Constructing Seasonality: A Study of Annual Cycles and Patterns of Energy Demand within Social Life

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Abstract

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The increasing emphasis on decarbonising energy supply faces challenges posed by the intermittent nature of renewable sources and the varying quantities of supply throughout the year. Current strategies acknowledge these challenges and plan for a blend of fossil fuels and renewables to meet targets such as net–zero emissions by 2050. However, the role of social seasons in shaping and influencing the timing of energy demand is often overlooked. Fluctuations in demand matter because different types of seasons are closely tied to the spatial and temporal patterning of gas and electricity consumption, and to the scope for incorporating more renewable sources of energy throughout the year.

This thesis shows how patterns of demand relate to annual cycles and temporal rhythms. Rather than considering these variations as natural or 'normal', the thesis shows how the timing of demand relates to and is intertwined with the timing of everyday life. To investigate this, the thesis consists of three linked studies that have been designed to provide new insights into the relationship between social seasons and energy systems. The first shows how seasonal variations in demand are removed from view by methods of averaging and weather correction. The second shows how demand for energy for domestic heating and cooling relates not only to the weather but to changing standards of comfort. The third study investigates the annual cycles of supply and demand and the intertwining of multiple temporalities that extend the 'Christmas' season throughout the year.

Collectively, these studies provide an account of the relationship between social life, seasonal cycles, and the timing of energy supply and demand. In taking this approach the thesis shows how multiple seasonal cycles are embedded in the construction of energy supply and demand, and how these are shaped by social rhythms distributed across the year.

Contents

List of Figures

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Declaration

I hereby declare that this thesis is my own work and has not been submitted in substantially the same form for the award of a higher degree elsewhere.

Chapter One: Situating Seasonal Variation: Matching Energy Supply and Demand

Increasing renewable energy supplies is crucial if the UK government is to meet the goal of net–zero carbon emissions by 2050. As the harnessing of energy from sources such as solar and wind power become more prevalent, their inherent intermittency poses a challenge to the project of maintaining a stable and reliable energy supply.

Fluctuating patterns of gas and electricity supply and demand are, and will continue to be, important for the day–to–day operations of the national grid, and for the expectation that energy producers will supply enough energy at any given time, to meet both current and forecasted demand for gas and electricity. These forecasts take account of seasonal variation in how much energy is required at different times. As part of the process of defining the scope of seasonal variation, long–term averages are recorded and forecast by both the National Grid (2016) and DESNZ[1] (Department for Energy Security and Net Zero), in conjunction with the ONS (Office for National Statistics). These averages inform understandings of demand fluctuations and specifically, how gas and electricity supply and demand changes across the meteorological seasons of spring, summer, autumn, and winter.

As Gavin (2014), an analyst at the former DECC[2] (Department for Energy and Climate Change) argues in reporting about seasonal variations of electricity demand in the UK,

> "Typically, demand is higher in the winter than in the summer. The peak demands in the summer are usually lower when compared to the peak demands of the winter and the low demands of the summer are low when compared to the low demands of the winter. Demand for electricity tends also to fluctuate over the course of the day, determined by human activity… On average, the demand on (a) winter's day was 36% higher than on a summer's day" (p.74).

According to Gavin (2014), changing patterns of electricity use across the year are tied to changes in what people do at different times of the year. I argue that there is more to learn about these kinds of seasonal variation. Firstly, there is nothing normal or inevitable about current seasonal variation in energy use. Instead, patterns of consumption are formed from the development of infrastructures and associated social histories of energy demanding

[1] This department was previously BEIS (Department for Business, Energy and Industrial Strategy) until February 2023.
[2] This department changed to BEIS in 2016.

activities. Patterns of gas and electricity demand are different (more gas is used during the meteorological winter) though both gas and electricity consumption are affected in different ways, not just by meteorological trends, but by the social and temporal organisation of daily life. Instead of taking energy consumption as an inevitable or fixed feature of society, the aim of this thesis is to show how changes in consumption relate to evolving infrastructures, and social practices that vary across time and space.

The thesis is, at the offset, interdisciplinary in its approach, working with ideas and positions from sociological and STS (Science and Technology Studies) disciplines, and tying these to the field of energy research. For example, I bring together ideas about the construction of accuracy and knowledge, situated within STS (Wajcman and MacKenzie, 1985; Mackenzie, 1990), the study of energy demand and social theories of practice (Shove et al., 2012; Rinkinen et al., 2020), and relationships to time (Zerubavel, 1979; 1981; Adam, 1990) to reconceptualise seasonal variation in energy demand.

I demonstrate the significance of the social organisation of seasons for future energy systems that are planned to incorporate more renewable sources of energy. More specifically, I explain how seasons figure in the social and temporal organisation of everyday life and why this matters for the organisation of UK energy systems[3].

In this research, I focus on energy systems within the Global North, specifically in the UK, but I also work with examples from the USA, to show how infrastructures and socio–technical innovations emerged, and why they matter for studying patterns of energy demand. This decision inevitably limits engagement with perspectives from, for example, countries within the Global South, where energy systems are shaped by distinct socio–economic, political and infrastructural conditions. Seasonality in these regions contrast significantly with those in the Global North, particularly in relation to issues of energy justice, and the influence of climatic patterns, which offers a rich landscape for further research, but is not included in the scope of this project.

Nevertheless, the research agenda of the thesis requires specific decisions to be made about the choice of localities leading to a focus on the UK and in part the USA, rather than a broader comparative study. These contexts have been selected because of their well–documented histories of energy infrastructure development, and technological roles in, for example, transforming indoor heating and cooling provision. These locations provide valuable insights

[3] The processes by which supply and demand are managed across the UK, alongside the actors involved in its construction e.g., energy producers, regulators, and government departments.

into how energy demand is managed within systems that prioritise decarbonisation as a key policy goal, and more crucially, the socio-technical changes that have influenced the constitution of energy demand over time.

I begin this chapter by explaining why seasonality matters for debates about decarbonisation.

Decarbonisation Agendas

The UK government has legislated to reach net–zero carbon emissions by 2050 (BEIS 2020a), and a 78% reduction in greenhouse gas emissions by 2035 (BEIS 2021b:1). The Net–Zero strategy document (BEIS 2020a) suggests that meeting these targets will require decarbonising industries such as transport and steel to reduce the amount of carbon being emitted nationally. Notably, the key focus is on changing forms of supply embedded in the UK energy system, with efforts to shift supply to lower carbon forms of energy, such as wind, solar or tidal etc. This isn't a new discussion; over the past 30 years, efforts to increase the quantity of alternative sources of energy that are not fossil fuel based have resulted in a mix of both fossil fuels and renewable energies in the daily energy supply. With these changes, the UK has been able to shut all coal power stations[4] that had previously dominated electricity supply, with only 1.5% of electricity generation in 2022 coming from coal, compared to 2012 when coal consisted of 43% of the energy mix (BEIS 2023). The UK has also increased domestic supplies of nuclear, wind and solar. As the National Grid explain, "Zero–carbon power in Britain's electricity mix has grown from less than 20% in 2010 to over 50% in February, May, October, November and December of 2022" (National Grid 2023:para 18).

As of 2023, UK supplies of electricity come from seven different energy sources, alongside imports and storage options that feed into the grid. These are gas, wind, nuclear, biomass, coal, solar and hydro (BEIS 2023). This coexistence of multiple energy sources contributes to meeting fluctuating patterns of demand across the year, with sizeable spatial and temporal differences in primary energy used for generation throughout the year.

To partially decarbonise gas and electricity supply by 2035 (the target for the energy sector), several shifts will need to happen. Current policymaking is focused on increasing forms of renewable energy supplies and storage options, that can reduce the reliance on burning natural gas to generate electricity, which happens throughout the year and especially in times of peak demand, contributing negatively to carbon emission generation (Watson et al., 2019). Similarly, government policies currently promote alternatives to natural gas for heating, which

[4] From September 2024.

is the prevalent way of heating homes, fostering greater use of heat pumps or hydrogen technologies in order to reduce carbon emissions. These initiatives, alongside those across other sectors which are closely tied to energy consumption such as in transport (e.g., switching to electric vehicles as an alternative to combustion engines), are inspired by the goal of meeting net–zero emissions targets. This depends on increasing renewable energy generation capacity at a faster rate than at present. Some estimates have suggested 16 GW of renewable generation needs to be built every year for 13 years to meet the 2035 target, when the average build rate between 2017–2021 was 3.2 GW per year (SNC Lavalin 2022). In this context, the scale of anticipated change is unprecedented.

The goal of sizing up renewable energy sources raises significant questions. Electricity demand fluctuates across various time intervals–minute by minute, hour by hour, day by day, week by week, and month by month. These variations complicate the challenge of making greater use of renewable energy. As government figures for gas and electricity consumption across the year indicates, there are clear peaks in demand at different timescales, such as in the meteorological winter, when consumers are spending more time indoors (BEIS 2020b). At the hourly level, times between 7am–10am and 4pm–7pm are when electricity use peaks during the weekdays, outside of holiday periods (Torriti, 2017). With the current energy mix, ensuring supply is available at all times can be managed with both fossil fuels and renewable energy. However, if there is a significant reduction in the use of fossil fuels it will be increasingly difficult to plug the gap and ensure that supply matches current temporal variations in demand (BEIS 2020a). This presents a challenge for future decarbonisation planning for two intertwined reasons.

Firstly, renewable energy sources, such as solar and wind power, are known for their intermittent nature due to spatial, temporal, and climatic properties. This intermittency becomes a more pronounced challenge in the context of decarbonising the energy system.

Secondly, and assuming the rhythm of demand stays the same, decreasing fossil fuel use requires increasing and developing the storage capacities for renewable energies. Fossil fuels are essentially ‘stores’ of energy, as they can be managed in tanks and pipelines which can be fed into the energy grid. For supplies sourced from renewable energies in the form of electricity, the main storage solutions include battery technologies, which uses energy to charge a battery, and pumped hydro storage, which stores energy in the form of water that can be released to produce power. These indirect forms of storage are, according to net–zero strategies (BEIS 2020a) central to managing future electricity demand over long periods (weeks and months). When the wind is not blowing or the sun is not shining, storage technologies are the envisioned sociotechnical solution to ensuring a consistent energy supply, always supposing that the timing of energy–consuming activities remains constant throughout the year.

Current long duration electricity storage, such as battery technologies, lack the capacity to store electrical energy over the extended timescales required–several months or more–as indicated by forecasts for achieving net–zero carbon emissions (DESNZ, 2024b). This deficiency creates a gap in meeting present and forecast year–round electricity demand, necessitating alternative energy and storage solutions or a reduction in overall energy consumption. As sectors undergo decarbonisation, leading to an anticipated rise in electricity demand (e.g., increased adoption of electric vehicles and heat pumps replacing gas boilers), there is a growing consensus that renewable energy storage will be required to ensure forms of demand can be met at different times of the year (Martinot, 2016; IRENA, 2017; Hunt et al., 2020). This raises a crucial question: Can shifts in the size and timing of electricity demand, driven by the transition away from fossil fuels, effectively handle the anticipated load as the overall energy mix undergoes transformation?

This creates a two–fold challenge for ambitions to decarbonise the energy mix; confronting the challenges of intermittency and storage and understanding how this corresponds to the annual timing of electricity and gas demand, when the energy system is expected to be 'always on', and to cope with whatever demands are made of it.

This expectation also draws attention to the constitution of demand, how demand is conceptualised in the first place, and the assumptions that underpin how future energy systems and infrastructures are organised, and how this relates to the organisation of social life, given the planned socio–technical innovations forecasted over the next decade. For example, how will the timing of the morning and evening peaks for electricity use change if there is an increased uptake of heat pumps as a replacement for gas boilers and charging of electric vehicles (EV)? These changes may shift the timing of electricity peaks in demand (e.g., extending the evening peak for EV charging), which will need accommodating on the supply side.

This question draws attention to other more fundamental issues about how and when energy is consumed, and the challenges of moving away from fossil fuels, that can plug gaps in supply throughout the year. It raises further questions about how patterns of demand are organised across the year, and, to take a step back, how these came about in the first place, and whether they could be reorganised in the future.

As this thesis will show, temporal variations in gas and electricity consumption are socially made and reproduced. The combination of co–evolving infrastructures and domestic energy provision has facilitated energy consumption at different times of the day, tied to, for example, temporalities embedded in work and leisure. Research in this area has tended to focus on how gas and electricity use changes throughout the year as tied to temperature and weather conditions (Staffell and Pfenninger, 2018; Alberini et al., 2019).

My approach considers how annual and daily seasonal variations within social relations are variously reproduced or ignored by those who focus on the impact of outdoor temperatures on energy demand. For example, the increased demand for heating in December is frequently tied to colder outdoor temperatures, and the greater use of heating technologies (Hanmer et al., 2019). However, those same technologies shape ideas about comfort and indoor temperature. This combination of social expectation and technological provision, and outdoor climate, creates peaks in demand for energy at certain times of the year. To take this as a natural or inevitable situation is to suppose that it is normal to maintain 18–22°C all year round, whatever the season or weather.

This thesis is designed to understand these relations, and to show how patterns of energy demand depend on the social and temporal organisation of everyday life. This depends on a careful investigation of how variations in supply and demand are conceptualised, for example, in demand forecasting methodologies, and related strategies and interventions.

Instead of taking for granted or disregarding temporal variation in demand, my aim is to bring this issue into the open and to question the assumptions on which estimates, and demand forecasts depend. This investigation includes consideration of the assumptions that feed these representations, including the extent to which social relations are organised around annual changes in the outdoor climate.

In what follows I underline the multiplicity of 'social' seasons that influence the constitution and the timing of gas and electricity demand over the year and through the day. The point is not to determine whether the target of net–zero emissions is achievable, or to propose alternative measures and policies. Instead, the current policy agenda, and the focus on decarbonisation provides the context for this project and for the goal of better understanding how social rhythms and histories affect the timing of energy demand, and how past and present systems of supply are designed and configured.

The next section of this introduction outlines the fields of study that inform this research, explaining the focus on specific features of energy systems and their connection to the study of seasonality and variation throughout the year. I begin by exploring how energy demand is managed, particularly through techniques such as demand–side response, which, while not a distinct field on its own, currently plays a practical role in balancing energy systems and is a focus of policymaking in relation to gas and electricity grid management. This provides an initial foundation for understanding how variations in energy demand are addressed and managed throughout the year. I situate these discussions within broader fields of study, drawing on research in energy systems, social practices, and seasonality to show how these areas intersect and inform the analysis of temporal variations in energy demand.

Managing Peak Demand

Moving away from fossil fuels towards 'greener' forms of energy supply and demand, from the provision of solar and wind power, to the emergence of electric vehicles and heat pumps, are policy foci for the UK government to develop the changes deemed required to meet net zero carbon emissions by 2050 (BEIS, 2020a). This includes identifying ways of providing demand–side responses.

By demand side response (DSR), I refer to the "set of techniques, policies and market programmes which are designed to address the problem of peak energy demand" (Torriti, 2016:9). DSR is not 'one' technology, instead it is a series of different ways of addressing peak demand, from regulatory, to practical measures. By peak energy demand, I refer to when demand for gas and electricity is at its highest at various scales, minute, hour, daily, weekly etc. Peaks in energy demand can be problematic because supply is required to 'size up' to meet demand when it is high. This typically requires fossil fuels to plug any remaining gaps, or storage to be released into the grid to ensure demand can be met.

These peaks do not occur uniformly. There are different types of peaks depending on the type of energy and the patterns of consumption. For example, household electricity demand typically peaks during the early morning and early evening, as people get ready for work, and return home from work (Mattioli et al., 2013). Weekly, there are different peaks that are, for example, tied to social seasons. This is the case for the day that Easter Sunday and Christmas Day respectively fall on, shaping energy demand for the week. Annual peaks often occur in the meteorological winter, when demand for gas increases because of the need for heating. Each fuel source, such as electricity, natural gas, wind, or solar, has different peak patterns and temporalities. For example, renewable energy sources like solar or wind are inherently seasonal, tied to weather conditions affecting the generation of supplies.

These varying peaks create complexities for energy systems management, as each fuel requires different strategies to ensure reliable and efficient supply. Managing peak demand through DSR is one way for grid operators to manage demand by encouraging consumers to shift their energy use to off–peak times and reduce reliance on fossil fuels to meet peak demand.

In theory, DSR increases forms of 'flexibility' available for the management of energy systems, and to accommodate peak loads at different times of the year. As the National Grid argues, DSR can provide increased capacity and flexibility within electricity systems because it, "can help us soften peaks in demand and fill in the troughs, especially at times when power is more abundant, affordable and clean" (National Grid ESO 2024a:para 5). Opportunities to shift demand when it is at its highest create the potential for less 'peaky' spikes in demand, when DSR can accommodate generation capacity challenges.

The strategies for shifting demand, as already implied, are typically focused on immediate, present–day demands. DSR primarily aims to shift or reduce energy usage in response to current grid demands, pricing, or supply conditions, often to balance the grid more efficiently in the short term. However, there remain questions about how those who design DSR strategies can plan for how infrastructures evolve, with shifts toward more renewable sources, smart grid technologies, and decentralised energy production (such as home solar panels or microgrids), and how these infrastructure changes will impact energy demands and generation. Ideas about seasonality are fundamental to these debates, because responding to short–term variations in supply and demand are contextualised by both how social practices change throughout the year and how the timing of renewable energies is intermittent and seasonally fluctuates, in the case of solar and wind.

Authors working with theories of social practice have offered some insights into the scope of demand–side responses, and how possible 'interventions' for changes can be considered with the social and temporal organisation of everyday life in view. Empirical studies show that integrating DSR effectively into domestic energy policy planning presents several challenges. For example, Nicholls and Strengers (2015), in their focus on the social practices of households with children, find that there is,

> "limited flexibility in the regular disruption or permanent shifting of weekday routines outside the peak period. This is not to say that family routines are immovable. Instead, we

have argued that family routines are disrupted by predictable and unpredictable events and conditions and are essential for providing a sense of normality to which everyday activity can return" (p.123).

Their point is that demand–side responses, such as time–of–use tariffs, would have a limited effect on peak electricity consumption because of the family structures of households with children, and could lead to inequitable effects on low–income families, because specific social practices tied to family routines, such as bathing, and washing, cannot be easily shifted within the day.

This isn't to say that all domestic social practices cannot be shifted. Walker and Hope (2020), take a broader approach to the topic of time–of–use flexibility, moving beyond households with children. They found that non–daily energy–consuming activities are more adaptable to being shifted within the day, while also highlighting specific barriers to time–shifting practices, such as household demographics and social roles.

The key question is whether demand–side interventions can be integrated into energy system changes in a way that accounts for the socio–temporal rhythms of daily life, including societal synchronisation of work schedules, school hours etc. Ignoring these socio–temporal dynamics when attempting to shift consumption to off–peak times would ultimately fail to account for the complexities of energy demand, and the constitution of variation in gas and electricity use across the year.

While DSR is a key focus in energy policymaking, the supply side remains critical to these discussions, given its vital role in decarbonising energy systems and expanding supplies of renewable energy. For example, solar power, and the provision of PV panels have increased dramatically in terms of scale and capacity. By July 2024, 17 gigawatts had been installed, which is an 18,000% increase since 2010 (DESNZ, 2024c), with the introduction of 'feed–in tariffs' helping to support their uptake in recent years, and pay generators for excess supply contributed towards the grid. [5]

Unsurprisingly, with solar being reliant on the sun shining for electricity generation, patterns of supply are at their highest during the daytime hours, and are inherently seasonal, in the sense that generation is also highest in the meteorological summer, and the lowest in the meteorological winter. Similarly, the mismatch between when electricity is generated and the timing of energy–consuming activities is especially noticeable with solar power, as evening

[5] Feed in tariffs were removed for new applications from March 2019.

peak demand requires significantly more energy compared to the lower demand throughout the rest of the day.

The emergence of microgeneration technologies, including solar, suggests identifying new ways in which supply and demand can be met at a more localised level, with consideration of when energy–consuming practices take place. Fox (2023), shows in an analysis of 'prosuming' [6] solar power for low–income households, that there are opportunities to adapt some household routines, such as laundry, with the timing of electricity generation, and the opportunity to sell that electricity back to the grid can support energy equity efforts. Similarly, Bulkeley et al. (2016) explain how the introduction of smart technologies within domestic households that have solar, such as in–home displays, offers opportunities to reconfigure energy intensive social practices through new ways of self–governance. By looking at the potential of smart grids in the North West of England, these authors show how new socio–material assemblages of social practices can emerge that help re–align demand and supply. As they argue,

> "where new interventions are taking place which seek to embed the logic of solar as requiring smart electricity use, we find that households are developing and employing techniques for self–government that accord with optimising their personal use of the PV electricity that they generate" (p.20).

The suggestion here is that households can directly respond to when solar is generated by the sequencing of energy consuming social practices, temporally tying their energy use to supply. Social practices can be reimagined and reconfigured by placing supply in the hands of the consumers themselves, in this case, solar PV technologies. This is because reimagining supply and demand under decarbonisation agendas originating from forms for policymaking, transforms ideas about where we get energy from and how it is embedded in energy consuming social practices.

The relation between supply and demand at a local scale is particularly relevant to the growth of the community energy sector since 2010, which was supported by feed–in tariffs that guaranteed fixed payments to energy producers sending electricity to the grid and created opportunities to bring local energy generation into the hands of communities. This has led to efforts to decentralise energy systems and involve communities in partnership with the government in decarbonisation transitions.

[6] Production and consuming

For example, 'Energy Local' clubs are virtual smart local energy systems (SLES) that offer time–of–use tariffs for when local energy generators are producing, directly tying energy consuming practices to when generation is at its highest (Braunholtz-Speight, 2022). By integrating demand response measures, such as time–of–use tariffs, there are opportunities for communities to better manage these seasonal fluctuations, ensuring a more balanced and efficient use of locally generated renewable energy throughout the year.

There remain key questions regarding the role of DSR that are relevant for this thesis. For example, there are multiple types of temporalities that matter for how energy supplies, such as gas, electricity, and renewable energy, are constituted. According to Bulkeley et al. (2016), shifting solar PV practices would involve users adjusting their energy–consuming practices to align with periods of peak generation, such as scheduling energy–intensive tasks during daylight hours when solar power is most readily available. This requires users to consider both the daily cycles of sunlight and the socio–temporal patterns that shape when energy is typically used, encouraging users to modify their routines to take advantage of temporally specific moments of renewable generation.

DSR strategies need to address not only short–term fluctuations in supply and demand (such as hourly or daily shifts) but also broader, emerging seasonal cycles, such as increased cooling demands in the meteorological winter, if the electrification of heat increases demand for electricity at peak times. Understanding how these multiple temporalities intersect is crucial to reimagining energy systems and practices that embed increasing supplies of renewable energy, and the specific role of how infrastructures are being shaped within decarbonisation agendas. The significant challenge of DSR responses, is that it treats energy demand as moveable, through incentives such as pricing, which can shift demand at peak times.

As energy social science contributions from Walker and Hope (2020) and Bulkeley et al. (2016) identify, opportunities to move energy consuming practices are constrained because of how practices are sequenced and materially arranged. The socio–temporal structures of social life, from the working day, school hours, the calendar year etc, govern the temporal organisation of social practices domestically, therefore DSR is not the catch–all solution to balancing peak demand. Instead of focusing on technological solutions, my approach is to investigate the socio–temporal constitution of energy demand, and how it has been shaped over time by considering how socio–technical innovations, such as heating and cooling provision, and the sequencing of social practices tied to these technologies, matter for the organisation of patterns of energy demand.

Moreover, the thesis considers how reconceptualising seasonality can help shape future energy system changes by not taking seasonal demand for granted across the year, but by actively considering how practices are spatially and temporally situated, and why this matters for increasing forms of renewable energy supplies.

I turn next to consider how fundamental ideas about supply and demand matter for how future energy systems and their infrastructures are constructed. This ties into developing further how energy demand can be understood as defined by social practices, and how this matters for the development of infrastructures that support these practices. This requires a conceptual understanding of energy demand that acknowledges its social, temporal and historical characteristics.

The Socio–Temporal Constitution of Energy Demand

Understanding fluctuating patterns of gas and electricity consumption depends on knowing how these patterns are socially and temporally situated. Put simply, variations in the timing of demand do not arise by chance instead, they are formed from long social histories of energy consuming practices domestically (e.g., heating, timing of lunch and dinner etc). In characterising some of these rhythms I pay particular attention to the dynamics of gas and electricity demand, moving beyond explanations that take energy for granted in the abstract (such as an outcome or condition of functioning societies), and instead, consider how energy demand is constituted. I follow and build on Rinkinen et al. (2020:8), and on how these authors position ideas of demand. They argue that demand is:

1. "an outcome of social practices"
2. "made and not simply met"
3. "materially embedded"
4. "temporally unfolding"
5. "modified and modulated, deliberately or not, via many forms of policy and governance"

It is worth unpacking these points in turn, as each informs my analysis of seasonal variation in demand.

First, taking energy demand as an outcome of social practices centralises 'what people do' as the unit of analysis. Social practices are, according to Shove et al. (2012:14), comprised of materials (things, what objects are made of), competences (skills, techniques), and meanings (ideas, conventions) which constitute the organisation and elements of practices. By implication, energy demand depends on the activities of everyday life. Concentrating on specific practices such as heating and cooling consequently provides relevant insight into the timing of gas and electricity demand and how it changes.

Second, recognising that energy demand is not natural and that it is 'made' and not simply met is a necessary starting point for my analysis of how seasonal variations are organised across different timescales. Current patterns and rhythms of demand are not the same as they were 15 years ago, nor 30 years ago, in that uses of energy change along with infrastructures, technologies and practices.

In some sectors (e.g., transport and heating) the goal of decarbonisation implies that electricity demand will increase, for example with growing reliance on electric vehicles or heat pumps. This raises more fundamental questions about whether wider energy system changes, such as increasing forms of renewable energy supplies will inform new patterns and social practices, depending on how different kinds of infrastructures and societal rhythms evolve.

Thirdly, recognising that social practices have a spatial and temporal ordering to them suggests looking at social histories of energy consumption, to identify the relationship between practice and timing of demand. For example, work from the DEMAND Centre (Spurling, 2015) shows how sociotechnical innovations (for example, the implementation of gas central heating) modified activities within the home. In this example, gas central heating meant that bedrooms were no longer only used for sleeping in. When the whole house was heated, activities spread out upstairs and away from the living room, which had previously been the hub of family life. This, in turn, changed the ordering and timing of social practices. This proposition reminds us that social practices are spatially and temporally situated within a wider context of provision.

The final proposition, that demand is modified by many forms of policy and governance, speaks to a larger debate about what energy is for and about how policy making affects demand and not only supply. Recognising that energy demand is 'shaped' over time requires identifying 'who' is doing the shaping and drawing out the assumptions that underpin energy policy.

This shaping of demand is closely tied to the infrastructures that enable energy use in the first place, such as the national grid, pipelines, and pylons that connect supply to homes across the UK. These material networks not only facilitate the flow of energy but, in regards to policy, inform assumptions about how energy supply and demand are understood, such as ideas of capacity, flexibility, and the 'always on' status of the UK power system. In short, these supporting infrastructures are critical for understanding the role of demand, and how it is socially and temporally situated; they are intrinsically connected.

In his famous book on the electrification of Western society, *Networks of Power: Electrification in Western Society, 1880–1930,* Hughes (1993) describes these connections, as he writes about how electricity was provided in Chicago, Berlin, and London, showing how networks were created based on the constraints and local politics of the region. For example, London's electricity network was the product of a haphazard approach to constructing the localised patchworks of provision. By contrast Chicago's system was more homogenous as one company was involved in creating the network and facilitating electricity generation. Hughes demonstrates how energy systems are designed, operated, and understood in ways that embed varying expectations around supply and demand.

More recently, there has been a growing body of research not only into the social and technological histories of supply but also how social practices shape the infrastructures that they depend on. This is relevant for studying the timing of energy demand and considers how infrastructures are connected to the performance of social practices, and how this relationship is conceptualised. In the edited collection, *Infrastructures and Practices,* Shove and Trentmann (2019) define infrastructures as the, "material arrangements that enable and become integral to the enactment of specific practices" (p.4). The suggestion is that infrastructures and practices will continue to evolve in tandem.

Taking a similar approach, Holmes (2019) considers the continually changing relationship between land use, planning and the spatial constitution of electricity demand with the ongoing development of electricity networks, focusing on the city of Manchester. Within his analysis, electricity demand is viewed as an, "an outcome of intersections between multiple flows which are part of shaping activity in the city and the electricity system" (p.36). These ideas and definitions suggest that infrastructures matter for the timing as well as the scale of demand, and to debates about capacity and peak load. How infrastructures are tied to societal, and in particular seasonal rhythms is an important theme across this thesis. Previous studies of how infrastructures and systems of provision relate to societal rhythms and the temporal organisation of daily life are important in that they suggest that new forms of supply may have some impact on the timing of demand.

In summary, the temporal aspects of demand, encompassing hourly, daily, weekly, and seasonal variations, coexist alongside and as part of the sequencing of social practices and the organisation of supply and demand. As those interested in the temporal organisation of everyday life make clear, the meanings given to the day/week/weekend influences what people do (Zerubavel, 1989), and the sequencing of activities, all of which matter for when gas and electricity consumption takes place. It is this relation, the timing of demand tied to social practices, that I investigate in the thesis that follows. In taking forward these ideas my challenge is to show how infrastructures, social and temporal rhythms and patterns of energy demand shape each other. The next step is to show how these rhythms and patterns of demand matter for the study of seasonal variations. In doing so, I develop a narrative that evidences how seasonality is intertwined within energy systems, and should be of critical focus for considering how patterns of energy demand matter when considering the development of future energy systems.

Dynamics of Seasonality

To reiterate, social and natural/meteorological seasons matter for the temporal organisation of daily life. There are different ways of thinking about how this works. For instance, religious calendars often align with the seasonal cycles of agriculture (Battey, 2000). To give a different example, Davidson and Park (2020) find that the richness of seasons lies in their dynamic transformations over time–shaped by social interactions, institutions, and experiences. It is precisely these historically mediated changes in the structure and form of seasons that are of interest. As they argue,

> "Like other social constructions, seasons are not universal, timeless, or essential. Our definitions of seasons in general and of each season specifically, our collective and individual relationship to them, and to each other within the context of seasonality, adapt to societal changes…for example, in shifting customs that mark or shape our relation to seasonal rituals such as Halloween, one of the key events of autumn…. New social practices form in response to new social conditions…Seasonal traditions change in relation to wider social changes, changing our relation to the seasons in turn" (p.11).

As with the example of Halloween, social seasons can be reinvented through changes in social practices. Although it is now difficult to reimagine Halloween at other times of the year, the activities that constitute these occasions change, for example how Christmas was socially organised 100 years ago is not the same as we know it today. The organisation of seasons, and seasonal events within everyday life depend on the configuration of social practices and of connections between them across the year.

Although these are social processes, they are not unaffected by the weather. This is evident in studies of the effects of climate change, in not only changing outdoor temperatures, but evolving the composition of long–established social practices. Studies such as the 'Calendars Project', based in Norway, sets out to understand how seasonal markers are shifting and changing because of the weather, whilst also being shaped by long standing social institutions (Bremer and Wardekker, 2024). For example, Bremer (2021) writes about how agricultural rhythms are increasingly becoming detached from previously important dates and calendars. In Bergen Norway, the meteorological seasons of autumn and winter have continued to change with more high intensity rainfall events, which have led to farmers changing the timing of harvesting crops. The longer crops are in the ground, the greater the risk of an extreme rainfall event that will ruin them. Similarly, on the Coromandel peninsular in New Zealand, fishing rhythms have changed as snappers used to be exclusively caught in the meteorological summer, but now can be caught all year round, changing the spatial and temporal location of fishing in this area (Bremer and Wardekker, 2024).

These examples indicate that previously important timings of fishing and agriculture are changing, as cycles of fish, crops, and weather shift in response to global temperature change. Changes in climatic conditions will have an initial impact on the timing of such practices as gardening, harvesting, sowing etc, which will often start/end earlier in the year. This research is important in that it draws attention to the *changing* relation between weather and social practice.

However, the relevance of such studies has yet to be realised within energy research more broadly, despite the 'weather' being an important aspect of energy forecasting. For example, methods of forecasting, and energy modelling of current and future patterns of demand assume that there will be seasonal trends in gas and electricity use (Hunt et al., 2003), whilst acknowledging the role of outdoor temperatures in influencing energy use at different times of the year (White et al., 2017; Staffell and Pfenninger, 2018; Conevska and Urpelainen, 2020). The development of energy models for purposes of forecasting future demand are influential in wider whole systems approaches that develop different types of climatic scenarios. These approaches depend on an implicit assumption about demand–supposing that expectations of comfort will remain constant regardless of the technologies or infrastructures involved, and regardless of how energy supply is constituted and organised.

By contrast, some energy related social–science research takes a more historical view of changing expectations, and of how these affect patterns of demand across the day and over the year. For example, ideas about societal synchronisation help explain why there peaks in energy demand occur when they do (Mattioli et al., 2013; Rinkinen et al., 2018). For example, the fact that domestic energy demand in the UK rises between 7am and 9am on a typical working day, and then falls, relates to the convention of a 9am–5pm working day. Domestic demand picks up again when people return from work (Anderson and Torriti, 2018). Other patterns, such as school holidays, complicate these rhythms and the timing of when, for example, electric vehicles are, and are not on charge (Dominguez-Jimenez et al., 2020).

These examples are exceptional and as I have explained, seasonal and daily variations are not yet central topics in energy research. In response, one of my aims is to show how changing patterns of energy demand are tied to changing temporal rhythms and to how these relate to the use of energy–related technologies and infrastructures.

In this thesis, I investigate the relationship between annual and daily variations in demand and energy systems, examining how the convergence of multiple overlapping seasons (both social and 'natural') influences the timing of gas and electricity consumption and mirrors the organisation of various social practices. In taking this approach I recognise that more intermittent forms of renewable energy supply might be designed to match current rhythms of demand: alternatively, we might imagine new and modified annual and daily rhythms that are more closely aligned to fluctuations in supply. Either way, it is important to learn more about the temporal organisation of demand, within the context of future changes in the configuration of energy systems.

In the next section, I turn to this future aspect, and to the kinds of expectations that are in play regarding energy systems. For example, expectations of gas and electricity consumption often take seasonal variation for granted as an outcome of changing meteorological conditions, and sustaining an idea of a necessary indoor temperature. For these reasons, it is important to identify the sorts of expectations that inform policy making, and that lie behind the strategies and methods examined in the thesis.

Expectations of Future Energy Systems

As I position this thesis within the context of government plans to achieve net–zero emissions by 2050 and the proposed changes needed to meet these targets, the 'sociology of expectations' provides valuable insights into how these goals are perceived, anticipated, and shaped by different actors operating within energy systems. Studies broadly located in the 'sociology of expectations' refer to how, "the future is mobilised in real time to marshal resources, coordinate activities and manage uncertainty" (Brown and Michael, 2003:2). This area of study is relevant in how the future is mobilised in the present, in relation to how current energy systems are constructed and maintained, excludes other possible futures that may be enacted. For example, planning for 'net zero' carbon emissions by 2050, as set in legislative targets, forecasts a future that will reshape the policy landscape, through a reduction in petrol/diesel cars, decarbonisation of carbon intensive industries such as steel, and the increased use of renewable energy technologies for energy generation (BEIS, 2020a). Resources and activities in this area are directly tied to expectations of futures that are embedded in government policy.

These expectations matter for how future energy transitions are conceptualised within public and policy discourses. This is relevant, because as Van Lente identifies, "the [expectation] statement itself alters social reality: it creates, reinforces, or destroys a social connection, or linkage. It is a 'speech act'" (1993: 190). Similarly, Porter and Randalls argue that, "expectations have material and discursive effects. They act on the world. Inscribed in texts, bodies, machines and actions they help steer present futures or take on a life of their own" (2014:2). The identification of different types of expectations matters because of how ideas are woven into action and into the material arrangements associated with them.

There is increasing interest in how expectations figure in energy policy goals. Hielscher and Kivimaa (2019), in their research on the rollout of smart meters in the UK suggest that, despite challenges in increasing their adoption, smart meters have remained central to energy policy, due to their alignment with evolving energy policy goals. For example, smart meters have been used to manage different kinds of tariffs, such as time of use tariffs, before evolving in use by consumers for increasing awareness of when and where electricity is being used throughout the day. As the potential uses and data capabilities of smart meters continue to develop, they remain central to the policy imagination and integral to policy discussions. The expectations surrounding smart meters–including visions of consumer control and supply–side monitoring–have continuously adapted alongside broader changes in energy policy, reinforcing their significance in future developments.

Similarly, Kriechbaum et al. (2018) write about 'hype' regarding solar PV in Germany and Spain and about future expectations of potential and profitability. The authors found that expectations in Germany were embedded in fears about the economy, whereas in Spain, expectations were limited by worries about how the sale price of electricity would benefit from solar PV being deployed. Both these examples of studies into expectations and energy systems show how proposed technologies shape and influence current and future organisations of energy systems. This is of growing academic relevance, given forecasted changes in the energy systems in the UK.

In taking up some of these themes, this thesis shows how expectations of future supply and demand are folded into present strategies. For example, I provide a nuanced analysis by showing how expectations, of changing patterns of seasonal variation, and of accuracy and comfort, are mediated by infrastructures, temporalities and social practices, that are socially and materially constructed. Expectations have not come from nowhere; they are reproduced, and shape understandings of what energy systems can provide users.

As policy forecasts suggest, electricity demand is likely to increase because of the shift away from using fossil fuels for, for example, electric vehicles and steel production (BEIS Select Committee, 2023). These expectations also matter for how policies that support these changes are enacted and overseen. The thesis takes these ideas forward by identifying how current and future discourses surrounding energy system transitions embed assumptions about energy policy and ideas about 'normal' demand in how decarbonisation agendas are understood, and the implications of this for studying seasonal variations of gas and electricity demand. This includes thinking about how expectations of 'normal demand' and of seasonality are materialised in practice.

As I show, expectations not only influence how energy policies are developed but also play a crucial role in shaping the narratives and perceptions around emerging technologies. By analysing the performativity of these expectations–that is, how they have an effect in practice –the thesis connects to broader debates in STS and economic sociology, focusing on how such discourses inform socio–technological changes and the direction of policymaking.

I turn next to the role of expectations in shaping how technologies are perceived and discussed, especially in policymaking. A key focus in science and technology studies is understanding how the concept of performativity–briefly discussed in the previous section in relation to expectations–affects technological change. This conceptual analysis is closely related to academic research into performativity, as I explain in the next section.

Shaping Socio–Technical Changes

In recent years, the 'performativity paradigm' has emerged, investigating how economics as a discipline actively contributes to shaping financial markets, instead of being used to simply describe or analyse activities in this area. In short, the claim is that economic theories and practices help bring into existence the very behaviours and structures that are being described. Michel Callon, a key contributor to these debates, outlines how economics, broadly defined as "all activities, academic or otherwise…aimed at understanding and analyzing or equipping markets", provides the tools to build specific economic environments, through the "utterances that determine the environment necessary for their survival" (Callon, 2008:332).

Similarly, Donald Mackenzie (2006; 2008) argues that performativity is embedded within three forms of theoretical thinking:

1. Generic–Whenever actors utilise a theory.
2. Effective–When theories are used, and therefore affect social realities.
3. Barnesian–in reference to the sociologist S. Barry Barnes, when a theory becomes self–fulfilling and actively creates economic processes.

These different forms of performativity matter for studying economic and financial systems because they reveal the relationships between theory and practice, illustrating how economic models and concepts can not only reflect but actively shape the behaviour and structure of markets.

For the study of energy systems, as Silvast (2017) points out, energy markets are embedded in these different kinds of behaviours. For example,

"an energy producer and energy retailer signing a futures contract in an energy stock exchange to hedge the energy price… if at the time of delivery, the actual energy price is higher than the hedged price, the producer has to pay the retailer this price difference…economic ideas about mutual obligation are hence reinforced by these actors and activities." (p.7).

By using the example of a 'futures contract' in energy markets, Silvast shows how economic theories and ideas–such as the concept of mutual obligation–become embedded in the practical activities of market actors, and that these behaviours, such as hedging energy prices, reinforce economic theories within social life. A similar suggestion of reinforcing ideas and theories can be made within energy policymaking, as Aykut (2019) finds in an analysis of energy policies in France and Germany in the 1970s and 1980s. By viewing energy policy as a contested field of competing narratives and models, they explore how energy forecasts helped establish energy policy as an independent domain focused on selecting between various energy supply options. However, this paradigm was challenged in the 1970s and 1980s, when energy policy was shifted towards new modelling techniques, centred on issues of demand and renewable energy, developing new political alliances in the process. As Aykut concludes,

"Models and forecasts occupy a central position in energy debates. They propose the future–visions that populate public discourse, provide market actors and policy–makers with ontologies to understand energy systems, and shape wider policy networks in scenario–building exercises and through the circulation of models across social spaces. In doing so, they can stabilise dominant framings, practices, and policy assemblages, or rearrange and reorder policy worlds, thereby contributing to the formation of new assemblages that enact alternative conceptions of energy policy" (Aykut, 2019:27).

Aykut's (2019) suggestion, that future–visions shape policy networks, informs how I approach the topic of forecasting energy demand, and how I think about the current and future planning of energy systems, as these embed specific assumptions, such as increasing electricity storage capacity, and the design of forecasts of supply and demand in 2050. This is particularly the case within forms of energy demand modelling, including proposed increases in forms of supply, demand, and storage available throughout the year (National Grid 2024b). The assumptions embedded within these forecasts–such as anticipated technological advancements in storage or shifts in energy consumption patterns–can either reinforce or open up new possibilities for managing supply and demand. Specifically, the thesis investigates how forecasts and representations of energy demand assume that seasonal demand will change over time, and how future energy systems are planned with this in view. In doing so, I position the underpinning debates about decarbonisation agendas within an analysis that considers the sociotechnical dynamics of energy demand, its infrastructures, and the expectations on which these are founded.

One such example of current debates about these futures is the operational embedding of 'system flexibility', within energy policy in considering how future energy systems are designed. Blue et al. (2020) suggest that ideas of flexibility are performative because of how flexibility is defined and used within energy systems (for example, as a need, as a quantity, as a commodity etc) have real effects. As they argue,

"Infrastructures and systems of provision and pricing do not determine the extent and the timing of demand, but decisions about the sizing of systems, including forms of storage and distinctions between flexible and inflexible or non–negotiable demands, are real in their effects" (p.939).

By framing flexibility in these ways, actors within energy systems influence decisions that guide the design and direction of energy system transitions, based on an extended set of expectations. The choices made shape how these systems evolve and adapt, including the lines of enquiry and types of questions taken forward that are considered relevant or valid as part of current debates. As both Aykut (2019) and Blue et al. (2020) establish, the way concepts like flexibility are framed within energy policies, and through forms of modelling, not only influence the design and functioning of energy systems but also affect the broader trajectory of how they are embedded within forecasted futures of energy use.

This assumption influences how future energy systems are designed and planned, with particular emphasis on ensuring sufficient supply and different forms of 'flexibility' to meet peak winter demands. By identifying how ideas of expectations and performativity are relevant to the study of energy systems, this thesis contributes to ongoing discussions about how future energy systems are conceptualised, with changing patterns of supply and demand in view. I do this by critically examining the lines of inquiry and underlying assumptions of understandings of seasonality, and how they are integrated into portrayals of energy demand within the social and temporal organisation of everyday life.

These debates frame my approach to understanding how representations of energy demand shape public and policy discourses surrounding variations in gas and electricity demand, specifically in reference to methods of averaging and statistical correction of energy consumption. These discourses, and associated expectations play a crucial role in shaping concepts of seasonality; however, these elements do not operate in isolation, as infrastructures, supply chains, and the temporal organisation of social practices collectively reinforce and sustain specific interpretations.

These discourses matter for socio–technical changes and for the design of future energy systems. For example, since gas consumption increases in the meteorological winter, commonly tied to colder outdoor temperatures, modelling and forecasts of gas consumption often assume higher demand during this period. The approach taken in this thesis, is to describe how these approaches and traditions affect which proposed transitions are considered, with the timing of energy consumption, and increasing forms of renewable energy supplies in view. In short, this research follows assumptions and their effect on energy systems.

Having established the core debates on which I draw and to which I contribute, in the final section of this chapter, I explain the design of the thesis, and how I have structured the research that follows.

Thesis Design

So far, I have described and positioned my research in relation to current decarbonisation agendas, including how I begin to define the constitution of gas and electricity demand. I have introduced the dynamics of seasonality within social life, and debates about expectations and performativity that for some actors, inform the development of energy systems. From these topics, three emerging themes inform the design of the thesis.

First, is understanding the relationship between energy demand and the social and temporal organisation of everyday life. This is particularly relevant to decarbonisation agendas, and issues of peak demand: as I explain, the timing of demand matters for balancing gas and electricity demand at different times. Instead of analysing technological solutions to managing demand, I raise further questions about the social, temporal and historical constitution of energy demand. By probing these further, there are opportunities to understand how demand has formed over time, with infrastructures, socio–technical innovations, and practices in view.

The second theme is how energy demand is represented and why this matters for the study of seasonality. This relates to the assumptions embedded in energy forecasts and the expectations set around future energy patterns, especially with the predicted role of current and evolving technologies shaping those patterns. This theme originates from how issues of performativity and expectations matter for studying energy systems. There is further work required to identify where normative assumptions of seasonality are located, and how this combines with how future energy system transitions are discussed in public and policy discourses.

Finally, the third theme centres on the role of annual cycles and rhythms in the constitution of social seasons. This cross–cutting theme is situated at the intersection of the organisation of social practices, and the constitution of energy supply and demand, by investigating how future energy transitions require consideration of how socio–temporal rhythms matter for structuring social life and how this aligns with the timing of energy demand by the minute, hour, day etc.

These are substantial topics, and the thesis begins by reviewing positions and ideas that speak to these concerns. This sets the scene for a series of empirical enquiries designed to investigate aspects of these themes, to reveal and foreground seasonal variations in demand, as these matters, and for the prospect of decarbonising supply.

In taking this agenda forward I have constructed a series of research probes, inspired by creative design research studies (Gaver et al., 1999; Hutchinson et al., 2003; Graham et al., 2007; Collins and Evans, 2015). This method depends on the deliberate and necessarily selective investigation of especially revealing sites or cases. The chosen techniques of investigation vary from one case to the next, depending on the purpose of the probe.

My first probe, or line of enquiry, shows how seasonal variations are ‘flattened’, removed, and bypassed in research that seeks to assess trends in energy demand. To understand this phenomenon, my method is to follow statistical techniques of energy representation and to learn about how ‘weather corrected’ data was produced. In essence, this probe allows me to show how knowledge about variation is configured in the realm of energy research and analysis.

The second ‘probe’ addresses the complex relation between social and natural seasons, doing so by carefully and selectively investigating changing interpretations of comfort as these affect what are known as heating and cooling seasons. Again, this requires selective analysis of secondary material describing the ‘seasons’ in these terms.

My third probe reveals the coexisting multiplicity of seasonal variation, and to complicate otherwise simple narratives of ‘the seasons’ and energy demand. To do so, I take ‘Christmas’ as an example, and work back to show how diverse annual cycles (of producing turkeys, toys, and trees) converge, and how this matters for the reproduction of seasonal rhythms, and for understandings of what constitutes ideas about seasons.

Because of this approach, the thesis is in two distinct but connected parts.

Part One–Situating the Thesis: Social Rhythms and Energy Use

The first part of the thesis sets up the core themes of seasonal variation in social life and in energy demand and situates these themes with reference to debates about the relation between the social and the natural, and between energy and society. The purpose of Part One is to review different ways of thinking about the relationship between energy systems and social life and about how everyday activities relate to indoor/outdoor climates. This exercise helps position my research and sets the scene for further investigation of specific aspects of seasonal variation, as these matter for energy demand and as they change over time.

Energy–society relationships

I start by observing that there are different methods of understanding the relationship between energy and society across the social sciences. Some of these ideas are important in framing energy policy and strategies to increase the amount of renewable energy in the system. These policies are developed against the backdrop of prevailing agendas for decarbonisation, and are also informed by questions about which renewable sources to invest in, and the impact of such investment on other factors including the job market and the operation of the National Grid (Gielen et al., 2019). Some of these debates touch on issues of timing, and the scope for modulating demand (or introducing storage) to align with moments when there are plentiful supplies of renewable power.

In taking stock of these discussions, I aim to characterise methods of thinking about the relation between energy systems (how energy is used, understood, harnessed, distributed, and represented) and social conventions, including matters of timing and demand. In approaching this task my method is to map out the positions of key authors, namely Leslie White (1943), Vaclav Smil (2017), David E. Nye (1999) and Elizabeth Shove & Gordon Walker (2014), who have written and contributed influential perspectives about this relationship.

Rhythm and seasons

My next step is to go deeper into a discussion of the social and temporal organisation of everyday life. This involves careful consideration of how 'social' and 'natural' temporalities are thought to combine, and how seasonal cycles, for example in the weather, relate to social life and vice versa. These are important questions given my aim of understanding daily and annual variation in gas and electricity demand. As I explain, I am interested in how 'natural' cycles have effect in the real world, and how they are socially and technologically mediated, such as through heating and cooling technologies.

I go on to suggest that ideas of rhythm (Lefebvre, 2004; Blue, 2019; Walker, 2020) are useful, and provide a means of conceptualising the interweaving of the social and the natural to understand variation in what people do across the year. In short, the social and the natural combine to form variation in patterns of gas and electricity use across the year.

Inspired by Walker (2020) I argue that there is scope for extending some of this work to take account of societal rhythms and how these develop and change. More specifically, ideas of rhythm help tie this discussion back to the practical challenge of relating the intermittency of renewable energy supplies to the timing of energy demand. I argue that multiple rhythms are embedded in the timing of gas and electricity use, and in the implications taking this position has for increasing supplies of renewable energy, such as the challenge of meeting daily and annual peaks in demand with a reduction of fossil fuel use.

These two chapters show how I position my analysis with reference to current debates about seasonal variation and the social and temporal organisation of everyday life. Second, in distinguishing between different positions I explain my own approach to the task of understanding seasonal variation in demand.

Although this thesis works with concepts and terminology that are associated with social practice theories, the thesis is not designed as a key contribution to this field. Instead, my investigation is framed by Rinkinen et al.'s (2020) conceptualisation of energy demand, and by reference to interdisciplinary literature that deals with issues of temporality and rhythm, in which ideas of practice are prevalent. In addition, I make use of ideas that have been developed within social science energy research, and science and technology studies, including methods that 'see' the social construction of knowledge about energy and its use, and that allow me to articulate some of the assumptions on which such knowledge depends. I bring these various threads together in how I go about investigating ideas of seasonal variation.

Having described the debates and traditions on which I draw (in Part 1), I set out the research questions that arise and explain how I intend to address these in the second part of the thesis. I do this in Chapter Four, which allows me to explain the logic of my research design and the rationale for designing a series of research probes to illuminate different aspects of seasonal variation, located within Part 2 of the thesis.

Part Two–Investigating Different Forms of Seasonality

The chapters in the second part of the thesis zoom in on three separate but related questions. The first has to do with the ways in which seasonal variation in energy demand is treated in contemporary analyses and forecasts. The next concerns the interface of 'natural' and 'social' rhythms as it plays out, with respect to domestic heating and cooling, and to the energy required to deliver 'comfort' whatever the weather outside. The third strand investigates the co–existence of, and interaction between multiple temporal rhythms, each of which have implications for the timing of energy demand, and all of which are orchestrated around the moment of Christmas. In combination, and as described below, these different 'takes' on seasonality provide a subtle account of the social and temporal organisation of energy demand.

Representations of seasonal variation in energy forecasts

My first step is to identify methods of representing seasonal variation in figures produced by government departments (DESNZ/BEIS) and energy suppliers. As I discover, established methods of averaging and of 'weather correcting' effectively obscure patterns of seasonal variation. In reaching this conclusion, I describe how energy statistics are developed and used, and how questions of local and seasonal variation are marginalised. There are clear parallels between these techniques and the work of what Mackenzie (1990) describes as 'inventing accuracy'–in his case in the context of nuclear missile technologies. More abstractly, I show that knowledge of energy demand is itself an outcome of social process, and of dominant questions that bypass potentially important issues about how demand varies and changes over the day and through the year.

I provide an account of how reports by BEIS (2020), Energy Savings Trust (2012) and Exxon (2019), average data to, for example, identify improvements in energy efficiency measures, and in forecasting future energy supply. In taking this approach, my aim is to show how statistical techniques affect representations of seasonal variation, and how this then figures (or fails to figure) in public and policy discourses.

Conventions of comfort

Although variations in the weather are flattened out and thus excluded from many representations of gas and electricity use, the outdoor climate is relevant for what people do indoors and for how much energy they consume. It is true that heating and cooling technologies protect occupants from variations in the outdoor climate, and that this kind of protection comes at an energy cost. However, there is more to say about how current conventions (and thus current patterns of demand) came to be as they are and how methods of heating and cooling mediate the relationship between the indoors/outdoors.

There are a number of core questions that frame how I approach these debates. How would rethinking the meteorological seasons shift the timing of heating and cooling seasons throughout the year? If energy supply is more closely tied to patterns of renewable energy supply, could the timing of heating and cooling change away from the daily peaks they are commonly associated with?

In brief, heating and cooling technologies are designed to deliver baseline temperatures inside homes and to meet standards of comfort that did not exist before. In retracing these histories my aim is to show how the relationship to the weather and energy demand has been mediated by ideas of comfort and convenience.

Co–existence of multiple seasons

This far I have dealt with 'classic' issues of weather and of heating and cooling. However, there is more to say about critical moments in the calendar, and about the social organisation of activities on which these moments depend. Christmas is one such example. Christmas Day is usually a day of relatively low electricity demand; most businesses are closed, and people are gathered to celebrate at home (National Grid 2020). However, Christmas in the broader sense, has an impact on energy demand across the year through for example, annual cycles of production and consumption, and of peaks and troughs in supply and demand for energy and other commodities as well. Understanding how these cycles operate and how they combine is important for understanding how 'systems of provision', developed conceptually by Fine and Leopold (1993), as a way of understanding connections between ideas of consumption and their related patterns, are created and re–enacted every year.

In this chapter, I work with secondary sources, predominantly documents, reports and guidelines relating to three different commodities that are associated with Christmas: trees, turkeys, and toys. I do this to show how various rhythms of supply and consumption, with their own cyclical peaks and troughs, spread out over the calendar year, combine to constitute the Christmas season. The purpose is to show how multiple peaks (and troughs) intersect and relate to different cycles and processes fixed in time in order to meet timings associated with the Christmas season. This example of multiple coexisting cycles is relevant for thinking about how practices are temporally sequenced and repeated, and the implications of social rhythms for energy systems now and in the future.

In the final chapter, I draw the two parts of the thesis together to describe the specific contributions of the thesis. I explain, through three positional statements, how ideas of seasonal variation can be redefined, and what the implications of this could be for the challenge of increasing supplies of renewable energy.

Part One–Introduction

The two chapters that follow is Part One of the thesis, consisting of Chapter Two and Three. These chapters outline the key debates that this thesis is speaking to, namely defining the relationship between energy and society, and understandings of rhythm respectively. These chapters position the research in relation to these ideas and establish how I navigate these areas within the field of study, namely ideas of seasonality.

Part One is bookended by Chapter Four, the 'research design' which explains how the key positions and debates I work through within Chapters Two and Three inform the creation of the research questions, and how I go about investigating seasonal variation within Part Two of the thesis.

Chapter Two: Conceptualising Relations between Energy and Society: Implications for Gas and Electricity Supply and Demand

This chapter is the first contained in Part One of the Thesis and has two aims. The first aim is to map different ways of conceptualising the relationship between energy and society. The second aim is to show how different understandings of the relationship between energy and society matter for defining how patterns of seasonal variation of energy demand are constituted. In doing so, I present an analysis that determines how the positioning of energy–society relationships matter for the study of patterns of demand, and how this is relevant for any future energy system changes.

It is clear, that, whether intentionally or not, various governments, organisations and actors connected to the project of future 'energy transitions' work with discourses that rely on specific ways of conceptualising the relationship between energy and society. Therefore, ideas about how energy systems change. The oil company, Shell frames the issue as one of capital investment: For example,

> "One reason systems transformations take time is that the success of one transformation – from horses to the international combustion engine, for example – can impede the progress of the next. A legacy of successful development is the potential for lock–in of the resource on which the current system was built. This potential for lock–in stems from the resistance to stranding the original capital investments and losing the jobs that have been created" (Shell, 2018:17).

In this particular framing, so–called transformations in energy systems depend on a financial and economic lock–in and resistance. Others focus on innovations in technology as so–called 'drivers' of energy transitions. For example, the Business, Energy, and Industrial Strategy Select Committee, made up of cross–party MP's, summarise what the 'future energy system' will look like, under current government plans:

> "Electricity demand will double as heat pumps and electric vehicles are rolled out and as increased demand flows from industrial processes increasing their use of electricity. This will bring about new challenges and opportunities. New energy infrastructure will need to be deployed at a pace never achieved before, and the system will require an upgraded, larger and smarter electricity network that can manage fluctuations in power supply. Smart technologies will enable customers to better synchronise their demand to system needs and access cheaper energy when supply is high" (2023:10).

The idea that underpins this framing of an imagined future energy transition is that changes in energy supply (including renewable and nuclear) and technological innovation (including 'smart' gids) will balance existing and future patterns of energy supply and demand. The activity that energy is used for is rarely presented as being significant for energy system transitions. Rather, new and existing technology and infrastructure is imagined to accommodate current and future ways of living and the patterns of energy consumption that follow.

The examples of how future 'energy transitions' will take place, described above, illustrate two ways of conceptualising the relationship between energy and society. However, there have been different arguments from the 1940's, through to the 1970's and beyond of conceptualising the energy–society relationship. As a way of an introduction to these arguments, I briefly narrate some of these positions, that I discuss later in the chapter.

Changing Approaches to Energy–Society Relations

In the early 20th century, understandings of the relationship between energy and society were dominated by typically linear narratives of how societies 'progress'. An important contribution was proposed by anthropologist Leslie White (1943), suggesting that the driver of changes in energy systems can be tied to culture, and ideas of 'human progress', titled later on as 'White's Law'. This materialist approach treats technology as the 'factor' in understanding how society 'evolves'.

Since this time, there has been a diversification in how this relationship has been understood, including focusing on how matters of consumption are important for the organisation of social life, and increasing caution over the sustained use of fossil fuels in contributing to global climate change. As Rosa et al. (1988) explain in their sociological analysis of energy–society relations, the oil crisis in the 1970's brought into view the overemphasis of supply, towards consumption in its own right. This included looking at the distributed social impacts of energy consumption, and how this matters more broadly, for energy policies globally. As the authors set out,

> "(the) study of the relationship between national patterns of energy consumption and societal well–being (or alternatively, societal welfare or quality of life) was thus instrumental in sparking a fundamental questioning of prevailing economic and policy wisdom. Furthermore, the deeper understanding it provided of the social impacts of growth patterns… coupled with efficiency arguments based in physics and

> engineering…. provided a solid foundation for seriously questioning the singular supply side emphasis in national policy debates" (p.159).

The change in focus from ramping up supply, to matters of demand, reflects ways in which conceptualisations of the relationship between energy and society has evolved. These changes continue into the present day, where an increasing focus on the dynamics of energy supply and demand has identified that energy systems, past and present, matter for how social life is spatially and temporally organised. With increasing supplies of renewable energy, and the need to reduce fossil fuel use as part of decarbonisation agendas, returning to core propositions such as 'what is energy for?' (Shove and Walker, 2014), reconfigures the focus away from the totality of energy systems and its functions, towards the daily activities that shape energy consumption, through ideas of social practice.

In this chapter I show how different underpinning positions on the status of the relationship between energy and society matter for how energy systems and possible transitions are conceptualised and studied, demonstrating how patterns of demand are connected to, and are not just a consequence of, sources of supply or technology. This is the first step in developing an account of seasonal variation that shows how histories of energy demand in the UK matter for the organisation of patterns of gas and electricity use seen today.

To describe the different possibilities for imagining the energy–society relationship, in what follows, I introduce four important positions which I have selected because they represent key positions within contemporary popular and academic discourse on energy system transitions. The four I have chosen for this analysis offer initial entry points into these debates, to identify connections between positions and to establish points of disagreement relevant for the study of changing patterns of energy demand.

The first two positions originate from White (1943), who I briefly introduced earlier, and Smil (2017), who treat ideas about energy and society as separate social phenomena that interact in different ways. The nature of the interaction is different between these authors, as I will detail, but they are united in creating a distinction between energy and society which matters for conceptualising this relation. The following two positions (Nye, 1999; Shove and Walker, 2014) see the energy–society relationship as intertwined, but with different ways of approaching this understanding, one from a cultural–historical positioning, the other from a social practice positioning.

I draw these four positions together in the discussion section of this chapter, where I make clear that demand for energy can, and should be considered through ideas about social practice, and the constitution of energy systems should be conceptualised through ideas of practice and their material arrangements, as presented by Shove and Walker (2014). It is with this view of the relationship between energy and society that it is possible to pay attention to seasonal variation not as something that is simply meteorological and accommodated by energy systems, but thoroughly intertwined and constitutive of them.

Energy and society as Separate Entities

1. Measuring societal progress

I start this discussion with anthropologist Leslie White (1943) who argues that the relationship between energy and society can be explained through the advancement of human progress. Writing during a period when abundant energy resources were becoming available with the development of hydropower in the USA (e.g., the construction of the Hoover Dam), White claims,

> "Culture develops when the amount of energy harnessed by man per capita per year is increased; or as the efficiency of the technological means of putting this energy to work is increased; or, as both factors are simultaneously increased" (p.338).

In White's articulation, energy is the driving force of societal transformations. When changes in energy systems happen, the implication is that society will also evolve consequently. Social change takes place when methods and techniques of energy conversion evolve, for example, by harnessing more energy, societies can move from 'barbarism' to 'civilisation' (p.346). White goes on to explain,

> "If we can continue to harness as much energy per capita per year in the future as we are doing now, there is little doubt that our old social system will give way to a new one, a new era of civilization. Should, however, the amount of energy that we are able to harness diminish materially, then culture would cease to advance or even recede" (p.350).

White is developing the theory that energy transitions are embedded in how much energy is currently being provided at a given time. A 'social system' can change to create new 'eras', in White's terms, directly with how much energy is harnessed. This includes reducing the constitution of a 'social system' to being composed through a multitude of factors. As White explains,

> "M (Means to an end e.g., food) is a variable factor in the process of cultural evolution. It is, moreover, a dependent variable, dependent upon the technological way in which

energy is harnessed and put to work. It is obvious, of course, that it is the technological activities of hunting people that determine, in general, their form of social organization" (p.346).

White's understanding of the energy–society relationship is causal, and linear. In his view, changes in the uses of energy can be explained by developments in technological and economic variables and leads to the splitting of energy and society into separate entities in how they are conceptualised and discussed.

2. Energy as embedded in historical change

The causal and linear view that energy drives changes in consumption and society more broadly is one that persists in contemporary lay and academic discourse. Smil (2017) illustrates how slow the transition was from preindustrial to industrial society, given the histories of farming and agriculture traced to the archaeological evidence of the first 'homo sapiens'. For example, a candle was the unit of indoor lighting for centuries. Writing some 74 years later from the publication of White's article in 1943, Smil's work in *Energy and Civilisation: A History* sets out a history of the development of 'civilisation' based on technological innovations that make it possible to harness different sources of energy.

Smil's work describes examples such as the first 'homo sapiens' developing tools to hunt, and methods of capturing wind and waterpower for agricultural use to argue that the technologies underpin the material and economic organisation of societies (p.21). As those societies 'develop', populations and patterns of consumption increase, e.g., for energy and food and these in turn prompt the necessity for further innovations in technology.

Smil's fundamental position, with some caveats, is that how energy is sourced and used is a key indicator of societal progression. He illustrates how technologies associated with specific energy systems helped instigate changes in society. For example, prior to industrial societies, wind and water were essential sources for energy production, with small scale windmills used for grain production, such as in the Netherlands in the 12th century. As more fossil fuel use started to occur in the 16th century, when England was facing wood shortages, coking fuel was used instead.

With the development of domestic electricity, a new way of thinking about energy emerged, in KwH and joules. The standardisation of energy units changed the scale of how energy was thought of; energy was quantifiable and could be compared to other forms of energy for the effect it would have on an object e.g., the efficiency of an indoor gas light as opposed to the light of a candle.

Smil explains the significance of this change,

> "Using energy as a principal analytical concept of human history is thus an obvious profitable and desirable choice. But we should not look at it as the principal explanatory factor… to conclude that every refinement of energy flows brought a refinement in cultural mechanisms… is to ignore a mass of contradictory historical evidence… energy conversion is always necessary to get anything accomplished but none of the extrasomatic conversions initiated and controlled by people is predestined" (p.418).

Smil, in this quote, says that the energy–society relationship is mediated by ideas about units, conversion, and application and that that is not predestined. Energy has a key role in influencing society, and for driving industrial changes in societies. For example, Smil explains how the socio–technical change of moving from charcoal furnaces, to coke fuelled furnaces in the mid–18th century in Europe resulted in, "800,000 t(ons) in 1750 to about 30 Mt (million tons) in 1900" (p.235) of iron being produced.

He balances this broader argument, by acknowledging that societies, and the political and economic systems they embody, do not always rely on changes in energy use as an instigator of change. Examples that he cites, such as the signing of the US constitution in 1776, the collapse of complex human societies such as the Roman Empire, and the proliferation of famous artistic painters in and around the 18th and 19th century highlight the development of culture without energy being at the forefront of change (Smil, 2017). This argument, uses notable historical events to show how societal change happened without major energy transformations, providing a more balanced outlook to White's (1943) view of societal progress being achieved mainly through changes in energy systems and provision.

Smil's account offers warnings about possible future energy transitions, including the rapid speed needed to size up forms of renewable energy to replace the reliance on fossil fuels, that he argues will take several generations to take place. Instead, Smil proceeds with caution about what future configurations of energy systems may look like, stating,

> "The only certainty is that the choices succeeding in the unprecedented quest to create a new energy system, compatible with the long–term survival of high–energy civilization, remains uncertain" (p.441).

Smil recognises that energy system changes don't happen quickly, nor can the socio–cultural systems of society (e.g., economic systems, in Smil's terms) be ignored for the role they perform in facilitating energy system change. His approach suggests that although energy and social transformations can be connected, they are not always explicitly linked together and relies on the actions of different sets of actors to instigate change. Smil contends that these changes that take place are tied to the challenges being faced during the specific time period, such as dealing with an increasing population in the move to 'industrial' societies in the 19^{th} century. There is however, through technological changes embedded in specific energy systems, a key indicator that the forms of harnessing energy that are available helps instigate changes within societies.

Instead of considering energy and society further, as separate entities, as this section has currently undertaken, I turn to explain how energy can be understood in combination with other societal dynamics, and the implications this has for defining the relationship between energy and society.

Energy and Society as Intertwined

3. The role of 'consumers'

David E. Nye's (1999) 'Consuming Power' takes a different approach to the analysis of energy–society relations emphasising the social histories of individual countries to establish how activities of everyday life influenced how energy systems were constructed. Like Rosa (1988), Nye demonstrates how simplifying the development of electrification to solely technological innovation (in part as White sets out to do) fails to account for the impact the infrastructure changes had for societal relations. As he explains, "The energy systems a society adopts create the structures that underlie personal expectations and assumptions about what is normal and possible" (p.7). Nye argues that the development of energy systems is not technologically determined, or on a linear path. Instead, they are socially constructed. Nye understands this, in terms of the supply of provision and demand, through ideas of social processes, as he explains in a summary of his book,

> "Electrification was not an implacable force moving through history, but a social process that varied from one time period to another and from one culture to another. In the United States electrification was not a "thing" that came from outside society and had an "impact"; rather, it was a contingent development shaped by its social context" (Nye, 2004:8).

In this understanding, the energy–society relationship becomes closer, more variable, and dependent, where electrification was closely connected to the wider context of social life. However, Like Smil (2017) and White (1943), Nye (1999) builds his argument by identifying the development of different energy systems, in this case, starting with human muscle prior to the founding of the USA as a nation state, to waterpower, to steam, and eventually to fossil fuels.

In contrast to Smil (2017) and White (1943), rather than treating each of these systems individually, Nye shows how each system builds on the last, and offers something new to contribute to society. Instead of arguing that the specific energy system caused the configuration of societies, Nye (1999) argues the opposite, explaining that societies have influenced the systems of provision and the possibilities for technological development. For example, the move from steam engine to electricity, oil and gas, emerged as the demand for more efficient and powerful sources of energy arose from consumers. The quantity of energy accessible within a particular energy system fosters expectations of a positively transformed future, grounded in perceptions of the accomplishments facilitated by energy.

Nye refers to the spread of the electrical grid across the USA as an example of the intertwining of social and technological changes, that is more than simply developing infrastructures to support energy provision. The growth of electricity, as an alternative to gas, developed in the 19th century, when Edison's lighting system appeared in Americas' wealthiest homes, presenting itself as a fashionable and convenient choice for lighting in the home. Electricity was seen as a tool of social reform, such as the role it could play in transforming housework at the beginning of the 20th century, with opportunities for new kitchen appliances advertised in national women's magazines (Nye, 1999). Despite this, the increase in appliances led to new tasks and new ideas of what a 'service' was within the household, which was aspired for from those across all social classes, as Nye explains,

> "More laundry got done more often…but neither scientific management nor the assembly line released housewives from toil. Yet the rise in factory productivity did lead to larger real incomes and to new desires: for the electrified home…" (p.153).

Nye argues that consumers played an active role in shaping how electricity was integrated into American society. This included promoting the benefits an increased uptake of electricity can provide, in terms of the convenience that electric appliances provide in revolutionising the home. This prompted additional shifts in energy provision after the 1950's, particularly with the introduction of air conditioning in residential homes. American manufacturers, in partnership with architects and engineers, pioneered novel conceptions of comfort that were previously non–existent. As air conditioning became ingrained as a societal norm, it fundamentally altered perceptions and expectations surrounding comfort. Nye refers to this inseparability of consumption with energy use, claiming that, "Consuming power had become at once a technical question, an ecological dilemma, an economic field, a political problem and a highly personal matter" (Nye, 1999:250).

As the development of air conditioning exemplifies, technological innovation linked to energy systems is more than a straightforward link; the changing social relations of American society facilitated their development. Instead of separating energy use out of the systems they are involved in (as White and Smil set out), Nye emphasises the role of consumers in shaping current and future systems of energy, to set out his view of the energy–society relationship, which is that energy use and energy systems are interwoven in the fabric of society.

4. What is energy for?

Rather than advocating for a structural understanding of energy–society relations akin to White (1943) and Smil (2017), or focusing exclusively on the role of the 'consumer', the final position I describe builds on Nye's (1999) argument that the social and technical aspects of energy and social systems are intertwined and argues that the energy–society relationship depends on, fundamentally, the organisation of social practices.

In a paper that questions 'what is energy for?' Shove and Walker (20124) shift the emphasis even further, arguing that not only are the social and technical aspects of energy and social systems intertwined, but that energy consumption, demand, is constituted by the organisation of social practices.

In making this argument, Shove and Walker change the conceptualisation of the relationship between energy and society from the technical development of energy systems and structures of provision that underpin social relations, and instead, focus on the recursive interaction between energy provision and consumption. This is how Shove and Walker (2014) argue that theories of social practice can inform understandings of energy use. In their positioning, energy cannot be thought of as something that is separated from social organisation, rather consumption of energy is embedded within the performance and distribution of social practices. As they explain,

> "Recognising that energy is used not for its own sake but as part of, and in the course of, accomplishing social practices, examples of which might include cooking, commuting to work, watching TV, or conducting meetings…having made this link

> between energy and practice we suggest that understanding trends and patterns in energy demand (and in provision and supply as well) is in essence a matter of understanding how social practices develop, change and intersect” (p.9).

Focusing on how practices matter for energy supply and demand fundamentally shifts the conceptualisation of energy–society relations from those previously described. Instead of situating energy use as embedded in societal progress, or as being shaped by different kinds of ‘cultures’, energy supply and demand is organised by the constitution and spread of social practices, which hold long social histories. Illustrating how practices shape energy demand highlights the necessity of revisiting the fundamental question: 'What is energy for?'. This question, Shove and Walker argue, is missing in the accounts such as those put forward by White (1943). They argue that,

> “In losing sight of basic questions about what energy is for, many social and political theories take the significance of resource management for granted. As a result, the politics and economics of supply are discussed aside from an understanding of the underlying dynamics of demand” (p.21).

The separation of supply and demand in this manner is indicative of how energy–society relations have been perpetuated in public and policy discourses. In contrast to other authors who separate the configuration of energy–society relations by moving energy into different systems and structures, a focus on practices embeds energy as fully part and parcel of social organisation and change. Positioning practices as central to energy–society relations shifts the analytical focus from previous representations, integrating both social life and technologies within the social practices enacted and repeated across time and space.

Discussion: Reframing Energy–Society Relationships

In this section, I explain the implications of the four positions described for understanding how the contemporary energy problems I describe in Chapter One can be understood. These problems, to repeat, were the challenge of scaling up renewable energy supplies that are notoriously intermittent, and how a less reliable supply might be matched to patterns of current and future patterns of gas and electricity consumption. The two grouped positions outlined on energy–society relations offer different ways of thinking about the role of energy in relation to social life and therefore the relationship between energy supply and demand.

As the discourses about proposed transitions to future energy systems I set out at the beginning of this chapter (DECC, 2011; Shell, 2020) show, agendas related to ‘the energy transition' depend on a particular view of the energy–society relationship. Namely, that technological innovation will accommodate current patterns of consumption. Instead of imagining these changes to energy systems as inevitable, it is clear, following the arguments made by Nye (1999) and Shove and Walker (2014), that this is not the only way to go.

White's (1943) account provides one explanation of how various energy system changes have happened. He presents a deterministic overview on the relation between energy and society, that energy and technology drive consumption and social configuration. This fails to account for how social life is intertwined with the coordination of energy systems, and how these systems are constructed in relation to the organisation of patterns of supply and demand. That is, these patterns are not inevitable outcomes of a functioning society; rather I argue they are an outcome of the social practices of everyday life. If energy demand changes, then this will be because social practices have changed, not as White would argue, the energy system itself.

This matters for how energy system transitions are conceptualised. For instance, Smil (2017) outlines the energy–society relationship through a historical timeline from the dawn of civilization to the contemporary era, echoing the linear progression evident in various texts. These perspectives, including White (1943), construct a linear narrative of societal advancement, attributing future changes in energy systems, defined by systems of provision and distribution, to shifts in how energy is utilised. However, such perspectives overlook the significance of social relations and organisational structures in driving changes within energy systems.

This viewpoint suggests that the adoption of renewable energy represents a novel transition. However, historical evidence indicates that reliance on renewable technologies predates industrialisation. Therefore, there is nothing inherently 'new' in harnessing renewable energy sources. What sets the current proposed transition apart is the scale and integration of renewable energy supplies within large–scale energy systems. What becomes clearer, is that energy systems do not progress in a linear fashion; instead, some forms of energy, such as wind, are configured within these systems within different ways.

In contrast to White, Nye's (1999) tracing of energy supply and demand changes in North America between 1880 and 1940 emphasises the active role of consumers and companies, who saw the potential of developing new forms of energy use. Although Nye doesn't work with the idea of social practices, he does explain the relevance of actors in society influencing the formation of energy provision and consumption, specifically in the localised context of North American society. The spread of the electrical grid is a consequence of the development of services that electricity provides. In this understanding, by framing energy–society relationships through the 'lens' of technological changes now on the demand rather than supply side, the challenge of scaling up renewable energy supplies are a technological problem to solve, and patterns of demand will be shaped by the technological provision that is available.

By showing how the relationship between society and energy is mediated by technologies, and managed by different types of actors, Nye identifies that there is a role for socio–technical innovations that matter for how energy systems are organised. As he argues in reference to US energy systems,

> "A sixth energy system is slowly emerging that re–emphasizes renewable power sources. An eclectic bricolage of many technologies and conservation measures, coordinated by computer technologies, its development will be constrained by the myriad choices Americans have already made–choices expressed in factories, roads, cities, and suburbs" (Nye, 1999:253).

Nye emphasises the significance of the legacies of prior energy systems and societal infrastructures which is crucial for understanding the processes involved in shaping both energy provision, and the organisation of future societies, such as those that rely on increasing amounts of renewable energy supplies. Technology is mediated by already established social organisations and co–ordination that has come about through the different 'choices' Nye refers to.

This position remains insufficient for considering the core problems of this research, because the focus on technology and consumers limits how these ideas relate to how the spatial and temporal organisation of everyday life matters for understanding energy–society relations. There remain opportunities to expand the understanding of energy–society relations, through conceptualisations that refrain from isolating either consumers, or technologies, from the broader dynamics of social life. Shove and Walker's (2014) analysis, is to reconfigure the question 'what is the relationship between energy and society?' and instead to argue that energy *is* society.

Shove and Walker (2014) are clear about the implications of how the energy–society relationship is configured for creating policy, as they describe,

> "Deliberate efforts to reduce energy demand necessarily rest on one or another social theoretical account of energy, society and social change. Energy policies consequently foreground and marginalise different lines of enquiry and intervention" (p.2).

The suggestion here, is that how the energy–society relationship is conceptualised feeds into policymaking, and matters for how future energy systems are forecasted, and planned for. Making the argument that 'energy is society', focusing on the practices and material arrangements that energy is embedded within, and how they subsequently constitute energy systems, allows potential future 'energy transitions' to be addressed in a different way than described by, for example Shell (2020) and BEIS (2023), that lose sight of the fundamental questions regarding energy use.

When it comes to the challenge of understanding how more renewable energy supplies matters for understanding the timing of gas and electricity demand, Shove and Walker's (2014) approach treats energy use as an outcome of the organisation and distribution of social practices. The study of energy systems is inseparable from social life and can be effectively examined through energy–consuming practices, which play a crucial role in how patterns of gas and electricity demand are organised across different timescales.

What this chapter has evidenced, is that the position taken on energy–society relations matters for how energy system transformations are conceptualised. To study issues of decarbonisation, such as increasing forms of renewable energy supplies, requires understanding how energy consuming activities are tied to the construction of patterns for gas and electricity use throughout the year.

Conclusion

In this chapter, I have discussed different positions of the energy–society relationship. I have identified how different formulations of this relationship are relevant for the study of energy systems, and for my research interest in seasonal variations within gas and electricity supply and demand. These positions revealed the diversity of thinking in this area, and the important role of how this relationship is conceptualised matters for viewing transitions between energy systems. Through reviewing the various energy–society relationships, it was clear that Shove and Walker's (2014) position that 'energy is society', reflected how energy systems, now defined through the reproduction of sequences of social practices, are intertwined with social life, and developing ways of viewing seasonal variation of gas and electricity use as an outcome of social practices that vary throughout the year.

This approach matters, in the broader context of the study of seasonal variation, because it informs how different kinds of variation within energy systems are constructed. By following Smil (2017) and White (1943) in how they treat energy–society relations, seasonal variation within energy systems would be viewed as an inevitable consequence of using energy at different times of the year. Instead, by tying energy demand to energy–consuming social practices, I suggest that patterns of seasonal variation will reflect how infrastructures, systems of provision and cultural conventions embed patterns of demand across the year. They are not inevitable, nor are they to be taken for granted in how future energy systems are organised. The outcome of this chapter is a way of navigating the study of seasonal variation as it relates to patterns of gas and electricity demand, not by studying energy and society separately, but as deeply interconnected in the construction of infrastructures, conventions, and practices that shape the organisation of variation throughout and beyond the year.

As I reach this conclusion, the next steps are to look more closely at ideas of variation, and how multiple temporalities are involved in the organisation of gas and electricity patterns throughout the year. This includes introducing new concepts and ideas that are relevant for the study of energy systems and seasonality, such as the role of rhythms and learning more about the cyclicity of social practices.

Chapter Three: Organising Rhythms: Explaining Variations in Gas and Electricity Demand

In Chapter Two, I explained why conceptually, the relationship between energy and society matters for contemporary debates about energy supply and demand, including for imagining future energy systems. These debates are significant because assumptions about how and why energy is used, and how supply and demand is interwoven into the fabric of social life, influence judgements about the viability of different sorts of energy system transformation. Ideas about how patterns of gas and electricity demand vary across time and space, and how relations between ideas of social life and the natural world combine, also frame interpretations of lower carbon solutions.

In order to investigate this aspect my next step is to explain how and why patterns of gas and electricity demand relate to the social and temporal organisation of everyday life. In my view, there are two ways of understanding this relationship, both of which rest on specific interpretations of the relationship between nature and society. One approach supposes that there is a strict binary; that social life and the natural world are separate and should be understood as two different but interacting realms. The other position rests on the view that they are entangled; for example, methods of managing indoor climates are not outcomes of social processes on the one hand and natural variations on the other: they are amalgams of both. In this chapter, I am interested in what these different approaches mean for conceptualising the timing of gas and electricity demand.

In Chapter One, I suggested that the annual timing of gas and electricity demand would have to be reconfigured and that significantly greater use of renewable energy supplies would affect the annual and daily timing of gas and electricity–consuming social practices. As Figure 1 below shows, gas and electricity are used in different ways. Although these different uses are not indicated on the graph, the 'size' of the peaks and troughs found across the year are evident. Over a year, electricity demand fluctuates less than gas, much more of which is used in the meteorological winter than in summer. Electricity has a multitude of uses, including for heating. These different uses together create an average load profile that varies considerably over the day, but that is relatively stable over a year.

My starting point is that annual and daily variations in demand are outcomes of social and institutional structures, and natural variations (for example, day and night, winter and summer etc.) which constitute the rhythm of daily life.

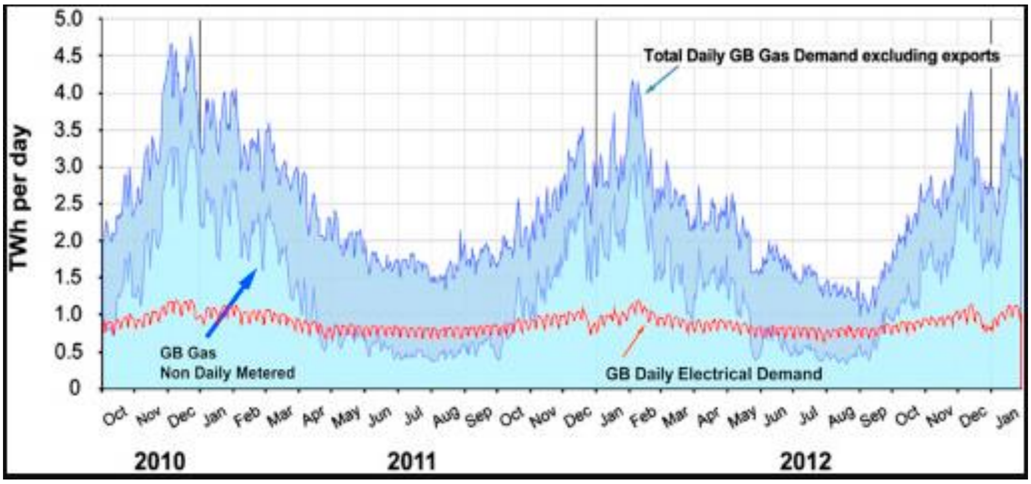


Figure 1– Daily GB Gas and Electricity Demands 2010–2012 (TWh). Data sourced from National Grid website, graph from Wilson et al. (2013:120).

In what follows, I explain how the temporal organisation of social life and variations in the climate matter for gas and electricity use. To begin this investigation, I take stock of some of the ways in which the relation between time and energy has been described.

Time and Energy Demand: Positioning Ideas

The temporal organisation of social life is an important theme across the social sciences. For example, Elias (1992) and (Zerubavel, 1979; 1981) in sociology, and Parkes and Thrift (1979) in geography, describe how socio–temporal orders are constructed and how they have changed historically. More recently, authors such as Blue et al. (2020), Cass and Shove (2018), Hui et al. (2018) and Shove (2020) identify the many overlapping temporalities that characterise the diverse social practices on which the rhythm of energy demand depends. These multiple temporalities are important in that processes of managing gas and electricity systems depend on balancing supply, demand and sometimes storage across different timescales.

Sociologists like Barbara Adam (1988; 1990; 2004) have thought about time and in particular, about the relationship between 'clock time' and natural rhythms, in ways that are relevant to my own understanding of how the temporalities of supply and demand change, connect, and evolve. Adam argues 'clock time' has come to dominate ways of thinking about natural cycles and seasons. She defines clock time as:

> "a technological time created to human design in which the variable times of nature– of day and night, seasons and change, growth and ageing, birth and death– are

> objectified, constituted independent of life and cosmic processes, of human activity and social organisation" (Adam, 2004:4).

As Adam explains, the clock is an artificial construct but one that is hugely important for the organisation and coordination of social relations. This conclusion matters because of the connection between timekeeping, particularly in the form of clock time, and natural variations of temperature and daylight, that also structure the timing of activities within social life. This association between clocks, timekeeping and nature is not constant; rather it has evolved over time, and in ways that relate to other social processes including employment, trade and labour.

An illustrative example of the malleability of these connections is the experience of Samoa, a country which in 2011 adjusted its position in relation to the international date line, from UTC−11 to UTC+13. Previously, Samoa experienced challenges in coordinating trade with partners whose businesses were closed on Sundays. By comparison, the working days of neighbouring countries, such as Australia and New Zealand were better synchronised with their partners: both operating on Mondays at the same time (Green, 2014).

For Samoa to 'switch sides' and align itself not with the USA but with other Australasian countries, the population had to completely skip a calendar day. According to Green, the decision to shift the date line was prompted by the need to synchronise practices with close trading partners. As this case shows, the process of setting and keeping time is intertwined with "political projects of policy–making and capital accumulation" (Green, 2014:218). More importantly, this example underlines the social construction of clock time, and its importance for the organisation of social and business life around the world.

In the context of energy demand, the clock and the calendar, and the practices that are scheduled and synchronised with reference to these 'devices', are evidently important for when and where gas and electricity are used. For example, the convention of working between 9am–5pm during weekdays is an important contributor to organising gas and electricity demand. At the weekend, the timing of energy demand changes as more people are at home during the day (Anderson and Torriti, 2018). These weekly cycles are identifiable in the peaks and troughs of energy demand across the day.

By contrast, patterns of domestic heating, which is predominantly powered by gas, are also tied to the timing of activities within the household, where there is an increase in heating demand between 6–7am in the morning. This pattern is even more consistent than heating demand in the evening, suggesting that morning activities are subject to stronger forms of societal synchronisation. Hanmer et al. (2019) suggests this poses a challenge to managing early morning peaks with decarbonisation agendas in view, as there is less flexibility or scope to shift demand for gas on winter mornings than there might be at other times of day or year.

Thus far I have shown that social practices – like going to work – are scheduled with reference to clock time (the 9am – 5pm working day, for example). However, infrastructures and systems of energy provision also assume and thereby reinforce patterns of demand across the day and the year (Hughes, 1993). Behind the scenes, electricity supply systems are sized to meet peak demand whenever that occurs. In reality, the size of the peak and its timing change historically, depending on what energy is used for and how those energy–demanding practices are sequenced and scheduled.

Crucially, patterns of demand like that shown in Figure 1 are outcomes of many parallel schedules. For example, in his study of time in hospital life, Zerubavel (1979) identifies numerous cycles of activities – patients are admitted and treated; staff arrive for work; new recruits are trained; holidays are taken – that combine, and that in different ways, also shape each other. In short, the rhythms of the hospital as an institution are both formed and influenced by the socio–temporal order of these many interwoven processes.

Schedules and calendars play a crucial role in structuring organisational operations. For instance, the hospital teaching year follows its own cycle, unrelated to the traditional school year or the Gregorian calendar. As Zerubavel states:

> "Time is among the fundamental parameters of the social order of the hospital, in accordance with which much of hospital staff's daily life is systematically structured and regulated. The main social institution which is responsible for the temporal structuring of hospital life, the schedule, regulates their presence and activities in the hospital and defines the temporal boundaries of their professional obligations and responsibilities there. Moreover, given the organizational priority of the collective temporal order to the personal one, work schedules also constitute the relatively fixed and unalterable starting point, in accordance with which most of their daily life outside the hospital is temporally organized" (p.124).

The hospital, as an example of an institution with its own scheduling and socio–temporal order, contains multiple temporalities that shape connections between practices. These temporalities, along with those external to the institution (school holidays, economic cycles) as Blue (2019) explains, matter for the structure and organisation of social practices across the year, and for how temporal rhythms are constructed. These kinds of sequencing are important for understanding how socio–temporal orders are constructed and reproduced. As Zerubavel's example shows, these patterns have not come from nowhere. Instead, they have been developed and structured through the organisational priorities of hospital life, not in isolation but as part of a more encompassing set of conventions e.g., working hours, holidays etc.

As both Adam (2004) and Zerubavel (1979) recognise, current societal rhythms do not arise by chance. They have a history, and their multiplicity means that they are subject to ongoing transformation and change. This is relevant in relation to variations in energy demand because it suggests that present patterns could be reshaped, for example, with new forms of living and working (no longer 9am –5pm) or with greater seasonal variation in social practice than is the case at present. What are thought of as 'normal' patterns and rhythms of demand today could be fundamentally reshaped and reconfigured in the future. I consider this possibility in the next section.

Synchronising Social Practices and Energy Demand

Societal synchronicity – that is a situation in which many people do the same thing at the same time e.g., eating, sleeping, or going to work – is embedded in the peaks and troughs found in daily demand profiles, such as those that characterise electricity demand. On a typical workday, energy demand rises between 7am and 9am as people wake up, and again towards late afternoon/evening when people return from work (Anderson and Torriti, 2018). These energy demand patterns are not isolated from the wider organisation of social relations; instead they are fully embedded in social histories of what people do, as that is organised around clock time and calendars. Parkes and Thrift (1979) write about how timekeeping technologies have enabled the introduction of scheduling, in train services, shop hours, bedtimes and more. This is combined with different forms of institutional timing, such as the school day and the convention of working hours during the week, combinations of which have shaped gas and electricity patterns through the day and over the year. As Torriti (2017) finds, washing clothes has a seasonal pattern in that the activity occurs more often in November than in February, and a daily rhythm of laundering usually happens between 8:30am and 11:30am.

This is not because the morning is somehow 'ideal' for laundering. Rather this 'time slot' is an effect of how laundering relates to other practices that people do, and to when these occur. The point is that social practices are connected with each other across time and space. For example, food preparation often happens at the same time each day, whereas using the computer is more flexible across the day, located in and between practices of longer duration, such as TV watching (Torriti, 2017). As Torriti concludes,

> "the findings… feed into a broader discussion on the internal heterogeneity of domestic practices which generate peak electricity demand. The time dependence of social practices, as measured by time use surveys, provides an effective way to re–think peak electricity demand as deriving from synchronous performance of domestic social practices" (p.46).

These patterns do not occur in isolation; rather they are closely tied to the social and institutional structures of daily life. For example, social histories of daily life have indicated how forms of synchronicity has changed over time, and where increasing forms of flexibility, in relation to social practices, have been found. For example, Southerton (2003; 2006; 2009), as part of his studies into the timing of daily life, suggests that practices are being shuffled within and around the timing of the day. He describes how temporal rhythms of daily life are constituted by social practices which take place at the same time each day, whilst more flexible practices can be enacted around those that are 'fixed' in the timing of everyday life (e.g. timing of the school day). In his view, institutional arrangements provide a temporal architecture around which daily lives are lived.

These arrangements, however, are not fixed themselves. He concludes that there has been a de–institutionalisation of socio–temporal organisation meaning that there is "a wider variety and greater flexibility of temporal rhythms in everyday life", with fewer institutional events (variation in the timing of work and eating meals, 'bath day', 'laundry day' etc) and more individual flexibility in daily life now than in the 1950's (Southerton, 2009:62). The organisation of activities Southerton describes matters for understanding how personal scheduling ties into wider temporal rhythms, and conventions of what counts as 'normal' or ordinary ways of life.

One example of the interweaving of 'normality' and timing has to do with the promotion of standardised indoor climates and central heating systems. As we know, outdoor temperatures in the UK vary across the year. However, the idea of maintaining a standard and steady indoor temperature all year round is associated with the introduction and widespread use of central heating. Changes in indoor heating had further consequences for social practices, arguably moving previously outdoor activities indoors, in response to the resulting comfort offered from central heating. For example, children's play has increasingly shifted indoors since the 1950's as revised standards of thermal comfort could be offered indoors, such as in children's bedrooms, as heating spread across the household (Kuijer and Watson, 2017). The spatial changes associated with the introduction of central heating technologies went hand in hand with new ideas about the character of comfort, and about the use of space, clothing and the need (or not) to adjust to the changing meteorological seasons.

As with histories of clock time, working hours and societal scheduling, mediating the social and natural in everyday life, as the example of indoor comfort shows, depends on the processes of organising social relations in everyday life. These are not separate from what some take to be 'natural' processes, including climate change and shifts in the weather over the course of the year, all of which also have a bearing on energy demand.

Energy Demand and Climate Change

The climate has continued to evolve, generating hotter and colder conditions over the Earth's geological history. The Intergovernmental Panel on Climate Change (IPCC), which conducts research into climate change, focuses on long term variability in order to show how temperatures have changed from thousands to millions of years ago, identifying sequences such as the 'Milankovitch cycles', which measure the shape of the Earth's orbit around the sun, alongside the angle of the Earth's axis (IPCC, 2022). This long–term variation is used to compare the Earth's climate prior to the rise of industrial societies, and subsequent emissions which have contributed to increasing global temperatures worldwide.

Short–term variability in climate, in some understandings, deals with variability at the minute, hour, day, week, month, year and decade scales. For example, Farinotti (2013) provides a framework for identifying temperature changes in reference to the glacial period. In their example, short–term variability can cover both the outdoor climate at the present time, and climate patterns linked to solar cycles and 'internal earth events', such as clashes between oceans and ice interacting with the jet steam. The extent of this variation depends on the meteorological forces affecting the climate, for instance, the gulf stream from the Atlantic Ocean affects the European climate with warmer temperatures, but the influence of this will vary year on year.

Other phenomena, such as 'el nino' and 'la nina' years create long–term weather patterns based on sea surface temperatures, which change through oceans absorbing heat from the atmosphere (Met Office, 2022). 'El Nino', when sea temperatures rise 0.5 degrees in the Pacific above the long–term average, creates warmer than average weather. 'La Nina' is the opposite, when sea surface temperatures fall below the long–term average (Met Office, 2022). These types of natural phenomena begin, for example, in the Pacific Ocean, and spread across the world to influence temperatures in specific localities. In these examples, observed meteorological phenomena have been categorised to forecast the effects these 'el nino' and 'la nina' years will have across the world, at different times of the year.

Beyond the lay explanation of, for example, variation in gas consumption relates to changes in the weather (Rahman, 2011), climate variation is more multifaceted than first appears. There are important geographical variations in the climate that impact the organisation of energy demand in the UK, and regional differences in how much energy is used. These include geographical variation in weather patterns in the UK due to the tropical maritime airstream, or the trend of increased temperatures in southern England compared to the north of England during the meteorological summer (Met Office 2022). Annual representations of energy demand, as Figure 1 indicates, average out regional variations in demand, presenting an overall picture of demand that shows how total UK–wide energy use changes over time, but without reference to the distinctive characteristics of specific localities or to how both gas and electricity demand relates also to localised external temperatures (Fox et al., 2018).

As already mentioned, climate change can be represented on very different scales: across hundreds and thousands of years, or over just a matter of months. The natural cycles relating to the astrological positioning of the earth and the sun help explain a long history of the Earth's climate as modified by external forces (Walker, 2020). By contrast, arguments about anthropogenic climate change focus on the last few decades. The accepted basis of climate change, as an outcome of greenhouse gases affecting the global temperature of the Earth, is in turn an expression and an effect of human activity. The impact of greenhouse gases and global warming has been seen, for example, through the rise in sea surface temperatures affecting the frequency of 'nino' and 'nina' climatic events (IPCC, 2022).

As the climate is being shaped by human activity, the natural/social variation cannot be considered strictly binary. It becomes clearer that treating social and natural variability independently of one another fails to account for how, initially, social practices are affected by the natural climate across the year, but also how the natural climate is being continuingly shaped by social activity. The mediation between social and natural variability in the context of gas and electricity patterns of demand is a process which requires further attention. Specifically, how do technologies like central heating or air conditioning bridge the gap between the indoor and outdoor climate, and how do forms of scheduling construct social relations with the weather and climate variability? As I will explain, this mediation is an ongoing, evolving relationship which matters for the organisation of current and future energy demand.

The final section of this chapter brings some of these threads together to show how energy systems are organised by multiple, interfacing rhythms of everyday life. As I suggest, these ideas are relevant for explaining how social life and the outdoor climate come together in the constitution of energy systems.

Defining Nature–Society Relations

The relationship between social life and the 'natural' world has been widely conceptualised and is critical for understandings that describe how ideas of rhythm relate to social life. In recent times, the social–natural relation has been challenged within sociological and environmental disciplines, advocating for a more integrated view of nature and culture rather than defining them in binary terms (Whatmore, 2002; Clark, 2011). For example, environmental and social theorists have investigated the connection between human activities and the living world–such as landscapes, plants, and the environment–and its significance in understanding societal structures in daily life.

For instance, Eder (1996) frames the debate around two opposing positions: the 'naturalist' view, which sees society as naturally constituted, and the 'culturalist' view, which is closely tied to the social construction of nature. Eder highlights the perspective of 'classical sociologists' like Marx and Durkheim, aligning them with the naturalist stance through a broad review of their publications. Eder argues that Marx and Durkheim perceive nature–society relations through the perspective of control and domination, measuring society's reproduction against the evolutionary standards of adaptability and control over natural resources. This representation of the naturalist viewpoint simplifies human relations with nature, casting humans as external to nature, exerting control and dominance over the natural world.

The culturalist position, as supported by Eder, considers nature as symbolically constituted, not as an objective and separate entity. Similarly, Castree and Braun (2001) emphasise that nature is not an objective reality but is deeply influenced by human values, interactions, and societal norms. As they argue,

> "nature has never been simply 'natural' – whether it's 'wilderness,' resources, 'natural hazards,' or even the human body. Rather, it is intrinsically social, in different ways, at different levels, and with a multitude of serious implications. Second, the all–too–common habit of talking of nature 'in itself,' as a domain which is by definition non–

social and unchanging, can lead not only to confusion but also the perpetuation of power and inequality in the wider world" (Castree and Braun 2001:5).

The suggestion here is that the conceptual analysis of nature requires acknowledging the social influence on how it is defined and represented without constructing nature as an object that is 'out there' to be controlled. Reconceptualising this binary requires identifying how what is considered 'social' is entangled with interpretations of the natural environment, and how we can move beyond this conceptual dichotomy.

Efforts to do so have taken place within STS, where frameworks like 'Actor–Network Theory' suggest how social life emerges from interconnected networks of relationships among technologies, institutions, and humans. For example, John Law (2004) proposes that scientific knowledge is a form of culture and that the 'natural' can be reshaped by different actors, challenging the fixed boundaries between nature and culture semiotically. This perspective seeks to illustrate the interconnectedness and social influence between human societies and the natural world, emphasising the social construction and active shaping of both nature and culture through various practices and interactions. Similarly, Latour's (1993) analysis of this topic suggests that the categorisations of nature–society are flawed because of, as Latour views, the 'hybridity' of this phenomena. Latour's argument is that the nature–society configuration requires reframing away from dualisms that perpetuate their separation, within the categorisation of different kinds of networks and their relations. As is clear, the debates surrounding nature and culture reveal multiple conceptual approaches for understanding this relationship.

Describing Rhythms of Energy Demand

An alternative approach to mediating this relationship between social life and the 'natural' world would be to consider how ideas of rhythm inform how to define this relation. For instance, Walker (2020) brings ideas about energy and rhythm together, working with Lefebvre's (2004) framework of rhythmanalysis to argue that conceptualising the rhythms of energy systems is crucial for designing energy transitions away from fossil fuels. This is because, according to Walker, fossil–fuel based energy systems are sustained through various societal rhythms. But Walker argues that these types of rhythm are not inherent to society, nor are they natural. He argues that:

> "There has been a co–dependency between rhythms and energies, with new patterns of energy expenditure co–evolving with shifts in social, economic, cultural and

technological rhythms and their polyrhythmic interactions. As a consequence, techno–energetic rhythms, largely powered by carbon fuels, have for much of the wealthier world become deeply embedded in the rhythms of society, in the spatiotemporal patterns, sequences and synchronisations of being together, in the energy infrastructures that power the beats and pulses of everyday life, and even in the bodies that we inhabit" (2020:160).

Walker goes on to describe categories of rhythm that are social, environmental, ecological, corporeal and cosmological, as reproduced in Figure 2.

Rhythm Domain	*Description*	*Energy-related Examples*
Cosmological	Rhythms in and of the movements of planets and celestial bodies	Cycles of solar radiation; tidal movements
Corporeal	Rhythms in and of the human body	Muscular energy enabling bodily movement
Ecological	Rhythms in and of non-human organisms, and in combination in ecological systems	Growth and transformation of plants as energy conversion and storage
Environmental	Rhythms in the working of atmospheric, hydrological, marine, geomorphic and geological processes and their interactions	Movement of the air; flows of water in rivers
Social		
Cultural	Rhythms in cultural norms, conventions, institutions, rituals and festivals	Energy demand patterns at weekends, or at Christmas
Domestic	Rhythms that figure within and run through domestic settings	Use of appliances within the home
Organisational	Rhythms that figure within and run through organisational settings (private, public, community organisations etc.)	Opening hours, work-shifts that shape switching on of devices
Technological	Rhythms of specific technological devices, and of sets of interlinked devices	Thermostats, central heating controllers
Infrastructural	Rhythms within infrastructural systems (energy, water, communications, transport etc.)	Synchronization between supply and demand; energy storage
City	Rhythms that figure within and run through urban settings	Traffic flows

Figure 2 – Classification of social and other rhythms (Copied from Walker, 2020:27).

This formulation is useful because it shows how energy systems are connected to different kinds of rhythms found within social life. However, it obscures the extent to which these intersect and overlap. For example, infrastructures play a vital role in enabling various forms of scheduling, coordination, mobility and energy provision, and the timing and sequencing of various energy–consuming social practices (Watson and Shove, 2022). Attempting to disentangle each of these overlapping social rhythms, and slot them into one or another of the categories listed above is difficult, in that these rhythms are closely intertwined and actively involved in shaping one another.

In daily life, the categories that Walker maps out have significant overlaps with one another, and the connection between them remains unclear. Walker acknowledges the complexity of this interaction by offering the example of 'energy demand patterns at weekends or at Christmas' and by representing these as ‘cultural’ rhythms (as evidenced in Figure 2). As I show later on in the thesis, what might look like a ‘cultural’ rhythm is itself composed of multiple other cycles and rhythms spread across the year. This interconnectedness highlights the need for a more holistic understanding of how social and natural rhythms together contribute to the formation of patterns of energy demand.

Walker goes on to explain that social rhythms (e.g., domestic, cultural and organisational) change as energy systems evolve over time, and that these rhythms have been influenced by the sources of energy that are fuelling society, such as fossil fuels. As Walker puts it:

> “It is clear from geographical, ethnographic and sociological work on energy and energy systems… that how energy flows through society – its amounts, intensities, forms and temporal patterning – is also a situated matter, subject to the particularities of history, culture, politics, infrastructure and environment, and thoroughly immersed in their making. There are universal laws of thermodynamics, and therefore of energetic exchanges and transformations, but how exactly energy is in society in all its diversity is far from the reach of any universal principle” (Walker, 2020:14).

Walker argues, in short, that the dynamics of energy systems are multiple and rooted in multiple ‘rhythms’ and cycles that have numerous, overlapping periodicities and cycles. The temporalities of the natural and social world are part of what defines energy systems and demand. This is because social life is embedded in routines that are sequenced and held together by rhythms (Southerton, 2003). Knowing how rhythms and practices combine, spatially and temporally, is important for grasping the variations in energy demand, including seasonal variations and variations that relate to energy sources, ranging from the intermittency of renewable supply through to the ‘always on’ potential of fossil fuels.

Walker retains the notion that there are distinct temporalities associated with the ‘social’ and the ‘natural’, and describes both in separate terms. In his words,

> “It is certainly true that clock time, time systems of various forms, senses of time, time as ‘kairos’ … and so on are essentially human and social in their constitution. But there are cosmological, ecological and environmental rhythms that are not, that are beyond the human and indifferent to human existence… and resolutely exterior to culture in their making and sustaining. As recent work on posthuman temporalities contends,

> there are non–human temporal structures in which human times then become entangled" (p.28).

What constitutes the 'social' in this description, as an outcome of the rhythms and structures that Walker describes, is blurred in that it is defined by multiple, overlapping rhythms that are neither social nor natural in form.

Nevertheless, Walker explains later on that "key rhythms of energy demand are socio—natural hybrids" (p.186). There are some points of agreement with this statement, despite attempts to disentangle this hybridity in earlier statements. It is clear that there are natural cycles, for example climate variability, which affect what people do in everyday life, and how social practices are sequenced and connected. But how the natural world is perceived and represented in everyday life is an unavoidably social process. In addition, growing evidence of the impact of social life on climate change shows how social and natural rhythms combine and interact.

This has important consequences for thinking about the balancing of the timing of gas and electricity supply and demand. For example, seasonal rhythms of climate (summer, winter, etc.) are being flattened out through domestic heating and cooling provision, and the convention of maintaining 18–22°C indoors. In this example, rhythms of the natural climate (the weather) and social life (interpretations of comfort) are entangled because they influence, for example, the timing of heating and cooling seasons throughout the year. Extended rhythms of demand, that stretch throughout the year (for example, how Christmas extends throughout the year) are absent from Walker's categorisation, despite the fact that interconnected cycles matter for how patterns of energy consumption are organised.

This argues for an approach that acknowledges the hybridity of social life and the 'natural' world, in constituting patterns of gas and electricity demand over different temporal scales. Despite the limitations I identify in Walker's arguments, he proves that ideas of rhythm are relevant, and inform the constitution of energy systems past, present, and future. I identify that variability in climate and social practice matter for the organisation of gas and electricity demand at different times of the year, and the identification of rhythms that make patterns of demand. The following chapters are designed to investigate how exactly social rhythms matter for understanding seasonality across social life, and the relevance of such rhythms for the prospect of decarbonisation and energy systems that rely on intermittent sources of renewable supply.

Conclusion

In this chapter, I have focused on the relation between social practices on the one hand, and peaks and troughs in energy demand on the other. In writing about how demand is shaped by the social and temporal organisation of daily life, and by variations in the outdoor climate, I have suggested that these interactions can be conceptualised with reference to the notion of intersecting, multiple and overlapping rhythms.

I have suggested that Walker's (2020) attempt to characterise energy and rhythm in society depends on separating out concepts of the social and the natural. By contrast I have argued that they are deeply intertwined. The limits of the social–natural dichotomy are apparent in the context of household energy demand, which relates to a huge range of different rhythms. By implication, changes in the timing of energy demand are not 'natural' responses to weather conditions. Rather, they are mediated by infrastructures, technologies, and the sequencing of social practices and rhythms that collectively shape the organisation of energy demand.

This chapter generates a number of specific questions, taken up in the rest of the thesis. For example, what are the temporal cycles that constitute different forms of seasonality? How do these cycles emerge and interconnect with social life? How are social rhythms involved in the reproduction of energy demand across multiple timescales? The next chapter describes a research design and an approach that allows me to address some of these questions.

Chapter Four: Studying Seasonal Variation

This chapter describes and justifies the methodological approach to the study of seasonal variation that I take up in the thesis.

In Chapter Two, I explained that conceptualisations of the relationship between energy and society matter for thinking about the interactions between energy systems, and social conventions. I argued that rather than imagining energy as a driver of societal organisation and change, and rather than supposing that social formations demand certain amounts and patterns of energy consumption, recognising that energy is part and parcel of social life (that energy *is* society) suggests that seasonal variations in patterns of energy demand are not driven by the fuel types, sources, or systems of provision. They are constituted by social practices. In Chapter Three, I explained that this conceptualisation of the relationship between energy and society matters for understanding seasonal variations as combined natural–social phenomena. I argued that ideas about socio–temporal rhythms are relevant for understanding variations in patterns of gas and electricity use.

At the beginning of the thesis, I posited the following questions that might follow from the idea that increasing renewable forms of supply into the UK energy mix might be limited by existing annual patterns of demand for gas and electricity. They were:

- How do variable patterns of gas and electricity demand matter for increasing forms of renewable energy supplies?
- Which specific activities and practices vary with natural and/or social seasons (holidays etc.) and which are consistent throughout the year?
- How do patterns of supply and demand vary over the year, and how does this relate to the social organisation of seasons?

Having explained how conceptualisations of energy and society, and of nature and society, affect ideas about the balancing of energy supply and demand, I can now refine these questions and formulate more specific lines of enquiry. In what follows I focus particularly on how annual variations in energy demand are represented within different public and policy discourses as societal responses to meteorological conditions, how expectations of comfort and the patterns of demand that follow are 'hardwired' into the material infrastructure of society, and how the temporal rhythms and social cycles of energy demand are extended and interconnected across the year.

Rather than supposing that seasonal variations in patterns of demand simply exist, my task is to understand how existing explanations (temporalities, thermal comfort, etc.) are themselves constituted by different actors, including government researchers, organisations that use energy, and companies that respond to seasonal peaks in demand. To catch sight of different interpretations and orientations, I need to develop methods of discovering how concepts of energy demand are formulated, and how seasonal variations are conceptualised.

A methodological strategy that can bring the study of these different aspects of seasonal variation together, and capture them is required.

In other words:

- How is seasonal variation in patterns of energy demand, and its causes, depicted in statistical representations and research that informs the design and operation of energy supplies?
- How are expectations of comfort, indoor temperatures, and the seasonal variations, in patterns of demand that follow, materially embedded into social life?
- How are social seasons constituted, and how can they be studied within research frameworks?

My aim is to approach these questions in a way that is consistent with the guiding idea that energy *is* society, as I explain and position in Chapter Three of the thesis, and that seasonal variation is the outcome of the configuration of social practices and their temporal rhythms.

In developing a methodological strategy that allows me to achieve these goals, I take inspiration from and adopt a type of social research that imagines investigations as probes – smaller and focused enquiries that each show up a particular aspect of a phenomena, and that in combination help to show it in a different light. I do this by working with secondary materials, such as reports, policy papers, and forecasts, that shed light on how seasonality is represented within a variety of different discourses.

An approach that examines various angles of a research subject requires methodological reflexivity, acknowledging the researcher's role in pursuing different lines of inquiry and forming conclusions. By using research probes, I place myself at the centre of the study, by orienting to focus on seasonal variations, and how they are constituted within the social and temporal organisation of everyday life. In doing so, I am particularly interested in identifying the assumptions that underpin how variation is represented within the energy sector at large, and how discourses sounding energy demand reinforce specific understandings of seasonality, through analysis of energy demand patterns throughout the year.

I am not primarily interested in understanding individual perspectives on seasonality and energy use. Instead, my focus is on how seasonality plays a role in shaping future energy transitions within broader public and policy discourses, as well as how these debates matter for the emergence of socio–technical innovations. I aim to explore how seasonality is framed and addressed in these collective contexts, and how it influences the development of energy systems and policies.

The probe method aligns well with the epistemological stance of my research, which does not assume the existence of a singular, objective "truth" about energy use and seasonality. Instead, this method of probing acknowledges the coexistence of multiple interpretations, or "takes," on these topics (Collins and Evans, 2015). It allows me to capture how various aspects (including temporal, material, and representational aspects) of seasonal variation matter for the constitution of annual patterns of energy demand in gas and electricity. Such an approach offers a more layered and dynamic understanding of the subject and a deeper understanding of how socio–temporal rhythms of practice and systems of provision shape temporal variations of gas and electricity demand.

In what follows, I set out the justification for this ‘probing’ style of research for this project, and for the selection and design of the three investigatory probes (on representation, hardwiring, and extended temporal cycles) that follow.

Research Probes

Research probes (also known as cultural probes) are widely employed in social science and creative design research as a tool for designing research projects. The term 'probe' itself can be interpreted in different ways, and varies significantly encompassing, for example, mobile probes, domestic probes, urban probes, informational probes, and technological probes (Gaver et al., 1999).

The purpose of designing any such probe is to discover how different aspects of social phenomena are framed within an area of research interest. One such broad definition is provided by Hutchinson et al. (2003), who states: “A probe is an instrument that is deployed to find out about the unknown – to hopefully return with useful or interesting data” (p.18).

There is an element of flexibility in the design of research probes, in how to interpret the kinds of “instruments” used as part of a research method, and in what is considered to be the “unknown” within a given field (Hutchinson et al., 2003:18). But crucially, the probe represents a targeted and purposeful line of enquiry.

As Graham et al. (2007) detail, how probes are defined and worked with varies based on the communities they are situated in, and implicitly, the paradigms within which research projects are being defined. For example, Hutchinson et al. (2003) work with ‘technology probes’, that as the authors explain:

> “Are a particular type of probe that combine the social science goal of collecting information about the use and the users of the technology in a realworld setting, the engineering goal of field–testing the technology, and the design goal of inspiring users and designers to think of new kinds of technology to support their needs and desires” (p.18).

In this example, technology probes enable the researcher to identify the impact of a form of technology on social life. In the setting in which ‘cultural probes’ originated, HCI (human–computer interaction) research, they have been employed to conduct different kinds of enquiry. For example, Gaver et al. (1999), who proposed the original idea of ‘cultural probes’, worked with selected users and provided them with physical items, including maps and postcards, to provoke responses rather than the researchers themselves directly questioning the participants. In a different interpretation, Paulos and Jenkins (2005) used ‘urban probes’ that were designed to capture responses to a material object, a rubbish bin, and to show how this one example revealed participants’ relations with the built environment. As these two examples show, the basic idea is to design a methodological strategy that does not pretend to be comprehensive, but that is constructed to shed specific light on a topic of concern.

How I work with probes in this research differs from the conventional ‘physical objects’ approach more commonly associated with HCI research. Instead of focusing on objects, the research probes I develop are defined by conceptual and methodological choices that illuminate different aspects of seasonality and energy demand, as a way of responding to the revised research questions that are developed through Part One of the thesis. This approach allows for a broader analysis, rather than restricting the focus to, for example, the study of objects within a participatory research framework, which is a different research agenda, and would not fit the aims of the revised research questions. These questions are designed to capture how actors, infrastructures, and discourses shape understandings of the relationship between seasonality and energy demand, instead of focusing on how specific objects are used within social life. This methodological decision ensures flexibility as a researcher, as I can navigate freely between topics, using probes as a means to identify new areas of inquiry and generate insights and cross cutting themes across different research areas. There are other research methods, aside from constructing research probes, that are designed in this way, to probe specific sites or settings in depth. For example, 'case study' based approaches. These are popular research strategies for conducting qualitative research to,

> "explore(s) in depth a program, event, activity, process, or one or more individuals. The case(s) are bound by time and activity, and researchers collect detailed information using a variety of data collection procedures over a sustained period of time" (Creswell 2014:241).

This method is a potential approach for this research project, as case studies allow for an in–depth exploration of phenomena and are grounded in a distinct historical context. These are not incompatible strategies; rather, probes can be used to investigate specific aspects of methodologically bounded 'cases'.

Thus, a focus on 'cases' does not of itself define the methodological strategy. This is clear in Priya's analysis of case study qualitative research which describes the flexibility of methods that can be used to study specific phenomena, as it,

> "allows the researcher the leeway to use any method of data collection which suits their purpose (provided the method is feasible and ethical). Generally, for a sound, unadulterated and unbiased study of the phenomenon under investigation, several techniques of data collection are used such questionnaire, survey, in–depth interview, participant/non–participant observation and the study of documents…" (Priya, 2021:94).

There are examples of this kind of mixed methods approach within energy research social science, for example, following changes in the timing and sequencing of social practices. Brauer et al. (2024) undertook a case study of Swedish households, including semi–structured interviews with single–family households, to consider how the 2022 energy crisis across Europe reconfigured social practices, whether short–term or long–term. Similarly, Balest and Stawinoga (2022) contribute to an increasing body of research looking into the effects of the COVID–19 pandemic on energy consumption, by identifying how lockdowns reshaped the timing of energy consumption domestically. In this case the authors used survey data of 3519 people in Italy, to analyse 'energy habits' during the pandemic. As both examples illustrate, case studies offer a degree of flexibility in choosing an appropriate method based on the objective of the research. The benefit of choosing to bound the field of study by concentrating on case studies, more broadly, is that this allows the researcher to provide an in–depth analysis of specific phenomena and examine multiple dimensions of a single case or a few cases.

One way of taking this forward would be to focus on how specific social practices change throughout the year (such as electric vehicle charging, the timing of showering, using cooking facilities etc), and how this affects the timing of gas and electricity consumption. In theory I could do this by zooming in (Nicolini, 2009) and following how specific activities change, and their sequencing. This kind of study would provide targeted insights into the views and responses of different sectors of the population, and how their practices change throughout the year but it would not allow me to 'see' how the seasonality of energy is collectively conceptualised and constructed.

Although this method of defining a case might suit another project, it did not fit the overall objectives of my study, because my research questions, both at the beginning of the project and after being refined, are not targeted at following the actions of specific sub–sections of the population.

Instead, my aim is to understand how seasonality is presented within specific public and policy discourses, and how socio–technical innovations in domestic energy provision have shaped indoor and outdoor life. In other words, my 'cases' are not specific practices. Instead, I focus on revealing processes in which multiple actors and practices combine to make seasonal variations in energy demand.

For this project, I require a methodological approach that can shuttle between different topics of interest, and not exclusively focus on a limited representation of specific sectors of the population or specific activities. I also bound the scope of my enquiry–and in that sense I do work with 'cases', but these are of a different order. Having carved out my 'topics' I can design relevant and appropriate research probes, and gather specific insights that show different aspects of seasonal variation, and how it matters for the constitution of annual patterns of energy demand.

Adopting a probe–style research strategy makes it possible to move between the ideas set out in Part One of this thesis and the details of three specific enquiries, each of which help to show up a different aspect of the constitution of seasonal variations in patterns of demand. C. Wright Mills describes this approach to 'shuttling' between conceptualisations and smaller–scale empirical studies of phenomena in '*The Sociological Imagination':*

> "The… craftsman does not usually make up one big design for one big empirical study. His policy is to allow and to invite a continual shuttle between macroscopic conceptions and detailed expositions. He does this by designing his work as a series of smaller–scale empirical studies…, each of which seems to be pivotal to some part or another of the solution he is elaborating" (Mills, 1959:126).

As the design of this thesis indicates, shuttling between different aspects of both energy provision and patterns of demand ensures that the research questions, and their objectives, can be practically addressed.

To elaborate, the research probes I construct are individually designed and adapted to specific research contexts, dynamically situated to change with the collection of secondary data, to probe and question how different aspects of seasonality are presented within sections of the energy sector more broadly. Their function is to guide me towards new insights into a topic of interest–defined by the discussions set out in Part One-through 'probing' assumptions and emerging themes, in my case, from secondary materials.

This is not a novel approach. For example, Wang's (2008) study of globalisation and emerging technologies in the Greater China region utilised research probes to investigate different slices of this vast research area. Despite not conforming to the more 'traditional' use of employing research probes, as found within HCI research, the inherent flexibility of the methodological approach to probing suggests that this would be an appropriate method for my project.

Part Two of the thesis consequently consists of three probes or lines of enquiry that allow me to unpack some of the underlying assumptions, on which explanations of seasonal variation in patterns of gas and electricity use depend. The aspects of seasonal variation that the three probes investigate do not add up to a comprehensive and totalising account. Rather these aspects–how seasonal variation of energy data is managed; how heating and cooling seasons evolve; and how social seasons generate peaks in demand across the year, have been selected because they speak to fundamental issues raised in Part One.

To construct each probe, I start with a specific area of interest that is relevant to the study of seasonality within UK energy systems, and 'probe' further, by tackling the underlying assumptions and performativity of public and policy discourses, technologies, and representations that capture how seasonality is understood. Each probe represents a 'slice' on seasonality and is directly informed by the conceptual positioning described in Part One of the thesis, where forms of seasonality are shaped, in part, by indoor/outdoor relations, rhythms and annual cycles. The challenge, and the logic for constructing each individual probe, is to ‘show’ how these themes are prevalent, in some ways more than others, across a series of research sites.

The first probe is designed to show how methods of representing energy demand factor in, and also leave out, potentially crucial aspects of social organisation. As I show, methods of ‘weather correction’, which are used in making statistical representations of average energy demand, have the effect of deleting variations in outdoor conditions. In focusing on these methods, my aim is to identify the significance of the weather for energy demand patterns.

The suggestion that patterns of energy demand are influenced by both social and natural phenomena inspired the design of a second ‘probe’, which focuses on changing perceptions of thermal comfort, and the specification of different kinds of heating and cooling seasons.

Finally, the third probe is designed in response to the suggestion that patterns of energy demand are entangled with social and temporal rhythms. This probe is created to examine the role of social seasons beyond traditional peak energy demand periods, focusing on how phenomena like the timing of Christmas affect supply chain dynamics and supply/demand fluctuations across the entire year.

Selection Strategy for the Research Probes

The selection of materials for each research probe is guided by the need to deepen my understanding of specific subjects. Since each probe pursued a distinct line of inquiry, a single selection strategy is not employed across all probes. Instead, and in each case, I rely on secondary data, which was selected, identified and analysed in relation to my research focus. These secondary materials include policy documents (e.g. white papers, policy briefings), reports written by actors operating within the energy sector such as NGO’s and energy producers, and supply chain reports written by commodity producers.

The use of secondary data offers significant advantages for this project. By carefully selecting documents tailored to the probes, I could shuttle between topics that inform the lines of enquiry, while critically analysing the context, assumptions, and discourses prevalent across themes. Secondary materials could be used alongside existing academic literature to explore how seasonal variations across different areas of interest are, or are not, situated within theoretical and conceptual frameworks, particularly those grounded in social science energy research and beyond.

To gather these materials, I employed purposive selection, a strategy where the researcher uses their judgment to select data for in–depth investigation (Rapley, 2014). This is a commonplace method within the social sciences for conducting research both with secondary data, and with human participants. For example, Beedell (2021), adopts a similar approach in their sociological study of social change, of how civil society actors contribute to ideas and policymaking within Bangladesh including those working in the NGO and INGO sectors. These authors conducted a study using purposive sampling to identify multiple 'small' stories of experiences influencing societal changes, which were then situated, using secondary data, within broader contexts and themes in their research narrative.

Similarly, Mirzania et al. (2023) use purposive sampling in their case study, identifying specific individuals who could offer expert insights into the 'barriers' of moving away from burning coal. Although this is not directly a 'strategy', it indicates that certain choices for research focus are dependent on the availability of resources, and the situated context in which they appear of interest. This kind of approach is similar to how I used research probes to show different 'slices' of seasonality, which are located within other key debates and themes about the future of energy systems with increasing forms of renewable energy supplies.

Since there is no ready–made 'universe' of texts on the topics in which I am interested, there is no obvious sampling frame that I could use to inform something like a method of random sampling (Bryman, 2004). Given that I am not aiming to provide a representative analysis, a purposive selection, rather than a 'sample' makes sense as a means of determining which texts to focus on and which secondary data suited the probe of study.

As Morse and Niehaus (2016) identify in their study of mixed method research designs, the data collection methods used within a research project are appropriate if they are consistent in being efficient and relating to a specific line of enquiry. However, there are still questions that I need to address about which documents to use, and how to interpret them.

One of these has to do with the effect of my role as a researcher and with the strategy of using my own judgement about which materials to analyse. One of the key criticisms of using the purposive strategy, as suggested by Akpan and Piate (2023), is the possibility that the researcher will make errors of judgement and that the selection will be prone to high levels of bias.

The problem with this criticism, and with this way of thinking about bias is that it assumes that there is one 'truth' that methods capture completely. I reject this view, and instead argue that documents and institutions construct their own versions of truth and that this is what I want to access. From this point of view, the notion of bias, as usually defined, is redundant, a point made by Hammersley and Gomm (1997) who argue that issues of bias depend on a parallel notion of truth–from which biased studies depart.

Issues of 'validity', defined as the "meaningfulness of research components" (Drost 2011:106) and 'reliability', referring to the "consistency/stability of measurement over a variety of conditions" (p.114) are commonly evaluated in terms of a similarly linear scale, as if selected methods might have more or less of these qualities. (Drost, 2011). In my view, this approach is problematic because it assumes that some materials are inherently more reliable or valid than others, and that it is possible to make absolute judgements about these aspects. This perspective risks oversimplifying the complex interplay between research method, context, and how materials are interpreted, as if reliability and validity could exist independently of the conditions in which they are applied. For example, a dataset or tool that is deemed valid in one setting may not hold the same meaning or applicability in another. This is an argument made by Pilcher and Cortazzi (2024), who find that methodological binaries are often constructed within research methods, overlooking the ways in which context and the complexity of research methods matter for understanding the collection of materials.

Following this line of argument, my method is to set these generic concerns aside and to say more about how I went about my work, and why I chose to investigate some sites and texts, and not others. For example, as regards the selection of documents and sources within each research probe, I sought to identify and work with examples of perspectives that offered different understandings of an issue of interest. By way of illustration, I was in contact with officials at BEIS (now DESNZ), to ask further clarifying questions about the status of several documents that ended up being key to my analysis of methods of averaging and weather correction. Similarly, in my third research probe, when I investigated three different commodities associated with the Christmas social season, I sought to identify and compare multiple supply chains of the same commodity in order to capture otherwise invisible aspects of variation.

I have also sought throughout the thesis to offer context and wider consideration of my findings, by identifying how each probe is a snapshot of a specific focus of interest and is not designed to be representative. Although I rely on a limited number of documents within each probe, this is not to suggest that the findings are intended to be comprehensive or generalised across the sector. Rather, they provide insights into different areas of seasonality that shed light on the areas that matter for reconceptualising energy systems away from fossil fuels, and towards new understandings of decarbonisation and changing patterns of gas and electricity supply and demand. The flexibility of shuttling between different lines of enquiry allows me to explore emerging cross–cutting themes and to identify trends and patterns that relate to my research questions.

The next step is to explain how I designed each of these three probes individually, and how they were constructed with the objectives of the thesis in view.

Probe 1–Variations in Weather and Methods of Weather Correction

The first probe I design investigates how variations in patterns of gas and electricity demand are represented, and how seasonal variation is understood within government, policy, and industry reports.

I arrive at this first probe through identifying understandings of how patterns of gas and electricity demand change throughout the year and during different meteorological seasons (Gavin, 2014). As I explain in Chapter One, there are a number of assumptions made about the constitution of demand, namely that it can be connected to changing outdoor temperatures (Hunt et al., 2003), and energy efficiency measures can impact the extent of demand (Exxon, 2019).

I want to identify how these assumptions are reinforced within public and policy discourses, since Chapters Two and Three begin the process of repositioning ideas of seasonality, with consideration to the broader relationship between energy consumption and social life, and how energy use is linked to changing relationships within social life and the outdoor climate. This leads to a key question: how are changing patterns of demand reflected within reporting of energy systems in the UK, and what does this mean for how specific representations of seasonality are constructed?

This probe focuses on the methods used to describe energy demand across the year. My analysis of the methods used, and in particular of the technique known as weather correction, is partly inspired by ideas contained in David Mackenzie's (1990) *Inventing accuracy: a historical sociology of nuclear missile guidance*, and his account of nuclear missile development during the Cold War. Mackenzie traces the construction of knowledge about missile 'accuracy' and the forecasted predictions of the damage impact of missiles on targets. Mackenzie shows that accuracy is a contested topic, not an inevitable outcome of technological development; rather it came about through a set of social processes in which different political agencies competed against one another with reference to the theme of 'accuracy'. Mackenzie describes this process through the idea of the 'black box', which refers to a process where complex systems or technologies become obscured from view. In essence, systems operate without questioning or without fully understanding the intricate details inside. The contents of the black box remain hidden, and only the outputs or visible functions are seen or acknowledged (Mackenzie, 1990; 2005).

While the accuracy of nuclear missiles is quite a different topic to my own area of research, the idea that social processes inform knowledge creation is useful for understanding how the weather figures in representations of variations in patterns of demand for gas. In this case, more 'accurate' treatment of variation remains an ongoing goal.

To capture this process, and to 'open up' the black box of energy demand methodologies, I focus on two methods for this probe: averaging and methods of weather correction. These issues were chosen because they present two different ways in which the relationship between the weather and domestic energy consumption is handled. As I show, both statistical methods flatten out seasonal variations in energy demand across the year and obscure the peaks and troughs of consumption that are spatially and temporally organised across the year.

To learn about how this kind of 'flattening' of variation takes place, I draw on selected reports and secondary materials that show how averaging and weather correction flattens certain kinds of variation. The reports I choose offer an entry point into how different discourses of energy demand are shaping how patterns of consumption are being understood within the energy sector more broadly.

To determine the selection of documents for analysis, I focus on three key sectors involved in producing reports related to energy demand trends: these are produced by government policymakers, third–sector organisations, and energy suppliers. This approach includes some of the diverse stakeholders operating in the energy sector.

To identify specific texts, I conducted a search on GOV.UK of official documents, including white papers, policy briefings, and ministerial statements from 2010 onwards, with this being the start of the tenure of the Conservative government holding office, and coinciding with policy developments regarding renewable energy and net–zero ambitions. The keywords of 'seasonality', 'energy demand', and 'seasonal variation and energy systems' generated over 10,000 results collectively, so I narrowed the search to locate white papers and policy strategies that were closely connected to the key words I chose, which produced nine reports.

As such, I evaluated documents that reflected key policy positions and strategic directions from government.

Within third–sector organisations, I reviewed publications from what I took to be influential groups in this area, and over the same period. These included the Carbon Trust, and the Energy Savings Trust. These organisations play a critical role in shaping public discourse and advocating for sustainable energy practices, making their reports (six in total) an important component of this analysis. Lastly, I examined reports from 2010 onwards, from both UK–based energy companies, such as Shell, as well as international suppliers such as Exxon. These reports (four in total) offered a commercial perspective on energy demand, highlighting trends in consumption and forecasts for future changes.[7]

By conducting a document review across these categories, I was able to gather a diverse set of 19 publications that presented energy demand projections and gave an indication of how variation in demand is described and explained in relation to changes in policymaking and tied to changing consumption throughout the year.

After this initial work, I narrowed my analysis to one report from each area, to provide an example of how each sector has presented variation in gas and electricity use throughout the year, and an indication of the types of methods used in gathering this variation together. The criteria for selecting these documents include: whether these documents provided insights into seasonal variation of energy use, how energy demand fluctuations were presented, and how these representations were embedded in both past, current, and future understandings of energy systems.

The selected documents, consequently, are a government white paper, 'Powering Net Zero' BEIS (2020a), a forecasting future energy systems report by the oil producer Exxon (2019) and a report on electricity consumption household demand by the Energy Saving Trust (2012). These three reports reflect different perspectives on energy demand within the energy sector at large.

In each case, my aim was to identify how specific positions and understandings are represented in each of these reports. This enables me to draw out assumptions underpinning the presentation of energy consumption data, e.g., if energy use was taken for granted, if any consideration was given that demand would stay the same in the future, and how the

[7] The full list of documents examined for the first probe can be found in the Appendix of the thesis.

modelling of ‘need’ was undertaken. Moreover, I determine the statistical methods used to represent energy demand, and how these were justified in each document that I examine.

These three reports, taken together, inform my analysis of how variations in the weather were embedded in the types of energy demand reporting that I studied. For example, I found out about methods of ‘weather correction’ through the processes of working through the reports. As BEIS (2020b) uses weather correction methods in their statistical reporting of energy demand, I could investigate the effect of using these methods and learn about how this technique was justified.

This probe sheds light on how gas and electricity demand is represented within different settings, and how the collection of statistical energy data is used to present specific narratives within the energy sector, such as those claiming to improve energy efficiency, and to model forecasted changes in energy systems. The chosen selection of documents is beneficial for this research because it presents the approaches and positions of actors operating within the energy sector and because it shows how narratives of energy demand variation are constructed, through the modification of statistical data by methods of averaging and weather correction.

The outcome of this probe is to show the effects of averaging and weather correction methods on representations of mainly gas, but also electricity demand in the UK. The goal of revealing trends in efficiency over time depends on forms of weather correction. This goal trumps the significance of recording and quantifying actual variation through the year, which is weather dependent. As I show in Chapter Five, one consequence of these statistical methods is to flatten and obscure the seasonal effects of temperature fluctuations on the extent and timing of energy demand.

Probe 2–Histories of Heating and Cooling

My second research probe investigates the relationship between the indoor and outdoor climate as it is mediated by ideas of comfort, and societal conventions that shape the configuration of heating and cooling provision in the UK. This line of enquiry followed from another common–sense position, which is that demand for gas and electricity for heating and cooling depends on providing the “same level of comfort” all year round (BEIS, 2016:3), and regardless of the weather outside.

I arrive at this specific probe by considering how the relationship between social life and the outdoor climate, as I investigate within Chapter Three, matters for the constitution of gas and electricity demand throughout the year. Within this chapter, I question how materiality and cultural conventions combine to form understandings of how we use energy through social practices throughout the year. One such example, is how domestic energy technologies help to ensure households are ‘comfortable’ throughout the year. The importance of maintaining ‘normal’ comfort conditions is illustrated by Ofgem’s (2016) conclusion that technologies such as electric heat pumps can meet this need and at the same time, flatten the load on the grid, meaning that the energy used to meet “underlying need for comfortable temperatures (would be) less peaky” (p.3). Claims like these depend on a prior notion of comfort, and consistent ‘standards’ throughout the year, with no seasonal variation in indoor conditions.

To investigate these assumptions, I consider secondary sources that reveal recent histories of contemporary heating and cooling. The resulting probe focuses on how the meaning of thermal comfort evolves with changes in heating and cooling infrastructure.

The aim is to show how heating and cooling technologies underwrite the project of maintaining baseline indoor temperatures throughout the year. I frame this discussion using the work of anthropologist Marcel Mauss (1979), who drew on a range of ethnographic research to detail the seasonal organisation of social life in relation to the Eskimo/Inuit[8] in his book *Seasonal Variations of the Eskimo: a Study of Social Morphology.* Mauss’ account of the shifting relationships between the outdoor climate and social organisation of the Inuit populations inspires me to think about how similar relations are organised today. This leads me to focus on indoor heating and cooling provision.

During my research for Part One of the thesis, I discovered Mauss' work, which provided an ideal entry point for discussing the relationship between changing meteorological seasons and the social and temporal organisation of everyday life. Mauss’ analysis reveals a striking contrast between how social life was organised in Inuit societies, compared to the material organisation of social life seen in the UK today.

As Mauss explains in his book, there were significant differences, including differences in the laws to be followed during ‘winter’ and ‘summer’. For example, summer, marked by the arrival of the caribou, saw Inuit families leaving their collective winter quarters to live in smaller family units. They spent the summer dispersed before returning to the main communal building for the winter, where different laws concerning property and social organisation

[8] Mauss refers to these groups of people as ‘eskimo’ in his book, as this was their label used during the time of publication. Cultural attitudes have since changed, and this term would now be viewed as derogatory in the present day. For the remainder of the thesis, aside from direct quotations, I choose to use the term ‘Inuit’ instead of eskimo, when referring to Mauss’ research.

applied. It is now difficult to imagine such a society, and that is precisely the point. Seasonal differences in ways of life have been eroded to such an extent that people today expect uniform conditions all year round. The flexibility and adaptation that once defined social and economic life in response to natural cycles have largely been replaced by a more standardised, year–round organisation of daily life, regardless of seasonal changes meteorologically.

My method for this research probe is to review social histories of heating and cooling (Cooper, 1998; Ackermann, 2002; Spurling, 2015; Trentmann and Carlsson-Hyslop, 2018) and institutional guidelines (Lancaster University 2019; New et al., 2023), to draw connections between these sources. I do this to show how temperature variability and ideas of comfort are socially organised and how relationships between energy demand and comfort are configured.

The social histories included in this probe are selected based on the materials used to position the study of energy demand and seasonality in Part One of the thesis. More specifically, as I conceptually align social practices with energy demand, I encountered social histories that investigated this relationship from a heating and cooling perspective, from groups such as the Demand Centre at Lancaster University. I chose to revisit the findings of studies designed to investigate the normalisation of central heating, and the introduction of air conditioning in the USA. I chose these social histories for these probes given the limited attention to seasonality presented in these analysis'. This probe therefore offers an opportunity to re–evaluate these previous studies by identifying how domestic heating and cooling technologies influence the understanding of seasonal variations in gas and electricity usage, particularly within domestic and institutional energy systems.

Regarding the focus on air conditioning in the USA, I briefly discuss in Part One of the thesis how the 'need' for air conditioning is constructed–a topic explored by Cooper (1998) and Ackerman (2002) in their social histories of the technology. Since air conditioning is less widespread in the UK compared to the USA, examining its adoption raises two key questions: whether such a shift in indoor cooling standards could occur in the UK, and whether there are parallels between the introduction of gas central heating in the UK in the 1950s and the current changes in indoor cooling in the USA. Shifting the focus to a different Western country allows for a comparative analysis that contributes to ongoing discussions about changes in energy systems, with decarbonisation at the forefront, and increasing demands for electricity (used to power cooling) as an alternative to gas (widely used for heating).

I also refer to institutional guidelines that define the boundaries of the 'heating season' in university buildings, specifically Lancaster University, University College London (UCL) and

Cambridge University. I turned to these documents to see how generic ideas about comfort were translated into concrete policies and into decisions about when to turn the heating on, or off. This supplements the main focus of this probe, doing so in a way that allowed me to 'see' how notions of comfort are enacted. Specifically, the criteria for choosing institutional guidelines are that the documents were publicly available heating and cooling policies at UK universities, and set out how indoor temperatures are managed throughout the year. Again, these are not embedded into my analysis to provide a representative account of heating and cooling within UK universities, but they present different understandings from geographically different settings, one being campus–based, the other city–based, for example.

By using both social histories and institutional guidelines, my aim was to find out how ideas about weather, thermal comfort, and social conventions of the 'timing' of heating and cooling matter for indoor climates, and the energy costs of maintaining them. The secondary materials I work with, are selected on the basis that they illustrate methods of understanding how baseline indoor temperatures were constructed, and what effect these have on current patterns of heating and cooling demand. These accounts identify historical developments, technological changes and cultural conventions that have shaped indoor comfort and energy consumption. These were not unique to the domestic settings. As mentioned above, I also refer to institutional guidelines (Lancaster University 2019; New et al., 2023) regarding the specification and achievement of 'comfort'.

The decision to use these selected secondary materials was informed by the goal of demonstrating how ideas of heating and cooling are shaped by the organisation of infrastructures and concepts of comfort. These are constructed around the fulfilment of specific temperature standards, designed within both domestic and institutional systems of provision.

The outcome of the review of secondary materials shows how heating and cooling systems have been configured to underline the extent to which 'the weather' and seasonal variations have been removed, and how energy demand relates to the social and historical 'need' to provide uniform conditions indoors all year round.

Probe 3–Multiplicity of Temporal Rhythms

The third probe focuses on the extension and connection of social temporal cycles. This is in response to the idea that cultural conventions, such as the Christmas holiday season, orders patterns of demand at the end of the calendar year. Instead, I show that the interconnectedness of annual social cycles with the timing of the season of Christmas, depend on multiple different rhythms extended across the year.

The construction of this probe began by considering how social seasons are materially constituted, and how they are entangled with various rhythms, practices, and cycles. I take a narrower view of this within the second research probe, as I focus on the formal and informal basis for heating and cooling seasons, examining how they are constructed through the establishment of baseline indoor temperatures in both domestic and institutional settings. However, the third probe expands this analysis, going further into how social seasons materially and temporally organise social life, and the implications of this for how understandings of seasonality, and variation throughout the year, are entangled across multiple temporalities.

This strategy ensured that I could move beyond the boundaries of how energy demand is constituted in relation to seasonality and move towards a broader focus of how social seasons matter for how annual cycles are constituted through the repetition of social practices, sequenced, and located throughout the year. In this case, my method is to select a particular 'social season' as an example of a cultural convention that organises activity, and then investigate how various activities are co–ordinated temporally across the year in ways that constitute the season (Tommi, 2016; Anable et al., 2017; National Grid 2020), and related energy demands.

Investigating Christmas has the advantage of representing the culmination of diverse 'tracks' and rhythms of production and distribution. With the convergence of agricultural cycles, industrial timelines of supply and demand, and the end of the calendar year, Christmas represents an opportunity to study how cultural and religious calendars intersect with social rhythms and practices during this period. Following the systems and annual timings of provision of different goods is one way to show how social seasons are constituted by the coordination of activity, not only on a single day, but in the sequencing and scheduling of contributory processes throughout the year.

In order to identify these sorts of connections I select three examples of commodities that have different temporal characteristics: some which depend on 'natural' growing cycles and others on commercial design and manufacturing. To be more specific, I focus on the production cycles of three commodities: turkeys, Christmas trees, and a popular Christmas toy called the 'Barbie Dreamhouse'. The aim is to show how social peaks are constructed by sequences of practices distributed across the year. In doing so, the logic of this approach was to complicate any singular or one–dimensional interpretation of social seasons.

Through researching the supply chains associated with products that are in demand during the Christmas season, I identified several commodities that could be explored further for this probe, beyond the three selected. For example, I initially identified baubles, tinsel, and the production of Christmas lights–commodities with supply chains that align with the seasonal timing of Christmas. However, the three commodities I selected for analysis in this probe, Christmas trees, turkeys, and toys, each provide valuable insights into the temporalities of perishability and storability which I am particularly interested in, in order to reveal how supply chains manage these 'pressures' during a time critical period, when Christmas falls in the calendar.

Christmas trees and turkeys, as commodities of interest, immediately stood out for analysis due to their association with the timing of Christmas, and their production processes requiring a strict attachment to the calendar to ensure goods are available by December. The choice of the 'Barbie Dreamhouse' is influenced by it being consistently a top seller at Christmas, and the brand having a rich history of development and adapting to new trends in social life (NPD Group 2021).

With the three products chosen, I am interested in highlighting relevant cross–cutting themes between the chosen commodities, such as issues of perishability and storage. These are important for this analysis because they are closely linked to matters of seasonality, for example, product availability, supply chain dynamics, and market/consumer behaviours throughout the year.

To elaborate, while turkeys can be frozen and stored, fresh ones must be hatched and reared well in advance of Christmas. Natural Christmas trees are harvested once they reach a certain height, requiring careful timing to ensure they can reach consumers in a condition (size, colour etc.) acceptable to the stockist. By contrast, products like the Barbie Dreamhouse or other non–perishable goods can be stored and stockpiled until demand peaks, though production is still ramped up in advance of Christmas to ensure supply. These examples highlight the varying temporalities of production and consumption, with some goods requiring long–term preparation, while others can be adjusted more flexibly to meet demand.

These themes suggest that the timing of Christmas plays a significant role in how these characteristics are embedded in the annual cycles of supply chains, and the three chosen commodities ensure that these insights could be drawn out of the secondary data.

In order to put this research probe together, I gather secondary materials related to the supply chains of each of these commodities. I do this because the supply chains of these commodities reveal how annual cycles of supply and demand are materially embedded within different kinds of social practices, sequenced throughout the year. To locate these materials, I research the manufacturers, their policies for producing goods, and academic research that provides further insights into the temporalities of supply and demand I am interested in. As the Barbie Dreamhouse is produced by one company, I could narrow my focus to finding materials that show how Mattel supplies the toy year after year. For turkeys and trees, I rely on individual and sector advocacy accounts of the production processes, as these vary, but I am able to highlight patterns in the timing of, for example, when turkeys are slaughtered, or trees are harvested.

Some of these materials include production guidelines for turkey processers (Aviagen Turkeys 2023), tree producer reports that detail the timeline of growing and harvesting different kinds of trees (PE Americas 2010; Claxton, 2014) and reviewing social histories of the 'Barbie Dreamhouse' (Medina, 2009; Eilers, 2012; Lasky, 2022) to inform how multiple kinds of temporalities shape the Christmas season. To map these commodities and their timings, I construct a timeline (Figure 4) that provides an indication of how these products rely on specific cycles of activities. The benefit of this, is to map how intertwining patterns of supply and demand matter for understanding different forms of seasonal variation, associated with Christmas.

The collection of materials I gather provide significant insights into the importance of the calendar, and the critical goal of meeting specific deadlines throughout the year, to ensure supply is ready 'on time'. The result of this probe is an account of how seasonal rhythms are constituted through annual cycles of supply and demand. This positions a social 'season', such as Christmas, not as exclusively situated within a specific time, but spread across the year within multiple, intertwining temporalities.

Reflections on the Research Design

I take this opportunity to reflect on the construction of the research probes within this thesis and why probing is a suitable methodological approach for studying seasonality and for conducting the empirical research for this project.

First, stepping back from the detail of the research probes, the key challenge in this research was identifying methods that would reveal new insights into how variations in energy demand shape the role of seasonality within the UK energy system and how it intertwines with the social and temporal organisation of everyday life through annual cycles and rhythms. This requires a reflection on my own position in the research process and the decisions that led to the chosen methods of inquiry.

The core research method used in this project was the construction of research probes. This approach places the researcher at the heart of the methodological process because the gathering of materials, and their re–interpretation with the research objectives is dependent on my skills and knowledge of the subject area, as I orientate in Part One of the thesis, where I position my approach to the study of energy systems. However, by providing a detailed account of the processes by which the research probes used in this thesis were constructed, and the rationale behind the decision–making in each probe, I have identified how this approach took the form it did, and how I use the resulting material to show why seasonality matters for the study of energy systems. I argue that I benefited from this approach because of the new insights and cross–cutting themes that emerge from the research.

More specifically, as I will outline in Chapter Eight, I conclude by arguing that seasonal variations in energy supply and demand are often obscured in public and policy discourses through their representations. Additionally, I demonstrate how rhythms are crucial to understanding the interplay between seasons, energy demand, and social life. These seasons are constituted by multiple overlapping temporalities, that matter for the study of energy systems, and how we understand how energy demand is organised throughout and beyond the year.

The probes I work with allow for a tailored approach, enabling me to move between different sites of interest to see different aspects of seasonality, and shuttling between specific debates and assumptions that, as discussed in Chapters Two and Three, required further analysis to show how they shape narratives around energy demand, its timing, and its relationship to social and outdoor life. Numerous research probes could have been constructed around this topic, each focusing on different aspects. For instance, I could have explored the impact of the UK's cost of living crisis starting in 2022, which led to rising energy bills due to the reliance on foreign oil and gas. This could have provided insights into how domestic energy practices might shift in response to increasing costs, and how this impacted the timing of gas and electricity demand. Similarly, I could have investigated emerging socio–technical innovations, such as the rise of electric vehicles or the use of domestic heat pumps, to understand how these technologies influence attitudes toward the timing of energy consumption. Both topics could have offered valuable insights into seasonality with further probing.

However, I chose not to pursue these lines of inquiry for this project, on the grounds that they would not have contributed to my more specific research agenda, as established in Part One of the thesis. To understand how seasonality is relevant for the study of UK energy systems, I identified key points of investigation: representations of energy demand, the role of indoor heating and cooling technologies in redefining ideas of comfort, and the structuring role of cultural events in the calendar. I stuck to these on the grounds that they spoke directly to the key research questions that emerged from Part One of the thesis. This decision reflects the research paradigms in which my study is situated, where the complexities of studying energy systems are best served by an approach that does not take technological changes, means of indoor provision, and patterns of energy demand for granted. As advocated by Varpio et al. (2020), who emphasise evolving research questions based on ongoing analysis, I adapted my questions based on the positioning that emerges in Part One of the thesis. From this perspective, constructing research probes–starting as initial sites of investigation and evolving into a reanalysis of existing materials–provided a starting point for the research.

The question of the significance of technology, or economic disruptions, could be analysed in the terms I have set out. However, their significance, or the question about why I did not start with or investigate those issues is based on an idea of economy and technology as being driving or independent of the timing and emergence of socio–temporal rhythms. That is not the position that I argue for through the chapters in Part One.

Looking back, I learned more than I expected about the distributed character of seasonal peaks (Chapter Seven) and about how conventions of comfort–domestically and institutionally–change over time (Chapter Six). Efforts to 'flatten' these variations result in tensions between 'standard' representations of the energy systems and the 'actual' variations, annually and over longer periods, that are in play. These tensions are revealed and foregrounded by the research that I conduct, guided by my research questions and by the logic of the project as a whole.

Conclusion–Developing an Understanding of Seasonal Variation

In this chapter, I have explained how my research has been designed, why I developed a probe approach to the study of seasonal variation, and why I have relied on diverse secondary sources in following these lines of enquiry. To reiterate, the aim was to capture aspects of the 'making' of seasonality and to do so in a way that allowed me to move across different empirical sites and settings. This approach has allowed me to consider various aspects of seasonal variation, influenced by concepts of energy demand and overarching themes of rhythm, cyclicity, and temporal cycles significant in the study of social life. The probes show slices of the phenomena I'm studying and do not add up to a total or general representation.

In combination and in conjunction these separate research probes provide a unique set of insights into relationships between the weather and energy demand, how this is mediated by different technologies, and how seasons are made up of many activities temporally extended and interconnected over the year. The method that I adopted allowed me to shuttle between seasonally variable areas of demand and catch sight of how those are variously configured, obscured, and reproduced. Along the way I have considered different kinds of representations, technologies, and annual cycles.

Because of differences in emphasis and focus, the three separate research probes each provide insight into the constitution of seasonal variations in energy demand. The combination does not produce a 'comprehensive' picture–other probes would have produced other insights–but my research strategy allows me to offer a nuanced view of the multiple routes through which seasonal variations in energy demand are made and reproduced.

Collectively, the three probes I describe reveal some of the limits of explanations and representations that depend on weather correction, on static accounts of thermal comfort, and on temporally fixed interpretations of social seasons.

Part Two–Introduction

I have set out in Chapter Four how I navigate the different ways of approaching ideas of seasonal variation, by creating three distinct research probes, I take this opportunity to provide a brief narrative to signpost the sequencing of the forthcoming chapters.

The next chapter in the sequence, Chapter Five, starts by considering how understandings of energy demand are constructed and reproduced. Taking inspiration from Mackenzie's (1990) work on the ways in which forms of knowledge can be socially constructed, I review a selection of reports from different energy policy discourses, namely from BEIS (2020a), Energy Saving Trust (2012) and Exxon (2019), to show how patterns of demand are constructed through methods of averaging and correction methods. These methods are important as they are used, for example, by energy modellers who forecast future energy scenarios that embed ideas about 'normal' energy demand and include assumptions about how patterns of gas and electricity demand change with the meteorological seasons.

Chapter Six takes a different approach by highlighting the significance of the outdoor climate in providing heating and cooling indoors. By examining how social seasons intersect with the outdoor climate within the context of domestic heating and cooling, I investigate the emergence of heating and cooling seasons, particularly in the context of domestic central heating in the UK and air conditioning adoption in the United States. These examples illustrate how socio–technical innovations have shaped user expectations regarding indoor comfort. Furthermore, I show how the outdoor and indoor climate matter for the emergence of baseline indoor temperatures, and how ideas of comfort are maintained and reproduced.

In Chapter Seven, I adopt a different perspective by examining the social organisation of Christmas. While electricity demand may be low on Christmas Day and during other parts of the social season due to societal customs focusing demand domestically, this is balanced by the shutdown of other industries over the holiday period. To explore this social season, I investigate how it is created and sustained by the rhythms of supply and demand throughout the year. By shifting the analytical focus away from energy use, I redirect attention towards the production of commodities throughout the year that contribute to the seasonal patterns of supply and demand.

By focusing on three different Christmas orientated commodities, I show how the organisation of supply chains rely on strict timings throughout the year to make sure products are ready for the 'Christmas season'. Multiple different 'seasonalities' are embedded in the 'remaking' of

Christmas, whether it is through turkey hatching, tree planting and sowing, or the timing of Christmas toys on the shelves in supermarkets. In sum, this chapter establishes how Christmas is constructed through annual cycles that extend beyond the typical boundaries associated with the Christmas season, and I explain the multiplicity of seasons that extend throughout the year.

These three chapters collectively offer different entry points into studying seasonal variation, from representations, to ideas of technology and comfort, and to the spatial and temporal organisation of social seasons and create new ways of studying and understanding different kinds of seasonal variation. Each chapter provides a different perspective on the topic of seasonal variation, that informs the key conclusions of the thesis, which I discuss in the final chapter, Chapter Eight, where I draw the various threads located across the thesis together.

Chapter Five: Representations of Energy Demand and the Weather

The first of the three probes start with the initial question of how seasonal variations are represented in generic representations of energy consumption. I consider how seasonal and weather–related variations in gas and electricity supply and demand are represented, and obscured, by government bodies, energy providers and energy advice organisations. As part of my investigation into seasons and their relation to energy systems, and social life, this chapter shows how understandings of gas and electricity consumption are shaped by a handful of orientating questions, including those about long–term changes in efficiency.

In taking this approach I draw on ideas about accuracy and the metaphor of the 'black box' from the STS theorist Donald Mackenzie. I use these to show how knowledge of energy use and seasonal variation is constructed. I focus in particular on the work that is done by statistical methods first of averaging, and then of 'weather correcting', both of which obscure temporal variation in patterns of energy use. These techniques are employed to make it possible to compare long–term averages and identify trends in efficiency.

As I describe in this chapter, averaging flattens out variation in order to represent underlying trends over time. This flattening has implications for how energy consumption is viewed. In order to get an 'accurate' picture of 'real' trends, further work is done to remove the complicating effects of the weather. I explain that weather correction is a method of increasing 'accuracy' by removing the effects that the weather has on energy consumption (Wortman and Christensen, 1985; Elkhafif, 1996; Rahman, 2011). I show how these two techniques-averaging and weather correction–are deployed in a selection of reports and in the models on which these reports are based. These reports are used to provide examples of how energy demand is presented within different public and policy discourses, where I provide evidence of how demand is flattened through both forms of averaging and weather correction, and the effect of this for studying seasonal variation.

This chapter is structured in two parts. Firstly, I introduce Donald Mackenzie's (1990) ideas about how accuracy is invented in order to contextualise my study of averaging and weather correction, and how I approach this research. I then turn to the details of averaging and weather correction in the second part of the chapter. I work through specific examples of each to show how these methods are used in practice. I conclude this chapter by commentating on the pursuit of accuracy, its unintended effects, and the problems of relying on methods that flatten out the impact of the weather on the organisation of gas and electricity demand across the year.

The Construction of Accuracy

As the title of this section suggests, I explain that the idea of an 'accurate' representation of energy demand is a social construction, and that interpretations of 'need' depend on the methods through which consumption is measured and known. This is a topic that has been widely discussed by Donald Mackenzie (1990), who has investigated the concept of accuracy with respect to the design of nuclear missiles. Mackenzie argues that accuracy is a contested topic, not an inevitable outcome of technological development; rather it was established through a set of social processes involving different political agencies competing against one another, and claiming different levels of 'accuracy', especially in relation to the ability to pinpoint specific locations. As Mackenzie explains:

> "Nowhere in this complex process of modelling and testing do unchallengeable elementary atomic facts exist. This does not mean that accuracy is a mere fiction and invention in the pejorative sense for this absence of atomic fact is characteristic of all scientific knowledge. It does mean however that the more deeply one looks inside the black box, the more one realises that the technical is no clear cut and simple world of facts insulated from politics" (p.356).

Accuracy in this description is an outcome of how knowledge is created. The meaning of accuracy consequently changes when modelling methods develop, and when they are thought to represent an 'improvement' on those used in the past. This understanding creates further questions, specifically how are the standards by which accuracy is judged created? Who are the actors making these decisions?

Mackenzie starts to answer these questions through the metaphorical concept of the 'black box'. This provides a means of understanding how scientific methods and ideas bracket out, or remove, certain issues:

> "The first is to refer to a guidance or navigation system that does not require input from the outside world to operate… the other meaning, a black box is opaque… it is a technical artefact – or more loosely, any process or program – that is regarded as just performing its function without any need for, or possibility of awareness of, its internal workings on the part of users" (p.26).

If the 'black box' of technology is opened (that is, if scientific methods are treated as topics of enquiry in their own right), it is possible to discover how technologies were developed and came into being. Investigating the role of black boxes prompts MacKenzie (2005) to ask two questions. First, "how do the contents and functions of black boxes shape their contexts?" and second, "how do the contexts of black boxes shape their contents?" (p.558). In my case, these two questions draw attention, first, to the ways in which energy consumption is known, and second to the kinds of concerns that guide these analyses. Both are important for 'making' a world in which models, studies and evaluations are carried out.

In the context of nuclear missiles, accuracy "is a shaping force that has been shaped itself" (Mackenzie, 1990:2), first being a method of shaping the construction of knowledges, and secondly, being shaped by the actors and social processes involved in missile development. MacKenzie (2005) not only identifies the role of black boxes (like the concept of accuracy) within nuclear missile development, but also within global finance and specific processes tied to the banking and financial trading industries. Again, he argues that the assumptions that underpin these market relations are rarely questioned, and that this collective amnesia allows markets to function smoothly. In my case, the concept of a black box makes sense of how data is collected and managed, and how these methods reproduce forms of knowledge that necessarily obscure questions about how patterns of energy demand vary across the year.

Ideas surrounding accuracy, as Mackenzie's social history of nuclear missiles demonstrates, are entwined in a broader narrative in which, in his case, led to cycles of technological development, creating an endless chase to challenge and improve accuracy. Although this is only one example of the performative effect of the concept of accuracy, it represents an entry point into conceptualising accuracy within energy supply and demand. Energy consumption figures (e.g., aggregated energy demand), as used in the studies described later on in this chapter, are also informed by a notion of accuracy variously defined with reference to the 'needs' of energy forecasting. Engaging with Mackenzie's (2005) concept of black boxes helps explain how models employing methods of averaging and weather correction foreground and obscure different aspects of energy demand.

Forms of Averaging

Domestic energy demand can be represented in different ways. For example, demand can be shown in terms of average per capita consumption (e.g Energy Saving Trust 2012). It can also be described with reference to household compositions and presented at different spatial (local, national etc.), aggregated, and temporal scales, such as half–hourly, daily, weekly, monthly, seasonally, annually (BEIS, 2020b; Sykes, 2020). What is common across these representations is the reliance on averaging.

An average is a number/value that represents the total values divided by the number of cases (Porter, 1996). It is commonly used to summarise a set of data. Averages can also be compared over time, to identify trends. Within energy research broadly, averaging is employed in different contexts. Average figures are, for example, used to show how energy consumption (on average per capita) has changed over time, or as a means of comparing average weekly, average monthly, and average yearly consumption (Li and Just, 2018). In this example, targeted at an energy policy audience, the authors model average energy–efficiency savings, and average price and income elasticity.

For others, current patterns of demand are averaged in order to inform forecasts about the increasing impact of weather on electricity supply and demand. For example, Staffell and Pfenninger (2018) explain that average outdoor temperatures and average patterns of electricity use are fed into forecasts used to model energy demand at different times of the year up to 2030. It is notable that averaging is embedded in reporting changes in energy demand and that this method summarises, and thereby obscures, what remain real variations in consumption. This feature is often overlooked by authors who take the technique for granted.

There are implications of using averages in this way. As already mentioned, one is to flatten out certain kinds of variation (e.g., within energy consumption) that is potentially relevant for knowing more about the ebb and flow of supply and demand across the year. This is a necessary and often desirable feature of averaging, but it is one that complicates detailed questions about how supply can be matched to different temporalities and scales of demand. Similarly, averaging masks outliers within datasets, even though these might be important for understanding how demand varies across the year.

None of this comes as a surprise in that averaging is used to address specific questions, for example, 'how have trends in energy demand changed over time?' to avoid potentially complicating details relating to sub–sets of the population, or to different times of year. The problem, as I define it, is to understand the paradigms and assumptions embedded in how averaging methods are defined and constructed and to specify the sorts of questions and lines of enquiry associated with this technique.

In describing how a selection of actors working within the energy system present and mobilise averaged data, I reveal the performative effect and the embedded logic behind averaging. I describe how averaging shapes these actors' knowledge of gas and electricity demand, and ideas about how demand changes over different timescales. For example, averaging energy use through standardised metrics (e.g. KwH) enables comparisons of different technologies such as freezers, boilers or lighting systems (Shove, 2020).

In the next section, I introduce three reports that illustrate the functions of averaging in a selection of different discourses. I discuss these in order to show how averaged data is used:

1. To represent changing energy usage over time.
2. To isolate and reveal the benefits of efficiency measures.
3. To describe future energy systems through forecasting and to estimate how supply and demand will change globally with increased renewable energy technologies.

Next, I explain the rationale for choosing these reports.

Describing Energy: Three Documents

To show first, how averaging is used and for what purposes, I discuss three documents. These are an energy white paper published by BEIS (2020a) titled 'Powering our Net Zero Future', a report by the Energy Saving Trust (2012) into household electricity consumption, and a report on forecasting future energy supply and demand in 2040 published by ExxonMobil (2019), a global supplier of energy fuels with interests in the UK. I have chosen these on the grounds that each exemplifies a somewhat different approach. Other documents would do the same, but the ones picked out here give a sense of the range of interests involved (government, advisory organisation, industry) and of how averaging figures across these domains.

The first report, 'Energy White Paper: Powering Our Net Zero Future'**,** published by BEIS (2020a), sets out the UK Government's policy ambitions in response to the net–zero agenda of carbon reduction. This white paper, published in December 2020, is the Government's attempt to detail future energy usage, and what the construction of future energy systems should look like in the context of legislative energy targets (net–zero by 2050), and within the context of the COP26 Summit that took place in 2021. With a '10–point plan' to move forward with a "green industrial revolution" (p.2), the white paper explains how government policy will be shaped by these commitments.

As a policy paper designed to explain the legislative priorities of the UK Government, this was chosen to show how averages are used to present gas and electricity consumption and how references to averages also informs accounts of future decarbonised energy systems. This document reflected the national policy position on renewable energy at the time of writing, and the assumptions that underpin how net zero is going to be met in the future.

The second document is an analysis of the 2010 Household Energy Survey by the independent organisation Energy Saving Trust (EST 2012), offering recommendations for government policy, and helping households understand their energy consumption as a result of the survey conducted (p.4). The aim of the EST report is to show how electricity is used across different types of households (e.g., household size, type of building, age etc). The report uses the findings of the Household Energy Survey, covering a period between 2010 and 2011 which monitored 251 domestic households across a range of timescales (one month to a year). The survey was designed to learn how many electrical appliances could be found in households, how often they were used, and what this meant for the total electricity consumption of the target households (p.5). The report explains that current patterns of energy usage create specific peaks and troughs in electricity demand, and describes what activities are contributing to these peaks e.g., evening TV habits. Composite figures are created to represent average per capita consumption expressed in terms of kWh. These calculations are compared to national averages to represent the impact of efficiency measures and make comparisons between household demographics.

As well as aiming to influence government policy, this survey is designed to identify patterns of energy consumption in households with different demographic characteristics, and from different parts of the country. I work with this report because it clearly shows how averaged data is mobilised in making comparisons between different types of households.

The third document I have chosen is a report published by ExxonMobil (2019), the aim of which is to show what energy systems worldwide might look like in 2040. The report anticipates changes in energy supply in response to increasing reliance on renewable energy technologies, and it assumes that current patterns of consumption will shape these strategies. The scenarios presented assume various global changes in the next twenty years, for example, the scaling up of renewable energy supply, increasing reliance on fossil fuels and socio–technical innovations in technology improving energy efficiency. Exxon is an energy supplier, hence the company's interest in anticipating future demand.

These three reports, taken together, illustrate different types of statistical analysis including weather correction, all of which affect representations of seasonal patterns of energy use. Other reports could provide similar or different insights, and the documents I have chosen are not intended to be wholly representative. Rather, they illustrate three different instances in which averaging is embedded in energy reporting. These reports offer an entry point into different actors within the energy sector and how they represent energy demand. This approach provides important examples of how demand is portrayed, and reveals the underlying assumptions supporting these views, including how seasonal demand is defined. Beyond a reliance on averaging, these representations show significant similarities in how energy demand is produced, including the use of temperature adjustment factors to 'correct' for various variables. This feature across two of the three reports presented suggests probing further into the practices and shared methodologies that shape discourses of energy demand.

Having described why these documents were chosen for further investigation, I use them to describe the performative work of averaging in the energy field.

Representing Change in Energy Use Over Time

Average annual per capita consumption of electricity is a common point of reference in energy reporting and is used as a measure of energy consumption. Within the Energy Saving Trust (2012) report, annualised average energy consumption for individual households, presented in KwH, is estimated based on the households studied in the survey. As per the report,

> "This per capita number was calculated on the average number of people in a study dwelling. If the total electricity demand were divided by the national average number of people in a dwelling, then the per capita consumption would be 1,515 (3,638/2.4 = 1,515 kWh)" (p.7).

With these averages (number of people in a dwelling), the complexities of energy demand is obscured in order to create a simple metric (average per capita energy use) that shows how demand changes over time. For example, the national average provides a benchmark for appliance use (p.6). The number of appliances in each household included in the survey is multiplied by the typical running costs of each appliance and linked to average figures showing how these appliances are used over the year.

Providing information about how much energy, on average, different appliances consume and showing how one household's per capita consumption compares with another–or with other households with similar demographic characteristics–allows people to compare their consumption with others. The use of these averages is not without its complications. The average number of people in households is 2.4 (at the time of the study), but there is a growing number of single person households, as the EST report identifies through its selection of target households. Rather than working with a single 'average' household, the authors of this report write about different household types (based on demographics, occupancy, type of house etc).

Just as there is no 'average family' in everyday life, 'household types' are also constructed entities. The use of averages in this context reduces the complexity of the social world in order to arrive at a single measure that can be used to quantify and compare changes in energy consumption over time, from the early 2000's to 2010, when the study was commissioned.

Identifying Improvements in Energy Efficiency

In order to identify the effect of energy efficiency measures[9], there needs to be a standardised way of describing energy use e.g., average domestic electricity annual consumption, average washing cycles etc. This enables comparisons to be made. For example, figures that represent average consumption of a given appliance over a period of time provide a necessary reference point for making claims about increases in energy efficiency of specific appliances. In the Energy White Paper (BEIS 2020a), similar methods are used to represent the relative efficiency of the entire housing stock. In this context, the method is to estimate average household energy bills depending on the number of houses that fit into the 'EPC' classes ranging from band A to band G. As the report states:

> "the modelled annual energy cost of the average Band C rated home is around £750 less than the average Band E rated home, assuming both homes are being adequately heated" (p.100).

The EPC band is linked to billing cost (created through the evaluated energy performance of the building). This supposes that on average, Band G households have higher energy bills than Band A households.

[9] Broadly referring to the same service provided for less energy consumption.

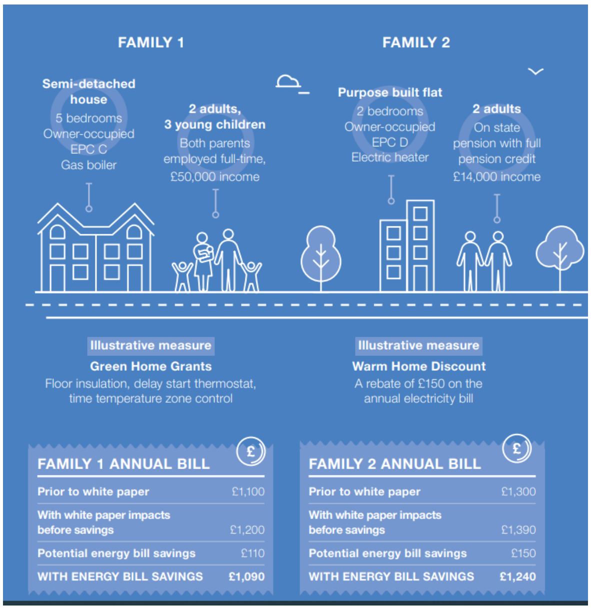


Figure 3–Average savings related to net–zero white paper policy implementations–Copied from (BEIS, 2020a).

Figure 3 refers to two households' types, including their demographic composition, along with averaged data on bedroom size, heating type and income. Average cost savings (expected from different interventions) are accounted for on a yearly timescale. The value of working with averages and with average house types is evident in that this strategy makes it possible to discuss and compare the merits of different policy initiatives.

The resulting forecasts extend beyond merely identifying consumer savings; they are also designed to show how efficiency measures will reduce projected energy consumption in the future. These averaged estimates of efficiency improvement are used to identify the savings associated with different policy actions.

Forecasting Supply and Demand

As the preceding analysis has identified, energy forecasts are typically rooted in averaged figures, such as family size, household demographics, and annual patterns of use. This is understandable, given the overall aim is to estimate what the future, 'on average', may look like. Within the ExxonMobil (2019) report, current annual averages of gas and electricity use in households and industry are represented, alongside forecast changes in average per capita consumption linked to expected energy efficiency improvements.

The Exxon report is designed to align company financial goals with current patterns of energy usage. For example, the report forecasts that energy supply requirements will change across different continents up to 2040 and that average demand per major nation (in quadrillion

BTU's) will increase over the next two decades. Forecasting this level of demand assumes various continuations and changes within global energy systems. In the report, average annual household usage of electricity counted in megawatt hours per household, per continent, is expected to rise in the non–OECD countries, but decline in the OECD countries due to increased efficiency measures being embedded into these energy systems (p.19). Averaging makes it possible to arrive at single estimates like these, and to do so on a global scale.

The risk is that forecasts like these treat energy as a uniform resource and treat demand as a similarly uniform expression of 'need'. In this context, the main 'drivers' of the energy system are thought to be increased income (and greater spending on energy) and increased technological efficiency (meaning less spending on energy). The work of averaging sustains this impression of uniformity and of a single, global energy market.

The result is a 'one size fits all' approach to energy forecasts that assumes how global energy systems will shift and evolve in response to policy and technological changes.

I have described some of the ways in which averages are used in a selection of documents chosen from across the energy sector. I have explained that averages are used in different ways to provide a more plausible, and in a sense more accurate, picture than those provided by raw totals (e.g., total household energy usage, or snapshots of individual circumstances). Although averaging has obvious advantages in making it possible to track changes over time, some of the complexities of energy demand, such as the sequencing of social practices that contribute to daily gas and electricity consumption, are flattened out. Beyond this, and in each of the reports I have discussed, methods of averaging are used in support of different agendas. In all cases, averaging is a necessary form of levelling and standardisation required to represent past, present and future changes within the energy system, whilst obscuring variation in order to provide comparable data.

The performative effect of averaging, as it is embedded in energy policy and in debates about energy efficiency improvements (e.g., BEIS White Paper), legitimises and embeds a 'flat' or uniform view of energy as a singular resource. This is not to say that averaging is wrong, rather, that is taken for granted within different representations of energy consumption. The process of using averages flattens variation (such as patterns of energy demand) and presents an 'average picture' which is, as we have seen, useful in promoting different agendas, including those that inform the reports I have discussed.

In the next part of the chapter, I go further into these relations by examining processes of weather correction, another method widely used by energy modellers when representing energy supply and demand. As I explain in the following sections, both averaging and weather correction are part of a quest for accuracy within the energy industry.

Weather Correction

In conducting this analysis, through the examination of the three selected reports to identify how they each represent energy demand and forms of seasonality, I discovered that energy demand data in the EST (2012) and BEIS (2020a) reports are 'temperature corrected.' Weather correction, or temperature correction, is a statistical adjustment applied to represent energy demand trends over time, by correcting for outside temperature fluctuations above or below the average.

This approach was evident in the EST (2012) report, where the authors note,

> "Some appliance electricity use is seasonal; thus, for monthly households, depending on whether they were monitored in winter or summer, their monthly usage was adjusted by a factor to project their usage over one year. The factor was calculated from annual data of households monitored for the full year" (p.7).

Similar inquiries into temperature correction within the BEIS white paper (2020a) confirmed that gas consumption data is typically seasonally adjusted across Civil Service departments (Rahman, 2011). This discovery informs my subsequent investigation into the role of weather correction in shaping representations of energy demand, as it directly influences how patterns of seasonality and the 'extents' of demand are constructed through statistical adjustments.

I turn my attention to this topic, because the problem, for those seeking to model energy use, is that in the UK, gas consumption increases when the outside temperature is cold (as gas is mainly used for heating) and decreases when temperatures are warm. An increase in recorded gas and electricity demand could therefore be tied to changes in temperature rather than what is considered to be 'real' change in demand over time. The expectation that gas demand will increase when it is cold outside relates to the parallel expectation that households will maintain a steady indoor temperature–using more energy in winter and less in summer.

In any event, the problem in this context, is that methods that do not deal with the impact of the weather on patterns of energy demand result in incorrect inferences about how demand has changed across the year (Duerr and Cornwall, 1984). To resolve this, adjustments are made on various timescales (daily, weekly, monthly) by identifying the 'average' outdoor temperature historically (through reference to previous years) and applying a correction factor that modifies the representation of the energy needed to achieve a constant temperature indoors. As Rahman (2011), at the Office for National Statistics (ONS) explains,

> "The purpose of temperature correction is to help users better understand underlying trends in energy consumption, which can be affected by fluctuations in temperature, by producing a monthly series which can be interpreted as the consumption that would have happened if temperatures had been at their average for the month" (p.3).

Typically, if only weather correction is taking place on energy demand patterns, then higher than average temperatures within a given timeframe would lead to energy consumption being reduced. In contrast, lower than average temperatures would lead to energy consumption increased, to account for the difference.

There are other approaches to this correction, for example those methods in which a temperature correction and then a seasonal correction factor is made. This is the case for energy consumption figures released by BEIS(2020b; 2020c), who present monthly statistics of national gas and electricity consumption, of which gas demand is weather–corrected.

The difference between the temperature correction and seasonal correction relates to the purpose and assumption behind the correction being applied. As the ONS notes on weather correction explain,

> "One would expect that in cold months more energy is required to warm up houses than in warm months, but this is accounted for by seasonal adjustment. The temperature correction that is applied is to adjust for changes in the month's temperature in comparison to that month's long–term average. So an unusually warm January should be adjusted up, even if it is still a low temperature in comparison with the whole year. The temperature corrected series then is interpretable as what the consumption would have been had the temperature in each month been the long term average for each month" (Rahman, 2011:6).

As this example demonstrates, two separate corrections take place to 'improve' the understanding of consumption. The seasonal correction, as the ONS suggest, can take account of the "systematic calendar related effects" on demand, such as the timing of school holidays, and the timing of "social, cultural and religious events" such as Easter (ONS, 2024:para 1). Temperature correction is a modification to the impact of the outdoor climate on patterns of energy consumption.

What is evident, is that weather correction is a method of statistically silencing the "noise" (that is the effect of the weather) in order to give a more 'accurate' picture of the 'real' trend in energy demand (Elkhafif, 1996:222).

There are numerous different types of correction; some range from a simple regression application (measuring the relationship between two variables, one independent and one dependent) to more complex formulae that account for multiple different variables. The chosen strategy is a result of different actors constantly seeking to 'improve' the final result by taking account of more and more of the natural elements of the weather (e.g., daylight hours) and adding these into the equation. This is for the benefit of the users Rahman refers to:

> "As well as 'raw' figures the Department publishes adjusted series which are temperature corrected and seasonally adjusted. The latter are the key estimates for users interested in energy efficiency at a macro level, and the Department judges that increasing attention is being given to year–on–year changes in the temperature adjusted data" (Rahman, 2011:5).

The corrected figures are intended for a specific kind of analysis that flattens out variation to establish long–term trends, rather than for researchers seeking to understand the extent of variation. The challenge is that these corrected figures are commonly used in modelling (Fox et al., 2018). Existing methods of weather correction now take note of mean temperature, precipitation, radiation, humidity and wind speed etc. (Sailor and Vasireddy, 2006). These variables are accounted for within the correction factor, and in the produced data that follows.

In practice, there is no 'uniform' way of conducting weather correction, as different factors account for different variables and phenomena. For example, in the designing of buildings and domestic houses, 'degree days', are used to measure energy demand. To be clear, the metric of degree days is usually used by designers. By contrast, weather correcting is applied to data used for a much wider range of purposes. However, the logic is the same in that the measure of 'degree days' is designed to establish how much heating and cooling is needed within a building–assuming a fixed indoor temperature and given knowledge about how the outdoor climate changes. Both heating and cooling degree days represent the number of days in a year in which outdoor temperatures are higher or lower than a set baseline temperature (Spinoni et al., 2018).

Degree days are of interest, alongside weather correction methods, because as Rinkinen et al. (2020) point out, expectations and interpretations of energy demand reproduce assumptions about indoor comfort and how this is to be achieved. These change over time; Rahman (2011) points out that 18°C is considered a more appropriate baseline than what was previously used in 2011: 15.5°C. As this example shows, baseline temperatures and ideas of comfort have changed over time, and this has shaped the organisation of degree day analysis.

Faced with different methods of weather correction (taking different sets of factors into account, e.g., just temperature, temperature and light combined etc.), there are ongoing efforts to standardise approaches across inter–governmental bodies. For example, the European Union updated the protocol for defining the 'Gas Day' in 2015–the methods by which gas is accounted for and measured (Eurostat, 2018). Based on this change, the National Grid had to update its own methodology, measuring gas consumption between the hours of 5am–5pm instead of 6am–6pm. This might not seem like much of a change, but harmonisation of metrics and measurements is crucial for 'fair' comparison with the rest of the EU nations.

As with some of Mackenzie's (1990) examples of the standardisation of nuclear missile accuracy between competing companies, standardisation is important to energy modellers, as the EU Gas Day changes exemplify. In effect, this configuration facilitates the sharing of data and agreed methods of averaging and weather correction ensure that it is comparable across nations.

In terms of the supply of energy, different fuels are used for different purposes. For example, domestic gas consumption is closely associated with heating, and as such is linked to outside temperature changes. Electricity is used for a wider range of purposes, meaning that the relationship to the weather is not clear cut. The question is whether estimates of electricity demand should be weather corrected or not.

Electricity has many uses linked to practices within the household, as well as some forms of space heating (Torriti et al., 2015). Specific practices such as air conditioning can be linked to weather conditions, and therefore make a difference to short–term variations in demand (Basile, 2014; Walker et al., 2014). As electricity end uses are (currently) not as seasonal as gas, the justification for weather correction (or not) depends on the underlying assumptions behind the modelling and the type of data being corrected e.g. local or national electricity consumption. If, as is planned, heat decarbonisation continues to remain on the policy agenda, increasing the use of electricity for heating may increase the use of weather correction for electricity.

The three reports chosen for analysis in this chapter not only provide some perspectives on the changing spatial and temporal role of electricity, but suggest how weather correction has been involved in the production of energy demand data.

The EST (2012:4) report notes ONS data from the 2011 census that 29% of all UK households are single–person dwellings, which the EST suggests is problematic for planning future energy demand. If the number of single–person households continues to increase, there will likely be a corresponding rise in energy demand, necessitating greater supply capacity to meet these demands. However, using weather correction to identify these changes and patterns in demand may obscure, for example, the specific impact of single–person households on energy consumption, depending on the timescales in question. There are, I argue, methodological questions about the use of weather correction when working with different kinds of consumption figures, and how this relates to identifying geographical, and demographic changes.

Similarly, in the BEIS (2020a) white paper, there is a focus on the potential for electricity demand to be transformed within energy system changes, as the report sets out,

> "This dependency on fossil fuels will change dramatically over the next 30 years. By 2050, electricity could provide over half of final energy demand, as it displaces petrol and diesel in cars and light vehicles and, to some degree, gas for heat in homes… this could mean that electricity demand doubles from today's 345TWh" (p.66).

While weather correction methods can provide a seasonal adjustment, they may not fully capture, for example, how the electrification of heating and transport impacts long–term demand patterns, if corrected data disguises the impact of the outdoor climate on energy consumption. To reiterate, these reports are snapshots into the presentation of energy demand within energy systems, but provide important examples for showing how energy demand is framed within public and policy discourses, and how demand is commonly predicted with methodological tools that shape the consumption figures provided.

I continue this analytical thread in the penultimate section of this chapter, by considering the geographical limits of weather correction for analytical purposes.

Geographical Variation and Weather Correction

One of the difficulties of weather correction is that there are considerable climatic variations within the UK. This raises issues about locality and the assumptions that are being made about baselines and adjustments. Weather correction, as used within BEIS statistics (Rahman, 2011), relies on national average temperatures for the correction factor meaning that significant variations at the local level are not accounted for (BEIS 2019). Would a range of local weather correction methodologies solve the problem? Would that be more 'accurate' than the present method?

Weather corrected data (based on national correction factors) is sometimes used by utility companies when planning supply to meet demand (Fox et al., 2018). But this can be out of sync with local trends. If local weather patterns are not accounted for there are likely to be errors and inconstancies in forecasting demand at substations. Analysis of these discrepancies by Fox et al. (2018), showed that national weather corrected power estimates of demand couldn't fit 'actual' power demand in specific locations, especially during the colder winter periods. The authors argue that if national weather corrected patterns were followed, gaps in supply could create local outages in the future, and mask crucial regional trends in demand (p.3). Inconsistencies in forecasted supply, as Fox's (2018) study suggests, poses questions as to how weather correction is managed and embedded within decisions about local supply made by energy providers, in the context of a national grid. As described above, geographical differences and relationships between the temporalities of demand are ironed out by weather correction methodologies, the main aim of which is to reveal and identify longer–term underlying trends–not to plan or design supply.

As I have shown, weather correction is widely used for different reasons and by different organisations. However, the technique is not without its complications: correction methods are updated over time, the use of correction for both gas and electricity is not yet standardised, and there are sometimes significant variations in local weather patterns.

To date, the response from actors operating within the energy sector is to increase the number of variables that weather correction methodologies include, in order to increase the 'accuracy' of the data (Rahman, 2011). This is evident in the reports described earlier in the chapter, where the Energy White Paper (2020a) used BEIS data, which is weather corrected alongside the Energy Saving Trust (2012) who also report using corrected figures for electricity within their analysis.

Forecasting energy supply, such as evidenced in the ExxonMobil (2019) report, relies on different scenarios of what kinds of indoor and/or outdoor temperatures are cold or warm in context to the local area. What is described as 'normal' or 'extreme' weather scenarios vary as the temperatures that govern these scenarios are updated and reviewed on a yearly basis, accounting for historical temperature changes and the ongoing standardised metrics of weather forecasting. One such example is in Canada (IESO, 2012), who categorise different kinds of weather scenarios, and forecasting both demand and energy system challenges based on historical understandings of local climate. These categorisations are notable for explaining how the construction of 'accuracy' changes over multiple timescales (months, years, seasonally etc). The 'standard' point of reference changes within weather correction forecasting as temperatures frequently shift year on year, and the effects of climate change are accepted and incorporated into scientific thinking.

In this sense, accuracy is constructed within and around the social processes of establishing and working with categories of weather forecasting (normal, extreme), shaped by the knowledge of frequent temperature changes. This suggests that weather correction is a rolling process, and that actual changes in average weather patterns are incorporated into its development. It serves a specific purpose in enabling 'underlying trends' to be identified without outlier temperature fluctuations affecting the accuracy of these descriptions. This enables energy modellers working with these figures to describe changes in efficiency and what this means for of the supply and demand of energy within the UK.

Returning to Mackenzie's understanding of the 'black box' (1990; 2005) introduced at the beginning of this chapter, my investigation of weather correction methodologies shows some of the different ways in which modellers foreground and background different aspects in pursuit of accuracy. In the examples discussed, various methods for weather correction are used, tailored to the needs of those implementing them. The work of weather correcting is flexible, accommodating different variables and contexts.

By characterising correction models as black boxes I have argued that their inner workings are concealed. This opacity is an effect of the methods used in presenting data on energy use, as illustrated in the three reports described previously. In taking up this topic I have shown that as one component of weather correction changes, as the search for accuracy continues, other parts of correction must change as a consequence. For example, forecasting is updated in line with changing standards (such as the conventions of measuring the Gas Day, changing temperature patterns indoors and out, and changing ideas of indoor comfort), that will have implications for the weather correcting of supply.

But questions remain surrounding the longer–term goal of weather correction as a method. Where do these developments lead? Will there be more variables to account for in the coming years? Is their scope for 'accuracy' to go further? Where are the 'seasons' in these figures?

As the three reports chosen as part of this first probe demonstrate, public and policy discourses embed specific portrayals of energy demand, in how patterns of gas and electricity use, across timescales, are discussed and conceptualised. By using weather correction in both the BEIS (2020a) and EST (2012) reports, assumptions about energy demand, and specifically seasonal patterns, are performative in influencing the scope of changes both on the day–to–day (EST), and yearly (BEIS) timescales. They help create a shared vision of current energy use, reinforcing expectations within the sector that these adjustments are required for the establishment of trends in energy demand over time, as Rahman (2011) points out.

Weather correction, while a technical adjustment, becomes part of a broader sociotechnical narrative that both reflects and enacts specific futures about energy demand, and associated energy system transitions, which the example reports provided as part of this chapter have helped to demonstrate.

I conclude by discussing the implications of this analysis for how temporalities and seasons figure in representations of energy supply and demand.

Conclusion: The Wider Search for Accuracy

My account of averaging and weather correcting has relied on Mackenzie's (1990; 2005) ideas about the work involved in the construction of knowledge, in this case knowledge of energy demand. As described, both techniques are framed by what I describe as an 'endless search for accuracy'. However, weather correcting in particular is designed to enable a comparison of energy use, and the impact of efficiency measures over time. By contrast, averaging is widely used to capture and summarise sometimes complex and varied processes in a single figure. These methods are widely accepted in the energy sector, along with agreed units and measures (Shove, 2020).

As the chosen reports revealed as part of this first probe, averaging was used in support of different agendas of actors within the energy system, and in different sectors (government, advice organisations, energy suppliers). In the BEIS (2020a) report, averaging made it possible to quantify improvements in energy efficiency measures to highlight the tangible effect of policy positions e.g. retrofitting, insulation payments etc. In the Energy Saving Trust (2012) report, averaging was used to show how the energy use of surveyed households compares to national averages, whilst the ExxonMobil (2019) report relied on averaged data on supply and demand figures to inform forecasts up to 2040. Methods of averaging facilitate these comparisons and help show changes in consumption over time. The risk is that averaging obscures and irons out variations (demographic, climatic, infrastructural) that are actually important for seasonal and weather–related responses and for the (sometimes local) practicalities of energy supply and demand.

Following on from averaging, weather correction is used to uncover underlying trends free from the influence of fluctuations in the outdoor temperature (2020c). Representing energy demand in this manner, and taking the weather out of the equation, supposes that this is a confounding factor, not a necessary aspect of demand.

Instead of confronting these fundamental questions, modellers seek to make weather correction ever more 'accurate'–adding more and more variables into the equation. Averaging and weather correction are embedded in the normal work of energy modelling, but are rarely questioned. As I have shown, both methods are important for how energy supply and demand are understood. Stepping back and acknowledging the social processes involved, and the assumptions on which these methods depend is an important step in creating space for careful consideration of seasonal variation in energy supply and in energy demand.

In the next chapter, I take on a separate line of enquiry, whilst keeping a core interest in the role of the climate on energy demand patterns. I show in the next chapter, how assumptions about the weather, and the relation between the indoor and outdoor climate, matter for how heating and cooling is organised across the year.

Chapter Six: Constructing the Baseline: The Emergence of Heating and Cooling Seasons

In this chapter, I explain how annual variations in electricity and gas consumption are mediated by a baseline expectation of comfort, which itself depends on socio–technical innovations in heating and cooling. I investigate the emergence of heating and cooling seasons in different settings (domestic, institutional) by following how baseline temperatures in the UK of 18–22°C have come to be expected for maintaining indoor comfort.

A baseline indoor temperature is important for managing demands for heating and cooling. This baseline is a feature of building design and construction. The effect of this is that, in reproducing standards of indoor comfort throughout the year, seasonal peaks in gas consumption are tied to the outdoor climate.

This chapter investigates the social histories of indoor comfort, to identify how baseline indoor temperatures, and seasonal patterns of consumption are created in relation to developments in technology and provision. I work with examples of social histories of domestic heating and cooling provision to describe the sociotechnical organisation of relations between the indoor and outdoor climate. This builds on the argument I set out Chapter Three, where I described how to understand the interplay between what is considered social and natural in regards to the arrangements of rhythms and practices that constitute the timing of gas and electricity consumption throughout the year. That is, social and natural rhythms combine in the organisation of energy demand, and cannot be separated out when undertaking analysis of the spatial and temporal features of gas and electricity use.

I start with the work of anthropologist Marcel Mauss (1979) to set up a way of thinking about the standardisation of social activity throughout the meteorological year. I then describe separately, two social histories of heating and cooling, to explain the technical and social emergence of baseline indoor temperatures that have enabled the reconfiguration of indoor comfort, and the promotion of 'standardisation' within the designing of indoor energy provision. To show how these temperatures are integrated across social life, I look at ideas of institutionalisation through different examples of universities, and the 'science' of optimal temperatures, as they are written into standards of heating and cooling provision. I consider these ideas in line with the use of 'degree days', as a way of measuring the extent of energy demand required for comfort expectations. I conclude by explaining how baseline indoor temperatures have emerged through socio–technical innovations in energy provision, and the emergence of conventions such as expectations of indoor comfort that inform how the relationship between the indoor and outdoor environments are managed and constructed.

Changing Relations Between Seasonality and Social Life

The remarkable change in Western societies where the search for ideal comfort leads to specific indoor temperatures all year round is a 20th century development. It signifies a cultural shift in maintaining a thermal comfort that was previously seasonal and expected to be affected by external temperatures. This section describes how expectations of thermal comfort go hand–in–hand with the social organisation of activity in everyday life.

Marcel Mauss' (1979) description of the Inuit population shows how seasonality penetrated the way of life for this culture, and reveals the changing relationship between the outdoor climate, and social life. Writing between 1902 and 1905, and drawing on an extensive range of literature, Mauss studied the 'social morphology' of Inuit life, which empirically for Mauss is the study of:

> "the form that societies assume in their patterns of residence, the way in which the population is distributed, as well as the entire range of objects that serve as a focus for collective life" (p.19).

The focus on Inuit society for this study, was tied to their unusual social organisation, and how their way of life was guided by ideas about the social and material arrangements related to changes in the seasons. Mauss describes a clear distinction between summer and winter in the activities of the Inuit. For example, the seasons were marked by animal movement, not dates or weather, governing the activities that took place in a strict and controlled manner. Similarly, the start of winter was not marked by the calendar, but by the arrival of caribou (Mauss, 1979).

Laws guiding the organisation of Inuit life also changed between the seasons. The type of housing changed from tents to stone and wood structures. In winter, housing was built to be close together to other families whereas in summer the housing was dispersed and the occupancy per house varied. As Mauss (1979) described, Inuit populations were socially scattered in the summer; the family type built around nuclear families designed to hunt and fish. Property rights were clearly asserted, where an individualistic attitude developed and led to objects being marked as owned. In comparison, winter was a collective experience and the opposite to the individuality of summer, practiced through different forms of leadership and religious rituals. Objects that were marked as owned in the summer would be shared in the winter months between groups. Food in winter was part of an exchange for something else (e.g., a household object, hunting tool etc.), which took place when the community was living in close proximity, in contrast to the summer, when the groups dispersed across the region. Overall, there was a shift in mindset between the two seasons, from an individualistic approach in the summer, to a collective experience in the winter that sustained this form of seasonal variation across family groups.

Mauss' analysis describes how the seasonal variation that occurs in the Inuit community matters not only for explaining changing activities but for the social organisation of the community. This is a significant difference compared with Western societies today where there exists a close relationship between the calendar and the organisation of everyday life, the same housing all year round, and the seasons are marked by the calendar and cultural events, instead of the arrival of animals.

Similarly, the relationship between the social organisation of daily life and the meteorological seasons has evolved to such an extent that indoor temperatures occupy the same temperature boundaries all year round, despite fluctuations in external temperatures outside. Despite this, Mauss states how:

> "Social life among the Eskimo goes through a kind of regular rhythm. It is not uniform during the different seasons of the year. It has a high point and a low point. Yet though this curious alternation appears most clearly among the Eskimo, it is by no means confined to this culture. The pattern…noted is more widespread than one would at first expect" (1979:77).

The suggestion here is that there are potentially other types of rhythms found across timescales; seasons, months, weeks etc. that exist outside of the strict seasonality that Mauss observed in the early 20th century. There are multiple points of relevance for this historical reading of Inuit society to how ideas about seasons are understood today.

For example, there are now multiple rhythms that matter for how social life today is constituted, in particular the organisation of energy consuming social practices. These kinds of social rhythms are constructed from, for example, the socio–temporal order of work, the timing of the school day, the timing of religious festivals etc. As Mauss provides an example of how this strict seasonality of social life mattered for the organisation of Inuit, I take this opportunity to investigate how this seasonality has been reconfigured with the emergence of baseline indoor temperatures. When it comes to patterns of gas consumption, baseline temperatures mediate the reconfiguring of activities across the year.

In the next section, I set out how I investigate baseline temperatures, how they relate to the development of indoor comfort, and why this matters for studying seasonal variation.

Investigating Heating and Cooling

To carry out the second research probe, and to investigate the emergence of 18–22°C as a 'comfortable' indoor temperature range, I look at how ideas of comfort have changed, as they matter for how indoor heating and cooling provision has been maintained. I gather materials related to the construction of indoor heating and cooling. These materials inform how baseline temperatures indoors have been achieved, by considering social histories of heating and cooling, institutional guidelines, and design regulations.

For the analysis of heating and cooling seasons, I draw on social histories from the UK and the USA, which illustrate how shifts in energy provision reconfigured social practices around indoor comfort and established new standards for optimal indoor temperatures. Rather than describing heating and cooling as distinct, separate seasons, these histories reveal how our contemporary understanding of them has evolved through innovations in energy provision. These shifts not only influenced societal expectations for comfort but also helped set benchmarks for temperature control that have become ingrained in energy policy and building design. Such histories are a valuable entry point into examining the relationship between energy provision and the timing and sequencing of social practices, to understand further the relationship between seasonality and energy systems.

In shifting the focus to institutional heating and cooling, particularly within the university setting, I examine how buildings designed to serve large, diverse populations handle heating and cooling needs throughout the year. Universities, with their inherently seasonal use driven by academic term times, present a unique case for studying energy demand in institutions. For this analysis, I use publicly available heating and cooling policy guidelines from UK universities representing institutions across both northern and southern regions (Cambridge University 2014; Lancaster University 2019; UCL, 2024). These guidelines reveal how universities manage temperature regulation year–round and offer a basis for evaluating how institutional and domestic standards of comfort intersect. Through this focus, it becomes clear that institutional policies often reflect broader societal expectations of comfort, illustrating how standards developed in the home can extend into public spaces, shaping expectations for temperature management across different localities.

These choices of universities are not designed to be representative of the sector. However, they are illustrative of how three different heating and cooling policies are embedded within institutional life, and to identify connections between them, in regards to energy provision, and timing within the year.

The focus on heating and cooling seasons, and universities, as two separate but thematically intertwined lines of enquiry, provide an understanding of how baseline indoor temperatures are embedded within the social and material organisation of energy provision. In doing so, this approach allows for new ways of conceptualising seasonal variation, and understanding how ideas of comfort tie into patterns of energy demand across the year, by studying connections between energy provision, annual cycles of heating and cooling, and social practices that constitute demand.

In the next section, I provide context on how ideas of comfort, as understood within the construction of heating and cooling provision, has been conceptualised.

The Search for Optimal Indoor Comfort

Underpinning the design of infrastructures, and a contributor to patterns of gas and electricity demand across the year are ideas about comfort. Thermal comfort, by which I refer to as the "satisfactory, stress–free thermal environment in buildings (which) is a socially determined notion defined by norms and expectations" (Nicol and Roaf, 2017:711), is closely intertwined with the dynamics of energy consumption. Socio–technical innovations in domestic heating and cooling appliances create idealised standards for indoor comfort, which depend on systems of provision that are themselves influenced by societal expectations of what is warm, and what is cold. Different standards for indoor comfort emerge from, for example, building regulations, legislation and guidance that legitimises what indoor working temperatures should be, and the 'optimisation' of indoor heating and cooling provision for different spaces, constructed by designers, architects and engineers.

These types of standards vary across the world dependent on a range of influences, such as building stock, typical outdoor temperatures, and types of heating/cooling appliances available. These standards didn't come from nowhere, as various investigations into the social histories of comfort acknowledge and discuss. For example, the rise of air conditioning in households has been tied to a combination of architectural and scientific objectives to find the ideal indoor temperatures, in order to control and manage domestic comfort (Cooper, 1998; Ackermann, 2002).

Similarly, the creation of the ASHRAE Standard 55 created a worldwide definition for indoor comfort through the creation of a building regulation code the purpose of which is:

> "to specify the combinations of indoor thermal environmental factors and personal factors that will produce thermal environmental conditions acceptable to a majority of the occupants within the space" (ASHRAE, 1992:1).

This standard, as Shove (2003b) points out, has a host of assumptions about clothing (e.g. within the standard, one 'clo' is a formal business suit), which have now been enacted across workplaces across the world, creating and sustaining a cultural convention tied to indoor comfort. The contemporary baseline indoor temperature range in the UK, typically between 18–22°C, has been enabled by heating and cooling technologies. The relationship between indoor and outdoor climates is mediated by technological advancements, societal norms, and ideas of comfort which in turn perpetuate the maintenance of the baseline temperature range.

In the next two sections, I describe the first half of this recursive relationship, by describing how histories of heating and cooling matter for the reproduction of heating and cooling seasons in both domestic and institutional settings.

Heating Seasons

There are common sense ways of thinking about heating and cooling seasons. For domestic heating, this is typically associated with the meteorological winter, with an increase in gas consumption tied to increased demand for heating. The '2011 Energy Follow Up Survey', investigated assumptions about energy use domestically, concluding,

> "The majority of householders report that they start heating their home on a regular daily basis in October and finish sometime in March or April. The average (mean) length of the heating season is reported to be 5.6 months" (DECC 2013: Executive Summary).

To unpack the organisation of heating seasons depends on moving past these kinds of explanations, and taking a longer–term view, to consider how ideas about infrastructure, practices, and the mediating and hardwiring of indoor comfort matter for the relationship between seasons and ideas of comfort. One way to do this, is to identify how domestic energy provision has shaped activities and the timing of energy demand throughout the year.

The advent of central heating systems revolutionised comfort expectations within homes. Prior to their widespread adoption (from the 1950's in the UK), households primarily relied on coal fireplaces in the living room for warmth, making it the focal point of household activities and the warmest area of the house. Controlling the heat produced by coal fireplaces required adding coal rather than adjusting a thermostat. However, the discovery of natural gas in the North Sea, coupled with the development of gas–fuelled heating systems, provided an opportunity to replace coal as the primary heating fuel in the UK (Trentmann and Carlsson-Hyslop, 2018; Carlsson-Hyslop, 2019).

The Clean Air Act of 1956, which mandated the use of specific smokeless fuels, further incentivised the transition. House builders capitalised on these developments by promoting central heating systems as modern, flexible, and energy–efficient alternatives to traditional labour–intensive coal fires. This shift not only eliminated the constant attention required to maintain a coal fire but also offered greater control, in turn contributing to the redefining of ideas of comfort throughout the home, including upstairs (Hanmer and Abram, 2017).

With the prevalence of gas–fuelled central heating systems in domestic settings, temperature control throughout the house has become more efficient in the last 60 years. Radiators placed around the household distribute heat, allowing for individual room temperature management and facilitating the migration of activities from the living room to other areas of the house. The introduction of central heating ushered in innovative methods of temperature regulation from outside the home. For instance, more recently, the emergence of 'smart' devices enables users to remotely activate boilers, pre–warming homes in anticipation of their return and achieving desired temperatures.

Additionally, modern boilers are equipped with responsive features, allowing for the establishment of specific temperature settings for different zones within the household (Carlsson-Hyslop, 2019; Hanmer et al., 2019). These responsive boilers engage automatically to maintain predesigned temperature standards, ensuring designated comfort levels are upheld even as external temperatures fluctuate. Thus, the evolution of central heating technologies not only reconfigures ideas about indoor comfort but also introduces new levels of convenience and control over home temperature management, and subsequently new social practices sequenced with activities around the household.

The establishment of baseline indoor temperatures, facilitated by advancements in heating and cooling technologies, has mitigated the impact of external temperatures on household design. However, despite these advancements, heating remains seasonal, particularly evident in the winter months, as it requires more energy to meet these temperatures when it is colder outside. This is reflected in the annual variations of gas demand for central heating, with peak consumption occurring during the meteorological winter and reaching its lowest levels in the meteorological summer (BEIS 2020c). Changes in heating provision have led to varying perceptions of expected warmth during the meteorological winter, influenced by shifts from traditional coal heating to modern gas central heating systems controlled by thermostats.

A study on changes in heating provision, and how this affected the organisation of social practices in Stevenage (Spurling, 2015; Trentmann and Carlsson-Hyslop, 2018) describes how heating practices have evolved, from coal fireplaces, to central heating technologies in that particular town. By examining the different fuels used for heating, the research highlights how technological advancements and fuel choices impact the role of heating in shaping and being shaped by daily routines (Spurling, 2015). For example, in the 1950's, households would have a central fireplace in the living room producing heat downstairs, resulting in many activities taking place there. As a result of the introduction of gas central heating, the upstairs opened up for socialising with central heating technologies, and control over the thermostat.

The Stevenage studies illustrate the importance of identifying how the technology–comfort dynamic enables the creation of new household routines and practices that depend on particular indoor temperatures. As similar research into the arrival of gas central heating in Stocksbridge indicated,

> "the growing demand for gas central heating reflected a gradual accumulation of new interpretations of thermal comfort, linked to changing ideas about the home and what it means to live well, and about the systems and technologies that are 'required" (Watson and Shove, 2022:385).

The social histories of indoor heating show how the relationship between household activity and the meteorological seasons have changed as the baseline of indoor temperature is negotiated and established, in different spaces and at different times. For example, the configuration of 'heating and cooling seasons', such as those set within institutional settings, brings together a standardised approach to moderating and maintaining indoor temperatures, and is an outcome of how heating technologies have been developed to provide both timed and instant provision of heat. Fundamentally however, the heating seasons, as the Stocksbridge and Stevenage cases exemplify, are a product of how social practices are sequenced and organised at different times of the year. In other words, there is nothing normal about heating seasons, both domestically and institutionally–they are socially shaped by infrastructures, conventions and practices.

I have, at this point, investigated and provided a narrative on the social histories of heating that matter for how comfort and energy provision is configurated within households in the UK. These histories reveal the shaping of indoor comfort, and the reconfiguration of indoor temperatures, through new ways of conceptualising thermal comfort tied to socio–technical innovations in heating provision. The next step is to show how histories of heating in the UK can be understood in relation to histories of cooling, particularly in the US. The change in location is to explain how, despite the setting and theoretical account, the same end result is arrived at: changing ideas of comfort can be tied to the means of energy provision available, resulting in the measuring and quantification of comfort indoors.

Cooling Seasons

Mechanical cooling, such as air conditioning, is a form of energy provision that was popularised in the mid–20th century and is an important example of how the introduction of this technology revolutionised ideas of indoor comfort in the USA.

Gail Cooper (1998) in *Air–conditioning America: engineers and the controlled environment, 1900–1960* states in their own words, that the discourses about indoor comfort and cooling are not just about the role of air conditioning, but also, “the debate, sometimes acrimonious, over open windows" (p.1). The development of mechanical cooling reflects approaches to provide standardised levels of comfort across diverse building types and indoor temperature norms.

Air conditioning became a household necessity during the housing boom in the US in the 1950’s, driven by the emergence of cheaper air conditioning units, and the construction of homes that were designed with air conditioning units as the central measure of indoor cooling. Rather than striving for a universally perfect indoor environment, consumers utilised air conditioning reactively, adjusting it based on personal comfort rather than adhering to the expectations of engineers. As Cooper explains,

> “Two distinct traditions [emerge] in the deployment of air conditioning. One is the choice of design professionals, engineers, and architects, who favor[ed] a controlled and rational system… A second is the choice of some users, who want[ed] an interior that is more comfortable but not necessarily ideal and who favor a technology that is above all flexible and responsive to the consumer's needs" (p.3).

This tension between engineers, designers, and consumers shaped the history of air conditioning in the US. Cooper explains the varying influences surrounding the politics of comfort, namely the actors who added to the understanding of what 'comfort' is–such as the scientists who sought to establish what the perfect 'level' of air conditioning is–in relation to external factors such as humidity, temperature and air flow for year–round 'comfort'. The differences that emerged between intended and actual use depended in part on the widespread adoption and geography of the US and its varying climates.

As air conditioning use expanded alongside the introduction of other technologies like TV's and fridge freezers, utility companies capitalised on this expansion as a solution to the (in their terms) 'lull' in energy use in the meteorological summer, akin to the winter peaks for heating. The rise of air conditioning reconfigured ideas of comfort across various buildings, from cinemas to domestic households, effectively erasing seasonal temperature variations and leading to increased energy consumption (Cooper, 1998).

Before the widespread adoption of air conditioning in the 1950s, cooling in US households relied on natural ventilation through open windows, demanding user attention to adjust indoor conditions according to weather changes. However, the scientific pursuit of optimal temperatures paved the way for the integration of air conditioning into domestic design and engineering, particularly in the USA during the 1950s, marking a significant shift in cooling practices.

By controlling the indoor climate, the air conditioning industry sought to create a uniform understanding of optimal temperatures indoors, as Cooper explains,

> "When it was shown that no natural climate could consistently deliver perfect comfort conditions, air conditioning broke free of its geographic limits. When no town could deliver an ideal climate, all towns became potential markets for air conditioning" (Cooper 1998:78).

As Cooper points outs, the lack of a 'natural climate' in the USA that was deemed ideal, and the determination that indoor comfort can be psychologically assessed within specific temperature guidelines, informed how air conditioning manufacturers designed their own technologies. It resulted in the conditions to ensure the commerciality of air conditioning, and specific goals for the 'sizing' of domestic provision, to ensure cooling across the home. For example, the 'Carrier Corporation' in the 1950's settled on 74°F (23°C) as 'ideal', 72°F (22°C) as the lowest indoor temperatures should drop in the mornings, and 78°F (25°C) as the highest indoor temperatures could reach in the evenings (p.144).

These developments led to the market for air conditioning becoming prevalent in the USA with the embedding of mechanical cooling into building design. This had implications for the ventilation choices in newly built air conditioned houses, as Cooper (1998) discusses, such as verandas and overhang eaves being removed, and space being reimagined to exclude natural ventilation. Embedding air conditioning into the design of buildings had further consequences for what activity then takes place indoors and outdoors

The arrival of air conditioning in the USA provides a case study of the significance of cooling technologies in reshaping what it means to be comfortable indoors and creating a laboratory–based understanding of comfort. Like the story of central heating arriving in Stevenage (Spurling, 2015), this is another example of the meaning of indoor thermal comfort changing with the means of temperature provision and that having a knock–on effect, by being built into standards and expectations, for example in building design. The introduction of air conditioning, and its ongoing development has revealed how the designing of spaces is centred around cooling rooms, rather than people themselves, and results in the designing of buildings which are sealed, so passive measures such as opening windows become unavailable, as active measures are prioritised, entrenching patterns of demand within these spaces.

In a UK context, domestic cooling, and its associated timings are more complicated to define than domestic heating, and in comparison to the USA, because air conditioning is not the norm for providing indoor cooling in domestic dwellings. Despite this, there are still some assumptions made about cooling seasons, and how they are temporally organised. For example, the domestic cooling season in the UK is attributed by BEIS to be between May and September, and can be split between two categories, active and passive which differentiate between the types of technologies used to create indoor cooling. As defined by (BEIS, 2021a),

> "Active measures use a refrigeration cycle to deliver cooling whilst passive measures are those that passively reduce the tendency of a space to reach high temperatures (such as solar shading or ventilation etc.)" (p.14).

Active measures, such as different types of air conditioning systems, are not commonplace in UK domestic housing, with around 2–5% of the population owning some type of air conditioning system, whether fixed or portable (BEIS, 2021a). They are more commonplace within institutions and office sites located in the UK, promoting standardised levels of indoor comfort for all users. This is compared to the US, where 83% of homes built after 1950, and 93% of homes built between 2010 and 2020 used air conditioning (EIA 2022). Passive measures are typically the focus in the UK for cooling, with shading, opening windows, and internal efficiency measures (e.g., types of wall insulation) being popular ways of producing cooling internally.

In terms of energy demand, domestic heating is a significant contributor to variation in gas consumption throughout the year, as opposed to the small percentage of households who have active cooling measures. If, by 2050, domestic air conditioning ownership rises to between 5–30% (Crawley; et al., 2020) in the UK, this has the potential to dramatically increase demand for electricity at peak times of the year. The challenge is accommodating this increased demand not just with increasing forms of renewable energy supply, but how ideas of indoor comfort will continue to change, through emerging ways of conceptualising active and passive cooling measures.

At this stage, I have explained how ideas of heating and cooling are mediated by different ideas of comfort, provision and social practice. Instead of providing an individualist approach to understanding the emergence of heating and cooling seasons, I instead, identify how taking a longer–term perspective, across different settings, has created baseline indoor temperatures that matter for the timing of heating and cooling throughout the year.

By re–evaluating existing social histories of heating and cooling, across two different geographical contexts, I have demonstrated how the creation of distinct heating and cooling 'seasons' is not normal or inevitable but is shaped by historical shifts in energy provision, infrastructures, and social expectations of indoor comfort. These histories reveal how existing understandings of seasonal energy consumption have developed over time, where socio–technical changes, and policy interventions established specific standards for indoor temperatures.

By establishing this organisation of heating and cooling, I turn to identify how this mediation is intertwined away from the domestic, towards the institution, to create a standardised level of comfort for different types of users.

Institutional Heating and Cooling

Although definitions of comfort vary across cultures across the world, households and buildings are now designed to provide specific conditions for comfort, scientifically developed to generate control over the indoor environment in places such as the UK (Shove et al., 2008). Laboratory–based studies designed to find optimal temperatures have now been integrated into ASHRAE standards, that are now used across the world in building design, creating specific climate conditions for occupancy. The indoor climate has been deemed controllable through these standards, to provide a level of scientifically designed comfort.

By referring to institutional heating and cooling, I describe organisations (e.g., hospitals, schools, businesses etc.) and their heating and cooling policies. These policies are characterised by formalised documents which create strict parameters for the spatial and temporal use of heating and cooling technologies within sites. As institutions accommodate a wide variety of users, the balancing of heating and cooling demands depends on when buildings are in use, and when peaks and troughs in building use occur throughout the year. For example, a hospital building needs to maintain specific indoor temperatures all year round to accommodate patients, whereas a school building, with term dates and daily operation hours, would only require heating and cooling at specific times during the day and not in school holidays (Blue, 2018).

A clear difference between domestic and institutional heating and cooling seasons are the formalised configurations of indoor comfort that are standardised across users, instead of accommodating personal preferences such as in domestic dwellings. The designing of specific temperatures, the types of heating and cooling provided, and the start/end of heating and cooling seasons vary across institutions. To explain this further, I use the example of universities as institutions that offer both variation and standardisation of heating and cooling seasons in their energy policies.

As research into the timing and configurations of university heating and cooling policies indicates (New et al., 2023), the majority of universities have a heating season that runs from October to April, or when there have been three consecutive days when the average outside temperature is below 16°C. Indoor temperatures at universities occupy specific zones of comfort governance, with minimum indoor temperatures set between 16–21°C and 19°C being the most common minimum temperature, during the heating seasons (New et al., 2023:228).

For instance, the heating season at Lancaster University starts prior to students taking up accommodation on campus (towards the end of September) and ends at the beginning of the Easter holidays, which moves depending on the date this falls in the calendar (Lancaster University 2019). As the Residents Handbook at Lancaster makes clear, “Our accommodation is heated from 6.00am to 11.00pm in most areas, though not normally in the summer months when the ambient temperature is higher” (Lancaster University 2019:para 16), segmenting the timing of heating within the calendar year.

There are also spatial differences in the timing of space heating at the Lancaster campus. The latest Heating Policy from Lancaster University (2016) states that academic buildings are '5-day buildings', with heating provided Monday to Friday 6am to 6pm, whereas residences are '7-day buildings' running Monday to Sunday between 6am to 11pm (p.2). This is to coincide with students and staff occupying rooms on campus, and the institutional scheduling of indoor activities such as seminars and lectures. Additionally, the policy specifies that heating in residences becomes available overnight only when "the temperature falls below 5°C for 48 hours continuously" (p.2), revealing how fluctuating temperatures are managed during periods of colder weather.

The timings of the heating season has not been chosen at random; it coincides with the start of the academic year in October and ends with the arrival of warmer temperatures during the Easter vacation period. Despite the frequent fluctuations in temperature and weather conditions in and around September–October, and between April–May in recent years, these dates are still abided by at universities within governing heating policies.

Cooling seasons at universities are more complicated as mechanical forms of cooling are not prevalent across university sites; instead, they are typically located in areas that need to keep specific temperatures all year round (e.g., server rooms, laboratories etc). Consequently, cooling season policies are shifted to place the emphasis on the individual to govern their own thermal comfort. Achieving thermal comfort through cooling policies has been suggested through, for example, dress codes, passive ventilation such as altering windows and blinds, and removing heat intensive appliances from offices. Heating and cooling policies from Cambridge University and UCL (University College London) help illustrate this.

For example, at Cambridge University, "full air conditioning or local cooling is not the standard throughout the University Estate where it is solely installed for the general comfort and wellbeing of individuals or any group of individuals during the 'summer' period (Cambridge University 2014:2). Instead, the University promotes the, "relaxation of formal office dress to encourage individual adaptation to conditions," alongside strategies such as "opening windows, the use of blinds, or moving out of sunny areas," and "increased air movement; e.g. the cooling effect of local fans can be equivalent to reducing the operative temperature by around 2°C" (p.3).

Similarly, UCL enforces strict limitations on cooling systems, stating that "air conditioning will only be considered where temperatures are consistently above 28°C and only after all other more environmentally friendly alternatives have been assessed" (UCL, 2024:para 11).

Those seeking air conditioning must “log temperatures to understand the temperatures [they] are experiencing” and, if approved, “the system would need to be paid for by [their] Department”. Additionally, “Estates engineers will also need to assess whether excessive temperatures are due to problems with existing ventilation and cooling systems” before granting approval (para 11). The UCL Cooling Policy implicitly suggests that air conditioning is considered a last resort, only implemented after all other viable alternatives have been exhausted.

In combination, both Cambridge and UCL cooling policies reveal the focus on individual adaptation to temperature changes, encouraging occupants to take proactive measures in managing their own comfort within the university environment.

With these policies considered, ways of achieving thermal comfort depend on individual understandings of what comfort is, and how it is defined, and therefore cannot be standardised to entire groups of people. By shifting cooling measures to the individual, the emphasis moves away from mechanical forms of cooling provided for example, by air conditioning, to active measures taken by the individual to create personal indoor comfort.

Creating the distinction between flexible (domestic) and formal (institutional) forms of heating and cooling seasons has revealed how arrangements for the provision of seasonal heating and cooling differ depending on the means of provision available within different types of settings. The choice to put the heating on at home depends on a variety of considerations to the user, such as ideas of thermal comfort, whereas at the institutional level, heating and cooling is governed by policies that dictate when and where heating and cooling takes place for a large group of users. What unites both types of settings is the relationship to the outdoor climate, which still matters for how indoor temperatures are set, whatever the weather is like outside.

Domestic and institutional heating and cooling provision depends on understandings of when outside temperatures are getting warmer/cooler. This, alongside other considerations, influence the timing and provision of heating and cooling at different times of the year, whilst keeping baseline indoor temperatures maintained all year round. Heating and cooling seasons are multifaceted concepts influenced by both climatic factors and institutional practices. They play a crucial role in maintaining indoor comfort, regulating energy consumption, and accommodating the needs of various settings, including residential, educational, and commercial environments.

The widespread adoption of central heating and air conditioning technologies has reshaped the way these seasons are defined and maintained, allowing for precise temperature control year–round. The institutional guidelines at selected universities support this conclusion, illustrating how domestic heating and cooling conventions have carried over to the institutional sphere, standardising indoor comfort, whilst closely following seasonal conventions of the timing of providing heating and cooling throughout the year.

This is evidenced at the University of Cambridge, which specifies the "aim to maintain internal temperatures in buildings within the range of 19 to 21°C," between September and May (Cambridge University 2014:1). and at UCL, where "in winter, autumn and spring UCL will aim to maintain spaces at a temperature of 19-21°C while they are occupied" (UCL, 2024:para 5). Both universities demonstrate a standardised approach to indoor climate control across different seasons and institutions and indicates how seasonal rhythms of heating and cooling are integrated into energy policies designed to facilitate baseline temperatures whatever the weather outside. The effect of this is the construction of indoor comfort away from the household to the institution for all users, regardless of season.

I use the penultimate section of this chapter to briefly discuss how degree day methodologies matter for determining the sizing of heating and cooling in building design, by reinforcing the 'measuring' of energy consumption to accommodate baseline indoor temperatures.

Degree Days

The size and total capacity of energy provision, such as boiler sizes required, are reproduced through 'degree days'–a tool used in the design process for buildings, and as I discuss in Chapter Five, for correcting patterns of energy demand as part of weather correction methodologies. Heating (HDD) and cooling (CDD) degree days are,

> "Both computed based on the cumulated daily deviations below (for HDD) or above (for CDD) a given temperature threshold (i.e. the base temperature) that varies according to the indicator" (Spinoni et al., 2018:191).

They represent the number of days that outdoor temperatures will be higher or lower than a designated baseline temperature. This difference informs how much heating and cooling will be needed to meet this difference in temperature, and the scale of provision required. As the CIBSE guidelines explain,

> "The two main uses for degree–days in buildings are: To estimate energy consumption and carbon dioxide emissions due to space heating and cooling for new build and

major refurbishments. For on–going energy monitoring and analysis of existing buildings based on historical data" (Day, 2006:3).

The goal of meeting 18–22°C is created in these standards by setting a specific baseline temperature and calculating provision to the institutional aspirations for heating and cooling. The weather is embedded within these calculations, as the indoor/outdoor relationship, and the degree day calculations are made by accounting for external temperatures. Degree days account for the weather, but then determine how much heating or cooling is needed to flatten out variation to make specific indoor climates, guided by the target temperature.

There are challenges with matching these standards in design, for example the marginal increases/decreases in temperature across different timescales (daily, seasonally etc), alongside the creation of a baseline temperature that is dependent on the thermal mechanisms of buildings, such as heat loss and thermal capacity, that can lead to different results between daily and monthly estimates of indoor energy (Day, 1999). Despite these challenges, degree days are an important tool in the construction of energy capacity within buildings, reinforcing the goal of 18–22°C as baseline temperatures indoors.

Degree days provide a standardised method of estimating energy use that builds on the notion of a baseline, and relates that to external weather conditions, providing a kind of reverse weather correction. The use of degree days builds estimated variations in the outdoor climate into estimates of energy requirements indoors. They reinforce the expectations of comfort that have been constructed over time by designers, architects and users, to size up heating and cooling in relation to the designing of buildings and to ensure maximum comfort is achieved for all users. The social and technical histories of heating and cooling, embedding the use of degree days in design, explain how optimal temperatures are written into standards and temporalities of comfort year–round.

Conclusion: The Changing Role of the Seasons

To conclude this chapter, I started by explaining Mauss' (1979) representation of seasonality through the Inuit culture, where two seasons of summer and winter dictate and govern the social organisation of everyday life, with changes in laws, housing and family relationships shifting between the seasons. I went on to explain how seasonality has evolved since Mauss' ethnography, where the outdoor climate is now flattened out to provide indoor comfort. I explained the relationship between technology and comfort with the examples of central heating and air conditioning, to show how the meaning of comfort changes with the meaning of provision, and the use of space and time, shifting based on changes in heating and cooling. I outlined how design changes reproduce a specific version of comfort that aspires for 18–22°C in the use of degree days to measure energy provision.

Through the two examples I have discussed of the Stevenage study for heating (Spurling, 2015; Trentmann and Carlsson-Hyslop, 2018), and the arrival of air conditioning for cooling (Cooper, 1998), the control of the indoor climate and the capacity to manage the weather suggests that the relationship between the indoor and outdoor climate has evolved over time, as standards of indoor comfort are shaped by changes in infrastructure and energy provision. Similarly, changing spatial and temporal dynamics of energy provision resulted in new social practices, and new ways of conceptualising thermal comfort both domestically and institutionally. Despite these social and technological changes occurring at different times, and in different locations, baseline temperatures have emerged as standard, reproduced through contemporary calculations of energy 'need'.

The emergence of heating and cooling seasons indicates the dynamic relationship between social and meteorological seasons, and gas and electricity consumption; tied to the calendar, and to ideas of thermal comfort by maintaining baseline indoor temperatures. The seasonality exhibited in Mauss' (1979) study of the Inuit is a stark contrast to the seasonality found today across social and temporal relations. In gas and electricity demand in the UK, there are distinct patterns of consumption that vary with the meteorological seasons. These patterns are closely tied to our perceptions of indoor comfort, the technologies we use, and our connected social practices, all of which are supported by the infrastructures that facilitate energy consumption. In the context of heating and cooling, the meteorological seasons are flattened out, but social seasons emerge–namely heating and cooling seasons–tied to conventions of comfort and when heating and cooling is typically sequenced and embedded in annual cycles. This creates patterns of seasonality, and seasonal rhythms of heating and cooling that are relational to conventions, indoor life, and technologies.

Despite methods to artificially construct 'normal demand' for example, through baseline temperatures and degree day methodologies, the relationship between heating and cooling and user expectations will be different for everyone, and sometimes outside of 18–22°C. What can be concluded, is that baseline indoor temperatures can be conceptualised in three respective ways:

- A mediator of comfort standards, through any regulating energy provision
- A performative expectation of users, of conceptualising indoor comfort

– An outcome of social and technological histories of social practice, of how buildings and locations are spatially conceptualised in relation to comfort.

These baseline temperatures I describe can be reconfigured and redefined in the future. The arrival of gas central heating, and the arrival of air conditioning in the USA provides two examples of how this has taken place. The question remains, returning to Mauss (1979), of why is there not a different social organisation when there are different meteorological seasons, and consequently temperatures? Could this change if energy systems, and patterns of electricity demand, are constructed in ways that rely on the timing of renewable energy supply? The answer relies on whether ideas of comfort, and the relationship to social and meteorological seasons, will continue to evolve as standards and conventions are reconstructed through changes in social life, and sociotechnical innovations in provision, and whether current arrangements could be reconfigured. The change from Inuit life, to the present day, suggests such a shift is not entirely out of the question.

Chapter Seven: Christmas Everyday: How Seasons are Made Throughout the Year

In this chapter, I shift the core focus away from ideas of energy demand, and instead, investigate the constitution of social seasons, namely Christmas. The purpose of this shift is to show how social seasons become entrenched within the calendar and create and sustain multiple kinds of temporalities that feed into the production of social and seasonal rhythms. In doing so, I aim to show how the entrenchment of social seasons has points of interest for considering future patterns of energy demand, through identifying the cyclicity of seasonal practices at different points of the year.

I draw on an investigation of the temporalities of the supply chains of selected Christmas commodities, as an entry point to studying how different kinds of production processes matter for meeting the timing of Christmas as the end of the calendar year. These cases show how the outdoor climate and social seasons are managed throughout the year and how they relate also to annual cycles of supply and demand that contribute to the Christmas season. The purpose of the chapter is to discover how 'social' seasons are organised around an extended set of temporalities that define activities throughout and beyond the year. By working with the example of Christmas, my aim is to describe how interwoven activities related to the Christmas period generate multiple peaks and troughs throughout the year.

My method is to follow the production of selected commodities (trees produced only for purchase at Christmas, turkeys, and a popular toy purchased at Christmas, known as the 'Barbie Dreamhouse') in order to track and identify the timings of their production and distribution, and to show how these supply chains converge around December. These commodities were selected because they represent production processes that overlap across the calendar year, and have characteristics that matter for the timing of the supply chain, for example, issues of perishability and storage. From this point of view, I discuss the timings of the journey of millions of turkeys to supermarket counters, the growing cycles of Christmas tree production, and the movement of toys onto supermarket shelves, in order to describe different but connected temporalities of supply.

These three examples I investigate allow me to describe three very different ways in which 'peaks' are formed prior to and in the run up to the Christmas season. Each commodity occupies a unique position in the distribution of 'Christmas–related' energy demand, and each requires us to think about how different kinds of 'demands' are made in the lead up to the 25th December.

I start the chapter by working through the histories of Christmas as a social season and locating its importance for structuring activities throughout the year. I then provide an analysis of the specific 'seasonal rhythms' that the timing of Christmas produces, before providing a detailed analysis of the three chosen commodities for further investigation. I conclude this chapter by drawing together these three examples within a broader discussion of how these commodities matter for the sequencing of practices throughout the year, and for the cyclicity of annual cycles that matter for sustaining Christmas year on year.

Situating Christmas in the UK

As historians such as Connelly (1999); Johnes (2016); Flanders (2018) and anthropologists of Christmas such as Miller (2017) show, this is a season (or holiday period) that transcends religious boundaries and is recognised as a key moment in the calendar, guiding the organisation of social relations in the meteorological winter months. For example, through the timing of school holidays, government designated bank holidays, and changes in the opening hours of shops.

In Western Christianity, the festive season of 'Christmas Tide' starts on the 25th December and lasts until the 5th January–the twelve days of Christmas as they are commonly known. The festival of 'advent' can also be used to define the festive season, linked to the days preceding the celebration of the birth of Jesus on the 25th December. This starts on the fourth Sunday before Christmas and lasts until the 24th December (Zerubavel, 1981). In North America, the festive season is interpreted as the day after Thanksgiving, while in the UK the arrival of Christmas food in September and the switching on of high street Christmas lights in mid–November indicate an earlier arrival of Christmas (Johnes, 2016). As these dates suggest, the beginning of Christmas varies according to both the cultural and religious settings, while also being flexible in accommodating new ways of extending the season, through cultural and commercial events.

During the lead up to Christmas, and Christmas Day itself, consumption of all kinds is magnified in the form of purchasing goods and services for presents, or food consumption as part of the festivities. The supply of specific goods is ramped up to meet expected demand. For example, as the most popular choice of Christmas meat in the UK, turkey slaughtering is at its highest, on average, in December, in preparation for birds being purchased for eating on Christmas Day

(Butler, 2021a). More widely, supermarkets take on seasonal staff in order to handle extra demand. The Saturday prior to Christmas Day is typically the busiest shopping day of the year, whilst Christmas Eve is the busiest on the roads as more people complete leisure journeys (RAC, 2021).

Christmas Day itself has a stereotypical temporal structure, held together through practices of gift–giving, eating 'Christmas dinner', and watching 'event TV' (for example, the King's Speech). All these activities take place at different times in the 24–hour day, but routinely occur each year as part of Christmas celebrations for families across different societies. These practices have led to specific 'peaks' that are only found on Christmas Day, such as within electricity demand at the minute, and hourly timescale. For example, in 2018 there was a small uptake in electricity consumption around 1:30pm, when Christmas dinner was being cooked.

This is in contrast to the average domestic electricity consumption across the rest of the year, when demand decreases throughout the day until the evening, when people return home from work and start consuming energy after 5pm (National Grid 2020). There can also be small uptakes found for programmes scheduled on TV, however this has reduced in recent years with the advent of streaming services allowing flexibility in choosing when to watch television. These peaks reinforce the view that Christmas is unusual through the temporal ordering of the day itself. As the anthropologist Adam Kuper (1993) explains,

> "Over Christmas, the whole nation is constructed as a series of identical family parties. Christmas is probably the only one annual occasion when virtually everyone in England is doing the same thing at the same time" (p.157).

Despite this social synchronicity, Christmas Day itself is not especially energy demanding. Demand for electricity on Christmas Day is low compared to other days in the calendar year, as many industries shut down in the lead up to Christmas Day itself (National Grid 2020). Instead, Christmas–related energy peaks in demand are found elsewhere, scattered across the year. As described below, the supply chains of Christmas products depend on different, interweaving logistics (materials, staffing, factories, transport etc), that have their own peaks and troughs of production. As the timeline in Figure 4 exemplifies, the calendar year consists of different 'moments' which lead up the making of multiple kinds of supply in time for Christmas Day or the Christmas season.

Seasonal Rhythms of Christmas Time

The sequencing of social practices within supply chains are only one part of the story of Christmas. I make the case, in this chapter, that the social season of Christmas is made and reproduced from one year, to ten years (in the case of Christmas tree planting) in advance. As Christmas is a social season that is annually repeated, it can be considered a 'socio–temporal order' because it,

> "regulates the structure and dynamics of social life [through] socio–temporal patterns which essentially involve the temporal rigidification of social situations, activities and events" (Zerubavel, 1981:2).

This seasonal cyclicity is tied to the Gregorian calendar, according to which Christmas Day takes place on a different day each year, but on the same date, thus creating the temporal fixity that Zerubavel describes.

In practice, celebrations of Christmas are not the same across the world. Countries located across the Northern and Southern hemispheres have different traditions and conventions meaning that, as Bohanon (2023:237) explains, for those living at Antarctic research stations, Christmas is celebrated in July, rather than in December. 'Christmas in July' is the end of the calendar event for the scientists and has similar traditions, from gift giving to a shared meal. As this example demonstrates, Christmas is reconfigured in both space and time, and is part of an annual cycle not because it is natural or inevitable, but because of the repetition of social practices that keep Christmas a seasonal event year on year.

In summary and as Southerton argues:

> "socio–temporal rhythms form and reproduce through the organisation and performance of social practices. The degrees to which those rhythms reflect strong collective timings of activities across social groups is, therefore, a reflection of the coherence of the practice" (Southerton, 2020:171).

There are many connections between the production of rhythms tied to Christmas, and those found in discussions about energy systems. This includes economic, cultural, political and social rhythms, that have continued to evolve and change as globalisation and technological shifts have taken place shaping understandings of time and space (Warf, 2011). Returning to Walker (2020) reflects this positioning within his study of rhythms, as he argues: "socio–

temporal structures are culturally embedded, reflecting the shared conventions and norms of a particular place, society, or culture" (p.99).

The temporal rhythms tied to Christmas are excellent examples of this embedding in that they represent the connections between practices that are closely sequenced and connected. This is also relevant for when and how peaks and troughs in gas and electricity demand occur throughout the year. As described here, the example of Christmas speaks to issues of energy demand in that it shows that there are annual cycles of peaks and troughs in supply and demand that arise from the ways in which social life is organised and configured, and for the forms of synchronicity that arise as a result.

Research connecting Christmas to energy consumption and the production of rhythms includes that by Anable et al. (2017). These authors argue that demand relating to Christmas has 'stretched' across the year, resulting in a '365–day society' in which multiple temporalities come together, and in which these conjunctions matter for peaks in energy demand. I take a similar approach in that I describe the annual cycles of commodities (and timings of peak energy demand) combine to make what is known as the 'Christmas season'.

As I will explain in this chapter, Christmas peaks are found across the year depending on the production cycle of the commodity being produced. I turn to focus on how supply chains are organised with the timing of Christmas in view.

Managing Christmas Supply Chains

> "The key to a successful Christmas is understanding what will be in demand and delivering it to the consumer. If the supply matches perfectly the demand, then companies can expect to achieve the desired profit margins for this peak season, consumers will not be left disappointed and companies achieve what they proposed" (Supply Chain Consulting Group 2023:p.11).

Supply chains are complex configurations of practices involving producers and consumers. In the food sector, for example, no one supply chain is the same as another, meaning that different relations lie behind the 'arrival' of the final product in supermarkets. Whether it is perishable food, or the production of toys, retailers and connected supply chains need to be resilient (operating under a multitude of circumstances) and flexible (adapting when required) to keep production on track.

At Christmas, as at other times of year, the sequence of suppliers is typically hidden from the consumers' view. Behind the scenes, the process of placing goods on shelves involves a series of decisions encompassing planning, timing of purchases, product selection, and balancing costs and profits for retailers. For instance, turkey producers aim to have birds available in stores by the end of November, requiring them to reach suitable weight and be ready for slaughter by early November. As consumers begin their Christmas preparations earlier, supply for certain goods, such as toys, are now available earlier to meet this demand.[10] Nevertheless, unforeseen disruptions, often termed as 'black swan events,' can challenge the entire supply chain, creating unpredictability and necessitating the need for flexibility to accommodate any shifts in process (Parrish, 2018).

Some events severely disrupt supply chains, putting the resilience and stability of production lines to the test as they endeavour to recover swiftly. For instance, the COVID–19 pandemic highlighted the critical timing of events throughout the year that support the Christmas season's supply chain. As disruptions occurred, the often–hidden infrastructure supporting these processes was suddenly brought into public view. Following Star (1999), this visibility arose from the breakdowns themselves, as the internal workings and timing of these systems, such as delays within supply chains for the delivery of commodities, became visible to the public.

These supply chains could now be scrutinised and investigated further after being previously 'hidden' from view, as these infrastructures operated in the background of social life. The supply issues that arose from the timing of the pandemic created uncertainty about supply and demand, due to shipping delays, and whether there would be an overproduction of stock, if families were not joining together on Christmas Day.

In the second half of this chapter, I investigate some of these aspects, particularly focusing on issues of perishability and storage. Perishability, deeply embedded in the design, production, and distribution of commodities, especially fresh food products, plays a central role in the Christmas season's dynamics. By this, I refer to ideas of food, but also of trees and toys that are perishable in the sense that they lose their value after Christmas. Understanding various forms of perishability is essential for understanding the seasonal cycles associated with different production processes.

[10] Also known as the 'Christmas Creep'.

Similarly, issues of storage emerge as a critical element in managing production around a key date or deadline. For example, 'natural' Christmas trees with roots require outdoor storage post–harvest, necessitating access to fresh air, sunlight, and regular watering. Conversely, toys for the Christmas market can be safely stored in warehouses for extended durations. As these examples suggest, supply chains and infrastructures differ depending on the practicalities of long or short–term storage.

To understand these details and variations, I follow three commodity production lines. In each case I identify how themes of storage, perishability, and temporality matter for how the production process is organised, and thus for when and where Christmas–related peaks in energy demand occur.

Raising Turkeys for Slaughter

> "I like the seasonality of growing turkeys. At the end of the calendar year near the holidays, time is spent cleaning the barns and spending time with the family. By January I'm done with the holidays and everything is buttoned up and we are hunkered down. But February arrives and the barns are warmed in anticipation of accepting the new turkey poults, day old birds, and the growing season begins again" (Parrish, 2018:p.9).

The first commodity that I describe are turkey birds. Turkeys, as the centrepiece of the annual Christmas dinner in the UK, are hatched and slaughtered every year to meet demand for roasting the birds at the end of December. The Christmas meal is typically a roast dinner in the UK, with a turkey bird now the meat of choice. This wasn't always the case; in medieval England, boar was served as the meat, whilst prior to the 16th century, peacocks and swans were also eaten as part of the Christmas dinner, at least for the elite (Flanders, 2018). When turkeys were first bred in the UK in the late 16th century, they were a luxury commodity up until the 1950's, and occupied a typically seasonal production process for specialist producers (Martin, 2009). These timings resulted in poults being hatched in late spring in time for slaughter toward the latter half of November/start of December (Kijowski et al., 2005; DEFRA 2021).

With the development of refrigeration technologies, especially the freezer, long–term turkey storage in the household became an option for producers, resulting in turkey production shifting to being year–round. A consequence of this shift was the emergence of a new type of intensively produced turkey, slaughtered at 9 weeks old and traditionally frozen for export, with new markets in Europe to export turkeys to with the development of international trade (Kijowski et al., 2005). This is in comparison to the ‘traditional turkeys’ with a much longer growing time (at least 26 weeks) and typically not frozen (DEFRA 2021). With freezing and the option of long–term storage, the timing of turkey production shifted, with eggs being hatched all year round instead of targeted towards late spring.

After turkeys reach a certain age and weight, they are transported for slaughtering. The types of birds produced (traditional or intensive) have different journeys of travel towards supermarket shelves. The traditional turkeys (not usually frozen) are dry plucked, then hung for at least 10 days, in order to tenderise and retain flavour. Once this has happened, the birds are then packed, with the giblets set aside, to be sent to supermarkets (Martin, 2009; Butler, 2021a). By contrast, intensively produced birds are wet plucked instead of dry plucked, a process which involves scalding the turkey in boiling water before its feathers are removed, which is a cheaper and more efficient process. The birds are then packed and frozen to be sent to supermarkets without an ageing period (Martin, 2009).

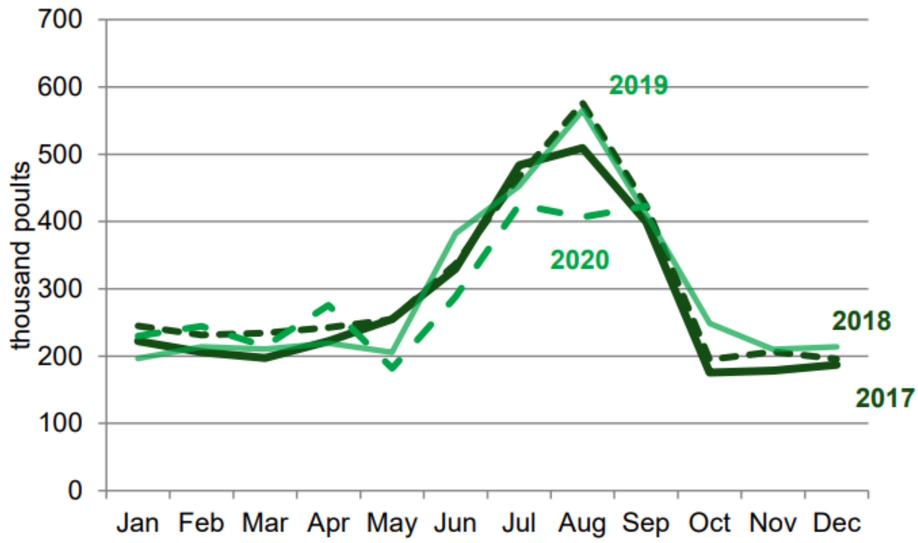
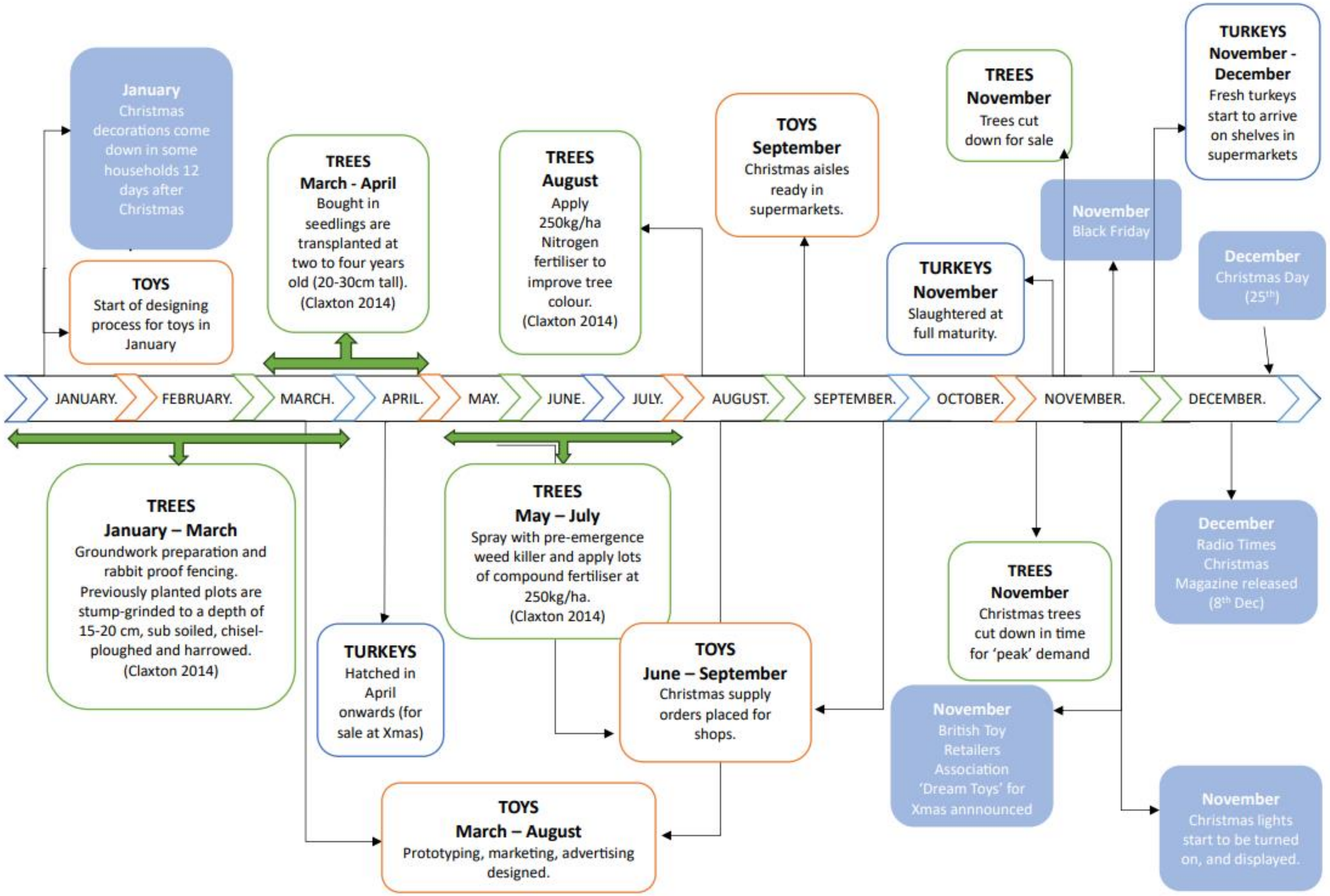


Figure 4–Turkey poults placed per week on average in the UK 2018–2021 (Copied from DEFRA, 2021).

Figure 5–Timeline of Christmas[11]



[11] 11 These supply chain dates are not designed to be representative, but are indicative of how certain producers time their production processes.

With the emergence of different supply chains, the seasonality of turkey production changed. The peaks in demand for full grown birds are still orientated around Christmas, but turkeys that are due to be frozen are slaughtered at different times of year. For example, referring to Figure 5, the average peak for laying of poults (a young domestic fowl, such as turkey) is August, suggesting turkeys grow for between 16–20 weeks old before being slaughtered for Christmas.

Turkey slaughtering is at its highest in December, with the last three years of figures revealing significant jumps to meet Christmas demand. Demand for slaughter is consistently flat halfway through the year, with turkeys being produced both for the UK markets, and internationally, mainly to countries such as Germany and the Netherlands (Tridge, 2022).

2020 was an outlier year for slaughtering, due to the impact of the COVID–19 pandemic. There was a reduction in the hatching of turkey poults during 2020, with uncertainties regarding the number of birds required with more households staying at home and not joining other family members, but a dramatic increase, in comparison to other years, of slaughtering from October 2020 onwards, as there was a greater understanding of expected COVID regulations in December (Rivington et al., 2021).

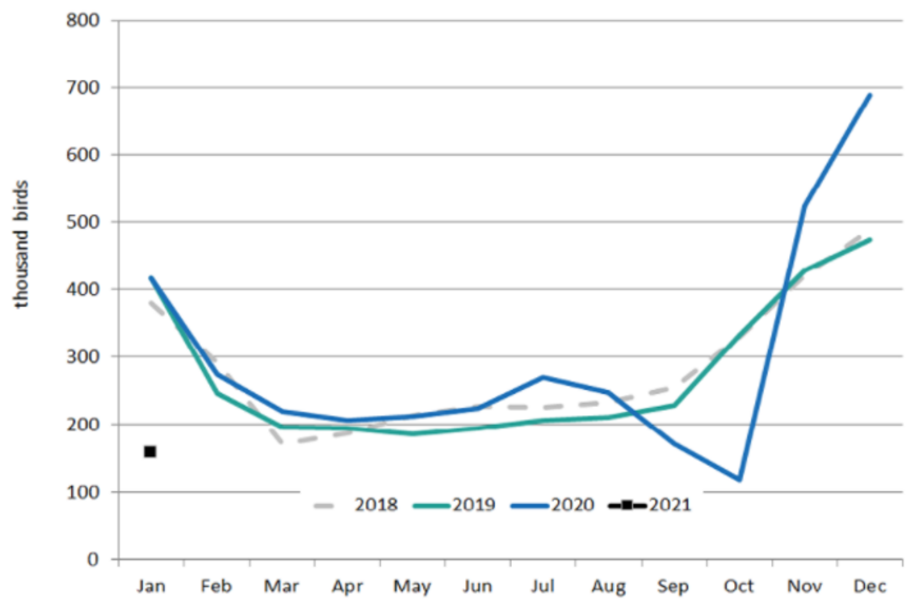


Figure 6–Average number of turkeys slaughtered in the UK 2018–2021 (Copied from DEFRA, 2021)

Turkey producers have to plan for the amount of demand expected throughout the year and at Christmas. No one turkey farm is the same in their production; some farms produce turkeys all year round, with a regular number being exported around the EU and sold domestically, before ramping up demand for Christmas. Other farms will be more seasonal in their output, producing chickens and other poultry throughout the year, before switching to producing turkeys to meet Christmas demand (Martin, 2009; Butler, 2021a). This type of production requires a complex interweaving of logistics to ensure turkeys are ready on time. Enough eggs need to be laid and subsequently hatched by August to ensure poults can develop and be fed to a sizeable weight, for slaughter by the start of December.

Although turkeys can be frozen–for up to two years–this comes at a cost, including a loss of 'quality'. The issue of perishability is important both for the rate of storage and sale, and for the practicalities of freezing and preservation depending on the size of the bird. What is considered 'fresh' will vary, depending on how 'freshness' is conceptualised in the food industry. For example, in the UK, poultry can be fresh, frozen, or quick frozen. Fresh turkeys are refrigerated at temperatures between –2 to 4°C, frozen is no higher than –12°C, and quick frozen (using gas to quickly freeze a product) is no higher than –18°C (DEFRA, 2011). The perishability in this context becomes time limited by the type of refrigeration involved. In theory, any 'over production' of birds can be handled by freezing or exporting them to other markets. Keeping them in good condition, sellable and edible means maintaining the frozen food chain, and frozen transportation.

The shelf life of a turkey is not dependent on trends in fashion, like the annual cycle of Christmas toys, but by the limitations set by regulators on how long fresh and frozen turkeys are considered 'safe' to eat. This results in short–term storage solutions at refrigerated distribution centres, with supermarkets placing orders months in advance, and turkeys stored ready to be on shelves when customers expect them (Butler, 2021a). The temporal nature of turkey production, centralised on specific months of the year, results in a cyclical process of ramping up supply in response to anticipated trends in demand.

I come back to the organisation of turkey production in the discussion section of this chapter. I turn now to introduce my second commodity, the process of producing toys aimed at the Christmas market.

Designing and Producing Christmas Toys

> "So far in December, the sales figures are suggesting that when it comes to toys, it's fun, imagination and innovation that are driving sales" (NPD Group 2021:p.2).

The second commodity I discuss is the production of toys targeted at the Christmas market, in which I identify a specific toy, the 'Barbie Dreamhouse' for further analysis.

The week before Christmas Day is, on average, the busiest in the calendar year for sales of children's toys, with on average eleven toys given as presents per child in the UK at Christmas, providing a lucrative market to capitalise on (Lyster, 2016). Toy manufacturers aim to create and capture popular trends in wider society, from video games, to popular IP[12], to create products marketed at children.

The product lifecycle of Christmas toys can therefore vary, with certain toys being on shelves from six months to two years in advance, with focused marketing campaigns at Christmas to rediscover interest in existing products. These Christmas ambitions of toy manufacturers results in a seasonality of toy sales, with 70% of all toys sold being bought just before, during or after Christmas (ECSIP 2013).

The tendency to publicise the most popular Christmas toys across sections of the media lead to dramatic rushes to buy products before stock runs out. For example, in 1997, a rush to purchase dolls from the children's television programme Teletubbies led to demand outstripping supply, and a frenzy to obtain them led to violent clashes between parents (Greenfield and Osborn, 2013). With the demand challenges of the seasonal market, the rush to produce more dolls led to stocks being 'too high' after Christmas, and the associated products created to meet the craze, such as books and cutlery, languishing in shops for months after (Greenfield and Osborn, 2013).

Although sales are notably seasonal, the production of toys can be consistent all year round (ECSIP 2013). In practice, the details depend on how long it takes to design, gather raw materials for, and produce a toy and at what speed. In some cases, toy inventory can be purchased a year in advance by retailers, who store them to specifically target the Christmas market (Lyster, 2016). However, most Christmas toys are in the hands of retailers by August, who store them in warehouses before their arrival on shop floors (Leach et al., 2021).

Prior to 2020, this process was relatively streamlined through the annual cycles of design and consumption. As I go on to explain in the discussion section of this chapter, the challenges of storage and the crossing of state lines have led to discussions surrounding the timing of the supply chain, and the importing of goods from abroad, for a fixed date in the calendar. For example, with the global disruption that occurred with the COVID–19 pandemic and the

[12] Intellectual property.

political effects of Brexit, some stores ramped up the supply of non–perishable goods earlier in the year to ensure the purchase of gifts 'in time' for Christmas could take place (Du and Shepotylo, 2022).

The advantages of producing toys which are made from long–life materials, such as moulded plastics, is that they don't degrade over time. Although this is environmentally problematic, for the supply chain, it is a major advantage. This is because there are no constraints of the product 'going off' as is the case with turkeys.

However, there are different types of 'shelf life' involved. For example, ideas of 'fashion' and 'trends' creates a form of shelf life depending on popularity. This is based on a range of material considerations, and the social histories of products. When toys go 'out of fashion' (through different kinds of societal changes) their value diminishes. Toy manufacturers, such as those who make Barbie dolls (Mattel) and board games (e.g. Hasbro), capitalise on the latest movies and TV shows by producing toys aimed at specific demographics of children (ECSIP 2013).

Certain toy brands possess enduring popularity, maintaining relevance over time due to their nostalgia that continues to captivate both consumers and young children. For example, Disney brands, which endure through the reimagining of beloved movies and TV shows, ensuring their continued presence and appeal in the market. The longevity of these brands relates to what could be considered the cultural lifespan of commodities.

To follow a specific example, the 'Barbie Dreamhouse' was the number one top–selling Christmas toy of 2021 in the UK (NPD Group 2021). This product has been a best seller for 45 years in the UK and USA, attributed to the lasting popularity of the brand and the multiple reinventions of the Dreamhouse over the years. Produced by the American toy manufacturer Mattel, the Dreamhouse was first created in 1962 and made entirely from cardboard (Eilers, 2012).

Today, they are produced from plastic, and contain multiple 'layers', different rooms, basements, attics, gardens etc. to increase the size and scope of the toy. It can take a few years to design a new version, which is usually 3D–modelled in advance. The materials are finalised, and the production is outsourced, usually to countries in Asia where the costs of labour are cheaper than in Europe or the USA (ECSIP 2013). From here, they follow a typical toy production life cycle in which they are manufactured, then boxed ready to be sold around the world. Toys manufactured in Asia are transported by cargo ships, taking a number of weeks to reach UK shores, before being distributed for sale to retailers and their customers (Leach et al., 2021).

The 'Barbie Dreamhouse' provides an insight into the social history of a toy which has been continually reinvented. A key question therefore emerges; how did a toy first produced 60 years ago become the top–selling Christmas toy in 2021? The answer lies in how the brand of Barbie has reimagined itself in recent years, with new versions of the Barbie doll being created that do not replicate the model produced in the 1960s (Lasky, 2022). The Dreamhouse, which is where Barbie lives, has also changed since the 1960's, starting off as a mansion, then being reinvented as a townhouse, and finally a studio apartment. As Eilers (2012) describes, the materials the Dreamhouse is made from have changed with new manufacturing methods and with production moving to Asia. The Dreamhouse is now made of five different plastics, which are moulded into shapes to create the Dreamhouse.

This example provides a longer–term view of adaptability–which is also part of the durability of the brand–and the shorter–term cycle of re–design, manufacturing and distribution. In this case, Christmas is a critical season, but the work, and the energy involved in production is geographically and temporally distributed around the world and across the year.

I turn now to explain my final example, Christmas trees, and the process of producing trees in many different forms for the festive market. These are grown to order and like turkeys, also have a limited 'shelf life', but the periodicities, cycles and supply chains are distinct.

Planting and Harvesting Christmas Trees

> "Christmas trees are a cyclical thing where they have to plant every single year. So, if you plant 1000, then 10 years later 1000 will be ready. But if you lose some then you're not going to have those ready 10 years later" (Overdeep, 2019:para 9).

The final commodity I introduce to this discussion of different types of commodities is the production of trees associated with the season of Christmas. These trees, such as 'Nordmann fir', 'Scotch pine' and 'Norway spruce', are harvested at 6–10 years old and when cut down they are usually stored outside to maintain their shape and colour (Downing, 2019).

The majority of supermarkets opt to procure their Christmas tree inventory from UK producers. This choice is primarily driven by the lower risk of damage during transportation, thus enabling the trees to maintain their freshness for an extended period (Tesco, 2021). Once trees are in supermarkets, the challenge is to sell them in the weeks leading up to Christmas, as they are of no value past that date. This is in contrast to artificial trees, which increase in value in the weeks leading up to Christmas Day but still retain cost at other times of year. In addition, and unlike turkeys and barbie dolls, real Christmas trees cannot be stored or sold later in the year.

There are different types of trees grown, with a multitude of features that are designed to be appealing to consumers, for example, non–drop needles, large height and life longevity. As explained by Wray (2009) in their analysis of Christmas tree production, most trees are planted during the months of February/March (dependent on weather conditions) and cut down in November/start of December. Trees are not left alone during these years. In the first year they need watering sometimes once a week, and pruning to ensure branches are of similar length. The need to produce an annual harvest means that there is a cycle of cutting and replanting, and of growing and tending (which can include spraying and pruning at regular intervals). Once harvested, land which trees previously occupied is cleared for new seeds to be planted (Wray, 2009).

The supply chain and temporal cycles are different for artificial trees, designed to replicate their natural equivalent. Instead of being grown, artificial trees are made all year round in factories, usually in Asia, and similar to other products aimed at the Christmas market (including the Barbie dreamhouse), they are shipped to the UK to meet demand from September onwards. According to Wray (2009), natural trees produced for the Christmas season are perishable once they have been chopped from their roots. In the tree market, quality relates to issues of longevity tied to the colour of the tree, the stability of the branches, how upright it is, and whether there has been any browning or not. With an increased focus on sustainability within supply chains globally, Christmas tree producers have responded by increasing the number of potted trees that can be placed in the garden and brought in annually. Although more expensive to produce, the growth in potted trees indicates a changing marketplace, albeit one still organised around an annual cycle of production aimed at the Christmas period (Downing, 2019).

One of the challenges facing natural Christmas tree producers and suppliers is forecasting how many trees to plant and ensuring they are sold prior to Christmas Day itself. For example, Christmas trees can be sold for less than £1 (compared to the usual £40–£50) in the two weeks prior to Christmas Day, depending on the amount of stock remaining (Butler, 2021b). As the Chief Executive of the Garden Centre Association noted: “You can’t just leave them – they are not worth a penny after Christmas” (quoted in Butler, 2021b: para 6).

The perishability of Christmas trees is not because they are 'alive', but because they only have market value at a certain time in the year. This time limit is associated with a bigger challenge of disposal and waste: if trees are left over, retailers need to dispose of them as cheaply as possible. In contrast to the supply and demand of natural trees, artificial trees are not perishable, as they are kept year after year, and can be purchased all year round. Artificial trees are not subject to the temporal constraints associated with natural tree cultivation and harvesting.

In this case, the supply chain depends on raw materials being sourced from multiple countries (China, Japan, USA) before manufactured trees are shipped to retail outlets all over the world. As with the Barbie Dreamhouse, new models of artificial trees are designed each year, with models now offering features such as integrated lighting, or LED improvements (PE Americas 2010).

Each of these three products follows a different course after Christmas. For example, artificial trees need to be stored at home. Natural trees are disposed of or replanted (in the case of potted trees) either by households or by producers, turkeys are eaten or frozen and 'Dreamhouses' are played with or fall out of use over time. There are also different geographies associated with each example. For instance, products like toys and artificial trees are typically produced and shipped around the world. Turkeys, and especially frozen ones, also travel between countries. By contrast, fresh turkeys and natural trees tend to be grown and consumed more locally.

The relative fixity and flexibility of these arrangements was recently revealed by the COVID–19 pandemic involving disruption to each of these supply chains, alongside the tendency for more households to stay home over Christmas. As this event shows, rhythms can and do change, and are not fixed. Instead, they are produced and embedded within annual cycles of supply and demand, intertwined with the calendar and the timing of 'Christmas'.

In the next section I consider the different characteristics of these three cases showing how multiple social seasons come together, and how this could matter for understanding the arrangements of energy demand located throughout the year, both in the present, and in the future.

Conclusion: Sequencing the Seasons

As the timeline in Figure 4 shows, supply chains and stages of production are sequenced across the year in order to meet demand for these goods at Christmas time, and reveal the multiple, overlapping temporalities of supply. As the discussion of issues like storage and perishability have indicated, each stage involved in the production and supply of Christmas trees, toys and turkeys is timed to ensure that these commodities are ready for purchase for the 'Christmas season', as widely defined.

To return to a discussion of energy and temporality, although Christmas day is not a day of 'peak' energy demand, the run up (which is of different duration, intensity and location in each of these three examples) involves peaks in production–related energy demand, the size of which varies depending on issues of storage, perishability and the scale of production.

In effect, the existence of Christmas, as a time–sensitive social season, depends on a series of invisible peaks in energy use and in production, timed and sequenced to meet the December deadline. These are different in each of the examples discussed, but all three cases involve critical moments (of hatching, harvesting, freezing, distributing etc.) that will have energy demand implications for a wide range of different organisations, some in the UK, some in other parts of the world.

Whenever they occur, peaks in demand put pressure on supply systems relating to energy and to other commodities as well. In other words, Christmas is not made in December; it is constructed all year round through the peaks and troughs within the supply chain.

There are, of course, arguments about the relative 'sustainability' of different production methods, and about storage as well. For example, there are analyses of the water and energy embodied in 'natural' and in artificial tree production (Chiu, 2022) and similar comparisons of fresh versus frozen turkeys (Martin, 2009). In this chapter, I have set these considerations aside in order to make a handful of key points about the spatial and temporal organisation of the evidenced commodities, as that relates to what appears to be one especially important day in the social calendar of consumption.

To be more specific, I have argued that:

- Different products and different methods of production are associated with distinctive schedules in the 'run up' to Christmas.
- These have the effect of spreading or distributing peaks in demand, such as those associated with supply chains, and consequently, peaks in energy demand, and situating them at different points in the year.

- As a result, the seasonality of consumer demand (for Christmas–related products) is translated into a multitude of parallel and preceding 'seasons' of production and supply.

These observations are important in the broader context of the thesis, and the various lines of enquiry I have followed in previous chapters. Namely, that they complicate an overly simple reading of 'social seasons' and of how they orchestrate and coordinate energy demand. Although I have focused on Christmas, I use this case to make this much broader point, and to provoke further thought and discussion about the timing of energy demand, about how peaks are sequenced, and about how these sequences relate to the reproduction of societal rhythms.

I end with a final question: is there the potential for the social season of Christmas to be 'reimagined' in the future, in such a way that flattens out this trail of associated peaks? One speculative response is to actively extend the Christmas period, that is the period during which Christmas goods are sold. This is already happening, with some Christmas items now on sale as early as September. Simply changing the date would change the 'timetable' of the run up, but not the peaks associated with it. There may be some energy demand reduction if social seasons like Christmas varied so that they matched the 'summer' months, meaning that Christmas in the UK would be on a different date to Christmas, for example, in the southern hemisphere.

There are recent examples of shifting the timing of popular societal occasions. For example, the Men's 'FIFA World Cup', traditionally understood as a summer football tournament, took place in December 2022 and January 2023, to take advantage of the cooler weather in Qatar, where it was being hosted. The change was the first time in FIFA history the tournament had been held in the meteorological 'winter' for countries in Western Europe. This resulted in football leagues around the world, including the UK Premier League, shifting the timing of its calendar (starting earlier, finishing later in the year) to accommodate the timing of the World Cup, and to enable a rest break for the players. The notable difference with this example is that Christmas is celebrated around the world, not in one location alone. The point remains, that the timing of a specific event shifted, which created a ripple effect around the world, changing football calendars and timings.

Another speculative option would be to disassociate 'Christmas' from the commodities discussed in this chapter, turkeys, toys and trees, from the cycles of production on which these products depend. Connecting the event to the consumption of non–perishable, easily stored goods would be a step in this direction, and would create new production processes that reimagine the conventions that Christmas is associated with.

The fact that these are somewhat provocative suggestions underlines the extent to which Christmas as we know it today is inscribed in the social calendar, and in the rhythms of demand associated with it, some of which stretch across the year. There are connections here to other chapters in the thesis, more specifically, to Chapter Six. For example, I questioned in that chapter whether baseline indoor temperatures can be reconfigured in the future, with decarbonisation agendas, and the timing and intermittency of renewable energy (e.g., wind and solar) supplies in view. I suggested that ideas of comfort could be reconceptualised, and the organisation of baseline indoor temperatures. To contrast with the examples in this chapter, there is an entrenchment with the timing of Christmas, with its long social history and location in the calendar, that any reconfiguration in terms of sequencing and duration will be more complicated and depend on reimagining Christmas and its associated peaks in demand.

Instead, what this chapter has detailed, is the role of annual cycles not only for studying different kinds of peaks and troughs in demand, but for identifying how social seasons are spatially and temporally constituted, and how this results in the production of seasonal rhythms tied to sequencing of social practices. This informs the study of seasonality located in this research, and the key role of social seasons of structuring social life at different points in the year.

In the final chapter, I bring together the various threads found across the thesis within a concluding discussion, in which I explain how this research has contributed to an analysis of seasonality, and the multiple constructions of seasons associated with the social and temporal organisation of everyday life.

Chapter Eight: Creating Seasons: How Ideas of Representation, Technology and Time Matter for Patterns of Energy Demand

This final chapter draws the threads of the thesis together, to connect the arguments about accuracy/representation, baselining and material provision, and extended temporal cycles. In concert, these ideas begin to show how seasonal variation is constructed, written into forecasts, standards, and technology, and with what effects for the temporal organisation of everyday life across different scales (i.e., daily, annually). With this new understanding of the constitutive elements and performative effects of seasonal variation it is possible to return to the issue and topic that frames the thesis–how patterns of demand for gas and electricity might balance with more intermittent patterns of supply that incorporate a greater proportion of energy from renewable sources.

The problem, as I explained in Chapter One, is how to deal with increasing supplies of renewable energy that are notoriously intermittent, whilst accommodating current and future patterns of energy use within a decarbonised energy system. As I demonstrated, the specific challenge is considering how ideas of seasonality, and different kinds of variation matter for energy demand at certain times of the year, including times of 'peak' demand. The focus of this research project, has been to show how seasonal variation is embedded within the constitution of energy demand, and why this matters for any future changes in energy systems.

I have, over the course of this research, reframed seasonal variation of energy demand, not as an inevitable outcome of energy consumption, or a natural part of social life. Rather, seasonal variation, I have argued is constituted by social practices that are mediated by ideas of convention, comfort and technology, that create and sustain rhythms of social life that extend throughout and beyond the year. While the arguments are developed specifically in particular chapters, the ideas connect and cross over with one another. In the next section I show how the three issues of representation, baselining, and extended temporalities matter for each other in constructing accounts of seasonal variation. This last chapter sets out how these features matter for how social theorists and energy researchers can understand seasonal variation, particularly annual variation in patterns for demand for gas and electricity. The first part works through three cross–cutting thematic statements that are developed as an outcome of the research probes. The second part draws out the implications for social theory and energy research, and subsequently policymaking.

Argument One–Seasonal variations in supply and demand are obscured from view through different kinds of representation

Through analysing gas and electricity demand patterns, and through examining the construction of the Christmas season as it extends throughout the year, I argue that the detail of variations in the seasonality of supply and demand and how they are made are obscured. To arrive at this conclusion, I embedded the very long–standing interest within STS, of bringing to light how objects are 'made' invisible through the processes they are constructed by, into the research agenda. Energy systems, act as 'invisible infrastructures' that promote specific understandings of what is considered 'normal'.

For example, Star's (1999:382) argument that infrastructure only "becomes visible upon breakdown" helps explain the 'internal' operations of technologies that societies depend on being taken for granted. Similarly, Nye's (1999; 2010) social histories of electricity use revealed how there was a persistent search by infrastructure developers for 'strategic invisibility' (Nye 2010:66) of electricity in the USA, enabling electricity systems to operate in the background of social life. As I identified in Chapter Five, within a different context, Mackenzie (1990) argued that nuclear missile accuracy is not an inevitable outcome of technological changes, but is constructed through social processes of knowledge accumulation, by many different actors. The suggestion, from these authors collectively, is that representations and the knowledge they embody are often multifaceted, emerging from diverse sources and viewpoints, rather than originating from a singular, streamlined progression.

I employed a similar approach for the study of the constitution of seasonal variations in patterns of energy demand, to identify how knowledges about patterns of demand, their histories, and their forecasting, depend on a set of assumptions and beliefs about how gas and electricity demand change throughout the year. Explanations of the social organisation of energy demand (Hui et al., 2018; Rinkinen et al., 2019; Rinkinen et al., 2020), raise questions about how demand is constructed, how it changes, and how (and by who) it is being shaped.

I described how infrastructures and knowledges are made invisible and obscured, and how different kinds of institutional priorities are established. The metaphor of the 'black box', or more accurately, black boxes, helps to describe the role of methods and discourses in keeping a specific topic out of the limelight. One of the aspects that is rendered invisible is seasonal variation in demand, and to a lesser extent in supply as well.

In Chapter Five, I described how specific representations of energy demand are shaped by methodologies such as averaging and weather correction that deliberately flatten out variations in energy demand across the year. Methods like averaging and weather correction modifications serve other purposes (such as establishing long–term trends in demand for certain users, like energy modellers), that depend on disguising the impact of the weather on patterns of energy demand, generating specific yet concealed portrayals of consumption. These methods are an outcome of the data production processes, where weather correction techniques reshape how energy demand is represented, creating a simplified version of consumption, for the benefit of specific users of these representations, such as energy modellers forecasting future patterns of energy demand. Dominant methods of estimating present and future demand, as I evidence throughout my analysis in Chapter Five of demand representations, also obscure historical changes in what energy is for and in the energy implications of changing temperatures through the meteorological summer, winter etc.

These typological understandings of the meteorological seasons are embedded in the 'normal' ways of thinking about the seasons within energy research, such as focusing on the climate and the weather, not on the distributed organisation of 'social' seasons and events such as Christmas that I pay attention to.

My approach, to follow the 'black boxing of seasonal representations' is to investigate gas and electricity consumption to understand how variation, as tied to changes within and across social and meteorological seasons, is constructed across the year. Following the development of heating and cooling, and air conditioning provision, reveals how the relationship to, and experiences of, the outdoors have evolved in Western Europe, in activity based on changing weather and temperatures being flattened out through the historical evolution of comfort (Shove, 2003a). As weather correction and averaging methods show how variations in demand are obscured, developments in indoor energy technologies reveal the invisibility of changes to standards of indoor comfort.

Social histories of indoor comfort reveal that standards of what is considered 'warm' or 'cold' have evolved as domestic indoor heating and cooling provision has evolved, for example, through the introduction of gas central heating and air conditioning in domestic dwellings in the US, and offices in the UK (Spurling, 2015; Trentmann and Carlsson-Hyslop, 2018; Carlsson-Hyslop, 2019; Watson and Shove, 2022). The emergence of indoor comfort standards (ASHRAE, 1992) has been obscured by the evolving technologies involved in mediating comfort. As the social histories of these heating and cooling technologies help to show, the emergence of baseline indoor temperatures, such as 18–22°C depends on how ideas of comfort, conventions and technologies are organised and developed. These 'standards' are constructed and depend on how indoor technologies and comfort are maintained. Bringing into view how comfort has been constructed ties seasonal consumption into indoor comfort, in particular within gas consumption, where indoor heating demand is highest in the meteorological winter (Gavin, 2014). Instead of imagining indoor temperatures at particular times of the year as 'normal', the emergence of baseline indoor temperatures, and the configurations of heating and cooling underwrite the emergence and development of patterns of gas demand.

I explained how seasonal variations are produced within a different setting in Chapter Seven, where I show how the social season of Christmas is not materially produced during the meteorological winter; instead, it is constructed through multiple, overlapping cycles of practices found throughout the year. The interweaving organisation of supply chains, and the strict timings of production, facilitates the increase in consumer spending. The materialisation of Christmas is intricately linked to the ongoing, overlapping cycles of production, supply, and consumption that extend well beyond the meteorological winter. The invisible threads of temporalities found throughout the year reveal how these processes are not merely a singular event, but an ongoing and evolving construct shaped by the dynamics of social seasons and the strategic organisation of supply chains throughout and beyond the calendar year.

These three cases, taken together, show how various aspects of seasonal variation are made invisible.

A novel approach, or a different way of representing seasonal variations is to 'reinstate', and bring these variations into view. By doing so, new methods and metrics of demand could be established, such as those which represent demand on a more 'localised' basis, or forecasting demand that is more weather dependent, which would inform how supply and demand could be increasingly connected to the outdoor climate, and the generation of renewable energy supplies. This is a point made by Fox et al. (2018), where, in the case of local demand, the variability of weather driven demand matters for the organisation of future energy systems that could plan for shifts in demand within a localised context. A renewed focus on seasonal variations would ensure that changes over time are considered within the study of temporalities and would appreciate the multilayering of temporal cycles that matter both for energy demand, and for the shaping of multiple seasons throughout the year. It would aid both consumer and regulatory led changes to consider how supply and demand is linked within everyday practices, with both climate and seasonal peaks and troughs in energy consumption in view.

The objective of bringing these seasonal variations back into focus, is closely connected to identifying and disseminating the rhythms that matter for constituting social life, which I discuss as my second positional statement.

Argument Two–Rhythms matter for studying the constitution of seasons, and for understanding relations between patterns of energy demand and social life

The relationship between social life and the 'natural' world has been widely conceptualised, and perspectives from the geographical (Eder, 1996; Castree and Braun, 2001; Whatmore, 2002) and STS (Law, 2004) traditions present distinct paradigms, which are not inherently compatible with one another, as they investigate and work with different conceptual terminologies and sites of interest. As I discuss in Chapter Three, STS contributions, such as from Latour (1993), deal with the social constitution of nature as a 'category', because in this setting, it has no material or real existence on its own, informing how a nature–society relationship could be conceptualised through, for example, ideas of 'hybridity', thereby moving beyond the dichotomy of the terminologies.

This contrasts with how the relationship between social life and the 'natural' world is described by others. For example, Walker (2020) and Adam (1990) suggest nature does exist, and that it is socially shaped, changing the emphasis to one where, as Adam states, "to be human (is to be in) a rhythmically living nature" (1990:29), where there are a multitude of rhythms, ranging from "environmental, cosmological, ecological, corporeal", and different types of 'social' rhythms (Walker, 2020:27).

Walker makes the case that the study of rhythms is integral to considering what future energy systems may look like, for example, matching seasonal rhythms of supply with consumption patterns, to scale up renewable energy supplies. Instead of separating out different elements that constitute energy demand, as Walker categorises in his analysis of rhythms, I took a different approach. I probed and investigated how infrastructures, technology and social practices matter for mediating ideas about energy demand, and seasonal variation across the year, and how social rhythms matter for the study of energy systems.

I investigated these topics across my three empirical chapters, which revealed how ideas of rhythm matter for the study of seasonality, and tied to this, relations across social life.

Firstly, representations of gas and electricity demand, and processes of weather correction, identify the weather as an absolute condition, as a nuisance and as a limitation to establishing patterns in energy consumption. In this example, 'correcting' the weather maintains the binary of 'nature–society' by separating out the effects of the outdoor climate, in order to maintain trends in energy demand that inform analysis across the sector, including energy system modelling, and forecasting future energy scenarios that depend on changes in demand over time. The identification of different kinds of rhythms, including those that are labelled 'social' and 'natural', is therefore concealed because of the processes of weather correction, and averaging, that disguise the impact of the weather on energy demand patterns because the weather is taken for granted.

Similarly, my evaluation of social histories of heating and cooling (Cooper, 1998; Spurling, 2015) provided another perspective on how the relationship between social life and the outdoor climate is imagined and employed in understandings of seasonal variation. While weather and temperature exist, they are always mediated by various forms of social organisation and socio–technical innovations. For example, as discussed by Mauss (1979), changes in clothing practices between the seasons, and more broadly, discourses related to ideas of comfort. What has evolved is the standardisation of indoor temperatures, establishing baseline norms that are shaped by both conventions of comfort and outdoor temperatures, that lead to the production of different kinds of rhythms tied to the sequences of social practices. An example of this is the timing of heating provision at different points of the calendar year.

This is not a one off or singular encounter in the case of heating and cooling. As I showed with Christmas, there are multiple rhythms that are linked, for example, to the lifecycle of turkeys, that are socially ordered to fit into the timeline of materially co–ordinating Christmas and the lead up to the 25th December. These seasons, of harvesting, growing and cutting/slaughtering, are scheduled within annual cycles some of which might be associated more clearly with 'natural' times (e.g., cycles of growing trees). In the example of Christmas trees, different types have different growing cycles, whilst for turkey production, the differences between traditional and intensive turkeys (growth time, size and weight) revealed the influence of the social, by concentrating the production of turkeys on specific months of the year, to ensure increased supplies in time for Christmas (Kijowski et al., 2005; Martin, 2009). These examples revealed the influence of seasonal rhythms on agricultural practices, being shaped by the timing of Christmas, and the seasons of production that shape supply and demand.

In summary, these three cases underscored the role of the 'social' in shaping our understanding of seasonal variation and how the interconnection between what are thought to be ‘natural’ and ‘social’ rhythms produce the temporality of everyday life including its annual and seasonal variations. This is because ideas of demand extend beyond mere weather patterns, or when it is ‘hot’ or ‘cold’ outside. Rather, the interconnection of natural and social rhythms produces the timing of everyday life. This position informs how the constitution of seasons, and patterns of energy demand can be understood.

By conceptualising social life in this way, the challenge is to consider what this means for future energy systems and how ideas about the constitution of seasons, and connected variation in practice, matters for the future. Existing decarbonisation agendas, as outlined in government policies such as Net Zero strategies (BEIS 2020a) emphasise the integration of increasing supplies of renewable energy and, ultimately, intermittent forms of energy supply with current and future patterns of demand. This integration aligns with an entrenched 'always on' mentality, displaying human control over 'nature' and its utilisation for societal purposes. Re–examining the entrenchment of demand within current patterns of consumption, as I suggested in Chapter Six, suggests identifying how strategies such as ‘Net Zero’ are performative in developing rhythms that rest on a number of assumptions that matter both now and in the future for the organisation of energy systems. One such way of reconsidering these strategies, as I develop across the thesis, is to reimagine how seasonal variation is embedded in assumptions about future energy systems, and how this is tied into both patterns of energy demand, and variation in social practices throughout the year.

Argument Three–Seasons are constituted by multiple, overlapping temporalities that extend throughout and beyond the year

Work on the ‘sociologies of the seasons’, as advocated by Davidson and Park (2020) argues for investigating how rhythms and cycles impact everyday life at various points throughout the year. Similarly, how seasons serve as frameworks shaping societal structures, including calendars, and guiding consumer behaviours during specific periods such as Halloween, Black Friday, and Christmas. Investigating annual cycles and their distinctive place in the Gregorian calendar reveals various societal frameworks that matter for understanding the construction of social life, and the production of rhythms.

This could mean reconceptualising relations between forms of seasonality and social life. For example, the ‘Calendars’ research group in Bergen (Bremer, 2021) has identified potential changes in seasonal practices in response to alterations in the outdoor climate. Some societal frameworks are no longer rigidly tied to traditional seasonal rhythms due to these changes. Farming and fishing practices are being shifted earlier or later in the year due to disruptions caused by changing temperatures. This is not a move away from the weather, but a move with the 'changing' weather. However, other social changes depend on growing insulation or separation from the outdoor climate. This evolving perspective acknowledges the dynamic relationship between meteorological seasons, social structures (e.g., calendars), and environmental changes.

The research agenda of this thesis has been focused on questioning the constitution of social seasons, and how they relate to the outdoor climate, and subsequently energy use. Instead of developing a research approach that makes a common–sense connection between the outdoor climate and gas consumption, or suggests the separation of social and meteorological calendars, I investigated ideas about seasons through patterns of energy demand. I identified how multiple social seasons are involved in layering gas and electricity demand use across the year. This approach is evident within the thesis in two ways.

First, work on the sociology of time, such as from Zerubavel (1979; 1981; 1989; 2003), reveals the ways in which socio–temporal orders are modified and tailored in response to institutional activity and social life, shaping temporalities across the year. In an energy context, changes in practices also took place within domestic energy provision. The transition from traditional coal–burning fireplaces to indoor central heating, reconfigured not only the physical processes of obtaining and delivering fuel but also the temporal dynamics associated with warmth provision (Watson and Shove, 2022). Similar temporal transformations are evident in relation to other fuel sources, such as wood burning, reflecting broader societal shifts in energy and heating technologies (Rinkinen, 2019). The movement and organisation of activities within the household became entwined with these temporal changes, of technological shifts, cultural practices, and the rhythms of daily life. The formal/informal constructions of heating and cooling seasons reflect combining conventions of domestic comfort with the timing of energy use across the year, for example, into offices and workplace as standardised indoor temperatures are maintained through baseline ideas of comfort.

Second, the example of Christmas presented a novel approach to tracing the multiplicity of seasons that come together to form annual cycles of supply and demand, and forms of seasonal variation. Christmas as a social season, coordinates multiple different cycles that organise and matter for the consumption of goods and services during the month of

December. Whether commodities are grown (e.g., turkeys, trees) or produced in a factory (artificial trees, plastic based toys), these products require specific timings throughout the year, contributing to the sequencing of social practices that result in the mass production of goods ready for purchase during the Christmas social season.

The sustained seasonal rhythms of supply and demand described through these commodities offer a connection between social life and outdoor climate. The annual cycle, such as Christmas, acts as a fixed point aligning with seasonal rhythms linked to changes in daylight duration, the 'Winter Solstice’, and colder temperatures, influencing the organisation of societal practices throughout the year. Seasonal rhythms that we know and see today are a reflection of the interplay between social life and the outdoor climate, evident in phenomena like increased gas demand for heating during the meteorological winter, not because this is ‘natural’ or as of ‘nature’, but to provide a level of comfort. As I show in Chapter Six, ideas of comfort are in a constant state of evolution, shaped by cultural conventions, social practices, and outdoor climate changes.

Seasonal variations in energy demand are not only socially rooted, but they are multiple. That complicates interventions or efforts to ‘re–seasonalise’ daily life in that existing cycles and rhythms are connected. This is to assume that ‘reseasonalising’ or increasing variation in what people do over the year would have the potential to reduce energy demand in the future, in order to make best use of energy produced by renewable sources, ‘when the wind blows’ or ‘when the sun shines’. Attempting to deliberately increase variation in activity, especially energy consuming social practices, would be an opportunity, admittedly provocative under current expectations of balancing energy supply and demand, to closely align ‘what people do’ with the timing of energy supply. This approach has already been suggested to be possible within future energy systems. As the energy journalist Kris De Decker suggests for shifting economic activities to timing of renewable supply,

> “Adjusting energy demand to supply would make switching to renewable energy much more realistic than it is today. There would be no curtailment of energy, and no storage and transmission losses. All the energy produced by solar panels and wind turbines would be used on the spot and nothing would go to waste” (DeDecker, 2017:para.55).

By implication, increasing variation would also have the opposite effect when renewable supplies are low, for example, having office buildings cooler in the meteorological winter, whilst changing standards of comfort, such as different clothing options to adopt new societal conventions that shift based on energy supply. Ultimately, seasonal cycles of social practices extending throughout the year offers opportunities to consider how social life and patterns of energy demand can be accommodated under energy systems that are more reliant on renewable sources of energy.

Implications for Social Theorists, Energy Researchers and Policymakers

The three arguments I set out matter for different groups. Decarbonisation policies are changing how gas and electricity are used, driven by policies that impact overall energy consumption. Socio–technical innovations such as heat pumps and electric vehicles are key to these plans and future energy goals (BEIS, 2020a). Like previous technological changes and developments, they will shape electricity consumption patterns at different times of the day/week/month/season etc.

I argued that new, more seasonally variable energy consumption patterns could potentially be developed and integrated alongside the expansion of renewable energy supplies throughout the year. These patterns may give rise to emergent cultural conventions in response to decarbonisation measures aimed at achieving 'net–zero,' particularly with policy transitions from gas to electricity. Additionally, the evolution of heating and cooling technologies may prompt the creation of new metrics or standards, particularly relating to indoor comfort, to adapt to changing energy dynamics. The difficulty is acknowledging that all these ideas are closely connected, and existing arrangements are entrenched making it difficult to change current ways of thinking about supply and demand, especially when fossil fuels currently still serve as the predominant baseline for energy supply, and will continue to under plans for net–zero (BEIS, 2020a).

With these conclusions considered, energy researchers, such as those working on topics related to the social organisation of demand, and on large scale energy systems could, and should, take an interest in how seasons are defined and embedded in research agendas going forward. For example, academics identifying the role of energy consuming social practices through ideas of flexibility (Torriti and Yunusov, 2020) and time of use surveys (Anderson and Torriti, 2018) would benefit from taking a broader perspective of how practices are sequenced, and connected through annual cycles that constitute patterns of demand annually.

Investigating the social organisation of demand depends on not taking social seasons for granted in approaching the sequencing and dynamics of energy consuming social practices. This thesis draws attention to these assumptions, in two ways. First, that demand is not inevitable or expected, following Rinkinen et al. (2020) in questioning policy positions that take energy demand for granted. Second, that you cannot separate meteorological seasons from social seasons if you want to understand how demand for gas and electricity is constituted at different times of the year. By doing so, energy modellers fall into the trap of separating the effects of the weather on demand patterns, falling into the nature/society and energy/society dichotomies that I have argued should be moved beyond in the thesis.

Instead, an alternative approach would be to identify ways of embedding the social constitution of the weather, and how the weather matters for the social world, into the configurations of energy modelling, instead of strictly focusing on the changes between meteorological seasons. This broader perspective encourages a more nuanced understanding of the interplay between weather, social practices, and energy demand.

Consequently, researchers engaged in producing energy models should consider issues of performativity and how these influence the shaping of current and future energy systems. As discussed in Chapter One of this thesis, the modelling of energy systems can embed different kinds of expectations and visions for what, for example, decarbonised systems should look like in the future. By doing so, energy models can serve not only as predictive tools but also as frameworks that actively shape policy and technological developments within the energy sector at large (Aykut, 2019). This suggested performative role means that assumptions embedded within models, such as increasing electricity demand with the projected costs of increasing supplies of renewable technologies, can significantly influence investment and regulatory decisions, such as those related to electricity market reform and designing grid capacity.

As a result, careful consideration of these embedded assumptions is crucial, as they contribute to constructing future energy systems. This includes how assumptions about seasonality are underpinned in such modelling, as they play a critical role in planning for fluctuations in renewable energy supply and demand. These assumptions, and subsequent modelling can be challenged and reshaped, as suggested by Nadaï et al. (2023) in their study of French efforts to reach net–zero carbon emissions, by considering how this objective is aligned with the modelling of energy systems, and subsequently closely intertwined with policymaking. As it stands, without reconsidering the social and temporal constitution of seasonality, this is unlikely to happen unless these debates are brought into focus within the energy sector.

As explained in Chapter One, this research focuses on energy systems in the UK, and in part, the USA. Within my research probes, I examined statistical changes in energy demand representation, heating and cooling provision, and annual cycles that shape seasonal supply and demand practices at Christmas. The conclusions drawn are specific to the localities discussed in each probe and cannot be generalised to other Global North nations, as energy systems across the world have different histories of development, and vary significantly across infrastructure and policy landscapes. However, the methodological framework developed in this research, along with its broader investigation of how energy demand is shaped over time, provides a foundation for future studies in social science energy research, that could be employed across different geographical regions. In particular, it offers an approach for examining how seasonal variation is constituted by investigating, and not taking for granted the rhythms, cycles and practices that combine to configure gas and electricity supply and demand patterns.

For social scientists, such as those based in Bergen (Bremer, 2021; Bremer and Wardekker, 2024) and elsewhere (Davidson and Park, 2020), with a broader interest in the role of seasons cultural conventions and the structuring of social life, the thesis has relevant points of interest. By delving into the social histories of technologies, this analysis provides ways of identifying how seasonal rhythms are organised and maintained. I have identified how issues of visibility and representations (averaging, weather correction) matter for ideas of temporality, and for understanding the multiple and extended constitution of seasons.

In terms of redefining ideas about seasonality, these debates are ongoing, with a particular focus on how the dynamics of social life matter for defining understandings of ‘seasonal frameworks’ (Bremer and Wardekker, 2024). This thesis is relevant for authors such as these, by bringing together the problem of representations, and the study of rhythms, temporalities and annual cycles to the study of seasons that can be developed outside of the parameters of energy research. In particular, how social seasons have evolved and been reimagined over time, reflecting the histories of seasonality that matter for the reproduction of seasonal practices, and how they are constituted within the social and temporal organisation of everyday life.

The interplay between socio–technical innovations and the production of different kinds of rhythms emerges as a point of interest for understanding how social life is managed with changes between the indoor/outdoor environments, for example, scholars working with ideas connected to STS wanting to conceptualise relations in this area (recent examples include, Hess and Sovacool, 2020; Sareen et al., 2021). A specific focus on how seasonal rhythms are reproduced and reconfigured is a specific contribution from this thesis, as I investigated in relation to patterns of gas and electricity demand, systems of provision, and separately, the study of social seasons such as Christmas.

For policymakers, the thesis has critically evaluated how ideas of seasonality matter for conceptualising energy systems transitions, with increasing attention to the scaling up of renewable energies. Actors involved in this transformation, such as DESNZ, could pay particular attention to the assumptions that underpin how seasonal variation is defined and reported on within policymaking, recognising how the seasonality of energy systems was reported on fourteen years ago, under the previous Conservative government, has significantly shifted and evolved to the present day, with changing trends and patterns. This could involve, for example, making seasonality of energy demand a central focus in the transformation of energy systems.

Similarly, the energy regulator Ofgem could embed seasonal pricing of energy in its regulatory framework, for example, how energy providers are supporting consumers with fluctuations in energy market pricing, especially in the meteorological winter months, when prices tend to be higher. One potential approach is to disentangle gas and electricity pricing. As the UK's energy market operates on a marginal pricing system, where the most expensive energy source required to meet demand sets the prices within the market, the overall electricity price is determined by the higher cost of gas generation. Reforming this market structure would allow for more flexible and responsive seasonal pricing structures that reflect the availability of renewable energy, particularly during peak seasons for wind and solar power.

With the introduction of a Labour government in July 2024, alongside the promotion of Great British Energy as a national developer of renewable energy projects presents a major development in UK energy policy (DESNZ, 2024a). A renewed focus on local energy markets and the expansion of onshore wind offers an ideal opportunity to rethink the dynamics of energy supply and demand within the context of net–zero transitions and associated policy frameworks. This moment provides a unique chance to recalibrate policies to better align with the seasonal nature of renewable energy, fostering a more resilient, sustainable, and potentially seasonal energy system.

The thesis offers a way to investigate the connections between technologies, social life, and emerging temporalities, while addressing the underlying assumptions that underpin how these representations can be constructed within different discourses, specifically focusing on the study of patterns of energy demand. The thesis provides a different way of identifying the connections between social life and seasonal patterns of supply and demand that will matter for future, reimagined energy systems more reliant on changes in the outdoor climate for energy supply.

Abbreviations

ASHRAE (American Society of Heating, Refrigerating and Air–Conditioning Engineers)

BTU (British Thermal Units)

BEIS (Department for Business, Energy and Industrial Strategy)

CREDS (Centre for Research into Energy Demand Solutions)

DEFRA (Department for Environment, Food and Rural Affairs)

DEMAND Centre (Dynamics of Energy, Mobility and Demand)

DECC (Department for Energy and Climate Change)

DESNZ (Department for Energy Security and Net Zero)

EV (Electric Vehicles)

ENA (Energy Networks Association)

EPC (Energy Performance Certificate)

EST (Energy Saving Trust)

IEA (International Energy Agency)

IPCC (Inter–Governmental Panel on Climate Change)

KwH (Kilowatt Hours)

MP (Member of Parliament)

MW (Mega Watt)

GW (Giga Watt)

NG (National Grid)

OFGEM (Office of Gas and Electricity Markets)

ONS (Office of National Statistics)

OECD (Organisation for Economic Co–operation and Development)

STS (Science and Technology Studies)

TWh (Terawatt Hours)

UCL (University College London)

UK (United Kingdom)

UTC (Coordinated Universal Time)

Appendices

Appendix 1–Reports Considered for Further Analysis within Chapter Five

Report	Year	Publisher	Description
The Carbon Plan: Delivering our low carbon future.	2011	DECC	A strategic document outlining the UK's approach to reducing greenhouse gas emissions and transitioning to a low–carbon future.
Energy and Emissions Projections 2012	2012	DECC	Provides projections on energy demand and emissions, helping forecast the UK's progress toward climate goals.
Powering the Nation	2012	Energy Savings Trust	Investigates energy consumption trends in the UK, using data from the 2010 Household Electricity Survey.
The Future of Heating: Meeting the Challenge	2013	DECC	Examines the role of heating in reducing emissions and supporting energy system resilience.
Electricity Capacity Assessment Report	2013	Ofgem	Evaluates the capacity of the UK electricity system to meet demand and ensure supply reliability
Electricity Market Reform: Capacity Market Impact Assessment	2014	DECC	Assesses the impact of the Capacity Market on energy supply security and system flexibility.
Clean Growth Strategy	2017	BEIS	Proposes pathways for reducing emissions across sectors while promoting economic

			growth through clean energy.
Sky–Meeting the Goals of the Paris Agreement	2018	Shell	Outlines Shell's approach to meeting the Paris Agreement's climate goals, including how they intend to mix fossil fuels with developing renewable energy sources.
How the UK transformed its electricity supply in just a decade	2019	Carbon Brief	Discusses how the UK energy system has changed in the past ten years, and what 2030 energy systems might look like.
Energy White Paper: Powering our Net Zero Future	2019	BEIS	Discusses how the UK will achieve a net–zero energy system, with a focus on renewable integration and emissions reduction, and decarbonisation of fossil fuel intensive industries.
Outlook for Energy: A Perspective for 2040	2019	ExxonMobil	Provides a long–term outlook on global energy demand and supply trends, focusing on future energy challenges and opportunities from the perspective of the oil producer Exxon.
Managing Flexibility Whilst Decarbonising the GB Electricity System	2020	Energy Systems Catapult	Discusses approaches to increasing system flexibility through DSR and other methods.
Could Renewable Energy Completely Replace Fossil Fuels?	2020	Shell	A discussion document on the role of renewables with a reduction in fossil fuels in energy systems from the perspective of the energy producer Shell
Net Zero Strategy: Build Back Greener	2021	BEIS	Details the UK's approach to achieving net–zero emissions by

			2050, focusing on sustainability and economic resilience.
Briefing: Flexible Energy Systems	2021	Carbon Trust	Examines the role of flexibility in energy systems to manage peak demand and integrate renewables effectively.
Balancing Mechanism Reporting Service (BMRS) Annual Report	2021	Elexon	Provides an overview of the electricity balancing mechanism and its performance over the year.
EDF's Regulatory Report –November 2021	2021	EDF	EDF's progress in generation, delivery and usage across the business, exploring trends across previous years.
Energy Security Strategy	2022	BEIS	Focuses on the UK's plans to ensure a reliable energy supply, following the spike in oil prices due to the Ukraine–Russia conflict in 2022.
Net Zero in Conversation: How Digitally–Automated Demand Could Transform the Way We Use Energy	2023	Carbon Trust	Explores how digital automation can enhance energy efficiency and demand flexibility in the transition to net zero.

Appendix 2–Materials used to construct the 'Christmas Timeline' within Figure 4

Christmas Trees

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