the property, opportunities that are raising, investment opportunities like solar panels, or ideas about audits, etc.' (Respondent#14212, institutional investor)*[69]

Such working relationship between the relatively more strategic role and the relatively more operational role also applies between senior board members and fund managers. The

[69] Opinion seconded explicitly also by Respondent#18116 (institutional investor).

importance of ESG concern and possible solutions such as solar panel deployment are communicated through these working relationships.

Moreover, initiating or proposing the idea of deploying solar panels can come from not only human actors, as mentioned above, but also non-human actors. It could come from a policy scheme. As reviewed previously (Cherrington et al., 2013; Muhammad-Sukki et al., 2013; Smith et al., 2014), Feed-in Tariff had been an impactful incentive that encouraged solar panel deployment on buildings, by both individual as well as institutional property owners.

> *'When it all started off, where those local authorities acted, they reaped the benefit of being able to access the Feed-in Tariff and get the returns on their investment. So it proved a sensible thing to do. That enabled local authorities, like Nottingham, to understand the technology and work through any challenges. And because the return was there it gave the right incentive to drive that technology forward and invest in it.' (Respondent#12713, public institution)*[70]

It could come along with a new-build project or a refurbishment project scheduled on the agenda, and solar panel deployment may have little to do with the determination of the schedule of the agenda. Instead, the progress of solar panel deployment receives impact from the decisions concerning those new-build and refurbishment projects and the strategic agenda-setting of those projects.

> *'So before 2005 that wasn't always necessarily done. But now it's done as a standard. So every new store that we build automatically has solar panels already. It's not a business decision anymore. It's standard equipment. … So we are opening three new stores next year. They will all have 50kwh on. … And we intend on retrofitting depending on, actually depending on internal project resources. We intend to retrofit between three and five more systems next financial year. ' (Respondent#16726, private company)*

[70] Opinion seconded explicitly also by Respondent#14212 (institutional investor).

It could also come along with a certain event in the lifecycle of the property. For example, lease renewal is commonly taken as an opportunity to engage building refurbishment whose cost and benefit can also be negotiated in the renewal process. In this case, the timing and terms of lease renewal would be important consideration regarding solar panel deployment.

> *'The lease renewal process. I mean the negotiation to extend the lease. That's what we would look typically, install solar as part of the, you know, when we do it, when we renew a lease we typically improve the premises and putting in solar would be part of improving the premises. ... It could be anytime. It depends on when we are in the middle of negotiating a new lease or we'll do some other work. There is no specific time. It can vary.' (Respondent#21519, institutional investor)*

Building refurbishment may also be scheduled regardless of lease renewal. However, significant refurbishment projects would not be frequently scheduled (Sayce et al, 2007). The possibility of including solar panel deployment in the future refurbishment would be considered by the institutional property owners in a similar manner as considering lease renewal.

> *'We know, legally, by 2050 in the UK you are expected to be net-zero. So any building not reaching that, or need a lot of work to reach that, would have an effect on its price. … There is brown penalty[71] in effect for not doing the work now. Or we'll do it when we refurbish the building. There are probably two or three, well maybe two refurbishment cycles if we buy a building at the moment till 2050. So we need to ensure that we are meeting that (net-zero by 2050).' (Respondent#18116, institutional investor)*

The high level of contingency, concerning many aspects including both the intention of human actors and the opportunities enabled by non-human elements, could indicate high possibilities of opportunities. However, it might as well indicate situations in which nothing is happening

[71] Brown penalty is defined as the loss of valuation of assets due to the lack of endeavour to attract tenants and future buyers. Reference: report published by IPSX and Carbon Intelligence, accessible in September 2021 at: https://media.ipsx.com/wp-content/uploads/2021/06/IPSX-ESG-Article-1.pdf

and nothing can be done, unless new opportunities rise and present themselves. This view is expressed by a respondent who refers to a property portfolio containing hundreds of buildings among which so far less than ten solar panels systems have been installed. This is also an example of institutional property owner who has little intention for portfolio-wide deployment of solar panels.

> *'So I think the opportunity that did exist, we've already taken them. We've already made those improvements. So what I'm saying is, with the current estates we have, there aren't really many other opportunities to introduce this (solar panel deployment). Because we've tried it and done it. … When we do, obviously for new builds mostly, we will then look at the opportunity of solar panels again on some of those new buildings. So that's going into the future.' (Respondent#122023, public institution)*

Solar panel deployment is considered based on each individual building, and the majority of the buildings in the portfolio may be, in this institutional property owner's view, not suitable or ideal to take up solar panels. Any consideration on solar panel deployment on buildings would wait until future new-build projects are ready to incorporate such deployment. As discussed previously, institutional property owners arrange their consideration in a process-driven manner. They hold in their consideration the potentially relevant insights they can access at certain point of time, and they progress if they encounter opportunities that can take such potential forward. In contrast, they have very little intention to urgently roll out solar panel deployment across all their buildings within a short period of time.

A high degree of contingency can also be seen in the process of seeking specialists to collaborate on implementing solar panel projects. The relevant consultancy market can provide many suitable partners. It is likely that someone suitable can already be identified within the personal networks connected to the staff of the institutional property owners. The network

could be established through previous experience, or it could be encountered through networking events.

> *'I think, maybe one of our old fund managers that has since retired may have come across them in the past, because his wife worked in real estate and used them. It was something like that. I mean, who knows, how these people come across your desk. Probably something like that, oh okay, you know, next time we will give them a ring and we did, and the rest is history.' (Respondent#26119, institutional investor)*[72]

The respondents have not claimed much difficulty in searching for a collaborative partner, but the identification of a partner could be highly contingent on individual persons and their networks. The collaboration among institutions could to a large degree starts from the contingent connections among individual persons. Certain practitioners may have professional experience in various fields, such as in both renewable energy and property management, and hence they can carry and utilise the links through their professional careers.

The concern is not to find a suitable candidate, but to find a trustworthy one among the many suitable options. The perception of trustworthiness is often influenced by the preference of someone with a degree of connection in the personal network or a degree of familiarity through previous collaborating experience. Trustworthiness may also be indicated through formalised channels of seeking collaboration. For example, in the public sector, institutions can refer to the national framework of procurement to identify suitable external parties that are categorised in expertise areas.

> *'I think environmental support market, consultancy market, is a bit chaotic. There is a lot of operate and design areas that are quite difficult to work out who were good and who were*

[72] Opinion seconded explicitly also by Respondent#1847 (institutional investor), and Respondent#21519 (institutional investor).

> *bad. So we spoke to a lot. What you end up doing is you put, you actually put trust in the ones that you worked with in the past.' (Respondent#141025, institutional investor)*[73]

Therefore, the collaboration is contingent on the individuals' network connections and previous experience in each specific institution. The empirical data does not suggest any convergence of the collaborating partners towards any particular company. The collaborating partners identified by the respondents are rather diverse. There does not seem to be any particularly dominant player in this specialist field. Similarly, there does not seem to be anyone particularly dominating the Nottingham region.[74]

The sense of contingency here aligns with the concepts of exteriority and emergence from the theoretical discussion in the previous chapter. The institutional property owners' consideration on solar panel deployment demonstrates how decisions emerging from the contingent interactions of various elements. The contingency of such interaction can be related to the exteriority of the relations among the various elements. As the exteriority of the relations blocks the determination of certain interactions or the nature of the related elements (DeLanda, 2016), interaction is allowed to emerge contingently. Relations of exteriority allow the related terms to start or cease interacting with large extent of freedom. Interaction can take place and persist even when the terms are contingently related. Actors contingently come across each other and realise that certain kind of interaction between them is worthwhile. There is not much prerequisite condition that determines what particular terms must be related or forces any particular kind of interaction to happen. DeLanda's (2016) claim that the majority of relations are extrinsic seems well demonstrated by the relations seen in the process of considering solar

[73] Opinion seconded explicitly also by Respondent#122023 (public institution), Respondent#23219 (institutional investor), and Respondent#21519 (institutional investor).

[74] There is a tech company called EVO ENERGY (https://www.evoenergy.co.uk/). It is based in Nottingham, it claims to be a leading expert in rooftop solar system, and it reports several projects done in Nottingham. This study expected it to be mentioned more often by the respondents, but actually only one of the respondents mentioned it as the collaborating partner. This study also sought to speak with EVO ENERGY, but got no response.

panel deployment by institutional property owners. As discussed so far, many actors and elements concerning institutional property owners' solar panel deployment can interact and collaborate in the manners they agree, and there is little sense of obligation forcing them to commit to such relations.

5.3 Emergent Sustainability Drivers

For institutional property owners, solar panel deployment is often considered within the wider concern of buildings' energy performance, and then even wider concern of sustainability. This wider concern may be assigned to different professional titles depending on the specific institution, for example, Sustainability, ESG (Environmental, Social, and Governance), and more specifically Carbon Reduction. Moreover, different respondents use different terms to describe the extent to which solar panels feature in this wider concern, but none has doubted the mutual relevance between solar panel deployment and wider sustainability concern.

> *'So our ESG strategies are quite broad. And so solar panels are quite a narrow part of that assessment. … So from a solar panel's point of view, and the installation of renewable energy generation on site, that's 100 percent on the kind of list of things to do for every single property that the two funds I work on are looking at. But we'll only do it if it makes sense for that building. And if it doesn't make sense to do solar panels and maybe there is something else we can do, or we can offset instead.' (Respondent#14212, institutional investor)*[75]

Before discussing the specific drivers later, it is important to clarify what 'driver' means in this context. The drivers to heed the wider sustainability issues may eventually translate into the installation of solar panels, but it may as well not. As mentioned by one respondent above, if installing solar panels makes sense to one particular building, the installation will be considered or done. If installing solar panels does not make much sense to that particular building, there

[75] Opinion seconded explicitly also by Respondent#21519 (institutional investor).

may be something else that can be done to improve the sustainability of that building. Similar to installing solar panels, there are a range of actions that can be driven by the sustainability drivers. These actions can include other options of on-site renewable generation such as installing heat pumps and wind turbines. It can also include other building energy efficiency solutions such as upgrading lighting into LED, and installing efficient water boilers. There are a small number of 'actual' outcomes compared to a larger number of 'virtual' options (DeLanda, 2016). There are clear logical steps from the drivers to the action, but there is no guarantee of causal links. Therefore, aligning with the theoretical insight from assemblage theory, sustainability drivers may get 'led to' the deployment of solar panels. However, there is no straightforward, singular, or linear causality between the strength of sustainability drivers and the extent of solar panel deployment. Buildings' sustainability and solar panels can be related through relations of exteriority that implies possibilities rather than determining certainty (DeLanda, 2016). In the theory chapter previously, the potential of deploying solar panels on buildings is theorised as an emergent property from relevant relations of exteriority. From the primary data, such potential is demonstrated as sustainability drivers for institutional property owners to take actions to improve energy performance of their buildings. Accordingly, sustainability drivers could potentially lead to the deployment of solar panels, but such outcome is not guaranteed or determined.

> *'So look at [name of respondent's institution] long term carbon reduction plans, we look at how solar panels and other renewable technologies could help us achieve that. And again that comes into a case where we look the optimal investment to help us achieve our carbon reduction plan, so whether that being solar panels, wind, all the forms of on-site generation, reduction project.' (Respondent#18219, public institution)*[76]

[76] Opinion seconded explicitly also by Respondent#141025 (institutional investor), and Respondent#14420 (institutional investor).

This potential disconnect between the sustainability driver and the deployment of solar panels is important in understanding the subtle meaning of 'driver' in this context. Generally speaking, institutional property owners are concerned that the lack of strong environmental credentials may discourage future investment in their buildings or discount income rate from their buildings. However, the lack of solar panel deployment specifically does not necessary lead to a building's poor energy performance. Buildings can achieve high energy performance and get qualified with strong environmental credential without having to adopt solar panels.

Moreover, the extent to which solar panels feature in the wider sustainability concern does not simply correlate to the chance of solar panels being installed. The causality may not be necessarily tied to the importance. As described by the following respondent (#12119, private company), it can be a very 'small' part that 'always' gets done. Some institutional property owners may have formalised the consideration on solar panel deployment to the extent that it is automatically integrated into the projects such as new-build and whole-building retrofit.

> *'PV in that process (property development and management), frankly, is a very very small part. It's a tiny tiny part of that process. One of those things that just happen more than anything. ... The policy from the [name of respondent's institution] point of view is that we got, we install PV panels on all the sites. And we are working our way through retrofitting them on the existing sites for a few years. That's what we are doing where budget allows. So in terms of their importance, they're a small small cog in a very very large wheel.' (Respondent#12119, private company)*

As shown by the above quotation, there are wider drivers as if a very large wheel under whose trend solar panel deployment takes place as if small cogs moving alongside. The potential of solar panel deployment as sustainability driver emerges from the assemblages related to energy performance of buildings. It also indicates the mutual plug-in of assemblages as conceptualised by assemblage of assemblages in the theoretical context (DeLanda, 2016). Assemblage is

influenced not only by the interactions among the related terms but also by the interactions with other relevant assemblages. The data suggests that the assemblage of institutional property owners' solar panel deployment is plugged into other assemblages such as the assemblage of building retrofit, and the assemblage of new building development.

The empirical data suggests two important sustainability drivers, including sustainability regulation and investment market. To begin with, regulation is recognised as one important driver. Relevant regulations apply on both local and national levels. As reviewed in literature (Rydin, 2012), local plans in the UK commonly require a certain extent of on-site renewable generation upon the grant of planning permission. The UK Building Regulation regulates the minimum level of acceptable building energy performance, for which installing solar panels can contribute to collecting points for increasing EPC rating (Sayce et al., 2007; Patrick et al., 2018). The relevance of these regulations is also confirmed in this study's empirical data.

> *'Okay, so, in principle, we are not specifically interested in just solar. We are broadly interested in on-site renewable energy generation. And that has been initially prompted by planning regulations. So, depending on the local regulations, we have an obligation to have a minimum of ten percent of our energy use generated through on-site renewables. … We realised that our stores and our business, solar is the best solution. So I would say since about 2005 or 2006 I think we have consistently gone with solar.' (Respondent#16726, private company)*[77]

Regulation acts as a kind of 'bottom-line' driver, which intends to guarantee a minimum level of sustainability concern. This minimum level is increasing as time goes by, for which institutional property owners are motivated to do more than what the current regulation requires.

[77] Opinion seconded explicitly also by Respondent#23219 (institutional investor), and Respondent#141025 (institutional investor).

> *'Clearly we have a sort of moral obligation to make our buildings as energy-efficient as possible. But also, you can see that environmental legislation is increasing all the time, and therefore, we don't want to get into a situation where we have some of our properties kind of stranded, if you like, because they don't meet the necessary environmental credentials.' (Respondent#14420, institutional investor)*

The extent of 'over-achieving' and 'future-proofing' can make any specific regulation itself less a driver to some institutional property owners. As also mentioned before, actions such as installing solar panels may be taken 'automatically' by some institutions with little referring to any particular regulation. The regulatory driver may not be reduced to any individual regulation. Instead, the regulatory driver is better understood as an emergent driver from the existence of relevant regulations through time. The regulatory driver resides more in institutional property owners' anticipation that there will be various regulations pressing the progress of sustainability. In this sense, regulatory driver can be understood as an emergent property over a long period of interaction between sustainability regulations and institutional property owners (DeLanda, 2016).

> *'Now you have government legislation, government legislation is designed purely to force people to change their behaviour. And we all know that the direction of travel in relation to sustainability and property is now obligatory, and we all need to do something about it. Now MEES[78], SECR[79], and ESOS[80] etc. etc. are all there to force the situation.' (Respondent#141025, institutional investor)*

The emergence reaches a degree where the regulatory driver is not reduced to any specific or individual regulation at certain time. However, the emergent driver is not transcendent to such degree that would still exist had specific regulations not existed anymore. In other words, the regulatory driver would lose the driving power had concrete regulations been all terminated

[78] Minimum Energy Efficiency Standard
[79] Streamlined Energy and Carbon Reporting
[80] Energy Savings Opportunity Scheme

(hypothetically). This demonstrates the ontological plane (DeLanda, 2016) on which the emergent regulatory driver can only exist side by side ontologically with the interaction between specific regulations and institutional property owners. This also hints at the understanding that sustainability is unlikely to become a transcendent normative driver existing all by itself, as will be discussed later. There will need to be relevant elements assembled through constant interactions.

However, there are also institutional property owners who are less worried about 'over-achieving', in which case the driving force of regulation is less likely to translate into solar panel deployment. Even though solar panel deployment would contribute to the general sustainability of buildings, there are difficulties of actually implementing such deployment (Mah et al., 2018; Roberts et al., 2019). For some institutions, the extent of them being less worried about complying the regulations indicates the lack of interaction between these institutions and the regulations. Accordingly, as suggested by assemblage theory, the regulatory driver of buildings' sustainability could not adequately emerge in these cases. As will be discussed soon, these cases help further demonstrate the emergence of another sustainability driver for deploying solar panels on buildings.

> *'So I don't think you fall behind by not installing solar panels. … I actually think that solar panels, unless the technology of solar panel becomes extremely updated … so unless, you know, the individual solar panel becomes a lot more powerful and produces a lot more electricity … I think unless the technology of solar panels actually catches up to where other technology is going at the moment. I actually think it will be surpassed by other sustainable power forms.' (Respondent#20613, private company)*[81]

[81] Opinion seconded explicitly also by Respondent#141025 (institutional investor).

Apart from the regulatory driver of sustainability, there is also the business driver which is recognised more important than regulation. Implicitly, many respondents indicate that the business driver is what underlies the regulatory driver. The regulatory driver is reinforced by the degree to which regulation compliance may have impact on the institutions' business. Because real estate investors and corporate tenants are increasingly interested in properties with environmental credentials, future-proving sustainability regulation compliance can help institutional property owners attract investment and let their buildings. Therefore, the intention and action of over-achieving in sustainability concern are driven more by business rather than regulation per se.

> *'There are two drivers of ESG and sustainability in real estate investment today. Number one is regulation. … But as I'd say, the far more important driver of investment in sustainability today is marketing. It's because our investors … they are signing up to sustainability pledges and initiatives like Net Zero Carbon , like Better Building Partnership, like TCFD[82], like UNPRI[83], etc. etc. And they are then driving us to adopt more ESG and sustainability issues in our strategies.' (Respondent#14212, institutional investor)[84]*

The empirical finding is to some degree suggesting a point hinted earlier. Emergence, but not transcendence, aligns with the ontological understanding of sustainability as a driver that encourages actions such as deploying solar panels on institutional property owners' buildings. Although the wider sustainability concern is where solar panel deployment is embedded, sustainability concern is neither the driver of its own nor the driver of solar panel deployment. Business concern seems the ultimate driving force, which may lead to actions of improving sustainability or more specifically installing solar panels. Sustainability and solar panel

[82] Task Force on Climate-related Financial Disclosure.
[83] United Nations Principles for Responsible Investment.
[84] Opinion seconded explicitly also by Respondent#141025 (institutional investor), and Respondent#14420 (institutional investor).

deployment may be considered equally driven by the business concern. As explained by one respondent (#26119, institutional investor), sustainability 'should not' be driving investment decisions, such as installing solar panels. It 'sits alongside' and it is no more important than many other considerations that need to be balanced.

> *'We don't demand, we don't bang the table and say, why did you not do solar panels on this, and if not, why not. … Yeah, I think otherwise you find that, the danger is that, you see ESG is driving the investment decisions and we've always been cautious of that because they shouldn't be. You know, our mantra has always been that ESG is integrated and sits alongside the conventional investment decisions. … We (staff of ESG team) are trying to influence rather than dictate. But it's not our place to dictate.' (Respondent#26119, institutional investor)*

In other words, sustainability driver as the potential of deploying solar panels has not been transcendent as if being able to determine or dictate actors and the way they interact. Instead, it emerges from the heterogenous actors and relations around building energy performance, and ontologically co-exists with the interactions among all those actors. Sustainability driver and the business concern of institutional property owners are on the same ontological plane.

Therefore, although wider sustainability drivers appear relevant to solar panel deployment, there seem more fundamental and complex considerations behind. The (simplified) association between solar panels and sustainability is not that impactful to drive portfolio-wide deployment of solar panels by institutional property owners. Such simplified association may indicate the presumption of relations of interiority, as if solar panel deployment and buildings' sustainability define or determine each other. In contrast, this study's finding suggests more of relations of exteriority, upon which interactions are contingent, related elements are diverse, and potential outcomes are emergent. The institutional property owners need to consider the

balance of many aspects, for example, not only improving building energy performance but also securing investment return.

5.4 Consideration of Nottingham

As discussed previously, Nottingham is selected as a local focus for this study because of its achievement of solar panel deployment on buildings and the local authority's explicit ambition of achieving further. It is claimed to be a front-runner standing out from other places. In contrast, most of the respondents do not consider Nottingham in any way special while discussing solar panel deployment on buildings. Nottingham as a geographical location or local influence from Nottingham local authority have not led to any special consideration regarding deploying solar panels by institutional property owners. Despite being recognised as an area with best practice, the primary data suggests the lack of spatial territorialisation in Nottingham regarding institutional property owners' consideration on solar panel deployment on their buildings.

> *'Eerm, any way special, I don't think so. We do lots of things in lots of places, but I don't think any of the Nottingham properties have any particular ESG criteria attached to them. … But to answer your question, no, I don't think there are any particular ESG or specifically net-zero type criteria attached to the buildings or associated with the buildings.' (Respondent#1847, institutional investor)*[85]

These institutions' property portfolios cover the geographical area of the whole UK, and as indicated by these respondents, there seems a lack of local considerations. Even in a place as Nottingham where the physical presence of solar panel deployment seems noticeable and the statement from the local authority is encouraging, local factors do not seem to exist in institutional property owners' consideration. There is a lack of evidence indicating any process that may spatially territorialise special consideration of solar panel deployment in Nottingham.

[85] Opinion seconded explicitly also by Respondent#12119 (private company), and Respondent#21519 (institutional investor).

As indicated from the desk-top research of this study, most of the participating institutions hold properties across many places in the UK. The respondents confirm that their institutions' consideration over solar panel deployment apply to all their properties without any locally attached special criteria. Therefore, the lack of particular consideration of Nottingham meanwhile further supports the potential of this study's local focus of data collection in indicating empirical processes taking place across the whole of the UK.

Speaking of the carbon-neutrality ambition that is declared by the Nottingham local authority, many respondents are unaware of it. Institutional property owners are aware of many local authorities' positive attitude towards sustainability, but they have not tracked the details of each place.

> *'No, I wasn't aware of that. But I know, obviously there is a few local authorities or regions, Greater Manchester for example, which are all trying to go for different dates. But I wasn't aware Nottingham was trying to do such thing.' (Respondent#1847, institutional investor)*

The unawareness of details is also reflected by some respondents' perception that the 'Nottingham ambition' is a goal concerning only the buildings owned by the local council. Compared to a city-wide ambition concerning all the buildings across the city, as publicised by the city council, there is a clear gap of communication, let alone collaboration or engagement.

> *'But that's, hang on, those would be Nottingham council-owned buildings. ... That's local authority owned buildings. Not privately owned buildings within the local authority.' (Respondent#141025, institutional investor)*

The intention mentioned before by the council staff to 'get the carbon-zero mindset across the entire city' is not strongly supported by the empirical evidence in this study. As also mentioned by one respondent quoted above, there seems lacking not only effective influence from the

local council to the institutional property owners, but also any concrete links or channels through which such influence could be realised.

> *'We have no link to local authorities at all.' (Respondent#141025, institutional investor)*

As for some other respondents who are more aware of the Nottingham's ambition, it is communicated rather indirectly through media.

> *'Oh yeah, yeah, through press release. I think it's local news actually, it might be. Yeah, a big press release by the city of Nottingham council.' (Respondent#111315, public institution)*

Moreover, as this respondent clarifies further below, such awareness does not necessarily mean compliance. Despite moving towards the same direction, such as carbon neutral, institutional property owners progress as much as they see fair and feasible, but their pace may not match the ambitious level as declared by the council's statement. Implicitly, this ambition is still considered more as the council's own ambition rather than a city-wide ambition.

> *'The city declare their own target as carbon neutral 2028. And then they are looking for local support. So we declare to support their ambition of carbon neutrality. ... I think it's something we are going to do anyway. So when that came, we just sort of agreed to support it. Something we'll work on anyway. ... We are not sort of along the line of being carbon neutral by 2028, that's why we agreed to support it. We are not declaring we will be carbon neutral by 2028. But we are working along that road based on science-based targets. (Respondent#111315, public institution)*[86]

In order to achieve the specific ambition of city-wide solar panel deployment, adequate relation and interaction may still be missing among the many institutional property owners, as well as between the local council and other institutions. Such missing interaction would theoretically impede any spatial territorialisation in Nottingham (DeLanda, 2016).

[86] Opinion seconded explicitly also by Respondent#18219 (public institution).

There are also respondents who voice positive opinion about their relationship with the local council, but during the interview conversation they seem encountering quite some difficulties in giving any concrete examples or anything more specifically related to solar panels. There seems a general sense of working relationship between the council and the institutional property owners so that they are always ready to quickly summon discussion and collaboration. However, regarding solar panel deployment specifically, there seems not much collaboration between the council and the institutional property owners, and there seems also not much need for such collaboration. This concurs with the lack of concrete details or examples while the city council claims to engage the private sector and properties across the city, as presented previously.

> *'There are various groups that we attend with the council members of Nottingham, work on sustainability projects. ... There are lots of things going on, but I can't give you examples for every single one at the moment. ... In sort of the older ones (solar systems), there was I suppose less of a need with the council because they were just part of the projects that are going on new builds. But we always engage well with the council. They are supportive. We are trying to work with them where we can. So we always have a good relationship.' (Respondent#18219, public institution)*

Concerning the concepts of 'virtual' and 'actual' in assemblage theory, there is virtual space of possibilities (DeLanda, 2002; 2006; 2016), and the city council as well as some institutional property owners are together exploring this space. As mentioned in the theory chapter, this study theorises institutional property owners' consideration as the virtual space of possibilities among which deploying solar panels on their buildings may become an actual outcome. There is data showing the interaction or plug-in of these virtual sites by several institutional property owners. One institutional property owner's consideration as one virtual site can be connected to another institutional property owner's consideration as another virtual site, in which way

these institutional property owners can take into account each other's interest and actions. Potentially this may create new virtual space shared by these several institutional property owners, or new virtual space that is spatially territorialised in the local area of Nottingham. However, it has not been actualised, and it has not concretely engaged materials such as solar panels.

> *'We do have a collaborative piece of work which is called Universities for Nottingham, and it's University of Nottingham, Nottingham Trent University, and the City Council. ... So there will be some common areas where the three of us probably can do it, pursue a joint initiative. We've just begun that type of discussion. ... So it's been running for just a short time and it's not just about the green agenda. It's actually about other things that we can do for the greater benefit.' (Respondent#122023, public institution)*

If there is any influence from the potential local factors such as the city council's ambition statement in terms of solar panel installation, this influence seems only marginal. As also discussed previously, the installation of solar systems is more influenced by institutional property owners' own project management than by the council's request or specific local policies. Such project management concern concurs with the building-scale case specificity of solar panel deployment (Hudson, 2007; Rydin, 2012; Bright et al., 2019). Many institutional property owners are confident that their actions are likely to have done more than what the council would request.

> *'So (our building in) Nottingham actually has, I think, 50kwh on. ... So Nottingham has 50kwh installation. That was built when we built Nottingham. So Nottingham opened in 2009 and we built a 50kwh solar PV on it. ... And at that point in time you know we've already had other stores with solar, so we would have been absolutely happy to comply with that (include on-site renewable in new-build projects). So that wouldn't have been an issue for us.' (Respondent#16726, private company)*

As discussed earlier, the regulatory driver for sustainability is not only related to any individual regulation. There are a number of regulations pushing institutions to pursue high building energy performance. Moreover, institutional property owners have been practicing future-proving their buildings' sustainability profile. They over-achieve in their building energy performance to such extent that they do not need to refer to the exact details of regulations for every single one of their buildings or projects.

> *'Eerm it's a good question. And I can't honestly say that there are (requirement from local policies to take up on-site renewable energy). It will do, but I can't honestly say, because we do it automatically. It's just not the thing. I don't know, it must do but I don't know specifically. I would have to check to see whether we refer to it in our planning application. But I've never, something I've not looked at in details, because we just do it anyway. But the councils will have policies around this.' (Respondent#12119, private company)*

Another respondent does not even consider the council's influence or strength to be much relevant to their decision of deploying solar panels.

> *'But my feeling is that they are not a grant awarding body in the sense that they don't have money to give us. ... The decisions we make how we invest will come down to a business case. ... There will be a number of factors. So in that there is a kind of matrix of things that we are going to need. We have our zero carbon target and our renewable ambitions as well. So we will have specific things that we are trying to test in each proposal as to whether we can make a scheme the most sustainable it can be and how it might fit our carbon plan.' (Respondent#122023, public institution)*

As the above quote shows, the deployment of solar panels needs to be understood in relation to the many considerations by the institutional property owners themselves. There is not much data supporting the strong influence from the local council of Nottingham or the strong territorialisation in the local place of Nottingham. It is not simply a lack of communication or a lack of concrete link that results in the lack of engagement. The institutional property owners

do not seem to expect any further useful engagement with the local council in terms of increasing solar panel installation. It seems unlikely to expect any spatially territorialised assemblage based on the interactions among these institutional property owners if there are hardly any concrete relations among them.

Based on this study's data, only one instance is found where the potential of territorialisation seems clear, but it is not about solar panel deployment. It may suggest that localised materials such as a local incinerator play an important role in fostering any assemblage's local territorialisation. Further research is needed to substantiate this point, but it is beyond this study's focus on solar panel deployment.

> *'So it was a long-standing deal between Intu, well Capital Shopping Centres Intu, and the local council. I think, from memory if I am right, Capital Shopping Centre half-funded the local incinerator for waste. So there was a closed loop between providing waste to the local council from the shopping centre. They then provided the heat back to the centre. And that would be done on a reduced rate of payment. So I don't think it would have gone anywhere else for heating.'*[87] *(Respondent#18116, institutional investor)*

5.5 Cost-Effectiveness

Aspatial territorialisation is arguably taking place around cost-effectiveness of the projects that involve solar panel deployment on buildings, which is seen in both public and private sectors. Such projects could be mainly involving solar panel deployment, but as also discussed previously, many of these projects have wider range of actions and goals which include solar panel deployment as a part. Much of the consideration by institutional property owners is highly related to the eventual cost-effectiveness of certain project that involves deploying solar

[87] Two large shopping centres in the centre of Nottingham city used to belong to Intu. Intu went into Administration in June 2020, reportedly as a consequence of the Covid-19 lockdown in the UK. (News article accessible in September 2021 at: https://www.theguardian.com/business/2020/jun/26/shopping-centre-owner-intu-expected-to-go-into-administration)

panels on their buildings. In other words, what cost is involved in deploying solar panels, what financial benefit would it generate, and in what way could the benefit at least equate, if not exceed, the cost? How long time it would take for the benefit to pay back the upfront cost? In both the private as well as the public sector, cost-effectiveness is recognised to hold central importance in institutional property owners' consideration of deploying solar panels.

> *'One of the things that we normally came up against with photovoltaics is we have to demonstrate the return on investment. So the payback is just the same as we would measure with any other improvement. You know what I mean, we would still, whether it's ground source heat pumps or some of other things or biomass boilers, whatever we are considering, we still have to compare the level of payback. And that's still effective for us with PV.' (Respondent#122023, public institution)*[88]

The empirical data shows hardly any doubt about the financial potential of solar panels. However, for many institutional property owners, simply being able to pay back is not adequate to intrigue action. The concern is on how effective the payback would be, how long time the payback period would take, and how much certainty or confidence there is in the estimation of payback period. The pursuit of cost-effectiveness enables some comparison among different energy-efficiency technologies, and then, as literature suggests, some competition over the available amount of capital spend (Roberts et al., 2019). The question becomes whether deploying solar panels could win this kind of competition, in relation to not only the other technologies, but also the other buildings in the institutional property owners' portfolios. Moreover, cost-effectiveness could be theorised as aspatial territorialisation. This aspatial territorialisation shapes the emergence of actualised assemblage from virtual assemblages of certain buildings, certain building-applied technologies, and certain partners in the virtual space

[88] Opinion seconded explicitly also by Respondent#20613 (private company), and Respondent#14212 (institutional investor).

of institutional property owners' consideration. Such aspatial territorialisation is demonstrated by the outcome that only the highly cost-effective possibilities would be actualised from the virtual space.

> *'So not always those ideal location, so we have a couple of buildings where, because of what the building make-up appears, solar panels might be in shade sometimes, which when the panels go into shade it significantly impacts on the performance of the panels. So not ideal. They still work, and they still produce energy, and obviously more than what we would do without them. But they are not the ideal scenario. In those cases the payback is extended. ' (Respondent#18219, public institution)*

As a measure of cost-effectiveness, the payback period is difficult to estimate, even though, as reported by some respondents, the energy output of solar panels has been made rather predictable and reliable due to the maturity of the technology. The difficulty of estimating payback period involves the specific perception of cost and benefit. In other words, what would be calculated into the cost, and what would be calculated into the benefit? There are issues in both sides of the calculation, which will be discussed in turns. Regarding the benefit, the direct benefit is the savings in energy bills. This leads to the issue of split incentive, in which case the landlord who pays for the solar panel installation only then deliver energy savings to the tenants, given that the building is not owner-occupied. Concurring with some literature published more than ten years apart (Sayce et al., 2007; Roberts et al., 2019), splint incentive could still be a significant hurdle that discourages landlord from further considering deploying solar panels.

> *'And the thing about putting solar panels is the tenants who benefit. Not the landlord. ... The landlord provides the capital. But it doesn't actually get a benefit. Because they don't actually get, reduced energy charge is a result the tenant who does, because the tenant is the occupier. The landlord is the investor.' (Respondent#141025, institutional investor)*

There are possible solutions such as green leases, but as the same respondent clarifies, some institutional property owners are not much interested in working towards such solutions. The

benefit from environmental technologies such as solar panels is not the main income source that many institutional property owners would endeavour much to capture.

> *'Yeah I know, I think you are getting into that of quite, that's quite sophisticate as outlook. You know, so we will put solar panels in which will save your energy by 30 percent, and by the way we want you to pay us 15 percent of that or 25 percent of that and, you know, I think that is not the business we are in. We are in the business of rental growth and rental return. And I think to get involved in returns of, income return based on capital expenditure on environmental initiatives, it's just not what we are about. We are not set up for that.' (Respondent#141025, institutional investor)*

Similarly, some real estate investors may be simply uninterested in dealing with any issues that are not immediately related to real estate, whether it is installing solar panels or resolving split incentive. To certain degree, the cost-effectiveness of solar panel deployment projects is also compared to other projects in a wide range of areas which could go beyond on-site renewable generation or building-applied environmental technologies. As indicated by the following respondent, the potential investment return of solar panel deployment could also be benchmarked against institutional property owners' real estate investment in general.

> *'You know, some funds don't want to spend a million pounds or whatever doing this, they want to invest in the properties. Others are more comfortable doing that. Because ultimately it's a real estate fund so they should be investing in real estate, not this, you know. If you are investing a million pounds in solar panels, well, what could you have done, how could you have used that a million pounds differently, and you know, could you get a better return by investing that money into real estate.' (Respondent#1847, institutional investor)*

Meanwhile, other respondents are not so much concerned by this issue, and some institutional property owners are willing to engage themselves in specifying the solution of split incentive. As also indicated above, one solution is to bill the tenants for the on-site solar electricity, in a similar way as they are billed for the electricity from the grid. In other words, the landlords sell

the solar electricity to the tenants, with a price that is cheaper than buying electricity from the grid.[89] This kind of deal between the landlords and tenants is able to re-bind the split incentive and re-assemble these actors for deploying solar panels.

> *'I mean, it's a win-win really. You know, it's good for the tenants, it's good for the funds, we get return, and we, you know, we are removing carbon from the grid. … Well, there's the avoided carbon, there's the savings to the tenants, so by selling it cheaper, there's a saving to that. And then there is obviously the actual financial return. The fact is that we are selling them energy. And when we sold enough energy, there will come a point when that will pay back the cost of the panel and then we are just making money.' (Respondent#1847, institutional investor)*

Calculating the benefit of selling the solar panels' output is rather straightforward, since the output of solar panels is rather predictable and reliable. However, this is only one of the many potential sources of benefit from installing solar panels. It is the other kinds of benefits that are much more difficult to calculate. For example, as discussed in the previous sections, solar panel deployment as part of the sustainability intervention is able to attract some real estate investors to invest. The prospective investment could be considered as the benefit of solar panel deployment, but it is difficult to attribute a specific financial figure to solar panels as the investment is to the property as a whole. Or certain tenants may be particularly interested in leasing properties with high energy performance, in which case the prospective rental income would be counted as the return of any intervention such as installing solar panels. But again, it is difficult to calculate how much of the future rent is 'due to' the deployment of solar panels now. So far, the empirical data has not found any solution to the calculation of these kinds of benefit from solar panel deployment. It would depend on the level of buy-in from the landlords.

[89] Landlords could 'sell' the solar electricity also to the grid while Feed-in Tariff scheme was in place, but this is no longer relevant in the UK since the termination of that scheme.

Some find it generally beneficial, and it does not matter how much benefit it is exactly. Whereas some others may hold the opinion with reserve because the exact benefit is hard to prove.

> *'Well, it's difficult to say that the actual solar has a massive valuation impact. It's the wider negotiation, it's the wider transaction which is what we would value. We don't really look what the solar itself, we don't quantify what solar installation itself adds to the value. The valuation increases, the property's length of lease, because it's an investment property. And the fact that it's got solar at the moment, I don't know what impact that actually has on the value.' (Respondent#21519, institutional investor)*[90]

Similar to the benefit, there are also many kinds of cost that may or may not be calculated into the cost of deploying solar panels. It would include not only the price paid to purchase the panels themselves, but also other items such as the labour cost.

> *'Yeah, I think, the cost of the panels has come down. But that's only a proportion of the total cost. You got all the electronics and inverters and the support frames and obviously all the labour of physical installation. Most of those costs are going up a little bit. But you are quite right, the Tariff has disappeared now. So, I mean, when we started, the chance was very good. You know, it made sense to do it financially. So yeah, it's a difficult one actually.' (Respondent#111315, public institution)*

In some situations, precisely demarcating the cost of solar panel deployment is not an issue because it is a small additional part of a bigger project. Since it is rather certain that the cost of solar panel deployment is only a small portion of the cost of the bigger project, accurately specifying the cost of solar panel deployment is no longer any major concern. The main concern is to establish the cost-effectiveness of the bigger project as a whole. If such broader project can be justified as cost-effective, it is likely to become territorialised in the aspatial sense and emerge into actual assemblage in which the assemblage of solar panel deployment is embedded and hence also actualised. As also explained by one respondent earlier (Respondent#12119,

[90] Opinion seconded explicitly also by Respondent#1847 (institutional investor).

private company), solar panel deployment is a very small part that can be easily tagged along by the wider process.

> *'So the cost has come down significantly. You know, we now pay maybe 50,000 / 60,000 pounds for 50kwh installation. So that is a very reasonable cost to add on to a new build, when maybe including the land cost, you know, we've maybe paid 5 million for the whole thing. So you know we look at it proportionate to the kind of buildings that we build as well.' (Respondent#16726, private company)*

In other situations, any additional preparation that is needed before solar panels could be installed may potentially be conceived of as the cost of the solar panel project. In contrast to the situation above where the cost of installing solar panels appears smaller in comparison to the whole project, in this situation the cost may be calculated bigger depending on what is considered as part of the cost. One example is preparing or repairing the roof. If the roof work is part of a bigger refurbishment project, in parallel to the work of installing solar panels, the cost of the roof work would be part of the refurbishment project, not part of the solar panel installation. If the roof work is required only due to the intention of installing solar panels, the cost of the roof work would be calculated as part of the cost of solar panel installation. This difference may easily flip the result of the cost-benefit analysis of the projects to deploy solar panels. Moreover, because of the significant cost of the roof work, institutional property owners would attempt to ensure that the roof condition is adequate to adopt the solar panels throughout the panels' lifespan which is about 20 years (Respondent#18219, public institution). This could help avoid having to conduct any significant roof work after solar panels have been installed. In other words, for the buildings whose roof condition needs improvement in order to adopt solar panels, the cost of preparing the roof is highly likely to be related to the consideration of deploying solar panels. It could be included as part of the solar panel deployment's cost, or it could be considered as parallel costs belonging to certain bigger project.

> *'It all depends on the building, the condition of the roof and its make-up, but if we look at putting new panels on old or existing building, the intention is that the panels will be there for circa 20 years, so we want to be sure that the roof covering would be, would have that similar lifespan. … We will tend not to put them on where there is a requirement to do a full roof recovering or something else unless it's part of the roof recovery project at the first place, because the cost involved are significantly higher.' (Respondnet#18219, public institution)*[91]

Another example similar to roof work is scaffolding. As also mentioned in a quote below (Respondent#20613, private company), scaffolding is very expensive, especially considering the likely height of the buildings in cities. Whether the scaffolding fee is calculated into the cost of solar panel installation would have significant impact on the cost-benefit analysis of solar panel deployment per se.

The calculation also needs to take account of the impact of future cost. A vague impression of the possible future cost may discourage further investigation or more accurate calculation of the cost.

> *'And the main issue is because we are such a tall building, the main problem with that is its maintenance. Because in order to just get scaffolding up to the roof where you may be able to have it, you are looking at a very very large cost. So every time something happens with them, you are looking at a very very expensive cost. And due to that, it's just not realistic.' (Respondent#20613, private company)*

There may be also future liability that can induce further cost. For example, as mentioned earlier, the tenants are responsible for repairing the building under full repair and insurance (FRI) lease. If the landlords initiated solar panel installation, and there appears roof leakage after that, the tenants could argue that the landlords or the installation partners should take the responsibility of repairing the roof. As discussed above, repairing building roofs could be a

[91] Opinion seconded explicitly also by Respondent#20613 (private company).

significant expenditure that any of these parties would rather avoid if dealing with such cost is not well prepared in any financial plan in advance. The intention of avoiding such liability could become a discouraging concern in institutional property owners' consideration on solar panel deployment on their buildings.

> *'If you install solar panels on say a 15-year old roof, which then starts to leak, the tenant will argue that the installation of the panels caused the issue, and so it is not their responsibility. In some cases that would be fair, ... but in others the roof may well have leaked without the works, so there will always be some friction between the company installing the panels and the tenant as to the ongoing repairing obligation.' (Respondent#23219, institutional investor)*

As explained further by another respondent below, this possible liability carries high risk because the potential benefit is considered significantly smaller than the potential cost. In comparison, the attempt of making no change seems to easily outweigh any incentive that could possibly be offered by installing solar panels.

> *'It was the appetite for risks. And, you know, here is a property which is let to [name of tenant institution], a strong covenant, for a long period. ... So there's long income, so why risk that by trying to generate just a little bit of extra income? ... By introducing this additional intervention, you may be attracting liability. ... So, the risk of maintaining that long-term secured income ... is being potentially undermined.' (Respondent#26119, institutional investor)*

In summary, the extent of being cost-effective seems an obligatory concern in the discussion of solar panel deployment. Different institutional property owners would have different appetite in this concern. Some may be interested in deploying solar panels as long as it is fairly cost-effective, whereas most institutional property owenrs may not want to do anything unless it is highly cost-effective, or even attractively beneficiary. The obligatory cost-effectiveness then becomes the basis reinforcing the predominance of the business drivers for deploying solar

panels on buildings. The institutional property owners expect the deployment of solar panels to not only pay back the cost but also pay it back effectively. Such high expectation then leads to reluctant attitude towards incremental effort or medium-level outcomes. The many buildings in cities often have shading issues to more or less degrees, which diminishes the output of solar panels. Due to the institutional property owners' expectation of high cost-effectiveness, shading may become a 'killer-issue' for deploying solar panels in cities.

The extent of being cost-effective also depends on how the benefit and cost are calculated, which also vary from one owner to another, from one project to another. It involves some extent of discretion in terms of what is included in the calculation and how the inclusion or exclusion is justified. Moreover, it is difficult to estimate the exact figures to decide the extent to which a solar project is cost-effective. Concerning the theoretical point of view, the institutional property owners' consideration focuses on how wider process may be able to assemble solar panels and other elements. For example, solar panel deployment is assembled as part of a building refurbishment or a new build project. Therefore, institutional property owners' decision on deploying solar panels highly depend on their decision on the possible wider projects that can re-assemble[92] solar panels with their buildings.

Cost-effectiveness territorialises in the virtual space of institutional property owners' consideration on solar panel deployment on their buildings. Assemblages of actors and elements are more likely to be actualised from this virtual space when they are highly territorialised towards cost-effectiveness. For example, new build projects are able to assemble solar panels and buildings, as well as many other actors and elements, in a way with strong and

[92] As discussed before in the data-driven theme of comparing new and existing buildings, it is easier to assemble solar panels and buildings during the assembling process of a building. If this has not been done, as seen in most existing buildings, it becomes more difficult to re-assemble solar panels and buildings when many physical aspects of the buildings have been settled.

clear territorialisation of cost-effectiveness. A more comprehensive building maintenance or energy improvement project, as compared to only applying solar panels on buildings, is also more likely to territorialise towards high cost-effectiveness. Assemblage theory offers conceptual imagination of such aspatial territorialisation that relates the virtual space of institutional property owners' consideration to the actual outcome of high cost-effective projects involving solar panel deployment. This then enhances understanding of how the outcome of solar panel deployment on buildings emerges from institutional property owners' consideration. Moreover, as the theory suggests, expressive coding components in accordance with the territorialisation of cost-effectiveness are also found in the empirical data. Payback period and scale of projects are two important coding components, which will be discussed later.

The pursuit of high cost-effectiveness or ideal situations indicates that institutional property owners' deployment of solar panels may only take place in a small number of ideal situations or on a small number of buildings. This then further leads to the gap between the normative stance and empirical reality regarding climate change and sustainability. Although the normative stance stresses the 'urgency' of taking actions mitigating carbon emission, institutional property owners have not voiced such sense of urgency to a similar extent. Actions such as deploying solar panels and reducing emission from buildings would only be taken if institutional property owners encounter ideally suitable opportunities with high cost-effectiveness. Although there is evidence showing that institutional property owners are seeking such opportunities wherever they can, this would not challenge the priority of the business-as-usual. As argued by a respondent earlier (#26119, institutional investor), the sustainability team may be an additional branch serving the business in similar ways as the other branches, for example, improving reputation, reaping benefit, and ensuring regulation

compliance. This arguably differs from the role of any sustainability team being added in order to 'change' the business due to the 'urgency' of climate change.

It seems perfectly justifiable to say that actions are taken only when institutions can afford to take those actions. However, there seems little questioning or reflection on what could be meant by 'afford'. The normative stance seems lacking articulation of the urgency of climate change that is able to demonstrate why institutions could no longer 'afford' to prioritise business-as-usual. Actions have been taken gradually, as many institutional property owners are highly aware of the need to improve the energy performance of their buildings. However, the pace of such gradual action-taking does not seem to match the urgency as argued by the normative stance. There seems also a lack of assessment of such pace in specific issues, in addition to the general goal-statement of achieving carbon neutral in certain year, being it 2028, 2030, or 2050. Conversation, discussion, and reflection may need to proceed to be more specific and concrete in terms of how much action is adequate at certain time.

5.6 Payback Period and Economy of Scale

Payback period is mentioned frequently by respondents as a measure of the cost-effectiveness of solar panel deployment. As also mentioned previously, payback period is the time length it takes for the benefit of certain project to equate its cost. An explicit threshold of acceptable payback period has not been found in the empirical data, but, as implicitly indicated by some respondents, 20 years seem a maximum time length that is acceptable.

> *'So the business case really is, I think our first installation (about ten years ago with FiT) was about 10-12 year payback, and now they are between 10 to 20 years depending on where they go, just because the lack of revenue streams coming through from them.' (Respondent#18219, public institution)*[93]

[93] Opinion seconded explicitly also by Respondent#23219 (institutional investor).

Within 20 years, it may vary. Some institutional property owners may accept a project with the payback period of over 15 years, while some others may not even consider it if longer than 5 years.

> *'If five years ago you'd gone to a fund manager and said, here's a solar panel opportunity and the payback period is three and a half years, they would probably kick you out straight away. You know, anything beyond two years, they probably weren't interested. Whereas I think now, you can go to them with something of five years, and they'll think, yeah okay that's five years you know, if we've got a twenty-year lease in place, and yeah we'll consider that.' (Respondent#26119, institutional investor)*

Payback period is also considered alongside some other factors that may not be possible to accurately quantify yet, for example, the willingness of taking account of non-financial benefit such as (reputable) achievement in emission reduction and net zero targets.

> *'And if, you know, eight years or ten years or twelve years is too long, but the carbon footprint savings are high, then is that more important, as long as you are getting your payback at some point within ten to fifteen years, as long as you are significantly reducing your carbon footprint of the property then, is there a significant alternative advantage of the investment to offset the longer payback period. So I don't think there is a single payback period that we use, maybe it depends again on the type of funds investing in that solar panel.' (Respondent#14212, institutional investor)*

Moreover, it seems also discretionary depending on the specific person or personnel that are involved at certain points of the process. This may be demonstrating that coding components can also have dynamic characteristics in line with the complexity and emergence of assemblage. In the example of payback period, it is not an unchanging or universal figure. Instead, its specificity can emerge from the specific processes, actors, elements, and interactions in certain projects which may be potential assemblages being coded and territorialised. As worded by the respondent below, 'making sense' can be articulated as a qualitative benchmark emerging from

specific coding processes. Such emergent qualitative coding suggests a more holistic and case-specific understanding of payback period in line with many assembled parts and many related assemblages, as compared to pinning down any universal numeric figures.

> *'But I mean, for example, if there is an office building with, I don't know, a thousand square footage of roof, and you can only install the panels on fifty square feet of the roof, it just doesn't make sense for solar panels, right? It just doesn't feel like it will be a genuine contribution to reducing the energy consumption of the building, or saving the environment by installing two solar panels on the roof. So I think it's more of a common sense angle rather than, you know, is it a certain percentage of electricity consumption for the site.' (Respondent#14212, institutional investor)*

Regarding institutional property owners with portfolios that contain many different buildings, it is often mentioned that a case-by-case basis is adopted in terms of considering solar panels. It is acknowledged by the respondents that every building is different, no matter whether they are in the same or different portfolios.

> *'But I'm making the point that we are looking at the problem within [name of respondent's institution] project by project. So we've actually put a lot of PV over the last few years. We probably got about 300kw of PV across [name of respondent's institution]. So we've certainly done a lot.' (Respondent#122023, public institution)*[94]

The case-by-case basis means it is difficult to scale up projects beyond one case or one building. Although institutional property owners possess portfolios of buildings, they are unable to simply scale up solar panel installation across the portfolio. As discussed previously, institutional property owners do not have any urgent sense of obligation to roll out solar panel deployment across all their buildings. Most of their buildings may have met the minimum level of energy performance as required by relevant regulations. Their portfolio may have only a few

[94] Opinion seconded explicitly also by Respondent#26119 (institutional investor), and Respondent#14212 (institutional investor).

rather old buildings whose energy performance must be enhanced to meet the regulatory standard. For these small number of buildings, the case-by-case approach of refurbishing, as well as deploying solar panels if suitable, would be adequate for improving the energy performance levels in time.

> *'You have to choose your battles. You can't, you couldn't possibly choose to invest in environment technology across the portfolio. ... You know you do on two bases. You do it when the legislation dictates you to do it. And you do it when you can afford to do it. ... We are not on the obligation to take [the number of buildings, hundreds] buildings by the scratch on the neck, and you know to turn around, because we don't have a problem in that sense.' (Respondent#141025, institutional investor)*[95]

However, scaling-up is preferable due to the economy of scale. When the project of solar panel deployment is managed in large scale, for example, a large number of panels on a large size building, or one project covering a number of buildings located in close proximity, the potential of cost-effectiveness would be enhanced. For many institutional property owners whose properties are scattered across the whole country, the economy of scale is only possible concerning the large size buildings. Due to the geographical distance separating their buildings, they are unable to scale up a single project by grouping installation together for several small size buildings. It is difficult for them to simultaneously satisfy the project-by-project basis and the economy of scale.

> *'I mean we will generally start off with large roof areas, I mean if you got large roof areas. So a retail warehouse or an industrial unit would be the starting point. You got a reasonably large, because the economy of scale, you know. If you got 200,000 square feet you can send the contractor there, and to set up scaffold and access and you'd better off doing it on 200,000 square feet than 50.' (Respondent#26119, institutional investor)*[96]

[95] Opinion seconded explicitly also by Respondent#14420 (institutional investor).
[96] Opinion seconded explicitly also by Respondent#12713 (public institution), Respondent#111315 (public institution), and Respondent#23219 (institutional investor).

The scale of solar scheme prefers not only large scale of physical materials such as large building roof and large number of solar panels, but also adequately high demand of energy from the building occupation. As mentioned in the section earlier, selling the solar electricity to the occupiers is a solution to enable not only the tenants but also the landlords to benefit from installing solar panels. Therefore, to maximise the financial gain of large-scale solar schemes on buildings, the buildings are expected to have adequate electricity consumption pattern to consume, and hence the occupiers would buy, all the solar electricity generated on-site.

> *'You can never guarantee, the sort of, the occupier demand for energy, I think that's the thing. And you know, we've seen it, we've seen people, you know, this year go under*[97]*. We manage to re-let premises, but the demand, you know, they just went into storage, you know, industrial unit, whereas previously, there may have been a little bit of manufacture in there, a little bit mechanisation.' (Respondent#26119, institutional investor)*

The requirement of both large-size building as well as high electricity consumption then further limits the chances one institutional property owner may find within its portfolio to install solar panels.

> *'But just said, the building has to be right and there has to be the demand from the tenant as well. So it isn't quite as simple as tenants' saying yes it would be nice, because the building might not be suitable for it. And equally it might be that the building is suitable, but the tenant doesn't have the energy requirement in order to fulfil the required threshold of energy consumption.' (Respondent#23219, institutional investor)*

Therefore, potential assemblages of applying solar panels on buildings are limited to a small number of buildings where the coding components of short payback period and economy of scale can be satisfied. Short payback period needs to be explored on the case-by-case basis,

[97] Business across the UK was undergoing impact from Covid-19 lockdown, during which this interview was done.

while economy of scale is more likely to happen beyond single cases. There is little evidence in the data to support the kind of systemic large-scale transition that is envisioned by literature (Eames et al., 2013). It may take a long time for solar panels to be taken up gradually on the buildings held by institutional property owners, comparing two or three projects each year against hundreds of buildings in a portfolio.

> *'So we are effectively doing ESG audits on the properties one by one. And these are quite expensive, about 10,000 pounds per certificate, per audit. So it would not make sense to do all of the properties at the same time. It's just far too expensive. ... So we phased these audits over time. So let's say we do two audits, maybe three audits per year. So gradually understanding all of the improvement measures we can make on our property and CapEx, cost required, the time, and etc.' (Respondent#14212, institutional investor)*[98]

Moreover, to remind of the finding discussed in the earlier section, some institutional property owners have very little intention to take up solar panels on every building in the portfolio (Respondent#122023, public institution). It is not simply the matter of how long time it may take. Considering the (ideal) suitability of a building's condition, including roof space, orientation, structural soundness, and so on, there may be only less than ten buildings qualified for solar panel deployment, among hundreds of buildings in the portfolio. Prioritising among the portfolio to a large degree also filters out many buildings that are deemed unsuitable for ideal-output solar panel installation. This implicit filtering process among institutional property owners' portfolios then simultaneously dismisses solar panel deployment on many of the buildings in cities that inevitably undergo some issues such as mutual shading. Payback period and scale of scheme play the role of coding to enable the emergence of only cost-effective projects as actual assemblages that can involve applying solar panels on buildings.

[98] Opinion seconded explicitly also by Respondent#21519 (institutional investor).

As for a large number of buildings in cities, decision-making processes, and more accurately speaking 'decision-emerging' processes, are highly contextualised in the institutional property portfolios to which these buildings belong. Despite this great extent of contextualisation, information about such portfolio context is much less accessible or visible than the physical environment that surrounds the buildings. Deploying solar panels on one particular building may be considered in relation to some other buildings that are far away in distance and are scattered across the whole UK. Such relations and those other buildings that are related are highly relevant in understanding the (lack of) solar panel deployment on that particular building. However, the awareness and understanding of those relations are often missing. Under this portfolio-wise relational view, many buildings sit in greater proximity with the other buildings in the same property portfolio than with the buildings physically located close by. Institutional property owners oversee the many buildings in their portfolios, through which they can in a relative and comparative manner assess the payback period and scale of certain project such as deploying solar panels.

This empirical example of institutional property owners' deployment of solar panels indicates that coding of assemblage is highly dynamic rather than simple static threshold. The coding components of payback period and scale of projects do not generate universal threshold that might be applied to all situations or buildings. Instead, they are utilised as adjustable perimeters (DeLanda, 2016) that can adapt to specific situations, provided that the adjustment falls in the range where the coding components align with the territorialisation of cost-effectiveness. For example, as discussed previously, although institutional property owners pursue short payback period within the acceptable range, they have not intended to use any fixed threshold for every building. They would consider it in the specific context of certain building as well as in relation to other relevant projects in their property portfolios.

5.7 Institutional Property Owners' Consideration

Institutional property owners' deployment of building-applied solar panels is embedded in socio-material context in which various actors, material components, as well as intangible arrangements are related, organised, and coordinated throughout rather contingent processes. As suggested by literature and supported by empirical data, many of the relevant elements in this context have been well recognised. Important actors include institutional property owners, building energy consultants, solar panel contractors, building occupiers, real estate investors, property developers, constructors, and so on. Material components involve not only buildings in general but also specific aspects of buildings such as roof area, roof structure, roof types, location, orientation, height, and so on. In such building-applied context, solar panels are also closely related to other materials such as scaffold, mounting racks, batteries, smart meters, as well as other types of technological appliances for enhancing building energy performance. Moreover, helpful intangible arrangements involve policies like FiT and local plans, building energy performance assessment schemes like BREEAM and EPC, green lease, building energy consumption data, optimistic system design for installation, and so on. As suggested by the following respondent, a current challenge in improving building energy performance is to find and design solutions that combine available technologies in the right way. Likewise, as focusing on solar panel deployment, the challenge is to 'actually' assemble the many relevant elements that have been well recognised in the virtual space of possibilities.

> *'The challenge we've got is the integration of those technologies in the right way and in the right combination. … This is the challenge in how you plan an energy system that is decentralised, while still having a national energy system almost as a back-up, and one that works for the consumer, whether that be somebody in the house, or you know, a huge factory. It's how you find that right, sweet spot, with the right combination of technologies.' (Respondent#12713, public institution)*

As articulated throughout the thesis so far, this study focuses on the assemblage of institutional property owners' solar panel deployment on their buildings, and unfolds the articulation through engaging several supportive theoretical concepts and the empirical data. As also mentioned throughout the articulation, this study conceptualises institutional property owners' consideration as the virtual space of possibilities to enable process-tracing virtually as well as to reflect on emergence in the past and potential emergence in the future. Assembling and emergence are conceived of as continuing processes for which they concern not only new potential but also existing dynamics. Despite not acting as the sole decision-maker powerfully dictating solar panel deployment, institutional property owners are involved in such central role in the assemblage that their consideration is able to virtually cover most of the processes.

The above-mentioned relevant elements in the assemblage play their roles across such range of time and space, that the assembling of them cannot be understood as if a group of decision-makers gather together in a meeting at certain point of time. Instead, the assembling efforts also spread across the time and space throughout which each relevant actors play their roles at certain point, and their impact is carried forward by agencies or passed on to other actors through certain connections. Institutional property owners' consideration as the virtual site enables the observation of the assembling of the many relevant elements and the complex processes through which the elements are connected. Each element and segment of process are discussed in detail throughout the thesis, which supports the brief overview as outlined below.

To start with, buildings are historical individuals. Their physical shape is assembled through processes in which various actors have given input, and the impact of such input is carried by material agencies such as roof structure, building height, orientation, location, and so on. Many of these agencies are relevant for the consideration of solar panel deployment at later points of

the buildings' lifespan, if solar panels have not been deployed through the assembling process already. The institutional property owners at certain time take those relevant building aspects into their consideration on deploying solar panels. Some institutional property owners may need to engage other actors such as energy experts and consultants to audit the building in order to assemble those aspects into their consideration. Moreover, the ongoing lifespan of the buildings continues to involve existing and new elements that are relevant to solar panel deployment. Again, institutional property owners need to pay their efforts to assemble these elements into their consideration on solar panel deployment, for example, engaging building occupiers and gathering building energy data. Meanwhile, institutional property owners keep themselves updated about relevant regulation obligations, policy incentives, and funding opportunities.

Institutional property owners draw relevant elements into their consideration as much as those elements are accessible at certain point of time. Such assembling effort in their consideration enables them to identify further actors and elements that could push the process forward. In some cases, institutional property owners may be able to proactively seek to assemble those further elements as much as such effort could be afforded. In some other cases, institutional property owners may prefer waiting until relevant opportunities present themselves. The ongoing assembling effort in institutional property owners' consideration enables them to recognise the chance encounter of such opportunities. Institutional property owners are also able to engage other assemblages, as compared to individual elements, in order to facilitate the assemblage of assemblages which could mutually enhance each other. Other assemblages such as building retrofit are also given a space in institutional property owners' consideration on solar panel deployment, and the assemblage of solar panel deployment may be taken over and progressed forward by the assemblage of building retrofit.

Overall, the assemblage of institutional property owners' solar panel deployment is contingent in process, and has not spatially territorialised around any particular local places. Aspatial territorialisation and the coding components in accordance shape the historical emergence of the assemblage from institutional property owners' consideration as the virtual site where the assembling effort takes place. Cost-effectiveness is argued to be such aspatial territorialisation, and payback period as well as the economy of scale are the two main coding components currently. These aspatial territorialisation and coding help actualise assemblages to a small extent from the broad space of possibilities. In other words, although institutional property owners' consideration recognises and virtually assembles a large range of heterogeneous actors and elements, only a relatively smaller assemblages emerge into actual outcomes. Solar panels are deployed through only a small number of highly cost-effective projects, as compared to the large number of buildings held by institutional property owners.

By enquiring into institutional property owners' consideration, the empirical data in this study illustrates how outcomes have been emerging and actualising in current common practice, as discussed in the previous sections and outlined above. This enquiry also finds some data that indicates what may be missing in the current status of the assemblage, for which certain potential is still only virtually considered but not actually emerging. For example, as previously discussed, it is widely acknowledged that the role of building occupiers and the data of their energy consumption are important factors for institutional property owners to consider solar panel deployment. However, so far in practice it has been a challenge to engage occupiers or to gain easy access to their energy consumption data. In other words, occupiers and their energy consumption data are well recognised as important components of the assemblage of institutional property owners' solar panel deployment on buildings. Occupiers' role and consumption data are included in institutional property owners' consideration, but such virtual

inclusion encounters difficulties in actualising itself. The following respondent imagined that certain technology solution would help actualise such virtual possibility. Such technology solution may be a material component that is still missing from the current assemblage to support further emergence of outcomes.

> *'It's a real challenge, and it's something the whole industry is grappling with. And I think we need to find a solution to make it probably more technologically simpler, so that we use technology to get the data rather than just having to ask about it. I think that's probably what we need to do. But it is a real challenge.' (Respondent#1847, institutional investor)*

Another example was encountered during the discussion of the liability issue. As discussed previously, possible liability such as roof leak to some degree discourages further collaboration among institutional property owners, building occupiers, and installation companies in deploying solar panels. The following respondent that discussed this issue imagined certain kind of solution was currently missing. It might be technology component, or it might be certain kind of intangible arrangement. There might be some early form of possibility in the institutional property owners' consideration, but it has not been emerging.

> *'I think that is the one hurdle that is sort of preventing us, so whose responsibility it is (to deal with roof leakage after solar panel installation), which is preventing a lot more solar panels going up on suitable buildings that are up and down the country. … For the existing stock, if the hurdle could be, well that problem could be solved, I think you will see a lot more, so the existing buildings would have solar panels installed on them.' (Respondent#23219, institutional investor)*

5.8 Nottingham City Council's EnergieSprong Programme

Nottingham City Council's EnergieSprong Programme is found to be an example to illustrate the assemblage emerging and being actualised from the consideration by the council as an institutional property owner. In addition, this assemblage has been highly impactful for taking up solar panels on the council's buildings as well as in the local area of Nottingham. Although

this study has not focused on Nottingham City Council only, but the primary and second-hand data so far is able to showcase such an example to a certain degree. Similarly, this example is helpful for further substantiating the theoretical concepts of assemblage theory, and for demonstrating this study's application of the theory to empirical analysis. Further research focusing on Nottingham City Council's EnergieSprong Programme will be useful for finding more data to analyse this case in further depth, which would go beyond the scope of this study.

Regarding the wider driver, Nottingham City Council takes the same approach as many other institutional property owners. Firstly, the wider driver of sustainability is not solely about solar panels, for which the council also considers a whole suite of possible technologies and solutions. The council's consideration can be theorised as the virtual space of possibilities, as articulated previously. Secondly, the business driver as pursuing high cost-effectiveness is also essential for the city council. In fact, the energy projects have been cost-effective to such an extent that they become a source of revenue for the council.

> *'Because essentially the Energy Services division is a commercial entity. So the roll-out is to ultimately generate revenue that helps protect frontline services for the council. ... So in that respect, as I said earlier that the revenue generated by the team obviously helps keep that team employed in posts, but also anything surplus goes towards protecting frontline services, frontline jobs.' (Respondent#81218[99], Nottingham City Council)*

Cost-effectiveness as aspatial territorialisation is well substantiated by the composing of the Energy Services division in the council. As articulated previously, potential projects as assemblages involving solar panel deployment are territorialised towards cost-effectiveness. In other words, the territorialisation of cost-effectiveness helps actualise and stabilise potential

[99] With consent from the respondents, the use of some quotations inevitably specifies the respondents' institutions accordingly. In order to ensure the complete anonymity of most respondents in this study, and hence to prevent cross checking quotations on the purpose of guessing the identity of respondents and institutions, same respondents can be tagged with multiple different numerical codes in this thesis.

projects as assemblages emerging form the institutional property owners' consideration as the space of possibilities. In this example of Nottingham City Council, cost-effectiveness as territorialisation has encouraged the emergence of not only individual projects as assemblages but also wider programmes of projects as the assemblage of assemblages, for instance, EnergieSprong.

Moreover, the high degree of territorialising cost-effectiveness also provides particular 'virtual territory' where the actualisation of certain possibilities such as deploying solar panels could be enhanced and reinforced. Such 'virtual territory' is a more specific (territorialised) part of the wider 'virtual space of possibilities', and it is from the virtual territory that the emergence of potential assemblages is more likely to happen. To start with, the city council evidently has a strong interest particularly in solar panels, despite not the only interest.

> *'We have a positive attitude to these things because they pay for themselves. … We're putting solar panels on anything that doesn't move, really, because it saves us money in the long run and helps support other work we're doing.' (Councillor Sally Longford, Nottingham City Council)*[100]

More substantially, one manifestation of this interest is the extensive human resource specialising in solar technology that is employed in-house. The energy department of the council not only has a whole team dedicated to work on solar projects, but also has other teams that are staffed with colleagues that have strong professional background in solar technology.

> *'Essentially we've got an internal solar PV team, who is able to deliver solar projects from conception through to completion, and then provide service and operation management after as well. And given the scale and size of Nottingham City Council's solar PV portfolio it makes sense to manage and monitor that in house. … Effectively the solar PV team has a*

[100] News article, accessible in September 2021 at: https://www.theguardian.com/society/2019/nov/27/green-new-deal-nottingham-wins-top-guardian-award

> *background in solar PV. So that's the solar PV team covered. Within the (Midlands Energy) Hub team, we've got, out of ten of us, four with a strong background in solar.' (Respondent#81218, Nottingham City Council)*

The council's in-house human resource in solar panels is in sharp contrast to the other institutional property owners, whose whole teams of sustainability in general may only have one or two members of staff. This in-house capacity gives the council better chances of taking opportunities in the processes with high contingency. For example, these experts would be more accurate while estimating the cost-effectiveness of potential solar projects. They may also be more confident in investigating further to achieve such cost-effectiveness, instead of too quickly deeming it not realistic and dismissing it for the moment. Therefore, as proposed earlier, it forms a kind of virtual territory where aspatial territorialisation is effectively facilitated.

> *'We have got such a diverse mix of people with that experience that again I think it comes down to one, having that knowledge and experience from previous roles, and then the ability to ask the right questions and go find that right information, and of course, it helps the team stay on top with changes in legislation, changes in policy, and being able to keep up-to-date with what's happening on the technology innovation side.' (Respondent#81218, Nottingham City Council)*

With the council's Energy Services division providing such virtual territory, EnergieSprong is emerging as an assemblage of assemblages that is highly relevant to deploying solar panels on the council's buildings. The current EnergieSprong programme is the council's highlight which retrofits many of the council-owned social housing properties, and it includes solar panels as a key component.[101]

[101] Preciously many solar panels were installed on Nottingham's council-owned houses during a programme called Greener HousiNG (reportedly 4000 homes). It benefited from the UK Feed-in Tariff scheme which was active then. However, the Greener HousiNG programme was finalised already, and little has been found specifically about it during this study. EnergieSprong is claimed to be the next phase that follows up Greener HousiNG. (References: news articles accessible in September 2021 at: https://www.sustainableni.org/blog/uks-first-energiesprong-homes;

> *'The retrofit work requires new walls, new windows, and a new roof. The walls are manufactured off-site, and it's a bit like putting a tea cosy around the building or a warm jacket and a hat. There are solar panels going on the roof and there is efficient electric heating. And that means that the homes can generate as much energy as it uses. The model is the tenants and the landlords pay no more than they would have paid. It's paid for by the energy savings and the maintenance savings over a 30-year period.' (Emily Braham, Nottingham City Council & Nottingham City Homes)*[102]

This assemblage has been assembling opportunities and effort, including the innovative model of EnergieSprong, the hard work of the partners involved in implementing this model, as well as the contingently suitable case properties that are selected for the pilot phase. Meanwhile, the nature of the council's property portfolio and the perceived stability of tenancy relation help the council to draw these opportunities into consideration as well as to turn the consideration into implementation.

> *'In terms of the property selection, we picked a terrace of properties where there was already a great community. Some of the tenants have lived in their homes for more than 30 years. This had real benefits for the engagement process, and for the project. ... The properties we picked were difficult, but they were desperately in need of regeneration, which means people are more excited about the transformation.' (Project report, EnergieSprong, p.17)*[103]

The data indicates a certain degree of mutual reinforcement among the elements in the assembling processes. One element assembled in the assemblage may help further assemble

http://nottingham.remourban.eu/news/nottingham-city-council-to-pilot-energy-efficient-homes-of-the-future.kl; https://www.nottinghamcity.gov.uk/greenerhousing#:~:text=Greener%20Housing%20is%20an%20area,Sneinton%20(Windmill%20Lane%20area); https://nottenergy.com/news/tackling-nottinghams-cold-homes-and-high-energy-bills/; http://www.mynottinghamnews.co.uk/nottingham-first-to-adopt-revolutionary-housing-approach/)

[102] Media interview accessible in September 2021 at: https://www.ashden.org/winners/the-national-energy-foundation-and-energiesprong-uk

[103] Project report accessible in September 2021 at: https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5bb1130fa&appId=PPGMS

other relevant elements. The assembling of the new elements may strengthen the connections among existing elements. Therefore, the assembling process is contingent as one thing leads to another. The outcome at certain time is a snapshot of the emergence that is caused along historical and continuing processes.

> *'It's special. This is very unusual. We don't usually customise product (solar panel) like that for other customers. ... Because as a company, we believe in the EnergieSprong concept. We think that it's the way that you can increase the deployment of solar panel. ... So we believe the concept of EnergieSprong is a good way to regenerate the old housing stock, and hence we help Melius do this project. ... We know about EnergieSprong through Melius Homes, through David Adams[104]. They introduced to us, we liked that concept very much.' (Respondent#201420, Viridian Solar)[105]*

A highlighted innovative point of EnergieSprong is that the solution principally builds a new, customised shell around the existing house.

> *'A new roof, almost always covered with solar panels is lifted on top of the existing roof (sometimes even leaving the old tiles in place). In effect you build a whole new house around the existing one.' (Stuart Elmes, Viridian Solar)[106]*

This innovation blurs the line between refurbishment project and new-build project, which makes important difference as often stressed by other institutional property owners. Moreover, this solution is supposedly not transferable to buildings with various size and shape. The council-owned property portfolio has many houses that are suitable for this solution. Same components such as the bespoke solar roof and wall panels can be applied to similar houses with the same construction techniques and procedures. Moreover, groups and groups of these houses are located in such proximity that the economy of scale can be achieved by increasing

[104] Melius Homes (and David Adams) is the contractor in Nottingham's EnergieSprong programme.
[105] Viridian Solar is the supplier of bespoke solar panels to Nottingham's EnergieSprong programme.
[106] Blog article accessible in September 2021 at: http://www.solarblogger.net/2018/01/what-is-energiesprong.html

the number of buildings in one project. For example, a project can arrange scaffolding for a row of houses in one construction plan. Such portfolio gives the city council such different opportunity as compared to looking for large-size individual buildings in the portfolio by other institutional property owners. Referring to the theoretical context, the council's property portfolio has high potential of satisfying the economy of scale as one important coding component in shaping the emergence of new assemblages.

> *'Social housing has got lots of properties that are very similar. So you can reduce cost, drive innovation and create millions of net zero energy homes.' (Emily Braham, Nottingham City Council & Nottingham City Homes)*[107]

While other institutional property owners may be waiting for future new-build projects to generate the opportunity to incorporated more solar panels in the property portfolio, as indicated by one respondent in the earlier section (Respondent#122023, public institution). The innovative EnergieSprong solution enables Nottingham City Council to bring this opportunity into refurbishment projects as well, which may find opportunities from a much larger number of buildings.

Therefore, there have been many perspectives that give Nottingham City Council distinctive opportunities to proceed with retrofitting the properties and increasing solar panel deployment. Because Nottingham City Council owns many properties in Nottingham, the council's achievement in deploying solar panels on its council-owned houses can automatically translate into the high rate of solar panel deployment in Nottingham city. In this way, certain degree of spatial territorialisation regarding deploying solar panels on institutionally owned buildings may be also taking place in the local area of Nottingham. Such spatial territorialisation has

[107] Media interview accessible in September 2021 at: https://www.ashden.org/winners/the-national-energy-foundation-and-energiesprong-uk

been largely missing from the empirical data of this study so far, as discussed previously. This could be a theoretical proposition supporting further research focusing on the assemblage of Nottingham City Council's EnergieSprong Programme.

Chapter VI Conclusion

Representing great potential of promoting sustainability energy transition, deploying building-applied solar panels has been encouraged in the UK by various policy schemes such as Feed-in Tariff.[108] Based on the interest in institutional property ownership in the UK, this study has raised the question: what is considered by institutional property owners regarding deploying solar panels on their buildings?[109] Literature suggests that the essential consideration is about viable finance.[110] In other words, can the deployment be funded in any way? This essential consideration evolves through several specific issues that are often encountered by institutional property owners.

As clearly shown by this study's empirical data, the essential consideration is that the cost of installing and operating building-applied solar panels would be covered by the benefit of those solar panels generating energy in a certain period of time.[111] Although this essential consideration is to some degree implied by the current literature[112], this study has found it highly explicit in the empirical data. It plays a fundamental role and underlies the consideration of further related issues. The straightforward benefit comes from the saving of the buildings' utility bills since certain amount of energy that used to be bought from the utility grid can then be provided by the solar panels' generation.[113] In addition, if the solar panels system was registered under the UK Feed-in Tariff, it would benefit from FiT payment for the solar system's' generation with a payment rate determined in that policy scheme.[114] Regarding the

[108] See section 1.1, and 1.2
[109] See section 1.3, 1.4, and 1.5
[110] See section 2.1
[111] See section 1.2, 2.1, 5.5, and 5.6
[112] See section 2.1
[113] See section 1.2, 2.1, and 5.1
[114] See section 1.2, and 5.2

cost, the straightforward expense goes to the purchase of materials including solar panels as well as other system components, and the fees for appointing contractors to conduct installation, and perhaps also to provide maintenance service.[115] In addition, institutional property owners oftentimes need to consult relevant experts to specify the details of such purchase and contract, which can induce further fees of consultancy services.[116]

These above aspects of cost and benefit are presented in the literature as well as found in the empirical data of this study. However, this study has found that many aspects of the cost may have been rather overlooked by literature. Literature tends to highlight the decreasing price of the solar panels in recent years, and hence indicates the reduction in the cost of solar panel deployment.[117] In contrast, the empirical data of this study has emphasised the significant cost of consultancy, building energy audit, and so on. These aspects of cost are currently more significant than the price of purchasing the panels, and result in the difficulties in financially benefiting from deploying solar panels by institutional property owners.

There is always a time lapse, known as payback period, for the benefit of deploying solar panels catching up with its upfront cost. The average payback period of building-applied solar panel systems is currently estimated as approximately 8 years.[118] However, institutional property owners often have buildings whose ownership is not held by the same owner for such a length of time.[119] For the many institutional property owners that operate with a high turnover of property ownership, the relatively long payback period of deploying building-applied solar panels becomes a discouraging issue. Without further measures to address this issue, these

[115] See section 5.5
[116] See section 5.2, 5.5, and 5.7
[117] See section 1.2, and 1.3
[118] See section 2.1
[119] See section 2.1

institutional property owners are unlikely to see any chance of viable finance for deploying solar panels on those buildings that would not be held for long. Therefore, the turnover of property ownership would be considered by the institutional property owners regarding the subject of deploying solar panels on their buildings.[120] This consideration is particularly important for institutional property owners as compared to individual households. Due to the lack of literature focusing on institutional property owners in the issue of solar panel deployment,[121] this consideration is also to some extent overlooked.

Since the benefit of deploying building-applied solar panels is highly related to the buildings' energy consumption and utility bills, the lack of engagement or control in such consumption could discourage institutional property owners for deploying solar panels.[122] This issue known as split incentive draws the building occupation and tenancy agreement into institutional property owners' consideration on deploying solar panels on those buildings.[123] Moreover, the length of payback period in deploying solar panels on buildings also receives impacts from the physical features of buildings, such as the available roof space, the roof structure's capacity of bearing weight, and the height of the buildings.[124] For instance, if costly roof preparation is needed before any solar panel could be applied on certain building, such roof preparation would be considered in relation to solar panel deployment by institutional property owners. Institutional property owners that hold many buildings in various size and shapes are likely to need auditing service to clarify details of their buildings, for example, whether roof preparation is needed for solar panel deployment. The estimation of auditing fees would then also be drawn

[120] See section 5.6, and 5.8
[121] See section 1.4, and 1.5
[122] See section 5.1
[123] See section 2.1, and 5.1
[124] See section 5.5

into consideration on deploying solar panels.[125] As also mentioned earlier, the existing literature is not explicit about this relevant link between institutional property owners' hesitation in solar panel deployment and the costly fees of such auditing services and roof preparation.

Consequently, building-applied solar panel deployment is often operated as a part of bigger building-related projects that combine multiple objectives together into consideration. Such scale and multiplicity embedded in the projects further lead to the need of involving various partners and social relations into collaboration.[126] The institutional property owner as one of these many collaborating partners will need to take the partners' interests into consideration. Literature suggests that viable finance persists as a central consideration in the wider scope of project operation and partners' collaboration.[127] This study's data confirms that the consideration of cost and benefit plays a central role in linking solar panel deployment with many other aspects of institutional property ownership and other issues encountered by institutional property owners.

The central consideration of viable finance in deploying building-applied solar panels evolves through several issues that are often encountered by institutional property owners. In the wider scope of sustainable projects and partnerships, the central consideration of viable finance also evolves through conditions that are particularly relevant to institutional property owners.[128] Deploying building-applied solar panels in new build projects is indicated to be more likely to achieve financial viability than the existing buildings. The concern is on the potential as well as clarity of linking building sustainability features to property value or long-term rental

[125] See section 5.5
[126] See section 2.2
[127] See section 2.2
[128] See section 2.1, and 5.1

income. In other words, in addition to the relevance of several physical features of buildings as mentioned above, whether placed on an existing building or embedded in a new build project is also relevant to institutional property owners' consideration on deploying solar panels.[129] Furthermore, deploying solar panels on existing buildings may need to involve tenants as important partners.[130] Such engagement can be difficult if the buildings have a high turnover of tenancy, as similar to the issue of high turnover of property ownership. From the viewpoint of institutional property owners, their existing buildings with high turnover of tenancy may not be taken into consideration regarding deploying solar panels.

Literature has offered a few case studies with the scope of individual buildings that exemplify institutional property owners' considerations on solar panel deployment on their buildings.[131] These examples also showcase the multiple actors, elements, and relations that are vitally relevant in the deployment of building-applied solar panels by institutional property owners. Based on the above learning from literature, this study defines the assemblage of institutional property owners' deployment of building-applied solar panels, which engages those relevant actors, elements, and relations in contingent and emergent manners. The centre of the assemblage is the institutional property owners, which are linked to various partners and material components as far as it is relevant to deploying solar panels on buildings.[132] It is likely to also involve building occupiers, building energy consultants, specific conditions of buildings, Feed-in Tariff, building energy performance assessment schemes, and so on. As intended by the theoretical framework, this study defines such assemblage and applies the conceptual

[129] See section 2.3, and 5.1
[130] See section 2.1, 5.1, and 5.7
[131] See section 2.4
[132] See section 3.1, and 5.7

construct of assemblage theory to the analysis of the research question and the empirical data accordingly.

In addition to the fundamental relational view of assemblage theory, the dynamics of social relations is acknowledged by the concept of exteriority.[133] It is a misunderstanding of the theoretical accounts and an exaggeration to suggest that 'everything' are 'always' related. Instead, relations are dynamic among heterogeneous elements responding to specific situations. They can hence form or break apart depending on the relevance of the linkages under particular circumstances. Regarding the assemblage of institutional property owners' deployment of solar panels, the relations involved in institutional property ownership are of fundamental relevance and worth in-depth reflection.[134] In line with several other supportive concepts offered by assemblage theory's conceptual construct, the concept of exteriority in relations is explicitly articulated in the theoretical account,[135] which helpfully contributes to the analysis of this study. This serves as clearer guidance in theoretical analysis as compared to the general relational perspective as seen in a wide range of literature.

As common practice in the UK, institutional property owners commission the deployment of solar panels on their buildings, and then become also the owners of such solar panel systems.[136] While some institutional property owners manage their properties themselves, many other institutional property owners are represented by managers and investors as separate parties. The managers are given the authority to consider issues such as deploying solar panels, but the investors' interest must be taken into account as well. Such collaborating relation between the management experts and the investors plays an important role in deploying solar panels on

[133] See section 3.3
[134] See section 5.1
[135] See section 3.3
[136] See section 5.1

those institutionally owned buildings.[137] Moreover, such property management in many cases is done strategically from afar, whereas the buildings occupiers operate the buildings day to day locally. To deploy solar panels on those buildings, vital input and collaboration from the occupiers must also be taken into account by the institutional property owners.[138] In addition to the several currently active actors, many actors and their active roles in the past process of assembling the buildings are continuously represented by the many aspects of the buildings as the agencies. Institutional property owners' deployment of solar panels must be considered in the processes of interacting among all those actors and agencies across places and time.[139]

The relation of exteriority allows for the dynamics of interactions and the diversity of roles played by various actors, which leads to a high degree of contingency in the choices of collaborating partners as well as the encounters of opportunities.[140] Institutional property owners' deployment of solar panels goes through processes that span across the many actors and elements as mentioned above. At certain point of time, the push of the process could be held by particular actors or materials, which may only contingently come into institutional property owners' consideration. Therefore, the potential of deploying solar panels on those buildings only emerges from the contingent progress of the processes. However, such contingency must not be misunderstood as complete randomness. Having a high degree of contingency does not mean that institutional property owners lack proactive effort to deploy solar panel on their buildings. The complexity and dynamics between complete randomness and full determination are what assemblage intends to help conceptualise and understand.[141] The assemblage theory's several supportive concepts as well as the theoretical framework

[137] See section 5.1
[138] See section 5.1, and 5.7
[139] See section 5.1
[140] See section 5.2
[141] See section 3.8

constructed from these concepts insightfully enrich the aspects of theoretical reflection rather than only a dualistic choice between complete randomness and full determination.

The contingent emergence by itself cannot become transcendent to control or steer the processes from which the emergence must be continuously maintained.[142] The interactions among actors and elements may contingently enable the emergence of certain emergent properties, such as the potential of deploying solar panels. However, because the emergence is based on interactions rather than any singular actor, the emergence cannot be fully determined or controlled by singular actors. As demonstrated in this study's empirical data, there is little evidence showing that institutional property owners' intention would be able to drive the contingent process in any form of singular determination.[143] Instead, sustainability drivers specified as regulatory and business drivers are conceived of as encouraging forces pushing towards the outcome of deploying building-applied solar panels by institutional property owners.[144] Depending on the specific encounters, sustainability drivers may foster interaction of relevant actors to make progress towards deploying solar panels on buildings. However, those drivers cannot determine such outcome from the many other possible trajectories. The emergent drivers exist on the same ontological plane as the many possible interactions.[145] The emergent drivers exist side by side with the relevant interactions that support such emergence. The drivers can influence the ongoing interactions but not fully determining such interactions.

The regulatory driver of sustainable buildings demonstrates the emergence of emergent properties as ontological individual that differs from specific regulations. The driving force stems from the long-term interaction between sustainability regulations and other relevant

[142] See section 3.4, 5.1, and 5.7
[143] See section 5.2, and 5.7
[144] See section 5.3
[145] See section 3.5

actors such as institutional property owners. Institutional property owners consider the potential effect of several related regulations in terms of deploying solar panels on buildings, but the deployment is not determined singularly by any particular regulation.[146] The business driver of sustainable buildings corresponds to the essential concern of viable finance while considering deploying solar panels on buildings by institutional property owners.[147] The empirical data strongly suggests that institutional property owners are likely to consider solar panel deployment only when such deployment would add positive value to their main business concern, such as property value, rental income security, and financial management. Solar panel deployment is only additionally influenced by sustainability concern such as improving building energy performance which is underlined by the business driver. This study has found that currently institutional property owners' concern on sustainability per se (e.g. building energy performance) has not been able to dictate their business and investment decisions such as deploying solar panels.[148]

In contrast to the local focus of this study's empirical field work, there lacks any spatial sense of territorialisation around Nottingham regarding the assemblage of institutional property owners' deployment of solar panels on their buildings.[149] Institutional property owners have not included anything attached to the local area of Nottingham in their consideration of deploying building-applied solar panels. The Nottingham local authority's ambitious statement encouraging sustainable practice across the city has not made much impact among institutional property owners that hold properties there.[150] As discussed earlier, institutional property owners have been responding to the emergent regulatory driver regarding sustainability

[146] See section 5.3
[147] See section 2.1, 2.4, 5.3, and 5.6
[148] See section 5.3
[149] See section 5.4
[150] See section 4.2, and 5.4

practice to the extent that they find adequate. Such regulatory driver has not been reduced[151] to any singular individual regulation, and hence it also has not been reduced to the Nottingham's local statement. Despite the lack of any spatial territorialisation of institutional property owners' sustainability consideration in Nottingham, a few signs of such potential in the future have been indicated in this study's empirical data, which may be followed up by further research.[152]

The assemblage of institutional property owners' deployment of building-applied solar panels has an aspatial sense of territorialisation at cost-effectiveness.[153] In line with the significant concern of viable finance, a high degree of cost-effectiveness is likely to stabilise and territorialise solar panel deployment in institutional property owners' consideration. Such territorialisation helps actualise solar panel deployment from the virtual space of institutional property owners' consideration where many other possibilities also exist.[154] In other words, among the many relevant issues and concerns, institutional property owners attempt to only consider the potential of an ideal solar panel system which is expected to be highly cost-effective. Therefore, institutional property owners' deployment of solar panels is not determined on a general level of comparing benefit and cost, such as Feed-in Tariff or price of the panels. Instead, detailed consideration is required regarding specific cases, and the detailed consideration enhances the accuracy of estimating cost-effectiveness which then differs one case from another. As shown by this study's empirical data, institutional property owners are looking to invest in high cost-effective solar panel deployment through ideal opportunities. This differs from the normative stance that expects institutional property owners to simply

[151] The term of 'reduce' refers to the theoretical context of micro- and macro-reductionism. See section 3.4
[152] See section 5.4
[153] See section 5.5
[154] See section 5.5, 5.6, and 5.7

equip solar panels across all their buildings regardless of the differences among individual buildings.[155]

Payback period and the scale of project are argued to be two main coding components of the assemblage of institutional property owners' deployment of solar panels, in line with the territorialisation as cost-effectiveness. These coding components are frequently used in practice and mentioned in the empirical data.[156] As the theory articulates, these coding components play an expressive role in strengthening the assemblage's territorialisation towards high cost-effectiveness. Institutional property owners are likely to consider opportunities that have high potential of shortening the payback period and enlarging the project scale for deploying solar panels on their buildings.

Institutional property owners' consideration can virtually assemble heterogeneous elements that are relevant to deploying solar panel on their buildings.[157] The virtual assemblage is dynamically and gradually actualised over processes, for which the actual assemblage of institutional property owners' deployment of solar panels is continuously emerging rather than simply determined. Institutional property owners' consideration can represent the virtual space of possibilities which can potentially draw together relevant elements that only present themselves physically across various time and places. Such space of possibilities also helps institutional property owners engage themselves with relevant elements at certain time point. It can also help them recognise the potential of certain elements that may encourage the emergence of actual outcomes of solar panel deployment.[158]

[155] See section 5.5
[156] See section 5.6
[157] See section 5.7
[158] See section 5.7

This study has presented the assemblage of institutional property owners' solar panel deployment as a clear entity of focus.[159] However, such assemblage is empirically intertwined with other assemblages. The interactions among assemblages support the emergence of assemblages of assemblages. The actualisation of the assemblage of solar panel deployment may be enhanced by the potential emergence of other assemblages. Currently, solar panel deployment on buildings is often actualised as part of building retrofit, long-term maintenance, and new building development. These wider projects as assemblages of assemblages are often more likely to satisfy the dynamic thresholds of territorialisation and coding.[160] In other words, they are more likely to enable short payback period and economy of scale that prove to be adequately cost-effective for a range of relevant actors including institutional property owners. Nottingham City Council's EnergieSprong programme can be taken as a radical example of such assemblage of assemblages, which is worth further research.[161]

As shown throughout this thesis as well as this conclusion chapter, assemblage theory and its conceptual construct have contributed to significantly enriching the content of empirical analysis in combination with theoretical reflection. Under this framework, a wide range of relevant elements, aspects, and information are systematically drawn together, which aligns with the complexity and dynamics of the empirical issues. With its thorough conceptual construct, assemblage theory has offered not only theoretical insights but also a useful toolkit and clear guidance in applying the theoretical framework to empirical analysis. Recognising such strength of this theoretical framework could enhance not only empirical finding but also theoretical contribution from further research. Further research could also substantiate the

[159] See section 3.1
[160] See section 3.6, 5.5, and 5.6
[161] See section 3.8

assessment of the applicability of this theoretical framework based on integrating the conceptual construct into the research's specific social and material context.

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Appendixes

Appendix A: Content of Interview Guide

Interview questions for **portfolio managers**:

-1- What is your institution's general interest in sustainability, and how are you involved?

Follow-up prompt: Nottingham is a pioneer in sustainability. For example, the local authority aims at becoming the first completely carbon neutral city in the UK. Is your institution interested in contributing to this goal? Could the property portfolio contribute in any way?

Based on the answer to the above question, the composition of following questions will fall into one of the 3 scenarios below.

Scenario 1: there are projects of deploying solar photovoltaics.

-2- How is the solar project developed?

Follow-up prompt: what is the initial purpose? Who suggested to consider solar photovoltaics, and for what reasons? Who are the leaders and who collaborate? What resources are needed, and how are they acquired? How is the solar panel market condition perceived? How is the influence from regulations and politics?

-3- To what extent are there other organisations involved?

Follow-up prompt: Do you consider any of the involved organisations, perhaps your institution or not, that play the leading role of directing this project? Is there a shared vision among the involved parties? How is the consensus negotiated? Were there any actions dropped due to disagreement?

-4- What is your role, as the property portfolio manager, in developing the solar projects?

Follow-up prompt: How do you engage the property portfolio in the discussion about the solar projects? For example, while meetings with other project members, how do you represent the properties, or how do you tell them about the properties? What is important to say, or what is not (e.g. energy data, performance indicators, structure features, aging condition, etc.)?

-5- What are the advantages and disadvantages of solar photovoltaics?

Follow-up prompt: How much or what does the portfolio managing team need to know about solar panels? How do you seek this knowledge about solar panels? Have you considered other technology?

-6- To what extent is Nottingham a special case for you, regarding the solar projects?

Follow-up prompt: Speaking of Nottingham's goal to be carbon neutral or the reputation regarding solar projects, do these distinct Nottingham from other places from your institution's perspective? Does owning or operating properties in Nottingham offer any advantage that are missing in other places (e.g. knowledge about technology, networking opportunities and gatekeepers, presence and reputation, etc.)? Can this advantage be shared by other properties in your institution's portfolio?

-7- How do you see the future of solar projects in your institution?

Follow-up prompt: Besides the current projects, to what extent is sustainability incorporated in your institution's decision-making or long-term strategy (e.g. carbon reporting, corporate social responsibility, green lease, energy saving, etc.)? Who are involved in deciding the strategy (e.g. CSR, finance, facilities, tenants' union, etc.)? What impact from the long-term strategy particularly to your institution's real estate portfolio do you envision? Does this impact

or commitment depend on any changeable elements (e.g. leadership, regulation, market, Brexit, technology, etc.)?

Scenario 2: there are projects of deploying building-applied sustainable technology, but not particularly solar photovoltaics.

-2- What is the priority or focus of your institution's interest in deploying sustainable technology for the real estate?

Follow-up prompt: which technology is favourable? What elements are considered for the preference list? What is the outcome you want (e.g. satisfying carbon reduction targets, rating and certificate schemes, funding schemes, international networks, etc.)?

-3- To what extent other organisations besides your institution are involved in designing and achieving these projects of deploying sustainable technology?

Follow-up prompt: which ones are involved from the beginning of decision-making discussion? How are the involved organisations selected? Which ones are the essential ones that direct the development of the projects? Why is particular type of technology considered suitable?

-4- What are the advantages of the preference technology?

Follow-up prompt: How much or what does the portfolio managing team need to know about the technology that is deployed? How do you seek the knowledge about this technology? Did you consider solar panels?

-5- What is your role, as property portfolio manager, in developing the projects of taking up technology?

Follow-up prompt: For example, while meetings with other project members, how do you represent the properties, or how do you tell them about the properties? What does the project team want to know about the property and portfolio (e.g. energy data, performance indicators, structure features, aging condition, etc.)?

-6- To what extent is Nottingham a special case for taking up technology for properties?

Follow-up prompt: Speaking of Nottingham's goal to be carbon neutral or the reputation regarding solar projects, do these distinct Nottingham from other places from your institution's perspective? Does owning or operating properties in Nottingham offer any advantage that are missing in other places (e.g. knowledge about technology, networking opportunities and gatekeepers, presence and reputation, etc.)? Can this advantage be shared by other properties in your institution's portfolio?

-7- In your institution, how do you see the future of these projects deploying sustainable technology for the buildings in the portfolio?

Follow-up prompt: Besides the current projects, to what extent is sustainability incorporated in your institution's decision-making or long-term strategy (e.g. carbon reporting, corporate social responsibility, green lease, energy saving, etc.)? Who are involved in making these strategies (e.g. CSR, finance, facilities, tenants' union, etc.)? Does this impact or commitment depend on any changeable elements (e.g. leadership, regulation, market, Brexit, technology, etc.)?

Scenario 3[162]: there is not any project of deploying building-applied sustainable technology.

[162] Interviews in scenario 3 is unlikely to link to further interviews with energy managers or policy makers, for which this scenario is not expected for the latter two interviewee groups.

-2- What is your institution's interest in sustainability, sustainable cities or sustainable real estate, and how are you involved in pursuing those interests?

Follow-up prompt: Can you give an example project? Are there indicators to demonstrate this interest? Who are responsible for those performance indicators?

-3- How is energy performance of buildings in your portfolio?

Follow-up prompt: Since both UK national and Nottingham local policies have requirement on the level of building energy performance, how does your portfolio or the particular property in Nottingham satisfy this requirement? What are the actions taken so far?

-4- How does your institution think about its properties' energy performance?

Follow-up prompt: Do you see any potential projects or discussion within your institution to deploy some technology to further improve the sustainability of the portfolio?

-5- How do you think about the possible sustainable building-applied technology?

Follow-up prompt: What is lacking at the moment for initiating any projects of taking up sustainable technology for the portfolio properties? Are there any plans to seek the lacking elements in the future?

-6- What is the strategic goal of holding the current property portfolio?

Follow-up prompt: Besides carbon neutral city or sustainability, does your institution pursue any other different but possibly related visions regarding the property portfolio (e.g. affordability, long-term freehold, profitability, dynamic/adaptive disposal strategy, etc.)? What is or will be the comparative advantage of your portfolio? And how does the particular condition in Nottingham affect the consolidation of these visions?

Interview questions for in-house **energy managers**:

-1- What is your role for your institution that owns properties?

Follow-up prompt: what responsibility or achievement the institution expects from you? What are the projects being done? How do you work with other teams in the institution?

Scenario 1: there are projects of deploying solar photovoltaics.

-2- How are you involved in developing the solar projects?

Follow-up prompt: Why and how are these projects selected through the decision-making of your institution (e.g. property condition, funding availability, expertise and network, etc.)? Are there any troubles taking up solar panels?

-3- To what extent is Nottingham a special case for you?

Follow-up prompt: Does Nottingham provide any advantage for solar projects compared to other places? Who or what organisations make Nottingham advantageous?

-4- How are the properties in the portfolio suitable for solar photovoltaics?

Follow-up prompt: How and how much are you informed about the properties or property portfolio? What kind of information you need about the portfolio? In what way this information is provided by the portfolio management team?

-5- Besides the portfolio, what support or resources proved important for these projects?

Follow-up prompt: do you require any particular kind of solar panels? Are battery or storage equipment necessary? How is funding managed? Do you need consultancy from technology partners? How do you think about the renewable energy policies currently? Who may be able to provide the resources you need?

Scenario 2: there are projects of deploying building-applied sustainable technology, but not particularly solar photovoltaics.

-2- How are you involved in developing these projects of taking up technology?

Follow-up prompt: Why and how are these projects selected through the decision-making of your institution (e.g. property condition, funding availability, expertise and network, etc.)? Has solar photovoltaics been considered?

-3- To what extent is Nottingham a special case?

Follow-up prompt: Does Nottingham provide any advantage for certain type of technology compared to other places? Who or what organisations make Nottingham advantageous?

-4- What technology is particular suitable for the properties in the current portfolio?

Follow-up prompt: How and how much are you informed about the properties or property portfolio? What kind of information you need about the portfolio? In what way this information is provided by the portfolio management team?

-5- Besides the portfolio, what support or resources proved important for these projects?

Follow-up prompt: How is funding managed? Do you need consultancy from technology partners? How do you think about the renewable energy policies currently? Who may be able to provide the resources you need?

Interview questions for **external/contracted energy managers**:

-1- What is the purpose of the collaboration between you and the property institution?

Follow-up prompt: What responsibility or achievement the institution expects from you? What are the projects being done? How is the contract developed and negotiated?

Scenario 1: there are projects of deploying solar photovoltaics.

-2- How are you involved in developing the solar projects?

Follow-up prompt: Who and what facilitate the collaboration between you and the property institution for these projects (e.g. property condition, funding availability, expertise and network, etc.)? Who and at what stage solar photovoltaics is decided and fixed as the focus? Are there any troubles developing this focus?

-3- To what extent is Nottingham a special case?

Follow-up prompt: Does Nottingham provide any advantage for solar projects compared to other places? Who or what organisations make Nottingham advantageous?

-4- How are the properties in the portfolio suitable for solar photovoltaics?

Follow-up prompt: How and how much are you informed about the properties or property portfolio? What kind of information you need about the portfolio? In what way this information is provided by the property institution?

-5- Besides the portfolio, what support or resources proved important for these projects?

Follow-up prompt: How is funding managed? Do you need consultancy from technology partners? How do you think about the renewable energy policies currently? Who may be able to provide the resources you need?

Scenario 2: there are projects of deploying building-applied sustainable technology, but not particularly solar photovoltaics.

-2- How are you involved in developing these projects of taking up technology?

Follow-up prompt: Who and what facilitate the collaboration between you and the property institution for these projects (e.g. property condition, funding availability, expertise and network, etc.)? Has solar photovoltaics been considered?

-3- To what extent is Nottingham a special case?

Follow-up prompt: Does Nottingham provide any advantage for certain type of technology compared to other places? Who or what organisations make Nottingham advantageous?

-4- What technology is particular suitable for the properties in the portfolio you currently work with?

Follow-up prompt: How and how much are you informed about the properties or property portfolio? What kind of information you need about the portfolio? In what way this information is provided by the portfolio management team?

-5- Besides the portfolio, what support or resources proved important for these projects?

Follow-up prompt: How is funding managed? Do you need consultancy from technology partners? How do you think about the renewable energy policies currently? Who may be able to provide the resources you need?

Interview questions for **policy makers**:

-1- What do you consider the role of building-applied sustainable technology in achieving carbon reduction targets?

Follow-up prompt: As some policies such as the local strategy of Nottingham acknowledge that large potential of emission mitigation lies in the existing stock of buildings and outside of the planning system, for which this potential should not be overlooked by policy-making, how

could policy making promote the uptake of sustainable technology among urban buildings? Does certain policy target certain technology? Has technology been considered during the process of setting the carbon targets?

-2- To what extent are property-owning institutions involved in or influencing policy-making?

Follow-up prompt: How are property-owning institutions relevant or concerned? How are they different from individual owners? How is the collaboration or potential relations formed between policy makers and institutional property owners? Who else or which else interest groups do you see also involved? What projects are initiated as the outcome?

Scenario 1: there is a particular focus on solar photovoltaics.

-3- Who are interested in the focus of solar photovoltaics?

Follow-up prompt: What interest groups are important for the promotion of solar photovoltaics? Who advocate solar photovoltaics in the negotiation of carbon targets? What rationale draws these interest groups together (e.g. tackling climate change, tackling fuel poverty, etc.)? Does policy set up any rationale to facilitate the alliance of certain interest groups accordingly?

-4- How are the relations between institutional property owners and local authority/national ministries/sector governing bodies?

Follow-up work: How do institutional property owners and their interest get represented? Do they influence policy-making in any way?

-5- To what extent is solar photovoltaics favourable?

Follow-up prompt: How much does the policy-making need to know about the solar panels? How do you seek such knowledge? To what extent this knowledge is needed in negotiating carbon targets and policies?

-6- How is the policy focus of solar photovoltaics developed?

Follow-up prompt: Is there any conflict of interest, or any institution that opt to not collaborate? Are there any unintended consequences resulted from the policy rationale? What is considered important for the success of the solar projects?

-7- To what extent Nottingham exhibit any particular advantage in deploying solar photovoltaics?

Follow-up prompt: how are Nottingham property-owning institutions respond to the policy or involved in local policy-making such as local plans? To what extent is there a positive local market for solar panels?

Scenario 2: there is interest in technology uptake, but not particularly in solar photovoltaics.

-3- Who are interested in the focus of technology in policy-making?

Follow-up prompt: What interest groups are important for the promotion of technology? To what extent does it depend on the specific type of technology? What rationale draws these interest groups together (e.g. tackling climate change, tackling fuel poverty, etc.)? Does policy set up any rationale to facilitate the alliance of certain interest groups accordingly?

-4- How are institutional property owners involved in policy-making?

Follow-up prompt: How do institutional property owners or their interest get represented in deciding carbon targets? Do they influence policy-making in any way? How does certain type

of technology become the focus of discussion between policy makers and institutional property owners?

-5- How is certain technology more favourable than others?

Follow-up prompt: How much does the policy-making need to know about the many types of technology? How do you seek such knowledge? To what extent is this knowledge needed in discussing carbon targets?

-6- How is the focus of technology developed in policy-making?

Follow-up prompt: Has solar photovoltaics been considered? Are there any elements lacking in order to initiate discussion about possible solar projects? Have you seen any conflict of interest, or any institution that opt to not collaborate?

-7- To what extent Nottingham exhibit any particular advantage in deploying sustainable building technology?

Follow-up prompt: how are Nottingham property-owning institutions respond to the policy or involved in local policy-making such as local plans? To what extent is local market particular good for certain technology?

Appendix B: Content of Information Sheet[163] for Interview Respondents

Title of Proposed Project:

Reassembling for Sustainable Urban Transition: Institutional Property Owners' Deployment of Building-Applied Technology[164], case study of Nottingham, UK

Investigator:

Name: Dexter Du (PhD researcher)

Email: j.du@pgr.reading.ac.uk

Affiliation: Department of Real Estate and Planning, Henley Business School, University of Reading

Supervisor:

Name: Dr. Jorn van de Wetering

Email: j.t.vandewetering@reading.ac.uk

Contact number: +44 (0) 118 378 7407

Affiliation: Department of Real Estate and Planning, Henley Business School, University of Reading

[163] The respondents also received an information sheet about data protection under GDPR. This additional information sheet was suggested by the University Research Ethics Committee, and its content was not subject to the specific content of this study.

[164] The information sheet used a broad scope in the title of the research in order to increase the chance of success in seeking interviews. The discussion during the interviews focused specifically on solar panels as much as possible.

Purpose of the Study

This study aims at collecting empirical data for the PhD research about institutional property owners' decision-making regarding deploying sustainable building technology. This data will be collected through in-depth interviews with respondents who are informative about the case study of Nottingham, UK. Respondents are selected through the investigator's desk-based research as well as other respondents' recommendations.

Length of the Study

Each interview is expected to take about one hour to complete.

Operator of the Study

This study is part of the investigator's PhD research project, for which the investigator will be conducting the interviews with respondents. Most interviews will be in a format of one-to-one discussion, between the investigator and the respondent.

Freedom to Withdraw

After you have read this information and asked any questions you may have, we will ask you to complete an Consent Form. However, if at any time, before, during or after the interviews you wish to withdraw from the study please just contact the investigator. You can withdraw at any time, for any reason and you will not be asked to explain your reasons for withdrawing.

Arrangement of Interviews

Respondents will be invited to participate in interviews with the investigator to discuss the topic of the study. Interviews will be arranged during normal working hours in office environment or working places that both respondents and the investigator are comfortable with.

Besides, telephone interviews during working hours will be an alternative arrangement. Arrangement will be made individually between each respondent and the investigator.

Before Interviews

Respondents will receive this Information Sheet and Consent Form before the interview. Respondents are free to raise any queries or concern about the study to the investigator. The interview has no special preparation required from the respondents.

During Interviews

This Information Sheet and Consent Form will be handed out to respondents at the beginning of interviews. If respondents agree to sign the consent form, the investigator will proceed to discuss the topic of the study. Alternatively, consent for telephone interviews will be sought beforehand through emails. The discussion will be only related to the study, and will avoid enquiries of personal details. The interview will be audio-recorded, and the record will be kept completely confidential under the concern of University data management policy and general data protection regulation. Respondents still have the freedom to withdraw from participation at any point during the interview. Respondents have their right to contact the University directly if they become concerned about research misconduct.

After Interviews

Respondents are welcome to contact the investigator about any further enquiries after interviews. Respondents can also withdraw from participation after interviews. The investigator will not refer to the discussion with the respondents who decide to withdraw.

Confidentiality

Data storage, processing and deletion will comply with the University of Reading's Policy on Research Data Management and the University of Reading Data Protection Policy. If you agree to the interview being recorded, the audio recording will be destroyed after the data have been transferred to a different format. The data will be coded, encrypted and stored on a secure University of Reading network drive. Pseudonyms will be used for each participant (for example, Participant #1, Participant #2 etc) and personally identifiable data will then be deleted.

Results of the Study

Discussion with respondents will inform the investigator's PhD thesis, which will be archived in University depository. Respondents are welcome to ask for update about the study results if they wish so.

Ethics Approval

This project has been subject to ethical review, according to the procedures specified by the University Research Ethics Committee, and has been given a favourable ethical opinion for conduct. Respondents' participation are not subject to any financial payment or physical reward, but it will be much appreciated.

Appendix C: Content of Interview Consent Form

1. I have read and had explained to me by the investigator, Dexter Du, the accompanying Information Sheet relating to the project on:

Reassembling for Sustainable Urban Transition: Institutional Property Owners' Deployment of Building-Applied Technology, case study of Nottingham, UK.

2. I have had explained to me the purposes of the project and what will be required of me, and any questions I have had have been answered to my satisfaction. I agree to the arrangements described in the Information Sheet in so far as they relate to my participation.

3. I have had explained to me what information will be collected about me, what it will be used for, who it may be shared with, how it will be kept safe, and my rights in relation to my data.

4. I understand that participation is entirely voluntary and that I have the right to withdraw from the project any time, and that this will be without detriment.

5. I understand that the data collected from me in this study will be preserved and made available in anonymised form, so that they can be consulted and re-used by others.

6. This project has been reviewed by the University Research Ethics Committee and National Research Ethics committee where relevant, and has been given a favourable ethical opinion for conduct.

7. I have received a copy of this Consent Form and of the accompanying Information Sheet.

Name: ……

Signed: ……...……

Date: ……...……

I am happy to be included on a register of research participants for the purposes of being contacted about further studies by Dexter Du. Please tick ☐ (optional)

Appendix D: Codebook of Data Analysis

Institutional property ownership in solar panel deployment (data-driven)

Definition: the extent of institutional property owners' decision-making power in deploying solar panels on their buildings, and the extent of such decision-making power being taken by other related parties due to their share of property ownership in various ways.

Example of coded data:

'In the UK I think it's more landlord investments. So it's more direct ownership of the solar panels.' (Respondent#14212, institutional investor)

Predominant opinion:

Despite the dependence of many different actors and material components, the consideration and ultimate decision-making would pass through institutional property owners. Institutional property owners do not dictate such decision-making, but they play the main role of leading and overseeing such progress.

Agreed by all respondents.

Property management (data-driven)

Definition: strategic management of buildings and decision-making concerning energy performance of buildings such as deploying solar panels, installing LED lighting, replacing water boiler, and so on.

Example of data coded:

'And also [name of respondent's institution] does not own the properties. The properties are owned by the investors. All we are doing is managing those properties on behalf of the investors.

So [name of respondent's institution] is the landlord in name, because we are making decisions, or we are advising our investors. But ultimately [name of respondent's institution] doesn't own any single asset. We are just managing them for our investors.' (Respondent#14212, institutional investor)

Predominant opinion:

Despite the difference of property sectors and categories of institutions, all respondents agreed that property management was the immediate context where consideration on solar panel deployment was embedded.

Agreed by all respondents.

Real estate investment (data-driven)

Definition: trading property ownership, possessing share of legal title, and claiming benefit attached to such ownership, as well as supporting the improvement of property conditions to increase such potential benefit.

Example of data coded:

'So we are an investment management company, so we manage investment on behalf of fund, so our chief fund is [name of investor institution]. But we also have a fund that has about [number of investors, over a hundred] investors in it, which range from academic, pension funds, corporate investors. And we invest that money, or we take all that money together and invest that in properties. … We work on behalf of the pension fund. They would, it's their money we are investing.' (Respondent#18116, institutional investor)

Predominant opinion:

Real estate investment and the investors interest are important factors driving the consideration on solar panel deployment. This was declared most explicitly by the private sector institutions.

Agreed by many respondents (9/16). 7 respondents represent institutions whose main income did not reply on external real estate investment.

Operational control (data-driven)

Definition: operating building functions on a daily basis, and hence having access to information or data about such operation processes as well as building functions.

Example of data coded:

'Once the tenant is taking a lease and move into the building, they are in full control of which energy supplier that they use or how much electric they use, or I mean it's their business they are running from the site, and therefore their decisions on those ongoing items.' (Respondent#23219, institutional investor)

Predominant opinion:

Information about the operation processes of the buildings is important for any consideration of solar panel deployment.

Agreed strongly by the respondents whose institutions' buildings were mostly tenant-occupied (7/16). Other respondents were not much concerned since the buildings held by their institutions were mostly owner-occupied.

Buildings in continuous assembling processes (data-driven)

Definition: consideration of solar panel deployment may need to touch upon the whole process of bringing a building into being from the conception of ideas, through design and construction, to its continuous functioning, operation, and trading.

Example of data coded:

'But if when we built our stores from scratch, from new, we make sure that the roof can support solar panels, because we have to factoring the weight of them, and the fact that people need to be able to access them, so maintenance.' (Respondent#16726, private company)

Predominant opinion:

Many physical aspects of the buildings that are settled during building development and construction become rigid factors in the consideration of solar panel deployment.

Agreed by all respondents.

Contingent interaction (data-driven)

Definition: chance encounter specific to individual person or event.

Example of data coded:

'I reckon maybe six or seven years ago, there were a couple of consultants that knocked on my door with solar panel opportunities, and I remember, there was two sites that they did illustration for me.' (Respondent#26119, institutional investor)

Predominant opinion:

Many steps in the processes of deploying solar panels have been thankful to chance encounters. It has not always been the same standard procedure.

Agreed by many respondents (10/16). 2 respondents described solar panels as standard equipment for their institutions' buildings. Other respondents did not give specific instances to respond to this theme.

Regulatory driver of sustainability (data-driven)

Definition: regulation-related influence that encourages or enforces response actions concerning sustainable buildings, such as energy performance.

Example of data coded:

'Okay, so, in principle, we are not specifically interested in just solar. We are broadly interested in on-site renewable energy generation. And that has been initially prompted by planning regulations. So, depending on the local regulations, we have an obligation to have a minimum of ten percent of our energy use generated through on-site renewables. We have in the past experimented with wind. So two of our stores had actually wind turbines. But we realised that our stores and our business, solar is the best solution. So I would say since about 2005 or 2006 I think we have consistently gone with solar.' (Respondent#16726, private company)

Predominant opinion:

Regulation is an important factor to consider, and the standard for building energy performance will keep increasing. Solar panel deployment is helpful but not always essential for meeting the regulatory standards.

Agreed by all respondents.

Business driver of sustainability (data-driven)

Definition: income-related influence that encourages or enforces response actions concerning sustainable buildings.

Example of data coded:

'We have, you know, this is investors' money that we are spending. And we haven't got a mandate to, you know, we are not philanthropists, our whole reason is to deliver investment returns. If adopting ESG practice helps to do that, then clearly we will do it, but if not, then we won't.' (Respondent#26119, institutional investor)

Predominant opinion:

Positive contribution to the main business of the institution is an important incentive to consider solar panel deployment. It can be specified as attracting investment, securing tenants, creating savings from utility bills, and increasing revenue.

Agreed by most respondents (14/16). 2 respondents were aware of such potential contribution, but they did not consider such potential significant.

Nottingham factors (data-driven)

Definition: relevant concerns or conditions that are specifically located in the area of Nottingham.

Example of data coded:

'Eerm, any way special, I don't think so. We do lots of things in lots of places, but I don't think any of the Nottingham properties have any particular ESG criteria attached to them.' (Respondent#1847, institutional investor)

Predominant opinion:

There was hardly any local factor particularly attached to Nottingham.

Agreed by most respondents (14/16). 2 respondents concerned Nottingham more than others because they were much involved in the solar panel deployment projects in Nottingham.

Cost-effectiveness (data-driven)

Definition: potential and extent of positive result from comparing benefit and cost of certain projects.

Example of data coded:

'And the main issue is because we are such a tall building (7 floors with double-height ceilings), the main problem with that is its maintenance. Because in order to just get scaffolding up to the roof where you may be able to have it, you are looking at a very very large cost. So every time something happens with them, you are looking at a very very expensive cost. And due to that, it's just not realistic. Because that building is also so tall, we deal with extreme weather at the top of the building. So you have very very very very high wind. You have very very very heavy rainfall and things that come down. It's just not.' (Respondent#20613, private company)

Predominant opinion:

The ability to be cost-effective is an essential concern in the consideration of solar panel deployment.

Agreed by all respondents.

Concern of new or existing buildings (data driven)

Definition: whether embedded in a new build project or retrofit of existing building is relevant to the consideration of solar panel deployment on the building.

Example of coded data:

'Well they are just brand new buildings, so you had the opportunity to include solar in the design. You have, you know, the opportunity to create them with renewable energy sources. So that would be why, given the opportunity to provide renewable energy as part of the build. … They can design them in from the start, which is so much easier.' (Respondent#21519, institutional investor)

Predominant opinion:

It is much easier and more likely to deploy solar panels in new-build projects along with the process of building development and construction. Retrofitting solar panels in existing buildings is gradually practiced but feasibly cost-effective solutions are rather difficult to find.

Agreed by all respondents.

Concern of occupation (data-driven)

Definition: whether the building is occupied by the owner institution or tenant is relevant to the consideration of solar panel deployment on the building.

Example of data coded:

'One of the problems that I recall is, they (external party that proposed solar panel installation) haven't really considered the fact that we didn't occupy the building. There was this disconnect between, you know, our clients own the building, we manage it, but we have an occupier, and it's largely dependent on what the occupier's needs are, and what their consumption patterns are, and how much they will take, how much will go to the grid, and so on so forth.' (Respondent#26119, institutional investor)

Predominant opinion:

Owner-occupation makes it easier to consider solar panel deployment whereas tenant-occupation would result in much more complex issues.

Agreed by all respondents. 4 respondents were more optimistic about dealing with the issues of tenant-occupation than others (7). 5 respondents were less concerned by those issues because their buildings were largely owner-occupied.

Payback period (data-driven)

Definition: the time it takes for the benefit of certain project to equate its cost.

Example of data coded:

'And particularly the first solar installations we got were about ten years ago from now. And at the time there was Feed-in Tariff attached to the solar installation. So it benefited from increasing revenue from the panels which made it more cost-effective at the time. But likewise the panels have come down significantly, in cost, for a number of years. So the business case really is, I think our first installation was about 10-12 year payback, and now they are between 10 to 20 years depending on where they go, just because the lack of revenue streams coming through from them. A few other things.' (Respondent#18219, public institution)

Predominant opinion:

Payback period is an important measure while considering solar panel deployment. Currently a feasible as well as acceptable payback period for solar panel deployment is about 10 to 20 years.

Agreed by all respondents.

Case-by-case consideration (data-driven)

Definition: solar panel deployment is considered regarding the specific condition of each project, mostly each building. There is little intention of standardising such deployment and simply repeating actions across many projects.

Example of data coded:

'But I'm making the point that we are looking at the problem within [name of respondent's institution] project by project.' (Respondent#122023, public institution)

Predominant opinion:

Solar panel deployment is considered case by case.

Agreed by all respondents. Most respondents (14/16) considered it building by building. 2 respondents were involved in projects that deploy solar panels on multiple buildings, for which the consideration was not strictly building by building, but project by project.

Economy of scale (data-driven)

Definition: effect of shortening a project's payback period by increasing the scale of project operation.

Example of data coded:

'Well the information that I had from companies that installed them is that to put in the infrastructure to, well allow you to benefit from the solar panels being there, if you are only doing it for a small area it's quite costly to do. But with the economy of scale, the more solar panels you are putting up, the more efficient it is in terms of cost to install it assuming that the building uses the electricity.' (Respondent#23219, institutional investor)

Predominant opinion:

The extent of cost-effectiveness increases along with the increase of the scale of deployment. The large scale means to involve many solar panels in one installation project.

Agreed by all respondents.

Relation of exteriority (theory-driven)

Definition: Relations that do not define the identity of the related terms but connect them in exteriority. It is a relation established between the related terms to transmit influences. It connects them but do not constitutes them. (DeLanda, 2016)

Example of data coded:

'That is certainly one of the challenges, because how do you, whilst we are keen to work with our tenants on this, at the moment, there is no legal obligation, legal requirement for tenants to necessarily comply.' (Respondent#14420, institutional investor)

Emergent properties (theory-driven)

Definition: Properties that are caused by the interactions among the parts of certain social whole, for which such properties cannot be reduced to individual parts' rationale or characteristics. Similarly, such properties cannot determine or define the parts whose interactions are what cause the emergence of emergent properties. (DeLanda, 2016)

Example of data coded:

'We have found them quite beneficial on refurbishment projects where we have specifically said, yeah that’s the thing we want to do, because we see the opportunity, because of the height of the building or the direction it’s facing. So we tried to use opportunities that our buildings

give us, sometimes we've done it on new buildings but that's not the only solution, that's what I'm saying.' (Respondent#122023, public institution)

Ontological plane (theory-driven)

Definition: Certain kind of ontological status that describes the foundation of entities' existence. For example, emergent properties are on the same ontological plane with the individual entities and their interactions from which emergent properties emerge. There is no transcendent power that pre-determines the emergence or existence of such emergent properties. (DeLanda, 2016)

Example of data coded:

'Yeah, I think they had personal connection, something like that. They knew each other. And so then he, you know, they got to know each other. He suggested this, they investigated it, decided it made sense, then that was it.' (Respondent#1847, institutional investor)

Territorialisation (theory-driven)

Definition: 'Territorialisation refers not only to the determination of the spatial boundaries of a whole – as in the territory of a community, city, or nation-state – but also to the degree to which an assemblage's component parts are drawn from a homogeneous repertoire, or the degree to which an assemblage homogenises its own components.' (DeLanda, 2016, p.22)

Example of data coded:

'Well, it's difficult to say that the actual solar has a massive valuation impact. It's the wider negotiation, it's the wider transaction which is what we would value. We don't really look what the solar itself, we don't quantify what solar installation itself adds to the value. The valuation increases, the property's length of lease, because it's an investment property. And the fact that

it's got solar at the moment, I don't know what impact that actually has on the value.' (Respondent#21519, institutional investor)

Coding (theory-driven)

Definition: 'Coding refers to the role played by special expressive components in an assemblage in fixing the identity of a whole.' (DeLanda, 2016, p.22)

Example of data coded:

'If five years ago you'd gone to a fund manager and said, here's a solar panel opportunity and the payback period is three and a half years, they would probably kick you out straight away. You know, anything beyond two years, they probably weren't interested. Whereas I think now, you can go to them with something of five years, and they'll think, yeah okay that's five years you know, if we've got a twenty-year lease in place, and yeah we'll consider that.' (Respondent#26119, institutional investor)

Virtual space of possibilities (theory-driven)

Definition: 'A possibility space is the diagram of an assemblage that not only outlines what an assemblage is, but also the multitudes of what an assemblage might be. That is, the assemblage as it is actualised is laid alongside all the other virtual forms that are potentially real given the components available.' (Kurtz et al., 2021, p.303)

Example of data coded:

'So from a solar panel's point of view, and the installation of renewable energy generation on site, that's 100 percent on the kind of list of things to do for every single property that the two funds I work on are looking at. But we'll only do it if it makes sense for that building. And if it doesn't make sense to do solar panels and maybe there is something else we can do, or we

can offset instead. So solar panels are only one small part of the list of things that we can do on a property to fulfil our ESG, or net zero carbon strategies.' (Respondent#14212, institutional investor)

Emergent causality (theory-driven)

Definition: Causality as emerging from non-linear processes in which certain degree of chance encounters allow one thing to lead to another (J. Bennett, 2005; Bender, 2009; Wise, 2011; Anderson et al., 2012; Buchanan, 2017). This is in contrast to pre-determined blueprint in which linear links among a chain of events are guaranteed and unchanging.

Example of data coded:

'Eerm, oh, I don't know, that's, you know, I couldn't tell you. It could have been some networking events, the exchange of business cards, I don't know. Well actually, I think, I think. Now, you really ask me to delve deep into my memory bank here. I think, maybe one of our old fund managers that has since retired may have come across them in the past, because his wife worked in real estate and used them. It was something like that. I mean, who knows, how these people come across your desk. Probably something like that, oh okay, you know, next time we will give them a ring and we did, and the rest is history.' (Respondent#26119, institutional investor)