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The Making and Unmaking of Hokkaido's Electricity Grid: Alternative Infrastructures of Resilience and Heat

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Anthropology

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Abstract

With Japan's energy dependencies shaken by the oil shocks of the 1970s and subsequently by the Fukushima Daiichi nuclear disaster, Japan's energy future has become increasingly uncertain, and public concerns about energy management remain. Since the 3.11 disasters in Japan, the government has promoted the development of renewable energy through a Feed-In-Tariff policy. This policy has had the effect of increasing the proportion of electricity generated by renewables, particularly from solar power plants in areas like Hokkaido. On the one hand, this development has precipitated changes to electricity grid management to allow new connections. On the other hand, it has favoured rapid development by private companies, often without seriously addressing the issues of local people and environments.

Public concern over energy infrastructure in Hokkaido was reignited on September 6, 2018, when an earthquake caused damages in the island's aging main coal-powered thermal plant, causing an island-wide blackout. To many, the earthquake was yet another *unthinkable* disaster that left many, particularly elderly rural residents, potentially vulnerable to the cold had the earthquake struck in winter. I argue that in response to disasters thought unthinkable within the resilience framework of existing energy infrastructure, biogas producers and renewable energy proponents are engaged in projects to build local energy infrastructure in ways that co-constitute alternative senses of energy in ecologies of heat practices.

I explore the making of Japan's post-war energy world and the way its assumptions have been challenged by such disasters. I then contrast the government's post-Fukushima energy policy as its own kind of future-making project that continues to build resilience around the electricity

grid, and greening electricity production with that of renewable energy experts in Hokkaido, who see potential in ambient energy and off-grid heat practices. Delving further into the practices around heat, I study the projects of dairy farms and rural municipalities in creating off-grid ecologies of heat practices, and independent alternative infrastructures. These may not be the solution to the climate crises, but can offer new political possibilities by changing our senses of heat and unsettling the practices associated with living in the world of the electricity grid. I end by interrogating the relationship between subjects, systems and ecologies through the making of off-grid solar experiments.

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1. Introduction

Very early on in the preliminary fieldwork for this project, I visited several hydroelectric dams east of Sapporo. I was interested in the way the introduction of renewable energy was changing the operation of the electricity grid, and trying to better understand the relationships between dams, utilities, government ministries, municipalities, and the environments they depend on . During one of my tours with two workers at the dam site, we had just come from inside the dam itself, and were looking out onto the river below, when a car from the Hokkaido Electric Power Company (HEPCO) drove down to a small building below. I asked what they were there to do, and the employees answered that they were not sure. I was slightly perplexed. I knew that historically the dam was built for irrigation rather than electricity production, but I had assumed that they might know the names of the HEPCO employees, or at least knew that there was some scheduled maintenance or verification.

After a series of questions, it became clear that there was almost complete independence in the day-to-day operations between the dam and the utility. Indeed, the site itself was structured to enable the two sets of workers to operate without ever needing to come face-to-face. I will admit I was expecting to find in the dam a sort of boundary object that called for more lively management of different kinds of technical expertise between dam staff and HEPCO. I instead found there was little need for active translation, and any boundary work with the utility was to take place further upstream (figuratively and literally) with the Hokkaido development authority in charge of the dams (Star and Griesemer, 1989). For these dam workers, the electricity grid existed in a separate world from the questions of ecological management: driftwood removal, seasonal rainfall, and irrigation.

This partition between the grid and the dams came down for one day, on September 6th 2018, when the East Iburi Earthquake struck south-central Hokkaido near the town of Atsuma, causing an automatic island-wide blackout to avoid affecting grid stability in the rest of the eastern half of Japan. As the main coal-powered thermal plant near Atsuma was taken offline by damages, hydroelectric plants were key to providing the power needed to bring the rest of the productive capacity back online in the hours and days that followed. The earthquake was a shock to many who assumed earthquakes of such strength could almost never happen in Hokkaido. It damaged trains lines, businesses, water lines, and public infrastructure, and several people passed away in landslides.

The 2018 earthquake became a pivotal event in my research, as it forced conversations about aging grid infrastructure, the shutting out of renewables from the electricity grid during the earthquake due to their unstable output, and the potentially aggravated loss of life that would have occurred if the earthquake had happened in much colder weather. After repairs were made and government investigations were completed (and found the utility not at fault for not being able to prepare for such a seismic event of such unthinkable magnitude in Hokkaido), the operations of infrastructure faded back into a sort of background. However, the issue of autonomy in energy infrastructure, and the fears of being left in the cold have not gone away, particularly for many rural residents of Hokkaido.

In the dairy-producing central region of Hokkaido, new practices of creating and sharing heat are emerging around the production of biogas by the fermentation of cow waste using methanogenic bacteria. The scale of dairy production led to biogas as a solution to avoid local environmental nuisances like runoff into water sources and smells. Following the introduction of the Feed-in-Tariff (FIT) policy after the 3.11 triple disasters, the biomethane produced was more profitably turned into electricity and sold to utilities. Now, many dairy farms are using biogas to make off-grid greenhouses, and local actors are looking to biogas and off-grid solar as a fuel and medium for autonomous infrastructure that would prevent economic losses and deaths in the event of another grid blackout.

The central story of this research,as reflected in the title, is the becoming of one *gridworld* (Boyer, 2016), and how other energy worlds might be emerging, in part as a result of the seismic disruptions to the grid in 2011 and 2018. I argue that in response to disasters thought unthinkable within the resilience framework of existing energy infrastructure, biogas producers and renewable energy proponents are engaged in projects to build local energy infrastructure in ways that co-constitute alternative senses of energy in ecologies of heat practices.

In chapter 2, I review two histories of Hokkaido's electricity grid, problematizing the predominant way of telling the making of Hokkaido's electricity grid as a unified object. I do so by contrasting that history of concentration of power with the history of community electric utilities in Japan and Hokkaido to examine what technological arrangements were pressured out of existence by the utilities and post-war government. The making of Hokkaido's electricity grid as part of the post-war national grid required not just the technological concentration of power over energy production with fossil fuels, but the unmaking of potential commons by settler communal utility efforts.

In chapter 3, I bring events such as the 1970s oil shocks, and the 3.11 triple disaster into relief to attempt to explain Japan's FIT policy from 2012 as a particular, technocratic future-making project for the energy transition that simultaneously began to unsettle the cybernetic order of Hokkaido's electricity grid. Japan's reliance on nuclear energy emerged from a nexus of overreliance on imported oil, American political power, and continued control over energy by elite networks in Japan. The energy future being built around this nexus suffered a serious blow following the 3.11 disasters that revealed the deadly mismanagement and dangerous status quo of assumptions by those in power. FIT brought with it its own future-making project of sustainability and domestic energy production but also challenged the historic inequalities between Hokkaido and Tokyo, embodied in Hokkaido's aging energy infrastructure.

In chapter 4, I introduce the 2018 East Iburi Earthquake as an infrastructural inversion that made visible the dangers of the government's FIT policy and ideas of resilience. On the surface, the government, experts, energy producers, and renewable energy advocates agree on the need for resilient energy infrastructure and more renewable energy production led by municipalities. However, the government ministries' scheme for resilience contrasts with those of renewable energy experts in Hokkaido who advocate for, and create models of, what a locally-specific and heat-sensitive energy future might look like. I do so by drawing on Mol's *Body Multiple* (2002) and Simondon's (2005) philosophy of co-constitutive relationships between people and technological systems.

In chapter 5, I examine biogas-producing dairy farms and the practices of heat use that are becoming the focus of new imaginations of local biogas infrastructure and senses of heat in Hokkaido after the 2018 earthquake. Biogas production has led to the creation of a variety of heat-based practices and projects like heat-sharing, greenhouses, and plans for regional biogas fuel, as well as a reimagination of energy and political dependency in the form of microgrids. I focus in particular on the way that technologies of sensing allow biogas producers to develop a different sense of heat and relationships with bacteria that are difficult to understand outside of their metabolic effects. I argue that while there is nothing outwardly revolutionary about dairy farms and microgrids, these practices and projects of heat and autonomy nonetheless offer alternatives in the way they shape thermoceptions, or sense of energy.

In chapter 6, I attempt to bring thermoceptions from making off-grid solar practices into relief with the problems of systems discussed in chapter 4, and speculate with these projects the kind of subjectivities and futures they allow. I begin from a DIY solar project applying Ratto's (2016) concept of critical making which I did at home during the pandemic, and branch out to the experiences of others. I mobilize these experiences to discuss the ways in which thermoceptions built around new practices of heat and off-grid solar can lead to different energy worlds than the gridworld, and create conceptual and material alternatives to the dominance of electrical, cybernetic systems.

This research is informed by many approaches within Science and Technology Studies (STS). It is attentive to the confluence of technology and their influence on popular imagination of the future (Jasanoff and Kim, 2015), the material politics of energy infrastructure (Barry, 2013), and to a lesser degree work on citizen science (Kasperowski and Kullenberg, 2019). Why choose to approach this using STS literature, and which kind of approach within STS? Asking the question is important in the context of STS, and all social science. In this case, a material politics approach can tell us much about not only the effects of the disasters that inform not only energy policy but also how the plans, desires and actions of energy managers and activists are made along with the materiality of infrastructure. STS can also help include non-human actors and objects in ways that can be less reifying, opening up questions around more-than-human subjectivity and perception.

The theoretical orientation of this research to the material engagement also draws on the later iterations of Actor Network Theory and multispecies ethnography. In particular, the work of Jensen (Gad and Jensen, 2010; Jensen, 2017), Mol, and Morita have been influential in their treatment of practices such as treating arteriosclerosis, model-making, and cultivating floating rice making their own worlds, with technologies embodying theories and comparisons that make particular assumptions about the world. Rather than apply theory as a window onto materiality and practices, they place actors' concepts, comparisons and practices laterally to their own, making the relevance of one's concepts requiring further negotiation with the peculiarities of actors and their practices. Is this so different from the *kula* (Malinowski, 2013) or Zande witchcraft (Evans-Pritchard, 1935)? By extending theory to the design of objects, materiality, and affect, it can unsettle assumptions that might otherwise neutralize difference (e.g. the assumption practices as functional), and allow us to let go of established concepts to embrace more grounded and specific modes of explanation (Latour, 1988). It also echoes the call by some feminist scholars to question the overdetermination of established, *hard* theory (Gibson-Graham, 2014).

This kind of theoretical orientation also raises multiple issues about methodology in terms of situating oneself and one's assumptions, but post-ANT approaches are at least clear in the co-production of the researcher and the field, as well as one's own concepts and those of participants as always potentially interrelated through practice and materiality. Some of the issues raised by ANT's history of practice involve the critiques of the lack of attention to politics, gender and a tendency to follow strong actors (while putting out weak theoretical language). However, there are also questions about this kind of approach and its ability to really follow the actors and objects, and how one frames one's own ideas of how these are defined, and how one's own concepts apply in a given set of relationships. The first set of issues has seen increasing debate lately, but dates at least back to the 1990s with Strathern's (1996) response to Latour's networks (Jensen et al., 2017: 529).

Though I have addressed some of these issues here and elsewhere, I evaluate the benefits of post-ANT scholarship to be greater than its shortcomings for its application in this research. By being more attuned to transformation, non-modern ways of thinking of action and objects, and the potential of practices to create their own realities and comparisons, I think I was more easily able to deal with the methodological problems of doing research in a pandemic with a deadly, confusing, airborne virus. I believe it also helped me become able to identify interesting problems with the way the purported transition away from fossil fuels is being done in Hokkaido, and how existing infrastructure shapes perceptions and emotional life at the margins of Japan's economic, geographic and political orders (while remaining aware of the price this order exacts from the land, workers, animals and indigenous people in Hokkaido).

1.1 Methodology

This research has been mostly based on interviews, participation in symposiums, and surveys of media on issues in renewable energy. Among the interviews, I conducted 16 semi-structured interviews, 5 structured interviews, and many informal discussions from 2018 to early 2020. Among the participants were renewable energy experts, renewable energy advocates, power plant managers, dairy farm workers, and technicians. Some follow-up questions and discussions were done via email correspondence from 2020 to 2021. On two occasions, I participated in tours of power plants where there were opportunities to ask questions but was unable to secure an interview. Given the age makeup of the population of rural Hokkaido and worrying uncertainties about the long-term effects of COVID-19 exposure, I made the choice to avoid direct meetings after the start of the pandemic in 2020. Some of my interviews also involved a tour component where I was shown around their workplace.

Following the start of the pandemic, I shifted methods to online participation in discussion events. I had already been participating in discussion events before 2020 through my membership in the Renewable Energy Organization of Hokkaido (REOH), but increased the frequency of my participation as the shift to online participation made many more of these events accessible. In total, I count that I participated in at least 52 such events from 2018 to 2022[1]. It is a

[1] I also participated in a crowdfunding event for a small hydroelectric dam in Nagano prefecture and followed a crowdfunding campaign for a solar sharing project in Hokkaido.

central disappointment of this research that I was unable to conduct less than half of my targeted number of interviews for this research project, and that I was unable to conduct much in the way of daily or regular participant observation work. Moreover, while the shift to online participation made more events accessible, it also generally proved to be a way of confirming existing institutional practices, rather than an opportunity to ask questions and discuss personal perspectives.

In addition to interviews, tours and discussion events, I gathered over 500 pages of media articles on renewable energy media on Hokkaido, using these in particular to better understand the narratives surrounding the 2018 East Iburi Earthquake, the problems of FIT policy, and the diversity of projects FIT made possible. These articles also helped in identifying some of the particularities of Hokkaido's *megasolar* power plants in dealing with snow and other environmental concerns, and finding sites to visit. These also became useful in thinking through environmental conditions when I and Professor Morita conducted a short DIY (Do-It-Yourself) solar array building project at home in 2020. Our use of critical making (Ratto, 2016) was not something I initially expected for this research but helpful in gaining more material awareness of the supply chains of photovoltaic arrays, how to assemble and install them, and the basics of off-grid living. Moreover, it helped relate biogas projects to off-grid solar and other energy literature focused on homes (Leder Mackley and Pink, 2012; Vannini and Taggart, 2014a).

Doing fieldwork from home, and discussions with other ethnographers, also brought me to question what exactly my field was. In a sense, starting from an analysis of Hokkaido's grid infrastructure, my field was bounded by the electrical wires and sites of energy production and transformation on and off the island, and I grew to see it as including the very place I lived in Yubari, in the central Sorachi region of Hokkaido. However, in another more practical sense, my field site was comprised of a variety of distant *islands* within the island of Hokkaido: a solar plant near Abira, two biogas plants and a thermal power plant in Tokachi, three hydroelectric dams east of Sapporo, two wind power projects near Wakkanai, the REOH office and a few conference halls in Sapporo, and a few municipal offices near each of the renewable energy production sites. It was only through this diversity and this complicated issue of distance to the field that I was able to more fully understand Bakke's (2017) description of electricity grids as machines of contradictions. The multi-sitedness of this research was in a sense the product of the multiple energy worlds that are increasingly difficult to contain within the one world of the grid (Law, 2015).

Similarly, while this research is also in a sense multispecies, this multispecies aspect is more of a theme or basic condition of the ecologies surrounding renewable energy than an analytic. As Morita (2017) demonstrates, the particular materiality of floating rice as infrastructure and the alternative, aquatic modes of adaptation and living they allow are more significant in Chao Phraya than simply the fact that they involve being domesticated by other species. I discuss biogas infrastructures and their emerging ecologies of heat as a kind of alternative and multispecies infrastructure[2].

Where this research eschews making direct contributions to the analysis of multispecies relations, it does make interventions on ideas of resilience, infrastructure, and most significantly,

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[2] I am interested in exploring multispecies relations of heat in more depth elsewhere. However, this would require more careful ethnography of the relationships with plant and animal life in solar power plants and dairy farms.

energy. It is to these bodies of literature that I turn to for a brief review of the theoretical background to my argument. I outline how each of these relates to the problems of energy infrastructure in Hokkaido, and attempt to show some preliminary conceptual connections between these literatures.

1.2 Resilience

Even outside the social sciences, resilience has had a history of producing different definitions and conceptualizations. Oliver-Smith (2016) sees in anthropology's holism the potential to bring together terms with disparate definitions used for measuring the adaptability of communities like "vulnerability" and "risk" as well as resilience in a framework for understanding climate change. However, Oliver-Smith (2016) notes the problems of imposing these measurements on populations anthropologists do not belong to, as well as the problems of conflicts within and between these categories of risk, vulnerability, and resilience (i.e. decreasing vulnerability is qualitative and may not mean meaningfully increased resilience to a given disaster or phenomena).

Critiques of resilience have also been made by Barrios (2016), who argues from a political ecology point of view that resilience is deployed as an anti-politics machine, often claiming that indigenous or impoverished communities are not resilient when they cannot rebuild back to how things were before a given disaster. Barrios' contention is that resilience, defined as the ability to rebuild back to an original state, ignores not only these communities' ability to adapt, but the history of colonial plunder that often created and sustained the impoverishment in the first place.

While a perfectly valid point, Barrios seemingly confounds the use of resilience in physical sciences with its sense in ecology.

Nevertheless, political ecology has played an important role in responding critically to neofunctionalist anthropologists like Rappaport and in criticizing the way resilience has often been an expert concept imposed on populations with assumed neutrality rather than one reclaimed or emerging from them. Fabinyi, Evans and Foale (2014) who recognize that while the emergence of socio-ecological systems and resilience together has allowed for humans to be included in nature as part of resource management, resilience tends to flatten interests of humans to the environment. The work of Sarah Coulthard (2012) as well as Foale and Macintyre (2000) draw on political ecology to argue that in increasing resilience one may decrease overall well being or cause other unwanted effects, and even the given problem, with its related interests, may not be the same for experts as other populations.

Cons (2018) argues that in development projects, resilience-building can often become a political spectacle to reassure Western publics that the outcomes of climate change might not be as horrific for the Global South as scientific consensus assures us every year. While not termed resilience projects, experimental local efforts to improve agricultural environments and pressure local government for action in providing infrastructure for impoverished communities arguably do both resilience-building and improving quality of life (if marginally). The idea of trade-offs as part of resilience is useful, but should perhaps only serve to guide one's attention to who is the beneficiary and what resilience does rather than be accepted as a zero-sum or neutral change.

Morita and Suzuki (2019) suggest part of this difficulty comes from trying to capture the dynamic property of complex systems which are difficult to define in static or empirical terms. They point to the seeming disconnect between the complex adaptive systems model used in resilience thinking as introduced by Holling (1973) and the empirical components of this system. Bringing together very heterogeneous phenomena to measure their ability to function or maintain fitness in case of a shock or disaster raises all kinds of questions about thinking and using models, how a system is delineated, and who defines what counts as a functioning system. These are important to consider in the context of Hokkaido's electricity grid following the 2018 earthquake that I explore in chapter 4, and are also questions that have guided the study of infrastructure in anthropology.

1.3 Infrastructure

Infrastructure, like energy, brings together many different themes and subjects in social science literature: machines, labour, power, scientific knowledge, among others. We find some of these themes already present in Karl Marx's lengthy discussions of technology (MacKenzie, 1984) in the first volume of *Capital*, and in Georg Simmel's (1903) *Metropolis and Mental Life* where city dwellers are alienated and trapped by the mechanisms of urbanity and money. In Japan, Nakaoka Tetsuro (1970a; 1970b) made factories and industrial systems into an object of sociological analysis, examining the production process as an ordered and divided system of labour, drawing on Marx's focus on social relations shaping technology rather than the other way around.

In their review of the anthropological literature on infrastructure, Larkin (2013) notes that while technological objects had attracted theorization by Marx, Heidegger and Simon, anthropologists had mostly shied away from studying technological systems until recently. Like ecology, infrastructure studies have been influenced by systems thinking. Much of the recent wave of anthropological thinking on infrastructure has been influenced by the work of Hughes (1987, 1993) on electricity networks, and Bowker and Star (2000) in thinking of infrastructure as a technological system that act and operate across heterogenous networks, drawing on Latour's (1993, 1996) formulations of Actor Network Theory. Not merely objects, infrastructures enable the movement of things and enable certain ways of relating. Star (1999; Star and Ruhleder, 1994) and Bowker's (1994) contributions drew attention not only to material structures, but technologies and laws that are part of infrastructural networks which are often made invisible until they break down.

A branch of scholarship on the technopolitics of infrastructures have argued how they can operate as invisibilized and ostensibly neutral facilitators of governance (Barry, 2001; Mitchell 2002), in the case of oil infrastructure, shifting from labour-intensive coal allowed more seamless flows of capital and energy without union disruptions (Mitchell 2011), and in the case of water infrastructure in Mumbai, becomes the means of contesting belonging and citizenship (Anand, 2012). Roads act as both a promise of modernity and development that reshape senses of time and space, while also enabling illicit activity and disorder (Harvey and Knox, 2015). Land management practices that promise modernity and transparency also reshape relationships to land and time (Hetherington, 2016).

Recent literature has also argued that infrastructure can also be sites of tinkering, visibility, and repurposing. Morita, Jensen and Harvey (2016; see also Jensen and Morita, 2017) in turn reinterpret infrastructural inversions as opening up the working of infrastructures to new kinds of visibilities, tinkering and sabotage for new practical ontologies. In this kind of inversion, it is empirical before it is analytical, as in Morita's (2017) case of floating rice gradually winning over authorities in Thailand as a new kind of multispecies infrastructure, or in Von Schnitzler's (2013) study of the legacy of apartheid being built into and contested in Johannesburg's electricity grid. The earthquake in September has the signs of being part of this kind of rippling infrastructural inversion, building on the aftermath of Fukushima, the growing effects on climate change, as well as the improvement and decrease in cost of renewable technologies.

Elsewhere, Dominic Boyer (2016) has revisited the history of infrastructure from the works of Marx, arguing infrastructure is both a form of stored labour potential, often allowing leveraged effects on large scales, and an unwieldy force that often prevents more rapid social change. For Marx, infrastructure was the material base to the capitalist class' ideological superstructure. Marx also described the way capital fixes itself into machines and automation as part of liberating itself from labour while trying to keep its productivity. This is interesting to consider in the context of energy, where labour or work is often used as a metric of energy expended and energy efficiency. Boyer sees in this reading of infrastructure, a potential not just a force for material and social conservatism, but a potential for revolutionary change, away from the "gridworld". The gridworld remains relatively undefined in the chapter, but it does help situate a certain mode of infrastructure (represented by the grid) as all-encompassing, invisible, and geared towards capitalist production as one of many *worlds* of infrastructure possible.

1.4 Energy

While this research is about energy systems and the practices that maintain them, it is also situated at the margins of what some have called *systems-centred* approaches to energy and history (Chatterjee and Pérez-Zapico, 2023). Indeed, by drawing on literature from STS and energy anthropology, I write against a progressivist, phasist history that naturalizes systems, prioritizes electricity, de-materializes energy, and assumes both modernity and energy transitions as given states (Gooday, 2015). I instead focus on the struggles, contestations and translations that both allowed energy systems to undergird systems thinking, and might allow us to co-constitute alternatives. The sheer scale of even a relatively small electricity grid like that of Eastern Japan invites problems. The recent literature on energy allows me to move beyond a focus on electricity and its enabling of some ideal of civilizational progress to ask questions about how energy is made, how we live with energy systems, and the indeterminacy of our relationships to energy infrastructure.

From the beginnings of modern anthropology, the study of energy by anthropologists has involved the moral and technological worlds of energy. Émile Durkheim, among other social scientists of his time, had previously appropriated scientific vocabulary through the metaphor of electricity to describe social forces acting in the same way to shape reality as physical ones: “Non-Western conceptions of moral power and magical efficacy, pre-eminently as expressed through the Oceanic term ‘mana’, provided an important model for Durkheim’s grounding of theoretical ideas of force in experiences of a social order, and mana was itself often directly analogized to invisible and all-pervasive electricity" (Coleman, 2019: 43). Almost mirroring the shift in physics described by Stengers (2010), the metaphorical use of electricity for forces driving social organization was seen as a mistake by later anthropologists, and for most of the century the word *energy* would be used in a more thermodynamic and scientific sense (Coleman, 2019).

It is in this thermodynamic, materialist sense of the idea that Leslie White (1943) would apply the concept, bringing energy more directly into cultural anthropological research. According to White, everything could be described in terms of energy. He put forward two principles for determining the level of cultural advancement based on consumption of energy per capita, and the technological efficiency of energy use. In other words, how much and how well energy was being consumed determined how developed a culture was, along an evolutionary scale that placed industrialized Western nations that relied on machines and hydrocarbons at the apex of the developed end[3]. This analytic concern for formulating the relationship between society and energy would inspire other anthropologists of a Marxist orientation like Marshall Sahlins (1972) to argue that hunter-gatherers were actually affluent in that while their energy expenditures were few, resources were often plentiful allowing them to feel less material pressure and to have more time to rest. While anthropologists lately are less likely to go around counting hours of sleep and calories ingested by themselves and participants, these earlier works on energy and their focus on materialism have had a lasting impact in the kinds of questions they asked: who and what does work in our energy systems? How can we understand and compare human activity across

[3] Victor Seow (2022) notes that a Japanese observer made a similar remark as far back as 1919, saying "the amount of coal used may be thought of as 'a barometer measuring the degree of
a country's culture'" (13).

societies, as well as our relations to animals and plants, through energy? Who or what is all this energy good for?

Taking up these concerns while also raising her own lines of inquiry about who designs energy systems according to what principles, and how experts use numbers as a means of projecting power in their social environments, Laura Nader (Nader and Milleron, 1979; Nader, 2004) focused a critical lens on energy experts acting against democratic norms, showing the management of energy systems to be couched by the power of a community bolstered by social forces, scientific authority, and special interests. Nader's approach to energy, rooted in long-term qualitative study and looking beyond technological explanations to see the ethical and social entanglements of energy technology. Her reflections (Nader, 1981) on experts assuming safety to be built into the design are useful even today, as justifications of Fukushima and the blackout in Hokkaido being 想定外 (*souteigai*, outside predictions or unthinkable) are still being mobilized (Hokkaido Shimbun, 2018). Nader's critical orientation to national energy systems and ethics of expert knowledge continues to inspire work in energy humanities and social science, as more recent work also explores the material aspects of energy.

Despite these earlier contributions, as late as the mid 00s, anthropologists were still calling for energy anthropology to come into its own as the Bush administration suggested reviving the nuclear industry, as fears of peak oil bubbled up and as the reality of climate change began to reach mainstream politics (Wilhite, 2005). In the wake of the oil shocks, histories of energy development focused on fossil fuels and of the concept of energy within the origins of thermodynamics emerged as the connections between the globalizing economy, technologies and fossil fuels came into renewed focus (Harman, 1982; Smil, 1987; Smith, 1998; Smith and Wise, 1989). Vaclav Smil's work (2003; 2004) is notable for drawing attention to modernity as a high-energy period, drawing on evolutionary perspectives like those of White above, while also questioning the connection between high energy use and well-being given the environmental impact of fossil fuel consumption. Setting aside the well-studied problems of applying evolutionary theory to societies and Smil's reification of modernity, we might attribute to this growing discussion and awareness of the industrial period as one of tremendously high and concentrated energy use as formative to the concept of the Anthropocene (Crutzen, 2006).

Nonetheless, the kinds of historiography and anthropology that have made thermodynamic energy – and energy *qua* resource– into the main driver of change have also tended to focus on the large-scale and institutional aspects of energy production. In doing so, they have also tended to absorb some of the assumptions of the structures they study, taking energy practices of maximizing production in the management of the electricity grid as a social good and a step forward in a teleology of progress (Winther and Wilhite, 2015). The end point of such a teleology is often a near modernity that assumes a transition towards varied new technologies, rather than making this transition into a question.

1.4.1 Energy Politics in Materiality and Expertise

It took a few more years for a real movement towards energy anthropology to begin. The latest wars of the American empire and claims to fossil fuels have no doubt influenced the growth of energy as a topic in the social sciences and humanities. The Fukushima Daiichi disaster and ensuing shift away from nuclear power production in many countries also undoubtedly drew attention to the relationship between energy, politics, expertise, and ecology (Hindmarsh, 2013; Fortun and Frickel, 2012). Perhaps as a result of the charisma of megaprojects and megadisasters, until even more recently work in the energy humanities and social sciences has focused on the baseload of modern energy systems: fossil fuels, and to a lesser extent nuclear energy (Appel, Mason and Watts, 2015; Chapman, 2014; Hecht, 2012; Hornborg, 2016; Love and Isenhour, 2016; Mason, 2014; Masco, 2017; Szeman and Boyer, 2017; Watts, 2017; Wenzel and Yaeger, 2017).

While it too focuses on hydrocarbons, Mitchell's *Carbon Democracy: Political Power in the Age of Oil* (2011) is a crucial text to understanding the boom in energy studies. In it, Mitchell attempts to explain the formative power of the substances that are used to produce energy by outlining the way coal, oil and even wood each have their own materialities that have enabled different kinds of political formations historically. In the shift from coal to oil, with infrastructure requiring more segmented labour and more concentration of control of resources abroad, states and elites have been able to stray from democratic control and avoid massive workers' strikes. In turn, the control of oil away from the territories of Western states and their labourers undergirded the post-WWII concept of *economy* as a field of government that limits alternative political claims, and envisions limitless growth based on low cost fossil fuels.

As with oil, concentration of knowledge and high costs for construction, security and waste disposal make nuclear power a material that can untangle states from democratic scrutiny and popular resistance[4]. Nader (2004) made a similar point and was among the early users of the

[4] In the case of nuclear power, France is an interesting example. Though 70% of the electricity produced in France comes from nuclear reactors (Wheeldon, 2023), Wikileaks (2016) has shown France has negotiated with factions in Libya to secure favourable deals for its oil conglomerates, notably TOTAL.

concept of energy futures (Nader and Milleron, 1981). Drawing on a 1976 article by Amory Lovins in Foreign Affairs, Nader (2004) argued hard energy paths like nuclear energy would centralize power and not be bound to democratic controls and interests. Even the labelling of such paths as *hard* would only make them seem more stable, sound and powerful in contrast to backwards and feminine *soft* paths, Nader argued, citing Margaret Mead's advice to Lovins to not use the word *soft* to persuade American male-dominated political and scientific publics (2004). Nader (2004: 776-777) would also note the callousness and conformity of energy experts in talking about mass deaths and being unable to imagine different solutions, removed as they saw themselves from the social fabric. I see these reflections as having been relatively novel outside the developing field of STS and indicated the potential of exploring affect within expert communities that were typically seen as unassailable authorities belonging to the world of numbers rather than culture.

Though sharing Nader's concern for power and expert knowledge, Mitchell's work has left a lasting impact on the work of energy scholars by placing the focus on materiality. Nader's work centred on nuclear energy has suggested outcomes that go against the common good should be expected from any form of energy that relies on experts or elites that see themselves as removed from the broader society even when they purport to be accountable to science and objective metrics. Though Mitchell's work focused on the politics made possible by the materiality of different forms of energy, and Nader on the politics of knowledge and expertise, they both complicate the idea that modern energy systems work in service of a democratic, common good. The emergence of energy social science in the 2010s has followed a material-cultural turn in the 1990s onward from the scholars like Daniel Miller (Miller, 2002; Miller, 2005; see also Tilley, 2006; Hicks and Beaudry, 2010), as well as out of growing debates on the modern subject/object dichotomy with its gendered and colonial histories (Abu-Lughod, 1990; Latour, 1993; Strathern, 1988) and discussions of thing-oriented or more-than-human anthropology (Braun, Whatmore, and Stengers, 2010; Jackson, 1996; Henare et al., 2007; Latour, 2005; Kirksey and Helmreich, 2010; Viveiros de Castro, 1998).

Andrew Barry's (2013) *Material Politics: Disputes Along a Pipeline* combines the material and epistemological dimensions raised in Nader and Mitchell's work in discussing both how the material of the BTC pipeline itself was part of political disputes (rather than just the object of the dispute), and how contestations about what was known by who, and what actions different kinds of knowledge and expertise enabled. Re-materialising politics in this way requires not only an attention to the science of materials, but also understanding each material outside of scientific discourse and through their dynamic relationships to the broader, living world of material and immaterial things (Barry, 2013: 11; Braun and Whatmore, 2010). Though Barry is concerned in particular with bringing materiality to a public knowledge controversy, materiality can help approach the marginal attempts to build different kinds of energy systems following Hokkaido's energy infrastructure after the 2018 earthquake. By placing the material particularities of renewable energy projects in Hokkaido in comparison to policy and data, the way these projects relate to policies and ideals of resilience, the grid, the common good, and *Society* 5.0 can be examined.

Much of this emergence of studies of energy happened alongside if not within a similar rise of infrastructure studies, being similarly concerned by the political economy of technology and the potential for infrastructure to be an obstacle to the changes needed to meet the crises built up over the centuries of colonial and capitalist development. Electricity grids figure large in the overlap between infrastructure and energy. The origin of the use of *grid* is not clear to me, but Grant (2001) suggests it may have begun in urban planning as a way to make public spaces rational, efficient and legible. There was also a fantasy behind the grid comparison, one of projecting egalitarianism while the geography itself is a display of the considerable concentration of power required to produce it. Nye (2010) also suggests, echoing Debord's *The society of the spectacle* (1992), that World Fairs and amusement parks, themselves direct symbols of bourgeois modernity triumphing over the chaos and darkness of nature, sparked the spread of electrical lighting that would make up the first electricity grids.

In Gretchen Bakke's (2017) study of US electricity grids -electricity grids themselves described as an American object- they are depicted as giant machines of contradictions that are fraying over decades of strain, being built around fossil fuels and now forming obstacles to a transition to renewables as communities continue to change the grid and adapt around its failures. Anita von Schnitzler (2013) has studied prepaid electricity metres as a technology used to suppress anti-apartheid boycotts in South Africa that has now become widespread in the country and also become a micro-political ground for tinkering and contestation of ethics and citizenship. Electricity grids loom large over the history of shaping material existence through continuous access to elecitricity as well as ways of thinking about society and nature.

1.4.2 Energy Worlds

Impactful works on the constraints and possibilities given by the materiality of energy and its infrastructure have raised questions about how we can imagine and enact different futures or worlds. As Boyer (2011) has pointed out, Mitchell's focus on the relationship between hydrocarbons and democracy leaves out how states, markets and publics are being remade through other materialities of energy like nuclear, wind and solar. A growing body of literature has explored energy justice, sustainable energy transitions, and the material possibilities of renewable energy. As the reality of climate change has set in, recent reviews of energy anthropology and humanities have commented on a growth of studies into the cosmologies of energy based in the experience of fuel and electricity in places like New York and Alaska, as well as the ethics of energy (the diversity of behaviours concerning the role of energy in a "good society") (Frigo, 2018; Smith and High, 2017).

In trying to address what a *renewable* or *solar* democracy might look like, Boyer (2011) cites Herman Scheer's vision of distributed solar power creating relations between people as both users and producers as upsetting the political order of hydrocarbons. Studies on the spread of solar in East Africa via pay-as-you-go and other financial arrangements to allow economically marginalized people to power their homes have shown how the financial infrastructure and search for profit by overseas actors have complicated ideas of 'leapfrogging' technological advancement in the Global South and the viability of off-grid solar without broader socio-economic transformation (Cross and Neumark, 2021; Riedke and Adelmann, 2022).

Winthereik, Maguire and Watts (2019) discuss how "energy walks" in Denmark, in which participants use a digitally-connected walking stick and headphones as they walk through the coastal landscape, can use the mediation of digital infrastructure to shape sensory experiences of a place and tell a story that helps people imagine a sustainable future in their environment. It is notable that many if not most of the works cited in this chapter are from infrastructure studies (Appel, Anand and Gupta, 2015; Blok, Nakazora and Winthereik, 2016; Carse, 2012; Jensen and Morita, 2017) rather than the humanities or social science of energy. Watts (2019) has elsewhere given more thought to the material and sensory dimension of energy on the coast, particularly in the way that energy is often discussed as an abstract flow, but there is more aptly characterized as carried by cables or boats (Starosielski, 2015), or as felt on the skin as harsh wind, or heard as a crashing wave. A similar point is made by Wanvik (2018), who argues that ideas of stability and path dependency or lock-in from existing energy infrastructures has taken undue preponderance in energy studies. Inspired by a Deleuzian assemblage approach, Wanvik puts forward that focusing on inertia may have deleterious consequences if we are to seek better futures, and advocates investigating the instability of infrastructures, landscapes and power in contested energy spaces.

The work of Watts and others to bring out the sensory and laborious aspects of different kinds of energies and their infrastructures is propitious for relating the lived experience of people and even other beings to structures that are often hidden, massive and bureaucratically managed. The *Cool Infrastructures* Project, contrary to the cold of Orkney and Denmark that Watts has focused on, is an attempt to study the way cities in the Global South are dealing with growing urban populations, pollution, and heat as the climate disasters worsen. Studies within the project have included profiles of Hyderabad, India and Jakarta, Indonesia (Anilkumar et al., 2022; Abdullah et al., 2022; Salsabila, Amir and Nastiti, 2023), examining water, waste, energy and transport infrastructures alongside official heat plans, and the material vulnerabilities of the built environment. Samo and Fatima (2022) have also written a short reflection on the way weather remains a force for imagination and experience despite the colonial legacy of needing to manage heat, and of science's ability to understand and predict it.

A recent open-access collection called *Energy Worlds in Experiment* (Maguire, Watts, and Winthereik, 2021) featuring many of the most prolific authors of energy humanities and social science also explores the tensions between lived experience and expertise, energy futures of hope and of calamity, and between play and study through a series of experimental writings. These are diverse in their form and content. One is an examination of Latourian propositional politics in offering occasions for entities, particularly non-humans, to enter into contact with us and surprise us, leading to a different kind of politics (e.g. energy data from home-built monitors become a proliferation of stories and conversations in a workshop rather than data being an explanation, failed neoliberal Water Pact exercises in Brazil becomes an opportunity to think about the potential of mobilizing precarious relations rather than deep commitments) (Danyi, Spencer, Maguire, Knox, and Ballestero, 2021). Another is a short graphic story set in a future, with a human protagonist, an electrical engineer named Unda, moving in the ocean between Mexico, California, the Atlantic and finally Orkney. Unda begins as a kind of cyborg and slowly grows fins and tentacles as they try to escape the high-energy light and pollution of the cities to reach Orkney where energy is lower, as radio waves, and wireless connections become something they can sense (Watts, Howe, and Bowker, 2021).

Though obviously varied, each is inspired by elements of the authors' research that is not as easy to communicate in the medium of academic journals (Maguire, Watts, and Winthereik, 2021: 21-22). Indeed, they are united in arguing that much as issues of energy are not solvable or subsumable simply via technology or policy (as the political leadership in most countries dances around climate agreements to avoid confronting the emergencies facing most life on the planet), imagining and making energy worlds of less intensity powered by renewables is not something that can be left to academic writing: it should be felt, fought for, and participated in.

As an island periphery in which the additional costs of maintaining and upgrading infrastructure create material disjunctures from the promises of the centre, Hokkaido shares much with Laura Watts' (2019) study of Orkney Island. Located off the coast of Scotland, people on the intensely windy island of Orkney spend disproportionate amounts of their income on fuel, and pay extra fees to pay for energy sent from the mainland despite producing a large quantity of renewable energy[5]. Watts contrasts the central authorities in Westminster and their black boxes handed down by consultants to the future-making work of Orkney residents, relying on each other for help and for means to reduce energy. As fuel costs soar prohibitively higher, thanks to governments being eternally pliant to the profiteering fossil fuel companies and underinvestment in simple energy-saving technologies like insulating windows, experiments are underway in Orkney to increase energy independence using tidal power, wind power, hydrogen, and lithium battery storage.

Watts describes this process as making energy futures, describing the island's development of a

[5] In Hokkaido too, fuel poverty amidst infrastructural disjunctures is a serious problem. This is felt most acutely in households of elderly people, young families, and families with a female head of household. This is particularly acute in southern Sorachi, the main coal mining area in Hokkaido (Konno, Mori and Iwama, 2018).

smart grid and a renewable energy surplus, outgrowing the energy dependency imposed on the island. This future built on waves, wind, local expertise and venture capital is for a more long-term future. It is a material process, but also one of imagining and experimenting in which Watts collaborates in, notably through energy walks that immerse people in the environment from which the energy that powers the island is made. Watts' approach follows what Boyer (2019) describes as a new materialist politics of energy that not only is attentive to the cultures of energy (Strauss, Rupp and Love, 2013), but also to the politics of energy emerging through the materiality of this energy and its environment. Energy and energy technologies shape time, space and the possibilities of subject formation (Maguire, Watts and Winthereik, 2021; Morton and Boyer, 2021; Harvey, Jensen and Morita, 2017). It is to these changes and possibilities in Hokkaido, and how they came to be historically that I now turn to.

2. Making Hokkaido's Electricity Grid

My attention to the problems of energy infrastructure were formed during my Master's research in Yubari. Though my research had focused on revitalization efforts and revaluations of place, I found myself increasingly thinking about the role of infrastructure and the materiality of coal in the ground in how people saw the space around them, and imagined different futures. Coal wasn't just an inert substance even as industry had largely left it behind: coal slag heaps were and still are playgrounds, a means of connecting to a new kind of nature growing on industrial waste, and surrounded by stories of the souls of the dead who perished in nearby mines (St-Pierre, 2017). Beyond the materiality afforded to coal by industry as a rich but illiquid and bulky energy source requiring a large labour source to exploit and move, coal has a new life as the foundation of a different kind of slag heap park and a resource to scavenge for for summer barbecues.

Although the coal mines of Yubari closed in the 1980s, the legacies of the waste, trains, and dams produced around the mines continue to shape life in Yubari. A local organization in central Yubari organizes events to maintain the park that one of the larger slag heaps has become, in order to maintain the steps, discuss the changing landscape of the surrounding town, and talk about the plants that grow on the heap. It also hosts events to walk around the town, to share ideas about particular places like the local train station, and to comment on public policy. Energy would often come up as a topic, either through discussions of coal, or the nearby public bath, or the winter cold, or the nearby dams. Yubari was one of the earliest parts of Hokkaido to have hydroelectric dams, and the Yuparo river[6] continues to play a key role in the water management and electricity provision of the prefecture.

Though commercially important areas like Yubari were early to adopt and be integrated into the network of new technologies like hydroelectric power plants, trains, and industrial machinery, most of Hokkaido was often relatively late and left behind in being reached by the developmental schemes of the metropole (Mason, 2012; Walker, 2001). In fact, early infrastructural development of dams happened mostly in response to disasters. As a colony, Hokkaido was mostly valued for its commodity production, and later its significant and strategic industrial capacity. The development of the latter should be seen in part as a consequence of local demand for government intervention, rather than simply the natural progression of a colonial scheme from Tokyo. The first dams built in Hokkaido by Japanese colonizers were in response to disastrous floods, particularly in 1898 as 248 people died. The colonial government of Hokkaido was pressured into doing its first hydrological survey of the rivers of the island that same year. Most of these first few dams from 1900-1920 were built for irrigation, but more would be built in the following decades for electricity production (Hokkaido Public Works Technology Association, 2007).

In looking at these historical events in Hokkaido from a more ground-up perspective, the present issues that concern this research are examined as part of a longer history of claims to the government that have been at times answered or rejected, and how people have had to form their own alliances to make energy infrastructure. By not taking Hokkaido's electricity grid for granted, it is possible to more clearly delineate how this ensemble of technologies have come to

[6] 夕張川 *Yuubarigawa*

be seen as settled networks in spite of divergent projects and desires that continue to come into conflict with the grid's systems. As Maruyama (2014) argues, questioning energy is questioning society: the patterns of production, distribution, dependency and so on that energy technologies are co-constituted with the society they are a part of (iii-iv). Though most modern grids have operated with some similar basic characteristics (baseload power provided by fossil fuels, alternative current, power plants distant from population centers, centralized management, etc.) these belie the particularities of each region's energy infrastructure and their material effects.

I will first go over the broader history of energy infrastructure in Japan as it has been told, and then offer some alternative fragments of histories as I have above to highlight and provincialize the heterogeneity that characterized the seemingly monolithic grid that exists today (Chakrabarty, 1992). This heterogeneity is not only important for context for the actions of participants in this research, but also to re-think ways of relating to the past in light of these divergences in history from within this global moment of transitions and crises.

The history of electric infrastructure in Japan is often divided into three periods, corresponding to a period of private competition turning into monopolies, a period of state control of electricity during WWII, and a period of regional monopoly turning into liberalization (Kikkawa, 2012; Takeuchi, 2013). What this history captures are the broad strokes of the contested relations of ownership of electric infrastructure in Japan. It is perhaps a familiar history even to those not from countries that experienced fascist state control: new technologies of the 20th century are eventually brought under state management for the public good, until neoliberal reform seeks to unleash the alleged efficiencies of the market. I do not contest this history here. Rather, I wish to add to this the relations of ownership left out by this history, and the material conditions necessary for fossil fuel-powered (and later nuclear-powered and renewable-powered) electric infrastructural development to occur as it did in Japan, and in particular in Hokkaido. By examining the relations that produced the history of energy infrastructure in Hokkaido, I hope to illustrate some of the historical and material confluences that created Hokkaido's electricity grid and interrupted the possibility of local alternatives.

2.1 Hokkaido's Modern Energy Infrastructure

I begin this retelling of the history of modern energy infrastructure in Hokkaido with coal. Victor Seow (2022) argues that the extraction of fossil fuels and the modern nation-state were co-constitutive processes, with one creating the conditions of the other. In order to extract these fossil fuels from coal fields like Fushun and Yubari, states required extensive systems to exploit fossil energy that mobilized the latest in technology and engineering. Seow calls this system *carbon technocracy* for its unwavering belief in the superiority of science and technology for realizing the projects of the state (Seow, 2022: 126).

With foreign and later domestic ships requiring fuel, establishing a supply of coal in ports like Hakodate became important to the Meiji Restoration government. Paper and steel mills developed around the ports, and would look to source their own power in the absence of state development. The trains of Tokyo mostly carried the middle and upper classes to well-frequented places, the trains of Hokkaido would mostly carry resources to port cities (Nakamura, 2012). Initially, Hokkaido's energy infrastructure was concentrated in the largest coastal cities, where the wealthy and critical export-oriented extractive industries met. Electricity developed later than in many parts of the country in part out of concerns for public safety among this urban upper class (Ihara, Takahashi and Aida, 1989: 189).

That said, the first electrical utility in the prefecture was started in Sapporo, in 1891 by wealthy industrialists. Started with two 25kw Edison generators. Over time, as consumption grew, direct current would be replaced with alternating current, and imported equipment would be replaced with those from growing domestic producers like Hitachi and Mitsubishi. Interestingly, by 1913, it seems there was no more direct current service in Sapporo but Tokyo in 1916 still had a large amount of direct current power provision, and some persisted until the Great Kanto Earthquake in 1923 (Ihara, Takahashi and Aida, 1989: 187).

Around 1908, HEPCO began building the Jozankei dam and hydroelectric plant, which exists to this day. That said, many projects did not unfold smoothly in Hokkaido. The developers' lack of familiarity with the rivers or the area, the need for emergency measures, and business problems complicated the first hydroelectric dam started in Iwanai, in 1905. As the Horonai river was not included in hydroelectric surveys, the data gathered was thinner and had overestimated the amount of water flowing. In winter and drier periods, the generator could barely function, and so a gas generator was installed to help keep output constant. Even with this, the developers had cut corners in cutting their costs and did not have the right level of technology to meet the engineering challenge of the river, and the project was eventually ended in 1922 (Ihara, Takahashi and Aida, 1989).

The ability to send electricity from dams more than a hundred kilometers away and the cost of maintenance plummeting from hydroelectricity relative to thermal generators greatly increased access to electricity in centers of consumption like Sapporo and Hakodate from the 1910s. This change was precipitated by two situational changes in the period around the Russo-Japanese War (1904-1905) that significantly affected Japan's electric power industry. One was the realization of long-distance power transmission at high voltages of over 50, 000V in the United States. Another was the sharp rise in the price of coal, a fuel used for thermal power generation, caused by the outbreak of the Russo-Japanese War in 1904 (Kikkawa, 2012: 7). Tungsten light bulbs also helped reduce costs for end users (Ihara, Takahashi and Aida, 1989: 190-191). Nevertheless, compared to most of the country, demand was lower due to there being more poverty and less concentration of inhabitants. While steel, coal and paper generated immense wealth for exporters that developed their own electric infrastructure, the rest of the internal economy's electricity demand remained more subdued.

In a city like Yubari that grew from coal extraction, labour was sometimes scarce, and the efficiency of coal generators was fairly poor, leading companies like the Hokkaido Colliery and Steamship Company[7] to focus on automating technologies and low-cost hydropower even with the abundance of coal. Where technology was too expensive or not advanced enough, seas of people were required[8]. This was the case for instance in the coal mines themselves, where many of the forced labourers and prisoners of war were sent during World War 2 (Ihara, Takahashi and

[7] 北海道炭礦汽船株式会社 *Hokkaido tanko kisen kabushikigaisha*.
[8] I have tried to include labourers and labour power in this retelling of the history of energy infrastructure, but a more full retelling would also include changes in building materials, agricultural practices, manufacturing processes, transportation technologies and ecological changes (and more) as these are indelibly part of energy infrastructure. I have tried to make allusions to these, but a more-than-human history of energy is beyond the ambition of this chapter.

Aida, 1989: 196-198; Mason, 2012). Japan also initially developed its own oil extraction industry until competition from firms like Standard Oil forced a redirection of capital investment from production to refinement by the early 1920s, shaping Japanese energy infrastructure for the rest of the century (Seow, 2022: 127).

It also meant that places like Hokkaido and Kyushu were later than the rest of the country in unifying the frequency of their electric systems. In Hokkaido, as many facilities were used exclusively by manufacturing and commodity producing companies, there was little need for them to unify their output for the general population. Though the issue of frequency unification was brought up many times between the 1920s through WWII, and unification was made official policy in 1925, it took until January 1946 for Hokkaido to join the rest of Eastern Japan in adopting the 50hz grid, with Hakodate being the last holdout (Ihara, Takahashi and Aida, 1989: 204-209).

Unlike in many other parts of Japan that were more developed and densely populated, electrification of rural areas proceeded into the late 1960s in some parts of Hokkaido, if not later.[9] HEPCO would usually extend the lines up to the point where service was efficient, and leave the rest, like farmland and villages further out, unconnected. By this point, the government had become more involved in the support of electric infrastructure, but by some accounts the division of funding still involved some percentage coming from the local electricity association

[9] David Sneath (2009) has studied how Mongolian practices of divination are enmeshed with but exceed the Soviet state projects of electrification that attempted to modernize and colonize imaginations. In other words, the successful control of electricity by the state had designs on bringing imaginations in line with goals of the state. Though in Japan this may have been more successful following US occupation, the struggles of community utilities and cunning post-war consumers in this chapter, and anti-nuclear activists in the next chapter suggest the Japanese state's future-making projects are also contested affairs.

and individuals (with HEPCO providing the majority and the national government some 30% or so).

2.2 Community Utilities in Hokkaido

However, more recent work has endeavoured to tell a different story about electrification in Japan. Human geography professor at Aichi University, Nishino Toshiaki (2020) writes in 日本地域電化史論—住民が電気を灯した歴史に学ぶ (*Japanese regional electrification history: Learning from the residents who turned the power on*) that while the conventional account of the development of Japanese electrical infrastructure being dominated by the large regional utility monopolies still holds true, it often leaves untold the stories of local communities coming together to finance and build their own infrastructures before the utilities took over. The book covers a period from 1908 to 1968, when the town of Omu-Esashi's municipal energy association got absorbed by HEPCO. More than just writing an alternative history of electrical infrastructure, Nishino also writes this history with an eye on contemporary energy politics, and the possibilities contained in the largely forgotten history of community electricity in Japan.

Having written for most of his career on the development of mountain villages in Japan, this sudden turn towards energy infrastructure might be surprising. Nishino, however, points out that approximately 30% of rural municipal electric utilities were concentrated in the mountainous, rural prefecture of Gifu. The main reason for this anomalous distribution was that the number of town-owned woodlands[10] was greater in Gifu, allowing regions with the most municipal woodlands to sell desired tree varieties at a high price and develop their electric infrastructure

[10] 町村有林 *chouson yuurin*

earlier. Indeed, the first municipal utility of this kind was in the town of Meiwa in Gifu prefecture, in 1908. Contrary to popular belief, compared to private utilities, these not only had broader reach, but prices were cheaper and the business was profitable. Towns would use their assets, and gather funds in order to bankroll these projects (Nishino, 2020: 94, 114).

The creation of community-led electric infrastructure did not just end with WWII, nor even with the Act on the Promotion of Introducing Electricity into Farming and Fishing Villages[11] of 1952. In particular, in Hokkaido and Iwate prefectures, private utilities seeking efficiency over delivering electricity to as many as possible had left many areas underserved or without service, and with distorted electricity distribution designs. Even following the war, in the areas without electricity, municipalities and people put up their own funds to provide electricity as without this effort, they would likely have remained without service for much longer. The Act on the Promotion of Introducing Electricity into Farming and Fishing Villages helped accelerate this process, but Nishino finds that development continued to rely on the financial contributions of cooperatives and residents, a fact often left out from the mainstream historical narrative.

In a separate article, Nishino (2019) uses the informative example of the Omu-Esashi municipality's utility and absorption into HEPCO to discuss the difficulties and loss of local energy management that transpired throughout the period of centralization. Omu's Electricity Use and Farming Association was established relatively late in 1951, the same year HEPCO was created. In 1947, Hokkaido Transmission had taken over from Omu Hydroelectric in supplying the town with power. At that time, only 8 districts had power, and 22 were without. Even in those with power, coverage of the power lines was irregular. Under the post war development (*kaitaku*)

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[11] 農山漁村電気導入促進法 *Nousan gyoson denki dounyuu sokushinhou*

policy, the population and housing had continued to increase. Omu would eventually unite with nearby Esashi in managing its community electricity infrastructure.

The exact details of the founding of the community electricity fund and associated groups are hard to follow in the historical record, according to Nishino (2019). It is clear that while the funds amassed were under the amount aimed for, a large amount of funds was amassed, and those investing in the community electricity fund included wealthy residents who already had electricity through HEPCO. One can interpret this set of facts as pointing to the wealthy residents trying to bring forward community electrification while taking share from HEPCO. In some sense, this was a return to the prevailing way of funding infrastructure in rural areas before the war, where rural residents were dependent on the wealthier, landowning class for investment. Help from the government was not usually forthcoming, and the utilities charged high fees.

From 1955 to 1960, the electricity association made losses, as cold weather damage and poor catches in the fishing industry resulted in demand being only 25% of the electricity produced. The remaining 75% was sold to HEPCO *at a loss* as the cost of fuel was higher than the price that HEPCO had fixed (the minimum). They were put under advisory by the Hokkaido branch of the Agriculture Forestry and Fisheries Finance Corporation, effectively a government agency. Their recommendations were to increase prices by 100% as these were among the lowest in all of Hokkaido, cut costs as revenues were not keeping up with expenditures (50 to 79% of which was for salaries and business trips, unusually high). The association stalled in introducing these measures, and defaulted on some of their loans. Demand remained too low, construction costs were too high to meet their ambitions, and it would take them centuries to pay off their loans.

Not 10 years after its foundation, wooden poles and cables began to deteriorate. The association asked for help funding replacements, which the government did assist with, but it marked the point at which, like many others around Hokkaido, the association began to accept it would have to be absorbed by HEPCO to continue providing service as funding it on community resources alone was proving too difficult. Even after being subsumed by HEPCO, 50% of the electricity bill was attributed to the beneficiary service fee[12] (Yamakawa, 2020). While there was some degree of mismanagement and adverse conditions in the case of Omu-Esashi's utility, the degree to which rural communities benefited from HEPCO's takeover is highly questionable given these high fees for a service that would become essential by replacing biofuels and other means of managing heat.

Nishino is careful not to suggest that the organization and development that took place to found and operate these utilities happened with equal participation from all. He instead writes against the subsumption of the minor history he constructs into the broader conventional narrative about class and power amidst monopolies and fascism. The history of electric utilities in Japan before the advent of the regional monopolies is one of crony capitalism and extortionate private monopolies.

This history has left out not only the impact of local utilities, but the creative re-wiring of electric infrastructure by consumers and households. Shin (2020) notes that the post-war period was marked by illicit overuse of electricity, rewiring, and consequently blackouts and inspections by utilities. Shin (2020) mentions devices and even the use of spiders to attempt to turn back the

[12] 受益者償還負担金 *Juekisha shoukan futankin*

meters installed by utilities to measure electricity use (104-109). House fires caused by obsolete wiring in the midst of widespread electrification driven by household use of new appliances like fridges and televisions prompted public drives and new legislation to replace these dangerous modifications with modern wiring. These targeted housewives as responsible for domestic safety (Shin, 2020: 113-115). As demonstrated through the examples of Hokkaido's dams, the shift to oil in part in response to protests by coal mine workers, and as we will now turn to in the coming section, the shift to nuclear power in response to oil shocks, a top-down analysis of the grid naturalizes processes of infrastructure development that have also been reactive, undetermined and led by smaller actors.

2.3 Commons Interrupted

Hokkaido's energy infrastructure has been shaped by changes to industrial and energy policy that have shuttered coal production, decreased the size of the fishing and industrial economies of several port cities like Muroran, Hakodate and Tomakomai, while privileging farming (Seki, 2017: 2-3; 17-18)[13]. Nishino (2020) suggests a history that looks at municipal power development as making up for the lacunae of Meiji era capitalist development and modifying its trajectory through the upkeep of an autonomous and shared capital in infrastructure (106-113). Nishino (2020) views this historical example as important for revitalizing and rethinking contemporary ideas such as the new public or commons (新しい公共 *atarashii koukyou*), and

[13] In many cases, the development of dairy agribusiness in Hokkaido seems to have been driven by municipalities copying each other without coordination, or yet again a romantic idealization of the green fields associated with Germany and the United States (Watanabe, 1940). This adds some context to the project of colonialism and industrial agriculture in Hokkaido as being driven by local colonial desires and intervillage competition as much as national priorities and Western colonial imagination.

local production for local consumption (地産地消 *chisan chishou*) (163, 175, 247-248; Yano, 2021: 82).

Nishino's history is one that attempts to meet the present moment in Japan's energy policy and climate change more broadly, and is told in response to the delegation of energy management and its effects on the climate to the national government and corporations. This concern for the commons, or the possibility of a commons for energy, comes out of an anxiety over the way Japan has developed its renewable energy following the 3.11 triple disaster. He outlines in the final chapter how Japan's Feed-In-Tariff has turned a chance at bottom-up reclamation of control over energy and economic life into a corporate welfare scheme that understands the public good as the private good.

Moreover, where efforts are made to make energy into something like a common good, the examples are almost invariably drawn from a handful of European nations like Germany and Denmark (and occasionally also the US) (see Maruyama, 2014: vii; Nishino, 2020; Takamatsu, 2018; and see also chapter 4). By importing examples of transition from abroad, it is easier to avoid confronting the policy choices made in the past in Japan, and the lost possibilities in its history of energy development. In this sense, Nishino's history of community energy management in Japan is intentionally an artifact of anxiety about Japan's mode of transition and a tool to those who feel the same.

There is reason to be wary of thinking of the intrinsic capacity for regions and their people as endlessly accessing internal, hidden resources in order to be capable of thriving under centralized state control, late capitalism, and the climate catastrophe, particularly when they have been dispossessed of valuable assets like woodlands and made dependent on public subsidies. (Love, 2013; Moritomo, 2000) Nonetheless, this history is informative for rethinking the electricity grid, how it came to supplant communal grids, and who benefitted from these arrangements. The often cited example of contemporary re-municipalization of energy in Germany through Stadtwerke is often cited by the government and renewable energy proponents in Hokkaido as a potential model for a more locally-managed energy system (and indeed mentioned by Nishino too), but I had never once heard any of them mention the 20th century history of what were effectively crowdfunded Japanese municipal electricity utilities.

What this concern for the relationship between energy and the commons (specifically technologically mediated power and democracy) also makes clear is that the common good is also taken up by governments for their own imagination of the public good. Yang, Szerszynski, and Wynne (2017) argue that high modernism in East Asia in particular has been characterized by the state's planning rationality grounded foremost in a collectivist and unitary idea of the public good. By performing objectivity and authority through technicality in planning for power shortages and setting feed-in tariffs, the state reinforces its idea of the public good over alternative indigenist-reformist rationalities, for instance. The concern for questions of the commons has also figured in anthropology lately. Blaser and de la Cadena (2017) note the activities of extractivism like large hydro-electric dams, expanding fossil fuel extraction and agribusiness require enclosing or destroying commons while the state or government often makes reference to doing so in pursuit of *the common good* (185-186). They argue this confounding of the commons with the common good as an inert pool of resources is violent and unrigorous. Commons should be thought of as an activity of making a common subject through relationships of cooperation and mutual responsibility (between humans as well as often between humans and non-humans).

Blaser and de la Cadena's concept of the *uncommons* refers to the unsettled state of relations within this activity around defining the commons and the common good, and the way heterogeneous assemblages of life exceed the conceptualization of resources and owners. As Jensen (2017) argues in the same issue of *Anthropologica*, the practices of domaining a commons are what make it and keep it commons, and that the scale of such commons-making is usually not a series of neat nesting one within the other, but a matter of how they relate to each other (i.e. the river as a source of livelihood can grow to different scales beyond the frame of hydroelectric power development through forestry, tourism, climate change, etc.).

Nishino's return to the history of the community utilities in Japan and the possibility of a new commons also points to the way in which the national electricity grid, and its promise of stability through fossil fuels and nuclear power have been eroded. The future promised by fossil fuels and nuclear power has also been disrupted in Japan by the oil shocks of the 1970s and the 3.11 disasters. The following chapter is also largely historiographical but leads us to the effects of the Feed-in-Tariff and growth in renewable energy following 3.11 in Hokkaido, and the impact of the 2018 East Iburi earthquake in making the future of energy infrastructure into a matter of concern.

3. Unmaking the Grid

Commercial nuclear energy in Japan emerged from the consolidation of US geopolitical power following World War II and gained further traction following the oil shocks of the 1970s. Nuclear power became the means to create safe and stable power throughout the country, and achieve sustainability. Despite significant opposition, Japanese political elites, experts and utilities had managed to deliver what seemed to be safe, domestically produced energy. However, to borrow Latourian language, the 3.11 triple disaster and subsequent FIT policy grew both the problem of nuclear power and the ability of elite networks to manage the grid into a wider gathering of people, technologies, and imaginaries, making them into a matter of concern (Latour, 2004; Stengers, 2011).

At stake is not just the stability of the grid and the political networks that supported it, but also a certain kind of future-making project of an energy transition that relied on quickly getting private energy producers to produce renewable energy to *feed into* the grid. Without nuclear power, the need to accelerate renewable energy production in order to join in emissions reduction efforts and improve domestic energy security led to the introduction of the Feed-In-Tariff policy. However, among other effects, the implementation of this policy has favoured the projects of large companies using cheap land and less capital intensive solar power in Hokkaido. If nuclear power's energy transition centered the reduction in fossil fuel dependency and stable output, FIT's version of the transition is one that encouraged private actors to rapidly and unevenly create areas of renewable energy production, naturalizing conditions of underinvestment, depopulation, and dependency. This makes a problem of the energy transition as an assumption, and asks us to see transitions as future-making projects that make use of a set of practices and technologies. I argue that even before the 2018 earthquake, the shape of post-Fukushima Japanese energy policy in Hokkaido was unsettling the relationship assumed by the government and utilities between the future of the energy transition in Hokkaido and the infrastructural conditions of its electricity grid.

3.1 The Emergence of Commercial Nuclear Power in Japan

At a national level, powerful business elites had managed to leverage their positions to influence the reorganization of the electricity grid and industry following the end of World War II. Sataka (2011) details in particular how Matsunaga Yasuzaemon[14], one of the 5 heads of the largest electricity companies, was appointed to the electricity industry reorganization committee[15], finding himself in both a position of unprecedented influence but also subject to the whims of the occupying military forces. The military sought to dismantle all sources of military power and funding, including the financial conglomerates[16] and the government control of utilities. The division of power into 9 regions was used to weaken the influence of the electric utility company worker's union. The union on their part had asked the management circles for the removal of government control, and the rationalization of electricity transmission across the country (78-79). Plans were disputed in parliament and outside. Social democrats and communist parties wanted nationalized management of the utility sector, unions wanted something close to this as well, desiring the flattening of relations of ownership.

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[14] Though he argues electricity should be freed from the profit motive for the public good, Sataka's (2011) discussion of Matsunaga verges on the rehabilitative and nostalgic, looking for a time when industry leaders had the courage to stand up to the government (even as he collaborated with the Japanese empire) (48-53; 75).

[15] 電気事業再編成審議会 *Denki jigyou saihensei shingikai*

[16] 財閥 *Zaibatsu*

Matsunaga and other energy barons of course strongly contested these mounting oppositions from the political left. Eventually, Matsunaga would win over GHQ, and his plan for 9 divisions would be implemented in 1951, bypassing parliament through the Potsdam declaration, despite criticism of this as an undemocratic measure (100-101; 112). The Law for the Elimination of Excessive Concentration of Economic Power[17] was used as the basis for this action, the same law used to dismantle the powerful conglomerates (Takeuchi, 2013: 37).

Even as GHQ changed the form of the energy industry, it granted further legitimacy to powerful actors like Matsunaga, and created conditions for new forms of collaboration rather than the begrudging compliance and competition that had prevailed during the war. Not long after, US President Eisenhower began promoting so-called *Atoms for Peace*, and in 1955 Japan established the basic law for commercial use of nuclear power (Yamazaki, 2009). In 1956 it then established a nuclear power committee, although for this early period of nuclear power development it mostly received reactors from abroad and conducted research. Commercial nuclear power began in 1970 in Japan.

The oil shocks of that decade provided a catalyst for more development of the domestic nuclear industry (Oshima, 2010: 29-30). Having already moved to oil at the encouragement of American oil interests and begun the shutdown of the domestic coal industry (Kimura et al., 1996: 236), nuclear power increasingly represented a much needed and economical solution to an energy problem exacerbated by the reliance on imported oil. Nuclear development tied together American interests, the Japanese government, utilities, large energy consumers and pro-nuclear academics by distributing authority to small groups that shared a priority of maximum

[17] 過度経済集中排除法 *Kado keizai shuuchuu haijohou*

production for the sake of shorter-term energy security, political stability and economic growth. These groups would be called the "nuclear village", a metaphor used to represent a small community that succeeded in concentrating power and guiding policy away from broader debate on the questions of nuclear technology, environmental responsibility, democracy, and control over energy (Sataka, 2011: 144, 147, 153).

In 1974, the Three Power Source Laws[18] were created. These were effectively used as a means of funding nuclear projects while placating local governments into accepting nuclear energy through promises of government support and economic development. Funding was amended in 2003 to also include more hydro and geothermal, but the amount given to hydro and geothermal has been extremely small compared to the proportion given to nuclear power (Oshima, 2010: 32, 35).

There was substantial opposition to the development of nuclear power. Yuko Hirabayashi (2013) argues that the image often held of the anti-nuclear movement as one that failed to win notable victories in the court or over facilities already being built ignores the many nuclear plant projects that were abandoned following public opposition. The same year the basic law for nuclear power was established, a full third of the Japanese population was said to have signed a petition against nuclear weapons trials, and public opinion remained unfavourable to nuclear power in the aftermath of the devastating nuclear strikes on Nagasaki and Hiroshima (Yamazaki, 2009). Hirabayashi (2013) identifies 53 cases where plans were retracted or have not advanced to construction with up to 30 more where issues with processing, nuclear waste have led to a public

[18] 三電源法 *Sandengenhou*: 電源開発促進税法 *Dengen kaihatsu sokushinzeihou*、電源開発促進対策特別会計法 *Dengen kaihatsu sokushin taisaku tokubetsu kaikeihou*、発電用施設周辺地域整備法 *Hatsudenyou shisetsu shuuhen chiiki seibihou*.

refusal or a deferral of a final decision on nuclear power plant projects (37-39). What is especially notable is that the majority of these are projects that were planned in rural areas, with Hokkaido alone having 6 of the 53 on the list. These opposition movements were tied up with broader environmental concerns around pollution (公害 *kougai*) and other social movements (Hirabayashi, 2013: 40; Miller, Thomas and Walker, 2013; Kurihara, 2005; Sataka, 2011).

Public outrage over disasters, ecocide and homicide by corporations (as in the case of Minamata), and many other environmental and social issues raised serious questions about sustainability of modern industries and cost to society. Out of these come concepts like 循環型社会 *junkangata shakai* (circular society) and 自然共生社会 *shizenkyousei shakai* (coexistence with nature society) that have been used by government to reform or rehabilitate industry in order to project a new kind of balance and stability between nature and modern society (Yoshida et al., 2012: 38-39). This is despite the fact that the roots of these concepts lie in a more complex and socially turbulent history of disaster, protest, violence grief, and fear for the future (Kurihara, 2005; Kanai, 2021). It also belies how so far in Japan (as in most developed countries) this ideal new coexistence with nature through the transition to sustainability has failed to seriously address the climate crisis.

Worse yet, Oshima Kenichi (2010) finds that climate change policy in Japan since the 1990s and the Kyoto Protocol as well as the 省エネ法 *shouene hou* (energy saving law) have been used as a pretext to strengthen the reliance on nuclear power. Accompanying policies have aimed for low-hanging fruit to implement soft changes through energy efficiency and saving rather than requiring large energy consumers to meet fixed, public targets. The policies also relied on models to calculate energy supply and demand that were not fundamentally transparent or comparable, but nonetheless centered exogenously applied factors such as population increase and GDP on energy use (implying a correlation without intellectually justifying it) (Oshima, 2010: 10).

Nuclear power was set apart from the rest of the energy production industry and had its development path confirmed yet again by governments making their reliance on it key to stability and emission reduction. The growth of nuclear power plants was used to offset the increase in coal-powered plants built as late as the 1990s, with the goal of combining cheap but dirty fuel with one that had relatively low carbon emissions (Oshima, 2010: 15). Japanese government models also had rough and optimistic estimates of nuclear reactor usage, aiming for 80% but consistently often falling below this from the 90s due to aging power plants and ignored safety standards leading to accidents and issues that were not always made public (e.g. the 1999 Hokuriku Electric Power Company accident not made public until 2007) (Oshima, 2010: 16-17).

Key assumptions of this world of energy management were based on the 1972 World 3 computational models and the Limits to Growth report that enabled the idea that efficiency and technology could lead to a soft landing for capitalist society so long as the population was kept stable or in managed decline (Yoshida et al., 2012: 44). The transition to a low-carbon society, circular society or society coexisting with nature was at the heart of imaginations in laws and strategies passed in the 2000s (e.g. Basic Law for the Promotion of a Recycling-oriented Society[19] in 2000, National Strategy for a 21st Century Environment in 2007) as possible through technocratic management, engineered efficiency and citizen compliance (reduce, re-use,

[19] 循環型社会形成推進基本法 *Junkangata shakai keisei suishin kihonhou*

recycle) as if human civilizations had not already irreversibly changed the ecological cycles of the environments they inhabited (Yoshida et al., 2012: 55).

3.2 Fukushima and the Feed-In-Tariff

It is difficult to overstate the influence the 3.11 triple disasters have had on thinking about nuclear energy in Japan and other nations. A single event managed to completely change the assumptions about economy, oversight and safety that social movements had been attacking for decades (Oshima, 2010; Yoshida et al., 2012; Srinivasan and Rethinaraj, 2013; Kikuchi, 2021). So much has been said about the Fukushima Daiichi nuclear disaster that *Fukushima*[20] has become another globally-used one-word expression for a myriad of different, overlapping problems from one environmental disaster that make it hard to summarize or limit to one aspect (e.g. Bhopal, Exxon Valdez, Chernobyl, Beirut) (Fortun and Frickel, 2012). For the purposes of this research, there are three aspects of the disaster that are of relevance for now: the impact on the idea of safety and of energy infrastructure as stable, the perception of the relationship between energy utilities and the government, and the introduction of a new Feed-In-Tariff in 2012 in response to the shutdown of nuclear power generation.

Some of the most shocking aspects of the Fukushima Daiichi disaster for liberal society was that it happened in a developed country like Japan, was caused by an earthquake (a phenomenon which Japan is used to experiencing), and that it was outside the expected area for a massive earthquake to strike. The assumption of nuclear power as safe combined with the cultural image

[20] In Japanese it is often referred to in katakana, フクシマ, as a means of denaturalizing or abstracting from the placename and point to the global and conceptual connections of the Fukushima nuclear disaster.

of Japan as a country known for its technological innovation and regulatory alignment with world powers like Europe and the United States to produce the so-called *safety myth* (安全神話 *anzen shinwa*). This mythology, as a set of assumptions about the infallibility of safeguards and expertise, made the possibility of such a large earthquake in this location producing this kind of disaster unthinkable (想定外 *souteigai*) (Fisch, 2013; Kubara, 2012; Saito, 2021), at least to those within the nuclear village of government and industry from which this myth exuded (Sklarew, 2018). The shattering of these assumptions allowed the disaster to expand beyond the reactors, into the regulatory bodies and government task forces before and during the response to the disaster, by allowing problems to be swept under the rug and then hampering a coordinated and timely response (Hatamura et al., 2014)[21].

This is not to say that the incident was unthinkable to everyone in Japan. As discussed above, there was significant opposition to commercial nuclear power development in the wake of corporate pollution incidents in Japan. Other nuclear disasters like Chernobyl and Three Mile Island had already shown that while the basic science behind nuclear energy worked, the secrecy and authority around nuclear science meant that even the most powerful nations were able to severely mismanage it. Japanese cultural products like Godzilla and Akira also speak to an imagination of disaster that does not conform to the safety myth in cleanly separating the commercial nuclear power of Eisenhower's speech with disastrous effects of atomic weapons (Napier, 1993). Similarly, Kurosawa Akira's *Dreams* (1990) anthology film involves a segment

[21] It should be noted that some (Nesheiwat and Cross, 2013) claim this disaster was brought about by the fact that loyalty to one's employer and the desire to not cause a stir have historically been valued attributes in Japanese society. Sataka (2011) makes a similar but much more nuanced claim that the *sontaku* or deferential surmising of superiors' intentions and expectations within utilities exacerbated the problems of utility management for decades. However, while there are surely particularities in the expressions of difference and communication within this expert community in Japan, these problems are not unique to Japan, and the reduction of a complex socio-technical system to workplace culture avoids broader questions about the assumptions that allowed this disaster to take place.

called *Akafuji* in which a natural disaster causes nuclear reactors to explode and release radioactive chemicals as people lament being told nuclear power was safe.

Despite the realization of some of the worst fears about a nuclear disaster from fiction, the attitude of utility companies towards the safety of nuclear power generation has been criticized for reiterating its safety and using the disaster as a call for expensive upgrades to help bail out aging facilities (Hatamura et al., 2014; RIEF, 2019). The government has in some respects recognized that it and the utilities fell in the trap of the safety myth, but also insists that it now has the strictest regulations in the world that would prevent a recurrence (Agency for Natural Resources and Energy, 2014). However, it has not prevented the government from continuously attempting to revive nuclear facilities despite the exploding costs of the necessary upgrades (Yoshida et al., 2012: 158-163).

Comparisons between 3.11 and the 2008 Global Financial Crisis (GFC) have been made, as systemic risks were ignored and solutions favoured a return to the status quo without the dissolution of the groups responsible, leading to a socialization of the costs and an erosion of public trust (Kubara, 2012). The effort put into improving the system serves to justify its extension and re-entrenchement, rather than a substantial transition. One related material expression of this is what Michael Fisch (2022) calls *fortress-ification* on the coast of Tohoku, a kind of hard adaptation through the building of immense seawalls that is largely heedless of the implied human, ecological and financial cost of its infrastructure (let alone if it failed), and eschews attempts at mitigation or bottom-up change[22].

[22] I would also argue we can increasingly see in this kind of policy response a similar attitude to the climate crisis and (relatedly) the European refugee crisis where some hope for mitigation has given way to more (sea)walls, and

Whether or not there is in the post-GFC, post-Fukushima Japan an infrastructural echo of incipient fascism, 3.11 represented an unprecedented breach of public trust in the energy system and the future promised by the networks of power around nuclear technology. The relations that made up the nuclear village were challenged as the electricity grid became strained by the lack of nuclear power. The breakdown in electrical infrastructure from the 2011 Tohoku earthquake and loss of power generation from Fukushima Daiichi was followed by a debate over the scope for planned blackouts (Takeuchi, 2013). Vice Cabinet Secretary Fukuyama Tetsuro (2012) recalls in his book 原発危機: 官邸からの証言 (*Nuclear Crisis: Accounts from the Prime Minister's Office*) that the Tokyo Electric Power Company (TEPCO) was asked to seek the collaboration of large clients in reducing their energy use to avoid blackouts for people at home. TEPCO replied that they could not say such a thing to their clients (outright refusing a government request in the middle of an unimaginable crisis). The Chief Cabinet Secretary was infuriated by this reply, forced compliance by saying that TEPCO would be held liable and sued for willful negligence, if not murder, for any death resulting from their actions. The incident outlines the logic of energy maximalism embodied by most electricity grids as having had initially more sway on the company's response than a government demand during a crisis: just as energy producers are entitled to produce at maximum capacity, consumers are entitled to consume as much as they are able to purchase. In this way, under modern grid logic, who needs the energy for what generally goes unquestioned and only the balance of the ability to supply stable quantities is allowed to guide normal, daily operation.

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more *solutions* where cruel and painful treatment is viewed as more expeditious than actually trying to understand and adapt to difficult conditions (Gržinić, 2014).

This balance is built around just-in-time, near-instantaneous consumption, expected peaks, and in Japan a grid split between two frequencies of electric current (50Hz in the East and 60Hz in the West), making electricity harder to share across the East/West divide (Kadoi, 1991). The materiality and the reliance on baseload, *stable* fuels like nuclear, hydroelectric and fossil fuels for the entirety of the history of the electric grid produced networks of authority with shared assumptions of safety that viewed forms of electricity production with more variable output as unsafe and unstable (Nader, 1981; Johnston, 2017; Mitchell, 2011). However, the long-term efforts of environmental groups around the world and the need to diversify the energy mix away from both nuclear and fossil fuels led to the implementation of FIT in July 2012 (Johnston, 2017; Agency for Natural Resources and Energy, 2014).

3.3 Megasolars and Municipalities in Hokkaido

The Feed-In-Tariff promised private developers a high rate of return and stable prices for producing renewable energy. Japan had previously instituted a Renewables Portfolio Standard (RPS) Law in 2002, but it was largely a subsidy for existing energy sources, and gave a lot of leeway to utilities in meeting their obligations. As such, it was not particularly effective in increasing the transition to renewable energy (Oshima, 2010: 22). FIT replaced RPS in 2012. The year of its implementation, it promised 40¥/kWh for projects in excess of 10kW for 20 years (Agency for Natural Resources and Energy, 2023). At the time of writing, the 20 year fixed price for solar power projects in excess of 50kW is left up to a bidding process or set at 9.5¥/kWh, with projects above 10kW being priced in a similar range (Agency for Natural Resources and Energy, 2023). This 75% collapse in prices speaks on the one hand to the success of the policy, but also to the problems it brought with it.

Kitamura (2015) argues that under FIT, solar in particular represented an attractive investment opportunity for many given its short startup time and Japan's ultralow interest rates and low growth economic environment (206). In the first 4 years of FIT, new solar power constituted the vast majority of the increase in renewable energy production (Agency for Natural Resources and Energy, 2017a). By 2014, it was clear that FIT was contributing to a substantial increase in renewable energy production, but mostly subsidized development by large companies, and was propped up by very rich pricing the cost of which was borne directly by consumers (Yoshida et al., 2014). There were a growing number of cases where projects were approved but never ended up producing any power, forcing a change of policy to penalize this kind of behaviour and enforce stricter business planning standards (Kudo, 2019).

By some accounts in the media, the spread of renewable energy was a "revolution" that had managed to overturn the long-standing attitudes by utilities, academics and policymakers that renewable energy was too unstable and expensive to grow into an alternative to nuclear (Johnston, 2017). Yet renewables still only accounted for a fraction of Japan's electricity mix, and the country was still only producing 6% of the total energy it used (Agency for Natural Resources and Energy, 2017b: 3). The government was also quick to change the rules on compensation for new connections which were overwhelmingly made up of renewables. By allowing unlimited suppression without compensation for new connections in 2015, any excess renewable energy produced would be worth nothing while fossil fuel and other established energy forms could continue to operate normally (Wakeyama, 2018). If, as Ian Miller (2020) has suggested, Japan's accretion of energy forms has been an energy revolution more than a process of transition, then the FIT can hardly be said to be in and of itself the start of a revolution that undoes the built up reliance on imported fossil fuels or nuclear power.

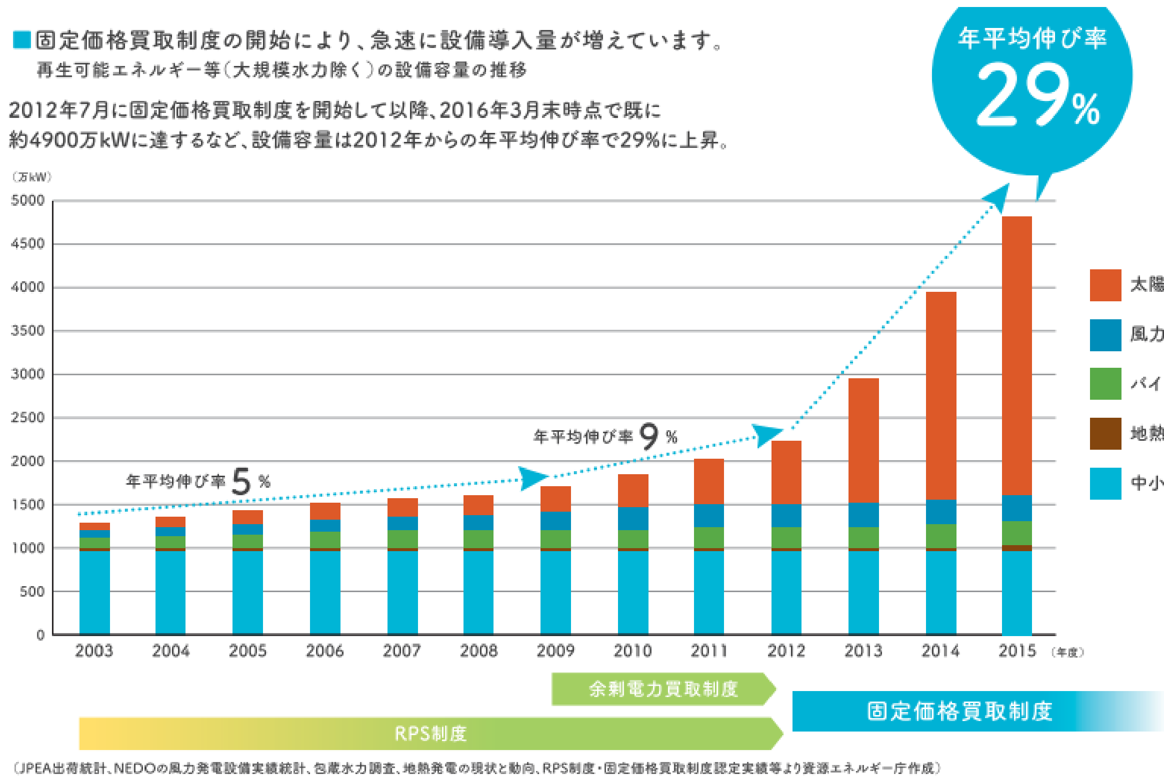

Figure 1: FIT dramatically increased the amount of solar power being produced (Agency for Natural Resources and Energy, 2017b: 5).

In addition, the communities that hosted large solar developments were not the primary beneficiaries of this private-led solar-intensive development. Instead of becoming a sign of hope for an energy transition in Japan, the large fields of solar panels fenced off and watched over through cameras from control centers afar became known as “megasolars” (Yoshida et al., 2014: 76, 81). Most people I interviewed who lived or had businesses around these megasolars knew very little about them, and had not had many, if any, interactions with employees of the megasolars. Some were glad to see the land used for green energy, but most had no particular feeling despite living or working right next to them.

When I happened to talk to some technicians checking on these megasolars, many of them did not work for the companies who owned the megasolar plants, but rather were contractors. They told me the company watches the sites from their control centre in Tokyo, and subcontracts the work in Hokkaido including regular inspections and troubleshooting to local technicians. One employee of a solar power firm operating out of Tokyo corroborated this mode of operation for their own company, and said that their work involved monitoring output levels. Infrared sensors on some sites would also indicate a defect in a panel, for instance, in which case they would have to have it replaced after a while. Megasolars were increasingly relying on cheap foreign parts for replacements, which meant the number of calls and costs for replacements had been increasing.

Figure 2: A relatively small *megasolar* being checked by a maintenance crew on the day of the East Iburi Earthquake, September 6, 2018 (photo by author).

Local ecosystems also presented their own challenges. Maintaining weeds at an acceptable level was a challenge for many sites in Hokkaido that were on unused farmland and other fields. In Osaka, one site I visited was on reclaimed land built on top of waste, which required drilling holes into the ground to let out the methane seeping out of the ground. Rodents and crows would also nip at wires. In other locations, the ground itself was uneven or at risk of impact in the case of a landslide, requiring monitoring for changes in these. In more northern and central areas of Hokkaido, the angles of panels must be sharper to allow snow to fall, and longer wooden pillars driven deeper into the ground to allow the panels to both stay above the snow and remain stable in case of an earthquake. In some cases, megasolars provide some cover from the wind for nearby houses, but this is rare.

For an island that accounts for only 3% of national energy consumption (Chang, 2013), Hokkaido has (again) become a zone for energy extraction as its underdevelopment has created the conditions for subsidized solar on cheaper land to thrive. Many communities are indirectly investing in megasolars through their local credit union, but these represent merely a fraction of the capital from large Japanese and multinational corporations that represent the investor class for these projects (Chang, 2013; Kaneko, 2017; Kato, 2017; Kudo, 2019; Yamada, 2018). Cymene Howe (2019) argues in *Ecologics* that despite their contribution to the energy transition, wind development projects in Tehuantepec, Mexico often reproduce the modes of extractivism and land management of the colonial petro-state. Given the imbalance between production and consumption, as well as the imbalance in benefit for communities near megasolar projects and indigenous people whose land has been taken, Hokkaido's solar development under FIT presents many of the same problems.

A key organization in Hokkaido renewable energy information sharing, the Renewable Energy Organization of Hokkaido (REOH), conducted a survey in 2017-2018 that gives some detail on the expectations of municipalities for changes to the energy system (REOH, 2018). It showed that only 20% of respondents wanted increased connections to Honshu, and 62% wanted policies promoting local production for local consumption. Impressively, it also showed that 40% of municipalities had already experienced some kind of trouble with their renewable energy projects, while the majority had not and also did not foresee any problems in the future. This survey conducted before the 2018 earthquake already suggested local governments were ready and willing to invest more in local energy resilience, had largely positive experiences with renewable energy implementation, and did not see reliance on the main island as a solution.

As one city employee in Muroran told me, some municipalities had created small-scale renewable energy projects in the late 1990s, but did not find the kind of support that let them continue those investments. “In Muroran, we built a few wind turbines. Perhaps you saw them on the way here. Those are expensive to build now, but were even more expensive back then [in the late 1990s]. It was a bit of an experiment. Unfortunately, most had to be taken down within a few years. Without the know-how and resources to operate them successfully, it turned into a bit of an embarrassment”. Though there are now many more wind turbines in Muroran, the municipality has not been active in large-scale wind or solar. Deindustrialization policy has hit the finances of industrial cities and created more dependency on Tokyo for direction, particularly in the wake of Yubari’s bankruptcy in 2006 (Seki, 1996; Tanaka, 2011). Muroran City has been ahead of most in Japan in turning its waste management system into an energy source through the creation of biomethane (which is then burned in a generator to produce electricity and sold through the FIT to utilities). However, it has had to rely on private investment and know-how: the city operates the sewers but a private company operates the energy production (Nagamachi, 2016).

The association between waste-recycling and economic decline is perhaps not seen as associated with moral failing as it is in other contexts (Gidwani and Maringanti, 2016). However, it does point to similarities between Hokkaido and other disinvested regions like Catalunia, in which the government's investment in energy relies on imagining the area as full of waste: lagging, materially impoverished, and on a path of agricultural decline (Franquesa Bartolome, 2018). As I have discussed in these two first chapters, it is not that there were not efforts to build up know-how and develop local energy infrastructures, but that these were rarely given much support, and soon replaced by the the post-war state and US-approved monopolies with technologies of the American empire: grids run by computers on imported oil and nuclear power. However, now left without many assets, without much know-how and with limited government support, local governments find themselves hard-pressed to lead a movement towards local production or any other form of energy transition.

3.4 Challenges to the Feed-In Future

Hokkaido's energy infrastructure has, like many other areas in Japan, shambled along without much change from the end of the period of high economic growth until relatively recently. Even following the 3.11 disasters and the introduction of FIT, renewable energy has not replaced the proportion of production once held by nuclear power. However, how renewable energies are changing the dynamics established between local areas and the central government, and the lives of people in Japan, remains an open question. Both of these sets of energy policies and technologies supported different generations of liberal assumptions about energy: maximum production should be guaranteed for those who produce, and usable at all times of day by anyone with the ability to transact. Science and technology studies have been shaped by challenging the assumptions of liberalism and the increasingly restricted scope of political possibilities that it and its supporting technologies offer (Marres, 2018; Thorpe, 2008)

Given the colonial history of Hokkaido, and the implementations of successive extractive policies, I have explored here that the hope for renewable energy companies and the government to deliver a green transition ignores the way the Japanese state has continuously collaborated with elites to take control away from local governments and people. The point of this chapter is not to explain the transition in Japan, or to fit it into this or that socio-technical or political framework (Cherp et al., 2018), but to make the liberal assumptions of the energy transition, too often imagined as merely tweaking the grid's system, itself into a theoretical problem. The focus on abstracted modes and places of production in national energy transitions (e.g. wind power, nuclear power plants, political influence writ large) does not bring us closer to understanding the redistribution or concentration of power, or the material changes for the lives and ecologies that renewables transform.

In chapter 4, I take up how these questions around who energy infrastructure serves and the negotiation of local autonomy of energy re-emerged in the wake of the 2018 East Iburi Earthquake. Chapter 5 focuses on the dairy-producing central regions of Hokkaido, the experiments with heat by biogas producers, and the new infrastructure projects emerging from the multispecies project of making heat and electricity using cow manure and bacteria.

4. Doing Resilience

In this chapter, I try to trace the impacts that the seismic shock in Hokkaido has had not only on the operation of the grid, echoing the shock of 3.11, and in particular with how it is shaking up ideas of resilience as well as the way people live with the grid (Sekine, 2018). I begin by going over the events of the East Iburi Earthquake of September 6, 2018 from my own recollection, interpreting it as an inversion of normal infrastructural operations that also left lasting disruptions to the way experts and others see the future of energy infrastructure. The earthquake was an event that made grid infrastructure into a public problem and a point of divergence between the resilience of national ministries focused on greening the grid, and resilience tied to local environments and people as articulated by renewable energy experts in Hokkaido. I then review the two main sets of resilience practices and finally examine their relationship to each other and the way resilience and its trappings in systems thinking may not describe the growing disengagements from grid infrastructure. In doing so, I am both drawing on the concept of resilience in exploring how collective life within the grid has not returned to an original, stable state of infrastructural relations, and interrogating the uses of the concept of resilience in scholarship reviewed previously, and in the field. This instability is marked by the existence of different ways of doing resilience, and multiple models of how to understand the place of the electricity grid in the future of a renewable energy transition.

Indeed, the name of this chapter is a reference to Mol's (2002) first and last chapters in *The Body Multiple*: doing disease and doing theory. In *The Body Multiple,* Mol discusses the various practices of different physicians in a Dutch hospital. The same disease, atherosclerosis, in the same body is enacted differently by these physicians, to produce different atheroscleroses. These are not just different understandings or social practices of the disease but different diseases by virtue of the effects, places and practices that go into diagnosing, treating and living with them. In this way, Mol argues, the production of a single disease called atherosclerosis is the result of significant effort and coordination between a few practices of disease. A similar argument can be made about resilience in Hokkaido's electricity grid, where multiple practices of resilience are in fact making different grids and different models of energy infrastructure. In this sense, infrastructure is not just physical structures of energy production, but the use of models, senses of heat, co-constitutive relations with national energy priorities, and fears of being left to the cold. The plurality of practices with and outside of the electricity grid present their own complexities, however.

Interestingly, the term resilience has a history of use in relation to earthquakes in Japan, and a complex history of use in anthropology. It was notably used to describe the ability to recover from adversity by Americans in Japan witnessing the response to two major earthquakes in December 1854. Use of the term in academic discourse has potentially grown out of anthropology. From mechanics and medicine, the term crept into the social sciences from the 1950s. Interestingly, it found purchase in anthropology (before C.S. Holling popularized the term) through the work of Melville Herskovits, from where Alexander (2013) assumes it was picked up in psychology. In turn, as I discuss later in the chapter, the electricity grid's issues of system stability became the basis for systems thinking before such a term even existed (Özden-Schilling, 2015).

This hidden history of anthropology as the possible cross-polinator of the concept of resilience across the “hard-soft" scientific divide is worthy of its own genealogical investigation. For the purposes of this research, it will have to suffice for now to say that the term resilience has enjoyed varied use in academic fields, with some ambiguity in how the term has been defined despite the changes in use throughout history and contexts from the strength and ductility of steel beams to the ability of social systems to retain function through dynamic equilibrium and adaptation.

Although on the surface, the central government, renewable energy experts, local producers and activists all seem to agree on the need to rely almost only on renewable energy, their models for societal adaptation and scale-making activities diverge significantly following the 2018 earthquake. While the relationship between these modes of doing resilience is unsettled, I argue there is still some measure of coexistence. Renewable energy experts in Hokkaido in part translate the practices of municipalities and activists to the government, even as the latter often must depend on central government funding to attempt to build more independence from the national electricity grid.

4.1 Seismic Inversion

I woke up in the early hours of September 6, 2018 to the feeling that I was at sea. Even through my bleary eyes, I could see I was in my bedroom and yet it was as if the floor had turned to some non-Newtonian liquid. I remained still. The sound of clattering kitchenware and light fixtures falling made me worry the roof or floors would be next. This only lasted a few seconds. It quickly became clear to me what I had experienced: I had survived my first earthquake of significant magnitude. Now thoroughly awake, if still disoriented, I checked my phone. There had indeed been a relatively powerful earthquake with its epicentre about 50km from my home in Yubari. Insulated by the mountains, we had only felt it as a magnitude 4.

I turned on the lights to see a few plates had fallen from the drying rack. Inspecting the rest of the house and looking out on the neighbourhood from my window, there seemed to be no signs of damage. The street lights were on. I went out to see my neighbours talking. One of them told me this was the strongest earthquake they had ever experienced, and they were in their 70s. It seemed there was no one in need of assistance around me. There had been a typhoon the day before, and power had only been restored late in the day. I remember feeling grateful to have electricity running for this second disaster in two days. I had sat down and began notifying family and friends when all the lights and appliances went out with a humming decrescendo. It was the beginning of an islandwide blackout that would transform the path of my research.

I gathered information from news websites and social media that indicated that the cause of the blackout was a failure at the largest active power plant in Hokkaido (providing 40% of its electricity demand) located in Atsuma, approximately 40km from Yubari, where I was based. Behind the scenes, at the Hokkaido Electric Power Company, a flurry of quick rebalancing efforts had been made through the computer systems that manage the grid, ultimately ending in failure (Sekine and Sakurai, 2018). First, immediately following the earthquake, the Atsuma plant's 2nd generator failed, leading them to shut down all variable output from wind, and some hydropower plants in addition to forcing some blackouts, restoring balance through the undersea connection to the main island. Second, not two minutes later, as people woke up and turned on their lights and appliances, demand began to takeover available supply, forcing them to raise the output from thermal plants outside Atsuma, but about 10 minutes later the remaining first generator at Atsuma, which had sustained damage and was leaking steam, was failing, forcing yet another round of blackouts a minute later. Finally, 3 minutes after this, the first generator at Atsuma's output went to 0, forcing a total blackout and stop to all remaining thermal plants.

I got on my bicycle and began to head towards Atsuma, a 3 hour one-way journey. The extent of the damages became apparent even before I left my neighbourhood. A large fault had opened up in front of the public washroom down from the local train station. At the train station itself, all trains had stopped. Employees I later spoke to said they were reporting possible damage to the train tracks. Following the Yubari river south, the hydroelectric dam built in the 1920s, which usually had only one car in front (if that) was a flurry of activity, with at least 6 people and multiple vehicles on the outside. Hydroelectric dams, I would later learn, were crucial in rebuilding capacity as they provided stable output that would enable thermal plants to restart, and then with that baseload would restart the rest. I noticed no outward damage to most other infrastructure in the area, but did see inspectors looking at rail lines in dismay, some of them clearly bent out of shape.

I visited the largest solar park in the area, and one of the staff informed me that everything was shut down. Rows and rows of solar panels extended south almost beyond my field of vision, one of Hokkaido's famous megasolars. At the entrance, a board showing statistics on electricity production showed the plant's current output: 0 kilowatts per hour. It was a total blackout here too. Workers were sitting inside in the shade, some were making calls outside to get more information. Speaking to one of a few employees onsite, a relatively rare occurrence given that they are usually monitored remotely, they said that they had to wait until they got word from HEPCO that they could send output into the grid again. They heard only a few power plants were online at that point. Renewables, even large ones like this, because of their variable production would be last, even on a perfectly clear day like that one. “It is a waste. Let’s hope they restore power soon”, he said.

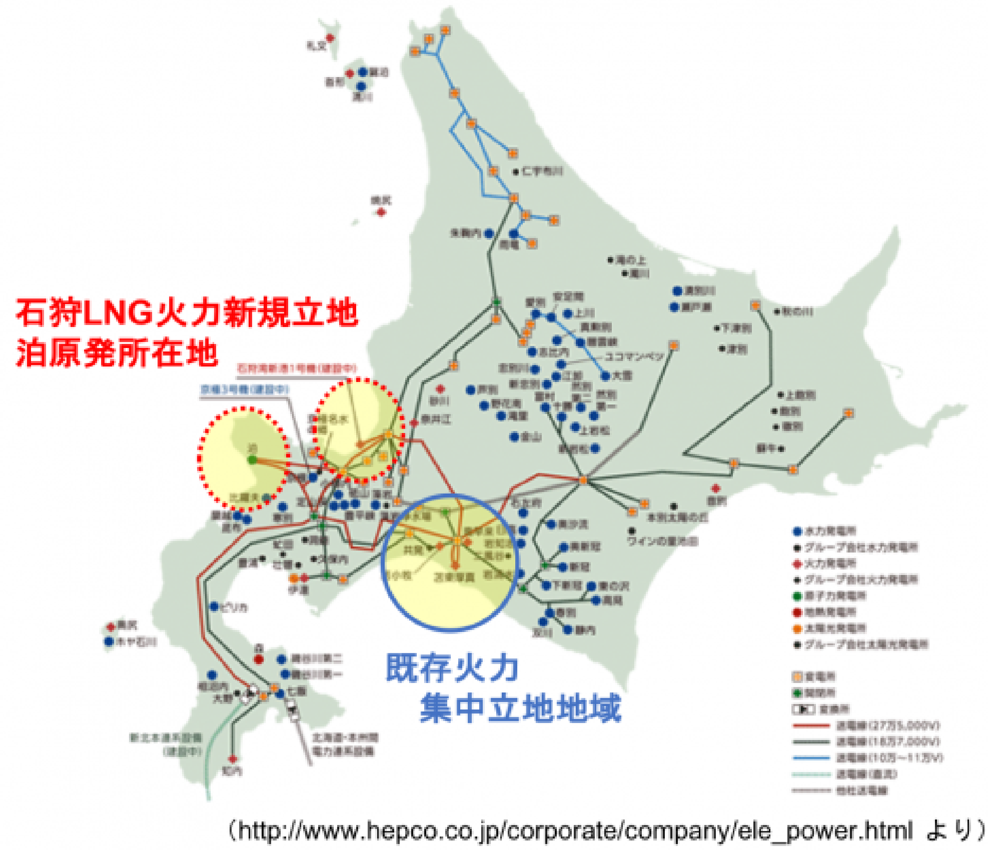

Figure 3: A map of power plants in Hokkaido indicating areas of concentrated production: older thermal plants in the blue circle including the plant in Atsuma, and the nuclear power plant and planned LNG plants in the red (HEPCO, 2017).

On social media, many people I knew in smaller towns in the Sorachi area had their water cut off, as well as power. Most had only gotten the power back in the afternoon the day before. Some were being instructed to take refuge in evacuation sites, usually local schools. Navigating towards the Atsuma power plant, I passed through a road that brought me close to the town of Atsuma, where the damages were most acute. I could see the landslide from afar. At least fifty JSDF and emergency vehicles passed by. In towns west of the epicentre, many were moving to evacuation sites. Convenience stores and other businesses were getting rid of melting inventory while also selling drinks to lines of thirsty people. Long lines formed outside gas stations. The Atsuma power plant itself was relatively quiet by the time I arrived, and there was no one around to speak to.

By the time I returned home in the early evening, it seemed power had been restored in most homes in Sapporo. It would take a few more hours for power to be restored in my area. In many other rural areas and even in certain parts of Sapporo, it would take days for electricity and water access to be restored (Umetsu, 2018). In subsequent days, on social media and in conversations with my neighbours and friends, many people would express disappointment and frustration about yet another “unthinkable” natural disaster that, while the strongest they had ever experienced, was not unforeseeable in Japan. One acquaintance commented that it was not fair that Hokkaido should have to shut down its whole grid to avoid compromising Tokyo’s while they used Hokkaido to make clean energy. In conventional media critical perspectives rang out as well, pointing out the parallels with the 3.11 disaster and questioning why the investigation had not dug deeper into the structural weaknesses that HEPCO had failed to account for (Asahi Shimbun, 2018).

Many I spoke to and many accounts I read continued to express fear of what would happen should there be another seismic shock or similar disruption like this in winter, with oil heaters selling out in many places in the days following the earthquake (Umetsu, 2018). The president of HEPCO, at a press conference on October 31, 2018 made reference to the government working group's interim report on their investigation and said they would implement the precautionary measures listed to prevent a widespread blackout in winter (HEPCO, 2018). Even three years after the earthquake, many participants would still raise fears of a blackout in winter. For elderly parents in rural areas and other vulnerable populations, it could mean death.

Although the Japanese government seems willing to continue to invest in the resilience of energy infrastructure in Hokkaido, the proposed improvements are mostly centred around keeping economic activity in cities like Sapporo stable and lowering reliance on foreign coal[23] (Agency for Natural Resources and Energy, 2020). For instance, there is a budget for creating "master plans" for microgrids in regions, with 4 of the 12 accepted candidatures coming from Hokkaido. However, each of these projects only received 2 million yen (approximately 156 000 USD) to conceive of the projects, with only one in Ishikari near Sapporo being implemented, and it had already been planned. Each entry from Hokkaido in the submitted plans cites the 2018 blackout and the anxiety of residents about the grid following the 2018 blackout (SII, 2021).

In the days after the earthquake, some semblance of normality would return. However, the seismic shock of the earthquake would begin to raise again the problem of infrastructural resilience to earthquakes for the first time since the 3.11 disaster. The 2018 earthquake gained national attention but it was not a globally mediatised disaster that held the world captive like Fukushima. Newspapers printed editorials calling for more distributed, autonomous and local

[23] This is not to say that METI and other arms of the government are not at all concerned with local use of ambient heat and snow. It has, for instance, published collections of examples from all over Japan in collaboration with the Hokkaido Economy and Industry Office (METI, 2012).

energy infrastructure with storage capacity while balancing needs between utility jurisdictions (Asahi Shimbun, 2018). Energy became an important issue during the 2019 Hokkaido gubernatorial election. Greengrocers, farmers, inn managers and others[24] I knew which had previously not given much thought to the grid (and did not have much interest in my new research topic) began to think about using solar panels, or bought generators with the government aid money sent during the start of the pandemic.

Clearly then, the earthquake and blackout had made visible relationships to energy that gave rise to feelings of vulnerability that have survived beyond the recovery of the technical systems that failed on September 6th 2018. Technocratic efforts and reassurances have allowed electricity to flow once again, but the experience of such a seismic inversion of everyday life has reified the material relationships between cities full of people, depopulating rural areas, electricity lines at full capacity, aging thermal plants, nuclear plant shutdowns, fields of solar panels, and the ecologies that surround places of energy production and consumption. My use of inversion here draws on the idea of infrastructural inversion by Geoffrey Bowker (1994), in the sense of a breakdown in otherwise invisibilized infrastructure that makes visible the relationships it undergirds and allows.

My review of history in the previous chapters shows that an overreliance on fossil fuels since the 3.11 disaster, as well as shaky assumptions about aging infrastructure and the unthinkability of disasters allowed this breakdown to happen. The fallout of the 2018 Eastern Iburi earthquake raises the issue of what relationships or principles it made visible to whom, and what affects and

[24] While anecdotal, I take these small changes to be representative of a shift in collective life because they represent significant investments for these small business owners to make despite the apparent stability of the flow of electricity since.

practices have emerged that might not be easily reconciled with the government's plan for resilience-building. Different understandings of resilience emerging from the 2018 earthquake are indexical of different practices and models for the future. In a more abstract sense, resilience can also be a process of making one or multiple systems more able to respond to an imagined, and often modeled, future.

4.2 Resilience in the Field

My first encounter with the problem of resilience in the electricity grid actually predated the 2018 earthquake. At a symposium about rethinking Hokkaido's electricity grid in August 2018 hosted by REOH, presenters from Hokkaido and Kyushu universities and businesses gave 30 minute talks to a crowd of about 160 people in a conference room in downtown Sapporo. Almost all the attendees appeared to be men in suits or uniforms. Based on the chatter around me, I gathered most of them were representatives of municipalities that were members of REOH, and representatives of the Hokkaido utility company HEPCO. A senior professor introduced the theme of the symposium through reference to the problem faced by renewable energy producers of late in having trouble establishing connections to the electricity grid in Hokkaido.

北海道でもソーラーパネルとか、風力、そして今日お話になされると思いますけれどもバイオガスですね、こういう発電をやり始めたんだけども、なかなかその送電線に乗ってられないという問題が北海道でもあるようです。こういった問題を始めとしてエネルギーをくいつくには色んなハードルがある訳で、誰が解決するかという時に、私たち自身が解決できなければいけないということになります。北海道で自然エネルギーを確保するためには、我々道民がですね、自分

でどうするかと...全て考えると、地域で、いろんな形で、エネルギーを自分たちで使えるようにしていくのを考えなければいけないというのは、必要だと思います。

(In Hokkaido too, we have started producing electricity with solar panels, wind and I'm sure biogas will feature in today's talks too, but the ability to have this enter the electricity lines has been a problem here as well. Starting from this kind of problem, to get a grip on the energy situation, there are many hurdles. Who can solve these? We must solve these ourselves. To secure naturally produced energy in Hokkaido, we the people of Hokkaido must ask ourselves what we should do. Thinking about it all, in each region, in multiple forms, we must think about how to make energy that we may use ourselves.)

While this senior professor made no direct reference to the concept of resilience, the call for a Hokkaido capable of creating its own energy, independent of the rest of Japan's islands, was representative of the kind of desire for energy independence that would gain even more traction in Hokkaido after the earthquake. One additional implication of the necessity of Hokkaido residents themselves accomplishing this was that the central government will not necessarily support renewable energy in a way that makes it available for the people of Hokkaido. As discussed before, the government's FIT policy itself is in part responsible for rapidly congesting the electricity lines in Hokkaido by allowing profit-seeking parties to tap into public infrastructure without much thought to slower-moving, less profit incentivized actors.

The professor's provocation pointed to the way in which market-driven policy had created strains on public infrastructure. These could be aided by changes in the electricity system's management, but ultimately required more fundamental changes in reorienting use and production to different, smaller scales. In other words, building *resilience* in the system could help in the immediate term, but the problems revealed called for a more radical independence. This is, in my view, the central difference between the government's understanding of resilience and the understanding of many renewable energy experts in Hokkaido: for the central government, the task of building resilience is a technocratic and national one focused mostly on the electricity grid and electrifying interconnectedness: they are changing the rules of the grid to permit more connections from renewable energy producers, reinforcing grid infrastructure that connects Hokkaido to Honshu, and promoting the use of IoT and smart technologies to digitally manage end user demand. For Hokkaido energy experts, there is no renewable energy transition without a massive movement of people acting independently of (but preferably in concert with) their government to make use of cheap and ambient energy, and build resilience locally. Though both are inspired by European examples of energy transition, both of these sets of technologies bring with them a theory of how to do resilience, how energy should be used, and how severe the climate crisis is. It is to these two sets of technologies of resilience that I now turn to.

4.3 Making Grid Capacity

At the same symposium, the following presentation from a professor from Kyushu University introduced the change of rules that the government was beginning to implement in order to manage new connections from renewable energy producers. This was the connect and manage approach to operating electricity grids, which opens up existing capacity in electricity lines through a change in fundamental assumptions about use and what kinds of producers should be prioritized. Under the traditional hard management system, capacity in electricity lines was capped at 50% of normal output (known as equipment capacity or 設備容量 *setsubi youryou*) to allow for leeway in emergencies. However, the way this capacity is calculated depends mainly on use at the peak of the year, usually during the end-of-year holidays in Japan. During most of the year, electricity lines would then operate well under capacity, but allow all producers to produce at maximum capacity. New entrants would be denied and forced to pay for new lines despite the relative amount of capacity left open in order for existing energy producers to maximise their output safely. This had created a situation in Japan where most main electricity lines were already at full capacity according to HEPCO, particularly in areas with lower population, lower infrastructural investment but fast growing renewable energy output like southwestern Hokkaido.

Connect and manage is an alternative currently in use in many parts of Europe and in the Philippines which changes the definition of safety and system resilience to accommodate new renewable energy producers in the grid. The connect and manage approach has two components: N-1 electricity management and non-firm connection. N-1 differs from the 50% cap in that the safety buffer for capacity is defined by a system that is resilient to any one node being taken out of function. In the case of the 2018 earthquake, even the traditional safety metric failed to prevent an imbalance in supply and demand. With a dynamic understanding of safety that (on paper at least) hedges against the concentration of power output in older, fossil fuel powered plants, capacity in the lines can be freed without necessitating additional construction.

Relatedly, non-firm connection is the principle of dynamically suppressing output based on which energy is most expensive rather than giving priority to prior connections maximising output. This allows renewable energy which has rapidly become inexpensive to produce like photovoltaic energy to take share from more expensive imported fossil fuels like coal and oil, but does create more overall congestion (i.e. use of capacity, wearing down the lines). Somewhat paradoxically, connect and manage proposes a system based more closely on actual use rather than fixed worst case scenarios as a means of avoiding worst case scenarios. The logic behind this being that a more dynamic and distributed system with more renewable energy will be less likely to suffer the risks of concentration from disasters, and more rapidly re-establish some capacity in the system after a disaster rather than having to do a hard reset as happened after the earthquake in 2018.

The Agency for Natural Resources and Energy, a department of the Ministry of Economy, Trade and Industry had put out a report in January 2018 outlining the possibility and issues of implementing a connect and manage approach in Japan as had been implemented in Europe in order to allow incoming renewable producers to connect to the electricity grid (Agency for Natural Resources and Energy, 2018). The report compares Japan's few accommodations to renewable energy in prioritising renewable output (but not connections) and its introduction in 2017 of auctions to bid for grid connection to three varieties of connect and manage in England's connect and and manage system, Germany's priority connection to renewable energy producers and Ireland's non-firm access approaches. All of these allow new connections without necessitating new construction on the electricity lines, but create congestion and different calculations of emergency capacity.

Since the earthquake, the Ministry of Economy, Trade and Industry has moved more quickly and introduced connect and manage principles to Japan's grid management in phases. This included important policy changes like introducing a connect and manage approach that scrapped the measurement of capacity based on installed capacity, the transition from Feed-in-Tariff to a Feed-in-Premium that helps price competitiveness of renewables at fluctuating rates according to the market as opposed to a fixed rate, and the legal separation of transmission network ownership from utilities. Each of these would require a more detailed description, but the general direction of these reforms is to use European models of renewable energy liberalization and grid management to attempt to lower costs for producers and consumers while reducing government subsidies by working towards grid parity (the cost of renewable energy production being equal to or under the rest of the grid).

The main undersea cable connecting Hokkaido and Honshū has also figured in the government's response since the earthquake. It was initially destined to carry electricity produced by coal-fired power plants *to* the main island, with Hokkaido's coal reserves being in high demand in the immediate postwar. However carrying the coal by boat was found to be less costly, and the project only resurfaced in the 60s when converter technology had also developed further (Nakano, 1977). Ironically, by the time the line was completed, in the late 70s, Hokkaido's coal industry was in precipitous decline (Culter, 1999). Until the earthquake, it had the capacity to send approximately 15-20% of Hokkaido's energy output or have the same amount of its demand covered.

Following the earthquake and an investigation by the Organization for Cross-regional Coordination of Transmission Operators or OCCTO (OCCTO, 2018; 2021), the Ministry of Economy, Trade and Industry's Electricity Resilience Working Group found that HEPCO was not responsible for the blackout, finding no problem with its power provision system, and recommended increasing the development of renewable energy alongside a 50% increase in the connection capacity between Hokkaido and Honshū, with the main purpose of sending electricity northward, something which was already underway in late 2014 according to HEPCO (2014)[25]. A recent review of Japan's energy future scenarios finds that this cable is more likely to be useful to send electricity from wind farms in Hokkaido as its output will exceed its ability to use it (Nakanishi, Saito, and Yokoyama, 2016).

The Ministry of Environment has been active in presenting its new policies in Hokkaido. In a presentation on its comprehensive vision of a decarbonizing *Society 5.0* in May 2019, the Ministry of the Environment emphasized municipalities resilient to disasters, distributed and independent energy production and consumption, while also noting the contribution of IoT to innovation in energy and design. A scheme shows rivers, villages, the sea and forests in the centre, but the vast majority of the chart is covered with areas of economic activity and policy ideas that stretch out and overwhelm the place in this vision of Society 5.0. The name of this scheme, *Chiiki junkan kyosei-ken* (the latest iteration of the circular/recycling society mentioned in the previous chapter), is translated by the Ministry as the 'Circulating and Ecological Economy' but might perhaps be better translated as the *Regional Circulation Co-Existence*

[25] Hokkaido has been slightly more proactive in its policies to achieve energy independence. Even before the 2018 earthquake, Hokkaido had started requiring new megasolars to build some battery capacity in order to avoid suppression and improve their ability to provide stable output (Kaneko, 2017). It has also inscribed its duty in law to secure its own energy and develop environmentally friendly energy to allow humans and nature to coexist (Hokkaido, 2011).

Sphere[26]. In this deliberate move to combine physical and virtual space for a human-centric next generation of society, it is envisioned that we will leave behind the constraints of hard labour, hidden information, and other social problems that still affect us in our 4.0 information society (Cabinet Office, 2023).

Figure 4: One of many iterations of the diagram of the *Chiiki Junknan Kyoseiken* used by the Ministry of Environment (2022).

Furthermore, in this scheme, AI, technological efficiencies and more renewable energy will make life easier. However, there is little in this society's scheme that is there to ensure that

[26] One could make a provocative argument for the existence of similarities between this co-existence sphere and the Greater East Asia Co-Prosperity Sphere (大東亜共栄圏 *Daitoua kyouei-ken*) of the Japanese Empire.

efficiencies are passed on to workers and eliminate poverty, or to provide basic services that ensure people are cared for in an emergency. What is more, the well-being of ecologies might be limited to reducing emissions and human enjoyment of a non-specific nature.[27] This is one rubric among others, including “diverse business creation” (in the purple bubble), “a transportation system that is enticing and people-friendly” (in the green bubble), and most notably “an energy system that is independent and distributed” (in the dark blue bubble, clarified to be in the service of rural revitalization and for local production and consumption) as well as “resilient urban design” (in the red bubble). In the notes for this last segment that energy infrastructure should work with the inherent resilience of nature, it should be prepared for new diseases and climate change, and most notably, the infrastructure and energy system should *give a sense of safety during disasters*.

Though material reality of energy, its history and its sources remain abstracted in the scheme, it presents many interesting assumptions about how energy infrastructure for the transition should be. Notably, it makes liberal use of images of natural settings such as forests, and the ocean, but the more specific tags and notes are about businesses, electric vehicles, renewable energy (there are at least three images of wind turbines), energy management through digital technology and green infrastructure[28]. From these plans and their associated subsidies, as well as the response to the 2018 earthquake, we can infer that the national ministries (particularly METI) see resilience and transition as a project of largely private actors creating green electricity for the grid, and new technologies of digital management to pair with electric vehicles.

[27] There is only a vague mention of ‘Lifestyles that are healthy and where one can feel connected to nature’ and ‘Rich nature as a stock, and the benefits providing a good life’.
[28] There are also tags that mention urban spaces for more people-friendly areas, and child-rearing support but these have not figured much in presentations I have attended.

4.4 Making Resilience with Heat

At a meeting on creating a society that is 100% reliant on renewable energy in October 2019 in Sapporo, Professor T from Tokyo who works for the Ministry of Economy, Trade and Industry, outlined the coming changes in the government's approach to energy policy in light of the 2018 earthquake and decarbonisation goals. The main change would be an adaptation of FIT into a feed-in-premium, with funding that is more geared towards small-scale biomass and biogas projects. A local professor, Professor B involved with biomass technology in Hokkaido asked the discussion panelists about the shortcomings of Japan's Feed-In Tariff policy. Paraphrasing his concerns and drawing on opinions he expressed at other events, it seemed to him that much of the more positive tone taken about the possibility of 100% renewable energy had overemphasized the role of the electricity grid, leaving Hokkaido not only vulnerable but trapped by national priorities. Indeed, other events I had attended seemed underwritten by a tacit agreement that renewable energy is (or should be) mostly seen as a matter of concern for the electricity grid, a view that FIT policy has encouraged.

There are many things that make the national electricity grid seem more available to public intervention: in the aftermath of Fukushima, Japan's electricity grid and regional utility system have come under increased scrutiny and been subject to increased liberalization (Kashiwagi, 2018; Takahashi, 2018). Hiroki Shin's (2020) recent writing shows how Japanese electricity companies have also retreated from the management of domestic spaces in the 20th century, but whose importance grew as post-war Japanese electricity consumption skyrocketed. The recent history of energy policy and political attention has thus been directed at national electricity infrastructure, leading to an unwarranted equivalence between “energy” and “electricity” in discussions of renewable energy in Japan.

On the other hand, what the professor was trying to emphasize were the other forms of energy in everyday life that were not being reached by FIT, producing an electricity market without the tools for public participation or a grassroots rethinking of modern energy use. At other talks, Professor B had drawn on examples from Hokkaido to show how businesses and municipalities in Hokkaido and northern Japan had achieved a greater measure of self-reliance by negotiating with the local forestry association to help dispose of unusable wood chips by collecting them for fuel. If combined with geothermal energy for heat and harnessing cold air to provide refrigeration, he said citing existing projects in Japan and Europe, much of the fuel used in homes and businesses could be replaced or provided for outside of the electricity grid in some areas.

In this sense, for their part, experts are comparing model projects from Europe, but think more specifically about Hokkaido’s environment and the construction of local model projects to motivate actors outside the central government to develop energy differently from the megasolar model. From conversations with activists and renewable energy producers before and after this presentation, I learned that the aspect of these new plans that was most well-received was the focus on *chisan chishou* (local production, local use): understood as investing in region-specific forms of energy and resources to promote independence and resilience. This is where European, and in particular German models of *Stadtwerke*, public utility companies, were often used by the government as examples of local flows and use preventing capital outflows[29]. Taking the town of Osnabrück in Germany as their main example in their presentation, the Ministry's representative emphasized how local use and local production had helped subsidize public services, as well as keeping expenses low and creating more jobs. Interestingly, the grassroots activism for (re)municipalisation and independent municipal ownership that define *Stadtwerke* were kept out of their presentation of the model (Hall, Lobina and Terhorst, 2012).

At discussions and panels with energy experts from Europe and Japanese municipalities or businesses who had sent teams to Germany and Denmark, the idea of local independence through local ownership was more clearly emphasized in their statement of model cases. One presentation by a mid-sized city in central Hokkaido in August 2019 cited the city of Freiburg's urban planning and ownership of energy production, Jühnde as a municipality being completely self-sufficient in energy production, and that 46% of Germany's renewable energy is owned by individuals and farmers – all examples for taking control of one's own energy future that could be adopted even in relatively under-funded municipalities in rural Japan.

Similarly, at a panel on fourth generation shared heating systems in October 2019 in Sapporo, hosted by REOH, Japan's relative lack of district heating was compared to Denmark's systems to maximize heat efficiency through co-generation, heated water circulation and improved insulation. A kind of evolutionary framework is implied by the idea of *fourth generation* systems in Denmark being ahead of Japan's *second and third* generation infrastructure, this time by a mix of Japanese experts, community members and activists. However, this was articulated with the purpose of emphasizing the particular challenges faced with heat in Hokkaido, and the way the

[29] Similar comparisons are also made in Japanese media on renewable energy (Takamatsu, 2018)

country's feed-in-tariff did little to promote something as basic but extremely effective as improved insulation. The Ministry's follow-up policy, the feed-in-premium, has addressed some of these criticisms by making a new category of subsidies available for local biogas, biomass and heat-use projects. In subsequent meetings organized by REOH in October 2020 and March 2021, centred on local use of biogas and the creation of greenhouses with IoT technology to control the temperature, the idea that a disaster could occur in Hokkaido in winter – making heat a matter of life and death – was repeated alongside hopes that this new generation of policy could be used to do more to meet local needs.

As the interaction between METI's Professor T from Tokyo and Professor B from Hokkaido shows, heat has become an important language for the fears of infrastructural failure, and the potential for doing energy differently. This is different from much of what I encountered *national* experts discussing in terms of resilience after the Hokkaido earthquake. For instance, one professor's talk in May 2019 that dealt with the 2018 Hokkaido blackout and comparisons to Western energy infrastructure (Japan Planning Institute, 2019) defined resilience in terms of a more distributed *electricity* production and distribution network, rather than talking about insulation, reducing energy use, and heat sharing (echoed as well by Professor Takahashi (2018) from the Renewable Energy Institute in the days following the earthquake) .

Professors in engineering involved in cold energy and biogas have also created model projects in universities to help local actors implement similar projects elsewhere. I met Professor Y when he gave a presentation on cold energy systems using the abundant snow in Hokkaido winters to preserve food, cool down large computer systems, and use recycled warm water for agriculture or aquaculture projects. Their experiment, a large container filled with snow on one side, and food on the other, with vents and pipes moving cold air in, and feeding snow melt back onto the top of the snow pile. Cold energy essentially means using the lack of heat from ice and snow. In systems that use a lot of energy and create excess heat, these can create more stable heat flows and use less energy by avoiding electric cooling systems. Though at that point in time they had only conducted preliminary tests[30], he pointed to Hokkaido's main airport and Kyocera's so-called "zero-emission data centre" (Ministry of Environment, 2023) as prominent examples of implementations of cold energy systems. Far from being cutting edge, the agricultural science department at Hokkaido University had been doing research on preserving food using snow since the 1960s, to say nothing of indigenous food preservation methods.

Professor Y explained it to me in this way: "With these kinds of projects, the government may of course see the potential but the goal is to convince municipalities, businesses, individuals and others. With FIT renewable energy expanded rapidly but megasolar and other projects were motivated by profit rather than improving the lives of the people. In particular, with snow, there's so much [of it] that people often are at a loss of what to do with it. I hope we can create model systems that make people appreciate the unexpected sources of energy around them." While Professor Y, like many experts, was concerned with the resilience of the electricity grid and changing the rules of the grid to allow new renewable connections, their hope was to inspire a subject that could operate mostly independently of government (in)action. This same concern is reflected in the senior professor's words at the beginning of this section. For these experts,

[30] In 2021, Professor Y's team launched their fully functional cold energy system and used it to farm abalone using the warmed water.

resilience-making is as much about diverse, independent energy projects led by citizens demanding autonomy as it is about creating a greener grid faster.

The model project that assumes a certain kind of subject is a transportable schema for what can also be achieved elsewhere, both a tool of persuasion and a microcosm of a different energy infrastructure, and a different relationship with the environment than what both the Ministries of Economy and Environment's policies propose. Models are "specially prepared, usually fictional descriptions of the system under study" (Cartwright 1983: 158), operating as speculative instruments (Black 1962; Jensen 2020; Richards 1955). I draw on the work of Casper Bruun Jensen as well as that of Atsuro Morita and Wakana Suzuki (2019) on hydrological and climate models, focusing on the capacity of ideal representations by experts to travel and serve different purposes. Just as climate models might be compared differently by activists, anthropologists or hydrologists, transition models by European energy experts exist in different schemes of comparison for Hokkaido engineers and bureaucrats.

Though in this case the models are not computed by scientists by inputting variables from data gathered through scientific instruments, they have similar effects: convincing other experts and participants of the validity of this experience for informing policy and action. Perhaps this on its own would be insufficient to justify using the same term of "models" as opposed to policy ideal or success story, but in Japanese these are also introduced as モデル事業 (*moderu jigyou*) or model projects, with *model* being directly borrowed from English.

Both government ministries and Hokkaido energy experts are engaged in the production of models and mobilization of European examples to justify and enact their form of resilient energy infrastructure as a means for society to achieve a green transition. However, the possibility of different resiliences also speaks to different systems being enacted. It also raises the question of the relationship and possibility of coexistence between these different resilience-building efforts. For example, the government's *Society 5.0* leaves little room for the complex and changing dynamics of ecosystems, while the experts at least take seriously the challenges of the climate crisis and the particularities of Hokkaido's environments by make use of ambient heat (as cold) for storage and insulation, as indigenous people in Hokkaido have. In the following section, I return briefly to the literature on resilience and infrastructural systems before discussing the relationships between these futures of resilience.

4.5 Doing Resilience Theory

The use of the term resilience has increased drastically and spread to many fields since C.S. Holling's (1973) paper on systems ecology. Holling argued for an understanding of systems ecology with multiple equilibria possible for a given system, rather than systems returning to the same equilibrium. He introduced the concept of resilience to describe the ability of systems to adapt to change rather than merely return to inertia. However, Holling (1996) would later describe the very idea of stability he was criticizing as another kind of resilience which he calls *engineering resilience*, this one associated with the field of environmental science, which has drawn more closely from physics and engineering, as opposed to ecology which has been influenced by biological sciences. Since Holling's landmark paper, this kind of thinking about systems as adapting to constant change, and measurable through resilience has spread to many other fields, becoming common in policy and research in fields such as disaster studies (Coetzee, Niekerk and Raju, 2016; Mayunga 2007) and psychology (Masten, 2007).

D.E. Alexander (2013) notes that while the academic use of resilience is often attributed to Holling's paper, its origins of the term are actually much older and not from the field of ecology. The term resilire or resilio existed in Latin to describe several phenomena. It was used by Seneca to mean *to leap*, Ovid used it to mean *to shrink* or *to contract*, and Cicero used it to mean rebounding. The most common use of the term appears to have been to describe leaping or rebounding, and had generally negative connotations. These connotations persisted when it became adopted in Middle French to mean *to retract* or *to cancel*, and when it became used in English. The first scientific use of the word *resilience* in English may have been by Sir Francis Bacon, Attorney General of England in 1625 in his compendium of natural history *Sylva Sylvarum*. By the first half of the 19th century, it was used by various people for meanings like *rebounding*, *elasticity* and *fickleness*. It was also around this time being used in mechanics. William J.M. Rankine used the word to describe the strength and ductility of steel beams. It also found use in anatomy, coronary surgery and watch-making (Alexander, 2013).

As a result of this varied history of use, certain conflicts are noticeable in the use of resilience. Holling (1996) also notes in a later work the possibility of an inverse relationship between two kinds of resilience, particularly in the case of managed ecosystems: agriculture, the removal of buffers, and loss of biodiversity achieve some social, economic or engineering objective reduces -sometimes irreversibly- the capacity to absorb shocks, meaning that "short-term success in stabilizing production leads to long-term surprise" (37). This later intervention over engineering resilience and ecological resilience, with the former focused on *efficiency* of function and the latter on *existence* of function (i.e. focused on the magnitude of disruption able to be sustained by a system while retaining function), points to the longer history of the term resilience. This duality of resilience, the older definition being focused on a fixed definition of capacity to a more variable one also captures the shift that transpired in Japan's grids after 2018. The government moved from a fixed definition of capacity to maximize the output of existing power plants, to a connect and manage approach to grid resilience that requires flexibility from all producers and managers.

Michael Fisch (2019), working on infrastructure in Japan, has studied the way the network controlling the commuter train system in Tokyo (ATOS) translates disruptive events like commuter suicides and other delays into data that feeds back into the system, forcing systems and operators to adjust to minimize service interruption times and avoid a vicious cycle of delays throughout the metro system. This rather dark resilience, built on operating without capacity, makes collective life into a margin of indeterminacy for the system in which machine and human behaviour that entangles and shapes both, Fisch argues drawing on Simondon. Simondon's idea of life objects such as societies and machines is one that assumes them to be self-evolving and autopoietic, in which the pre-individual motor of *transduction* leads to change and transindividuation without individual or even collective effort. While not the inspiration that people in my field draw on when using the word *resilience* and not the singular theoretical focus of this chapter, Simondon's attention to process, change and the co-adaptation of people and objects are useful to this discussion for understanding the conditions of coexistence between machine systems and people (Letiche and Moriceau, 2017; Simondon, 2005)[31].

Resilience and the idea of complex adaptive systems in ecology owes its spread in part to the flow of concepts from post-World War II computer science and machine thinkers like Simondon. Fisch outlines the branches of thinking by contrasting the cyberneticists, who conceived of life as reducible to information processing, to machine thinkers who imagined the relationship between humans and computer systems in co-constitutive terms. Co-constitution here does not mean symbiosis as would be implied by cyborgs or even Mol's (2002) coordination and coexistence, but is instead a dialectic relationship between ontologically incommensurable parties. This claim of ontological incommensurability and transindividuation coming from machine thinkers deserves some careful consideration.

As a form of infrastructure that also sees daily, uninterrupted use experiencing new problems of capacity, Hokkaido's electricity grid offers another machine to think about co-constitutive relationships and what happens when the grid begins to fail. Indeed, as Özden-Schilling (2015) argues, the problem of grid stability led to cybernetic solutions that would become the basis for systems thinking and natural monopoly in economics, existing as technology even before they were theoretically elaborated. By 1949, the US had realized a grid capable of powering the economy with thermal power plants, and by 1954 computer control of such systems was implemented. Japan, using combined thermal and hydroelectric power, required different equations, but by 1957 had developed methods using both digital and analog systems for dealing

[31] I also take inspiration generally from Simondon's (2017) history of tinkering with technology and of appreciating technical schemas perceptually and affectively (Lampworth, 2019). These themes are present throughout but will return to the forefront in chapter 6.

with both long-term and short-term operational issues to ensure stability and system resilience (Ueno, 1963).

In *Electrifying Anthropology* (Abram, Winthereik and Yarrow eds., 2020), electricity's nebulousness and omnipresence make a focus on practices and infrastructures helpful for bringing the political and material effects of electricity into focus. In the volume, Özden-Schilling (2020) argues that cybernetic thinking and big data has emerged from the creation of the big machines that are modern electricity grids. Interestingly, Norbert Wiener, credited with being the founder of cybernetics, was part of the electric community of the US, and helped turn grid-specific computers into general purpose computers for other scientists. Özden-Schilling argues, drawing on Bowker, that cybernetics emerged from practical concerns like turning voltage synchronization in grids into a general approach to the world.

In the same volume, Bakke (2020) drawing on von Meier (2006) describes grids as machines for misunderstanding that works in practice but not in theory, holding heterogenous desires and projects while the problems of running and planning them complexify. While engineers attempt to build seamlessness and coherence around the infrastructures of electricity grids, an analytical look at the everyday practices within and around them shows cracks, failures, and divergences in desires and understandings. Perhaps then, as the provocation of Boyer's (2016) *gridworld* or Fisch's (2022) *fortressification* would suggest, growing distrust of the machines of modernity can still allow for coexistence in a co-constitutive relationship, but this coexistence is haunted by disasters and fears of becoming a sacrifice zone (De Souza, 2021).

The electricity grid in Hokkaido is now allowing more indeterminacy through renewable energy production, and through new thresholds for capacity. This brings it closer to Tokyo's train network as a system. However, left out of this discussion is the potential longer term effects of each accident or delay being fed into the system: what are the cumulative effects of compounding indeterminacies? In Hokkaido, renewable energy is forcing change onto the way the grid operates, and the fear of another unthinkable accident has many taking action to live without the grid. As the literature on resilience points to, resilience-building for one system may also be taking resources that may be more effectively spent away from those interested in building resilience outside the system because of a currently *unthinkable* risk of its collapse. In the case of Hokkaido's electricity grid, the divergences in desires for resilience seem to be building, and taking on infrastructural forms. For biogas producers, as we will see in the following chapter, resilience is less part of the vocabulary, and the independence they build is closely based on life rhythms, sensing, and heat.

Rather than dismiss resilience as yet another flawed academic category, I am compelled to think with it, as it is a concept used by several of my participants to build their models of what is required for an energy transition[32]. It is used by energy experts and activists seeking a greener grid, but also by biogas and biomass activists and operators, who seem unconvinced by the reliability of the grid, even as new definitions of safety are introduced.

4.6 Co-constitutional Unmaking

[32] In Japanese, I have found the terms often used are 強靭化 (*kyoujinka*), but レジリエンス (*rejiriensu*) has also become a word in Japanese, along with 防災 (*bousai*, disaster prevention) and 減災 (*gensai*, disaster reduction). In discussions of the electricity grid, I have found the former and latter are used interchangeably but when it comes to discussions of sustainability, the latter is predominant.

On the surface then, the government, experts, organizations like REOH and renewable energy producers would all seem to have been in agreement that Hokkaido's electricity grid must be made more resilient, and energy production should become more closely tied to local energy sources. However, as we have seen above, there are divergences in how they have reacted to the blackout and ensuing policy changes. The government's response since the earthquake has been largely in line with its pre-existing trajectory of greening the grid by ceding energy infrastructure to market forces, and creating greater interconnection between regions. For energy engineers in Hokkaido, the future of doing resilience is inherently tied to actual environmental conditions but still sometimes a technocratic task, mobilizing models and petitioning officials to that people themselves can then undertake serious transformation of collective life in improved insulation, heat-sharing, microgrids, and a renewed sense of stewardship of the environment that provides energy. For renewable energy producers and citizens who feel left behind by the government's management of the grid and response to the earthquake, there is less concern with the concept of resilience. However, there is a desire by many to take control of energy infrastructure that was delegated to others back into their own hands, often as part of their own local economies and living heat ecologies.

The 2018 earthquake made visible many problems that were inherent to the electricity grid's development since WWII and others that had emerged alongside the introduction of renewable energy and the Feed-in-Tariff. While in practice, for the government, resilience has first been an issue of the national electricity grid and an issue of regions to figure out on their own second, local experts have been building models for a different kind of collective life. The fears of people about the grid have gotten some policy response, though it remains to be seen what will actually come out of the Feed-in-Premium and associated funding. The story of the microgrid proposal in a town in Hokkaido in the following chapter indicates the government's ideas of resilience and those of rural residents in Hokkaido continue to diverge. Viewed co-constitutionally, the relationship between the grid system and society suggests some level of co-existence is currently possible, but that equilibrium is already shifting as experts and producers advocate for the tools to create local energy autonomy.

There are echoes here of the practice of finding hidden resources that can restore the livelihoods of the people in the face of governmental paralysis mirrors the practices of rural revitalization projects in Japan. Bridget Love (2013) argues that community mapping to rediscover dormant resources and neoliberal efforts at decentralization that demand autonomy from Japanese regions devolve responsibility for the future onto these same places. In my experience in Yubari, Hokkaido, there is undoubtedly a dereliction of responsibility on the part of the national government for the future of towns hit by the resource shift to oil and then by the collapse of the bubble economy. However, this does not mean we should dismiss the way people are finding ways to try to live better lives together within the ruins of the economic growth machine (Tsing, 2015).

There is a similar kind of subject assumed by these projects in energy and rural revitalization that is not unlike Morton and Boyer's (2021) hyposubject, unplugging from the grid to redistribute stored energies and repurpose existing infrastructure. In many ways, this does align with the projects of some biogas producers. Biogas producers and the experts above share a concern with heat as a shared local condition or infrastructure that makes life possible. However, if we think in terms of *response-ability* to the future (Haraway, 2012), the experts we have surveyed in this chapter have largely framed their future-making projects of energy transition around democratizing and greening the electricity grid, and the resilience of human communities to disaster through better heat management. What kind of collective life and what kind of infrastructure are actually being made by rural inhabitants is explored more thoroughly in the following chapters.

5. Biogas Infrastructures, Heat Practices, and Thermoceptions

To examine what kind of world is being made in renewable energy projects in Hokkaido as the grid is being unmade, a turn through energy anthropology literature is necessary. Energy itself has a complicated history in science, and is even lately a difficult concept (Harman, 1982: 7). Energy is an abstraction, and yet it is everywhere in us and around us: food, electric devices, gas, transformers, batteries, sunlight, trees, and asphalt. The idea of energy as *forces* had been common throughout the history of what is now called Western philosophical or natural philosophical thought, but the practices of devices for measurement of such forces would change science and lead to the modern concept of energy.

Following an explanation of this process through Isabelle Stengers' *Cosmopolitics* (2010), I look at the origins of energy anthropology sharing a fixation for formulas and calculations of energy as important ways of understanding the development of societies, beliefs and behaviours. Laura Nader's work and the emergence of science and technology studies would open up discussions on expertise, power and technology in relation to energy. I then review key works to the emergence of the recent wave of energy anthropology as part of a growing interest in materiality, non-humans and infrastructure from the 90s to now. In the last part of the review, I examine the ideas of energy futures and energy worlds that have become associated with speculative thinking and cosmopolitics, coming back to Stengers, to answer the question: what are the cosmopolitics of biogas infrastructures following the 2018 earthquake?

Through interviews and field visits with biogas producers and city officials in biogas producing towns, I examine the origins, motivations and problems of creating gas from the waste of dairy cows, and the infrastructure that makes it possible. The materiality of experiments with microbes and sharing heat between species as part of an ecology of heat practices allows a different sense of heat and energy, opening up the potential for more independence from the grid through new dependencies with cows, bacteria, sensors, and heat. While none of these biogas projects is particularly revolutionary infrastructure, I discuss the thermoceptions that come from the process of recycling heat from biogas as having the potential to unsettle the primacy of the gridworld.

5.1 Energy in Thermodynamics

First, some discussion of the emergence of *energy* as a scientific concept, and its relationship to anthropology is necessary. Energy has had a broad range of meanings. It was used by Aristotle to mean being-at-work or activity. It has also had a variety of uses in the history of science. The contributions of proto-scientists from outside the West throughout the history of science have historically been too often ignored. More recently, some scholars have tried to compare Ibn Sina's idea of the *vital spirit* produced by the heart to other ideas of energy as a vital force. The vital or medical spirit, itself drawing on Egyptian beliefs of the immortality of the soul and Aristotle's idea of a material soul, shares certain similarities with what modern medicine identifies as properties of the heart's electrical activity (Behbahani et al., 2013). A disciple of Ibn Sina also used a version of shock therapy using crampfish to cure epilepsy, suggesting connections at the time between the vital spirit and electricity (Gorji and Ghadiri, 2001).

Subhash Kak (2017) has also described in an article in *Current Science* how philosopher Swami Vivekananda had fascinated Tesla with his discussion of Indian physics concepts and in particular, the concept of *ākāśa*. It was clear from his creation of alternative current that Tesla was interested in finding ways to transmit energy across long distances, and in *ākāśa* he found the mediating potential for force and matter to be interconvertible. Vivekananda saw in this ideal the validation of Vedantic cosmology through mathematics. Tesla would continue to believe in the possibility of wireless energy transmission even if it flew in the face of the new conventional wisdom of physics.

Modern thermodynamics reintroduced energy to resolve the problem of how to understand phenomena like heat and motion together. In the 1840s, Joule had demonstrated the equivalency between heat and mechanical work, bringing together what were once seen as separate non-mechanical and mechanical processes. Thomson and Rankine, building on Clausius' mechanical and molecular formulations of thermodynamics and entropy, sought to create a framework for physical theory centred on the concept of energy in order to generalize the convertibility of forces. Thomson and Maxwell would add concepts of ether and field that would then challenge the mechanical view of nature, and lead to further exploration of the properties of magnetism, light and subatomic particles to help further unite physics. Energy marked the period of unification after the disunity in 18th and early 19th century physics (Harman, 1982: 1-3).

Smith (1998) details the history of the emergence of a science of energy and an understanding of the universe as one of "continuous matter possessed of kinetic energy" that could be intervened on by humans with free will rather than a deterministic one as put forward by earlier scientists

Laplace and von Helmholtz (2-3). Interestingly, energy physics was not the inevitable consequence of the *discovery* of the principle of energy conservation, but the product of a community of elite scientists in the Northern United Kingdom driven to reform physics whose main audience was made up of industrialists and engineers. Key to their search for credibility (Latour and Woolgar, 1986) was James Thomson's ability to gain engineering skills in the iron and shipbuilding works in London and Manchester, and work with his brother, as well as Rankine and Joule to convince scientific communities in London, Manchester, Glasgow and Edinburgh.

The ramifications of subsequent changes to thinking and measuring heat and forces for the scientific understanding of the world were significant. Though the conservation of energy had been proposed more than a century before, by French noblewoman, mathematician and natural philosopher Émilie du Châtelet which was itself inspired by previous work by Leibniz on the concept of the *vis viva* or living force (Hagengruber, 2011), the concept of the conservation of energy only gradually became better understood. In *Cosmopolitics,* Stengers (2010) thoroughly discusses the tribulations of the emergence of thermodynamics from within physics, noting the shift that occurred from an aesthetic understanding of nature as unified and forces (from Leibniz's *vis viva*) as convertible, to the contestation of theses about energy through practices of measurement and interpretation. Unlike Galilean acceleration, where the inclined plane produced both measurement and its interpretation, the devices that measured the conservation of energy did not offer determinate interpretations to scientists. Conservation implied measurement and the measurement required interpretation, which led to controversy. Even though both von Helmholtz and amateur of physics Freidrich Engels both accepted the concept of the conservation of energy, von Helmholtz questioned the ability to directly observe force and work by reducing qualitative changes in energy to mechanical energy alone, while Engels emphasized the qualitative transformation of energy and saw work as a practical measurement done through artificial devices. In 1843 Joule's device established the means for force and its measurement to be interpreted.

In this way, the concept of energy has moved through different ontologies in the formation of modern science, upsetting the idea of heat as a substance or living force of matter, and establishing practices of measurement and interpretation for understanding the dynamics of energy. Stengers (2010) outlines the different relations between scientists, their politics and the world. From the measurement of energy through devices, an entirely different set of activities and politics for scientists emerged through controversy, and from it emerged entirely different understandings and ways of relating to energy and the cosmos: relativity, quantum mechanics, gravitation. Even as energy unified sciences through thermodynamics and formed the baseline for modern energy infrastructure and measurement, it has continued to be challenged, and be re-analyzed, as Einstein has shown mass has its own energy outside of kinetic motion, and quantum mechanics abandons the assumption of traditional thermodynamics that energy conversion is process driven to focus on different states (Tanev, 2013: 732, 735-737).

However, Stengers' focus on the politics of science and measurement largely leaves out discussions of the politics of energy technologies, materiality, the cultural history of 19th century physics, and the relations between energy physics, industrial production, and empire (Barry, 2015; Harman, 1982; Smith, 1998). Further discussion of 19th century physics would be less relevant to this review of energy anthropology, though the politics of energy technologies and science, the political economy and materiality of energy, and the different futures or cosmologies of energy form important threads in the existing research that help answer what kind of energy worlds are being made and contested in Hokkaido.

5.2 Politics and Cosmopolitics of Energy

As I have discussed in the previous chapter, on the surface, everyone agrees that local actors should be leading an energy transition towards a more sustainable and resilient society. However, the substance of that future society's infrastructure, and the practices needed to create resilience, are different. In particular, the government's approach to resilience appears to welcome an open-ended approach to the shape of local energy practices, but in practice its policies have favoured a particular kind of fast-and-big development by private actors. The tensions in questions of indeterminacy and the means of escaping the techno-political and infrastructural hold of conservative actors are also reflected in the anthropological and STS literature on energy. For the sake of illustrating the difference in positions in the literature, I have focused on two scholars, both of whose works have been a direct inspiration for this research anthropologist Dominic Boyer, and STS scholar Casper Bruun Jensen.

Dominic Boyer (2016), in the edited volume *Infrastructures and Social Complexity*, reimagines the potential of infrastructure from a metabolic interpretation of Marxian theory to be a kind of stored energy, and calls for a revolutionary, transformative re-appropriation or squatting in of what he terms the *gridworld* that is our modern energy paradigm built on exploiting resources and people. The electricity grid as both Anthropocenic machine and a site of contestation or new possibilities continues to attract attention in energy studies along with the power plants that feed them (Kirshner and Power, 2019; Özden-Schilling, 2020; Loloum, 2020), even as these studies also propose questions for current research about what imaginations of different energy futures are possible and how different worlds are being made from technologies and practices around energy.

While it is hard to argue that anthropologists can continue to write as unconcerned observers, particularly given the realities of climate change, the forms of feeling, subject-making, justice, and participation that should be pursued or are possible, are unsettled matters in the study of energy infrastructure. Boyer (2016) opposes the *gridworld* of endless growth, extractivism, and exploitation to what he calls *revolutionary infrastructure*. Comparing the economy to a metabolism via a reading of Marxist theory, infrastructure can act like surplus or capital, he argues. Infrastructure is thus a particular kind of stored energy facilitating other activities. As climate crises wear at the permanency assumed inherent in infrastructure, the task of nimbly creating a sustainable infrastructure is made difficult in the case of energy because of the scale, complexity and fixation with predictability and stability of this infrastructure which excludes alternatives. Boyer (2016) suggests revolutionary infrastructure is "a kind of ubiquitous creative squatting in, and repurposing of, a gridworld that will find itself incrementally disabled by a redistribution of its materials and energies" that is ecological, feminist, colourful and queer, focused on urban areas (18).

Though seemingly aspirational or still germinating, revolutionary infrastructure is useful as a heuristic lens to be attentive to the way in which less powerful actors than engineers and policymakers can be repurposing energy infrastructures around us. However, the descriptions of the subjects of this revolutionary movement are also potentially over-determining if read ungenerously: turning away from the energy worlds of rural farm workers in Hokkaido because they are not queer or urban. Read more generously, we can interpret this list as an attempt to be attentive to movements of hyposubjects (Boyer and Morton, 2021) for a better society outside the gridworld of exploitation and energy maximalism.

Jensen (2019; 2020) also looks at parallel possibilities outside of a destructive gridworld, in the form of experimental solar power growing in parallel to China-backed dam projects that are destroying deltas in Cambodia. In looking both at solar experiments and the destruction of dams and rivers, he tries to account for the material realities of different kinds of energies, their infrastructures and their promises, focusing on the alternative, experimental ontology made possible by decentralized, socially less harmful and relatively cheap solar power that is struggling to emerge from within a cascade of hydroelectric infrastructure, posited as necessary to meet the growing energy needs of the region's population in a way that provides stable and also renewable energy. There is nothing revolutionary in the sense of squatting or repurposing or queering in the typical sense in this potential solar future, but its (improbable) potential for changing the flow of rivers, the geopolitics of China and Cambodia, and the way energy is thought of in relation to power and democracy carry a different promise and ontology. As Harvey, Jensen and Morita (2017) have put it elsewhere "the differential powers of water or sun, (for example), inflect not only the temporalities and spatialities of energy, but also the subjects we may be able to become" (158).

The main difference I see with Boyer's (2016) call for revolutionary infrastructure is Jensen's more open-ended, Strathernian approach to difference, and what can become of experiments with alternatives. Boyer's revolutionary subject is tied to the concepts of critical social science, while Jensen is more interested in arrangements of materials, rivers, broken promises, government allies, climate data and more that could come together to produce an alternative and sunnier reality. Jensen is more focused on the different worlds that are possible through realities and practices on the ground: infrastructure is less an analytic lens than a heuristic comparison used to sound out other ways of being, drawing on the past while actively participating in making the worlds it describes (Swanson, 2018). The difference is one of attitude to established analytical tools and their effects more than quality of observation, as Boyer (2019) and Cymene Howe (2019) in their dual-volume *Energopolitics* and *Ecologics*, produce captivating accounts of the difficulties of establishing community wind power within the structures of the petro-state in Mexico's isthmus of Tehuantepec. The richness of their ethnographic work, particularly with powerful actors that rarely give interviews to researchers, and the impact of the concept of energopower in particular (which Jensen himself cites) is without a doubt significant.

However, the connection between revolutionary infrastructure, or its subject, and the struggle for wind power in Mexico were not clear to me, as the revolutionary subject is perhaps closer to a Zapatista than the campesinos of Tehuantepec. Howe's *Ecologics* (2019) is more attentive to the more-than-human and the potential of wind energy to lead to a different future, but the framing of this change as *transition* whose quality is already somewhat assumed and framed in opposition to fossil fuel extractivism tends to at the same time unify and reify the transformative potential of changes brought by renewable energy. In other words, one could start from the question of whether energy transitions are extractivist, and then question who uses the term transition and why. Ian Miller (2020) has argued along these lines in favour of the Japanese term *enerugii kakumei* (energy revolution) over energy *transition*, given the tremendous undoing of the miracle of economic growth and the cataclysmic ecological and societal devastation that will likely accompany even a wildly successful energy transition.

In other words, both Jensen and Boyer's (and Howe's) attention to alternative kinds of infrastructure are compelling because they refuse to start from what would be necessary to maintain the conditions of economic modernity and simply reverse-engineer a "solution". This is the main criticism leveled by Boyer (2016) at Hermann Scheer, the "chief architect of Germany's renewable energy revolution" and Germany's FIT system who argued that solar power allows for decentralized energy systems, creating democratic ownership and control over energy to replace pipelines and large-scale grids (3). However, Jensen's open-ended approach to the ontological possibilities of this alternative are useful for exploring the experiments in renewable energy in Hokkaido without over-determining the future subjects, hyposubjects and shape of the arrangements made possible by renewable energy. Jensen (2019) suspends criticism of Scheer's ideas and the supply chain of solar cells to speculatively engage with the emerging particularities of solar experiments in Cambodia: suspending the idea that a solar future must be developed and determined by confronting hydroelectric development, and that the development of hydropower must mean a democratization of solar power was always and is still futile.

Speculative approaches and ontological thinking about our ways of being in the world and the infrastructures that make them possible are increasingly prevalent in the literature, emerging from the works of (among many others) Donna Haraway (2003; 2016a), Viveiros de Castro (2004), and Isabelle Stengers (Stengers, 2010; Braun, Whatmore and Stengers, 2010), to come full circle from the first section of this chapter. Recently there has been significant interest in anthropology in science fiction and its ability to influence both science and social imaginaries while stretching theoretical horizons to different (but often eerily close) worlds (Jensen and Kemiksiz, 2019). I also recall again Morita's (2017) aquatic ontology of floating rice as living species, food, and amphibious infrastructure that had existed for centuries as buffers to flood waters that made -and could make anew- another way of existing in Thailand's Chao Phraya Delta against the imported terrestrial principles of modern urban planning.

In energy infrastructure literature too, far from simply imagining alternatives and frictionless transitions, the cosmopolitics of making different energy infrastructures is almost exclusively difficult, messy and hopeful despite itself. Schick and Winthereik (2016) have written about the friction between consensus-seeking politics to onboard decisions makers for a not-so-different future, and a cosmopolitical commitment to create spaces of hesitation, slowing down reasoning and engaging with different contrasts, demands, and practices to access more degrees of alterity. Jennifer Gabrys (2015) too has written about energy monitoring and different energy practices not as an instrument, but as a means of making a new materiality and set of practices around energy.

In other words, a cosmopolitical approach would not just rely on energy monitoring to produce some pre-defined result we could call *sustainable*, but rather challenge us to feel and act a different way about energy. By making its materiality available in different ways, we may reduce energy but also do it by changing sets of practices, as well as assumptions about data, sustainability, and infrastructure. To return to Stengers (2010), if Joule's device allowed the creation of the object that it measured, inspiring new practices of measurement and world-making in science (that is enabled different ways of imagining and being in the world), we should be open to that same possibility of different worlds being possible from different practices through different devices and different energy infrastructures. It is to these different practices and possibilities in Hokkaido that I now turn to.

5.3 Ecologies of Heat Practices

In October 2019, I visited a small farm west of the main dairy-producing area in Tokachi I will call Farm S. I had contacted the owner previously, introducing myself as a graduate student from Osaka University, to see if there was interest in giving me a tour and answering some questions about their biogas operations. They agreed, and set a time. My other contacts had mentioned they had experience giving tours to local schools, and had visitors from other universities and businesses come regularly, so my inquiries were far from remarkable. Although, like many sites I visited, arriving alone, often on my bike, as a mere graduate student, I could tell they were not impressed. Still, the staff of Farm S, consisting mostly of people in their 20s and 30s greeted me and presented me with fact sheets about their operations. That day, 4 people and their manager were at the office. They chatted away, chuckling in the office as they took a break. The manager of the farm, a man in his 50s who I will call Tokunaga, sat down with me at a small table in a corner of the office with various records of operations lining the wall.

Perhaps as a result of describing my research project as being about energy infrastructure,Tokunaga gave me a summary of the foundation of the farm and the kinds of systems and equipment being used. Farm S employed 34 people, including some foreign trainees. Like most farms, low wages, rural lifestyle, and physically demanding work tended to require the hiring of young people from Asian Global South countries who needed to send remittances home. Tokunaga explained all this in a casual, friendly tone. I noted that he also sounded a bit world-weary. Farm work is of course particularly hard work, and on a smaller farm like this they did not have all the help they possibly should have.

I then asked Tokunaga about how they got into producing biogas. “We ignored biogas for a while, even while it was growing thanks to companies and the national government getting involved. Being in Eastern Hokkaido, we had heard about the problems with connecting to the grid due to Hokuden’s management of the power lines.” They were approached by a company that sold equipment to almost every farm I visited in Tokachi and sold on the idea of doing it, mostly to help get rid of waste in a local, and greener way. After we applied, we spent “around 2 years waiting for HEPCO to give the ok”.

While the FIT system guaranteed a decent return, the time spent in bureaucratic limbo and initial expense were a bit daunting. When the reply came back from HEPCO, they were required to accept their output being restricted for around a week during the start of spring when hydroelectric and solar energy plants would start to produce more. This was among the first locations to be part of this power control system[33], as a result of the power lines becoming congested. Even with FIT rates, because of all the expenses, including having to pay monthly for

33 潮流システム, *Chouryuu shisutemu*.

installing and using their own electrical wires to HEPCO to connect to the grid, for Farm S it evened out to be about the same as paying to burn the waste.

Even then, the system could barely keep up with the waste generated by their approximately 1000 cattle, and gas generation was a very finicky affair. Since 2016 when they started operating, they had been unlucky in operating the ecosystem. The cold of winter seemed to affect the fermentation of the material, resulting in less gas, requiring an awareness of heat and its impact on the operation of generators and the greenhouse.

Tokunaga then led me around the farm, showing me where they stored the manure, the fermentation vats, and the generator room. In the generator room, I asked Tokunaga what the biggest challenge for the farm and for biogas generation was. He opined that finding workers was probably their biggest long-term challenge (this unsurprisingly only got worse with the pandemic). As for the biogas operation, he said they faced long and obscure bureaucratic procedures that seemed to change every year, and that the Ministry of Economy, Trade and Industry sometimes didn't seem to know how to fill in their own forms. On top of which the utility company forces them to pay out of pocket for the power lines. He added, "I don't think we would have done it unless we had been persuaded by the equipment company. It's just a lot of hassle. Just like the greenhouse. Though that was the owner's idea. I didn't want to do it, but he thought it would be a good idea to recycle the heat from the generator. Now we're taking care of cows, plants and bacteria. I don't really know how to take care of the mix that feeds them. It's the world of micro-organisms."

Curious to know more about this relationship, I asked about the mix he fed the bacteria. Tokunaga said that he bought the pre-packaged mix from the same equipment company, and tried not to let anything weird fall in. However, he admitted sometimes he experimented with throwing other things in, or that hay or dust would fall in. "One time, I put some milk in there. Just to try it. I don't think it had much of an effect, but maybe it's not bad for [the methanogenic bacteria] them."[34] I asked whether he thought about the bacteria as another kind of animal to take care of on the farm. He chuckled a bit. "I suppose so. I don't think about them that much like I would the cows, but I do check if the heat is alright, if the mix looks too dry. It's hard for me to know what they want. They seem to be alright though, they're heating the greenhouse and even our own buildings," referring to the gas they generate being burned, and using the excess heat for their offices and greenhouse through the hot water pipes they installed as part of the biogas operation.

I asked the manager if he thought this kind of heat-sharing or biogas technology would be useful if there was another earthquake or disaster. Tokunaga answered that he thinks it would be technically difficult, and the support wasn't currently there to enable them to do such a thing effectively, but he would want the energy to be used locally as much as possible, especially in the next disaster. "I agree with the idea of *chi san chi shou* (local production, local consumption), but even installing the auto-control hardware to allow us to use the generators in an emergency cost us 1 million yen, and we're just one farm. Moreover, the biogas is hard to move around currently. I'm concerned for the people of the area. With government investment and the right technology,

[34] A 2015 guidebook put out by the Hokkaido branch of the Environmental Partnership Office (an organization established by the Ministry of Environment) conducted its own experiments and found that adding biomass, particularly straw, but also waste including dairy waste could actually increase the output of gas while reducing the costs of disposing of these (though it's not clear from this guidebook if any extra cost of cleaning and longer-term maintenance would influence this outcome) (Environmental Partnership Office Hokkaido, 2015).

we might be able to do something. In the meantime, we try to use the farm to educate people about how biogas is a greener way of getting rid of waste, that can even allow us to grow fruits in winter".[35]

With this, Tokunaga led me back across the farm to the greenhouse. They had only set it up the year before, and it only had one pipe running along the bottom, with the plants suspended above raised metal trays to hold the melons (Figure 5). None of the melons were currently fruiting, but the sight of such green plants and yellow flowers, and marked difference in temperature from the cold October wind, was nonetheless stark. Tokunaga explained that there were sensors set up on the side and the corners to measure the temperature of the greenhouse. "Being able to sell high-quality produce outside the regular season using this kind of excess heat is not a bad idea. At least it's easier to deal with. [Compared with biogas], this is maybe more likely to turn a profit" he admitted, looking somewhat begrudgingly at the success of the greenhouse.

[35] Other farms in the same area have used excess heat to cultivate mangoes and even sharks (Shikaoi, 2018)

Figure 5: The melon greenhouse at Farm S, with a pipe carrying heated water using the excess heat of the biogas generator (photo by author).

Tokunaga's explanation of the difficulty of both creating this biogas ecological-energy complex, and of caring for the methanogenic bacteria that were its primary engine, highlighted the differences and similarities between smaller farms and larger farms in the Tokachi area that were using and experimenting with biogas. At a larger farm I had visited that same year, the issue of crowded electricity lines and having too much manure had come up, but with much more staff and integrated businesses, the biogas-greenhouse complex they had built was talked about more enthusiastically.

I was introduced to this larger farm's team by another anthropologist working in the area, Paul Hansen. He was most familiar with the dairy operation from his own fieldwork (Hansen, 2010; 2014), which had stimulated my interest in Hokkaido from as early as 2015 when I sought to begin doing my master's degree research in Japan. I was intrigued by the descriptions of Hokkaido dairy farms as formed by processes of Othering, where dairy is designated as a necessary agricultural product for the nation, but is a mostly imported practice that occurs mainly in Hokkaido, on farms that rely heavily on foreign labourers kept transient through exploitative practices and strict immigration laws. Hansen's (2014) analysis of the rotary milking process echoes Fisch's (2019) analysis of ATOS albeit with more human control, as humans and cows are controlled by the system and time requirements. The workers, covered in protective equipment, interact with cows mainly through data, without touching them and without the cows seeing them while in the rotary where they are milked by machines. Workers who stop to attend to animals with impairments were called slow or lazy, and both cattle and workers are bruised by the pace and shape of the machine and the dance it requires to produce sufficiently (Hansen, 2014: 65). I had met him on multiple occasions, and was glad for the opportunity to do a bit of a joint visit to one of his fieldsites, albeit to hear about a different side of the farm's operations.

I had made Dr. Hansen aware that I intended to visit a large farm in north-central Tokachi. Dr. Hansen walked into the office to ask if anyone would be available to answer questions about the biogas plant and the greenhouse. Calls were made, and soon after, two employees drove up and introduced themselves as the people that managed the biogas plant, a father and son duo. The son had only been working at Great Hopes for 3 months, as a kind of successor to his father who was nearing retirement age who himself had only worked there for around 2 years. Both were former

JA employees from another town in the region. This farm was one of the first in the area to consider using biogas as a means of dealing with excess manure. Following the concentration of dairy farming operations in the 80s and 90s, the smell of effluent began to bother townspeople and fermenting it into biogas presented itself as a solution. However, it wasn't until after the 3.11 disasters and the introduction of FIT that biogas plants of larger scale, and using biomethane for energy, began to take root in Hokkaido.

Due to the continuous expansion of Great Hopes, which had gone in the last decade or so from under 2000 to 4000 head of cattle, even their large biogas plant could not keep up with the amount of waste created. Built in 2017, this large-scale biogas plant was among the largest in Hokkaido, fitting the size of the herd. The son commented that while there had not been any complaints they knew of from local residents, they themselves wanted to help keep the stench of manure from permeating the area they worked in as they liked to keep things clean, he said laughing a bit to himself. "We don't really make money from selling electricity [from biogas]. We still have manure we can't process quickly enough to turn into fertilizer through the biogas fermenter. We can break even, or make a bit, but that's only because it's being bought at a high price under FIT. Thankfully, this is set to continue for 20 years[36]". Due to the support of policy[37] and the need to process waste effectively, Great Hopes was actually planning to build another biogas plant, despite building this one already costing 600 million yen (subsidies greatly

[36] When I asked about the future of FIT, both Tokunaga at S Farm and the managers of Great Hopes seemed to have mentioned having visits from government officials, and knowledge that some successor policy was on the verge of being announced. As it turns out, this was the case with the FIP policy being announced in late 2019. A city official from a southern city in Hokkaido I spoke to speculated that this policy was meant to reflect a more mature renewable energy market, and a need to diversify from the intense increase in solar power everywhere in Hokkaido.

[37] More recently, the approval of a biomass industry city plan (バイオマス産業都市構想 *Biomasu sangyou toshi kousou*) can bring some additional help from the central government in the form of policies, advice and funding (EPO Hokkaido, 2015: 20).

mitigated this cost). The facilities required to generate electrical output consisted of approximately half of this cost.

Figure 6: Technicians in front of one of the fermentation vats (photo by author).

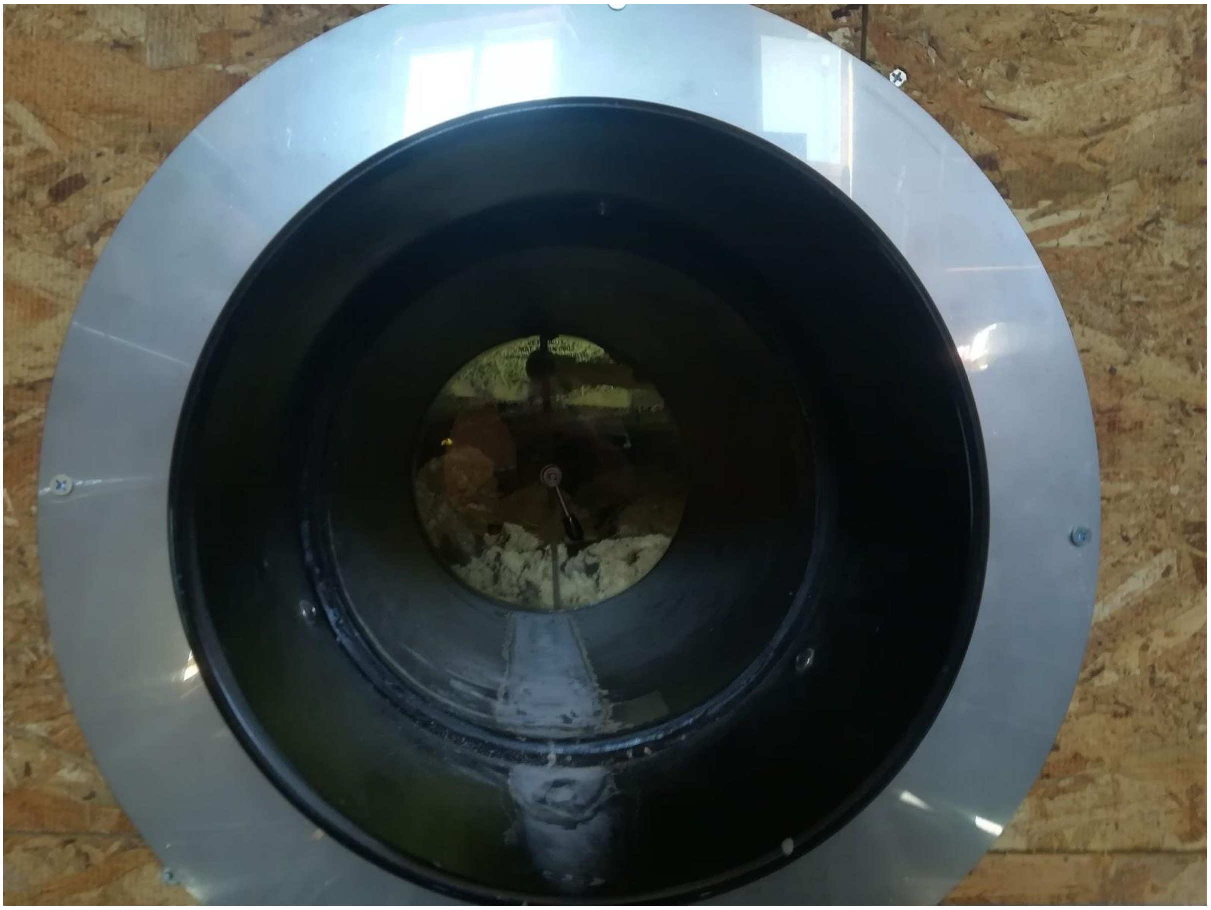

Figure 7: Window onto the inside of a fermentation vat where the contents have hardened (photo by author).

This farm had a room from which one could see inside the biogas fermentation tanks. The architecture seemed to be mostly plywood and sheet metal, and did not feel insulated. Inside the fermentation tank, one could see what looked like an alien landscape of hardened waste. I was surprised by the rocky, dehydrated appearance as I assumed fermentation usually happened in a wet environment, and asked if that was normal. The young man said: “Yes, it happens when the waste is older and almost fully digested by the bacteria. We are still getting some gas production but we will have to empty it and refill it soon.” There was no real need to have a window onto this odd landscape, but it helped to be able to see what state the waste was in to be able to decide when the bacteria had eaten their fill from what was there. The window invited people to look in and get a sense for the conditions of the methanogenic bacteria. Although at this farm, no one professed to experimenting with the mix in the waste, checking in on the bacteria was part of caring for them as part of the process that would give methane, fertilizer and heat.

The window allowed a sense of things that the sensors did not. At the entrance of the fermentation tank room, there was a control panel that depicted the 'energy flow' system that included the gas pipes, the generators, a gas flare, a hot water storage tank and an oil-fueled boiler that could supplement heat when the gas output was too low. A set of sensors would measure the temperature of the generators to avoid overheating, and the temperature of the hot water at the point at which it would leave and then re-enter the system after circulating through the greenhouse. Another set of sensors, at the point of entrance of the gas from the fermentation tank to the sulfur filters, measured the concentration of methane, hydrogen sulfide and oxygen. As the figure below indicates, the gas had around 60% methane content (this was slightly lower than other farms I had visited), but most importantly had no oxygen. The fermentation process works best in anaerobic environments, so a presence of oxygen could indicate a fault in the system or a crack in a pipe or fermentation tank.

However, the sensors afforded little information as to what was happening inside the tank or the greenhouse, as these were outside the 'energy flow' panel. Having the window allowed the technicians to sometimes understand what was happening through the material conditions of the bacteria. Usually they did not find any problems, but while being in the room they might notice it was a bit colder than usual, or that after looking at the methane reading they would check and see that the waste was getting hard as it was when I visited. Feeling something of the lifeworld of the bacteria was outside the 'energy flow' system, but also important to its maintenance.

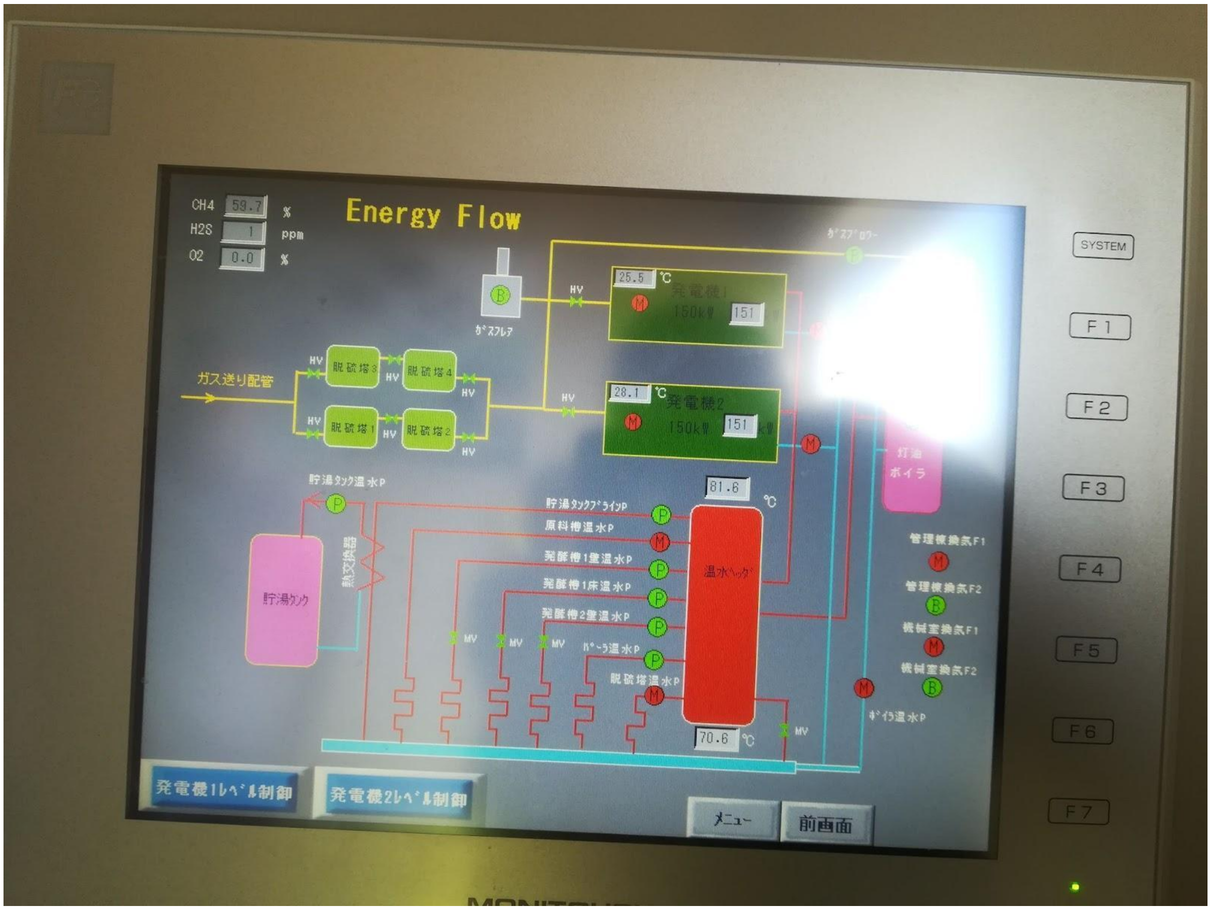

Figure 8: Monitor for checking the flows of gas into the generators, and hot water through the pipes and storage tanks that form one system of heat (photo by author).

It seemed that though the pair of workers were in charge of the digesters and the generators, they were not engineers. Any maintenance work that required technical knowledge was left to the same equipment company that seemed to work with almost all the farms I surveyed. While the control panel displayed information in the form of a technical schema, it was not beyond someone with a high school education to see what was going on. The lines that formed the pipes of the system were even colour-coded: yellow for gas, red for hot water, blue for colder water. So far, the technicians had yet to encounter any real problems outside the occasional generator trouble that would require a maintenance team to visit.

The main issue was heat. If there wasn't enough, gas production would plummet, the generators would produce less heat, which meant they would need to supplement it with the boiler to keep the plants in the greenhouse alive. They re-used heated water to keep the temperature of the fermentation tank high enough so that the bacteria would live and keep producing biomethane. "Heat is distributed throughout the system as you can see on the panel, but it all comes from the fermentation tank, which the greenhouse is dependent on. We can still get some electricity and fertilizer even if gas output from the tank is weak, but the greenhouse needs the heat from the generators otherwise it costs us a lot to keep it warm with oil. Even the tanks themselves have heat sent back to them through the system. We are even thinking of using the heat for the stables as well. Anyway, checking the tank is quite important."

We then moved to the greenhouse, only a few metres away from the fermentation tank room and the generator room. The greenhouse, matching the scale of operations of the farm, was vast. It was quite warm under the vinyl in the summer heat. They mostly grew strawberries, which they used in a nearby business under the same umbrella as the farm. It allowed them to have high-quality, local ingredients even through the winter. In another small, experimental greenhouse they grew grapes, and I was offered one to taste by the greenhouse workers. They tasted very sweet and had a nice crunch to the skin. In the main greenhouse, I could not see sensors, only UV lights and electric fans hanging overhead. The heated water pipes ran beneath the floors for the most part, so these were not visible.

When the energy flows ran properly, it *almost* made it all look like a self-sustaining sub-ecosystem of the farm, with human workers facilitating each step of the conversion of energy: the cows produce waste, the humans place the waste with bacteria, the bacteria produce gas and fertilizer, then the humans use generators to burn the gas to produce electricity and heat, and the heat is carried to the greenhouse where strawberries and grapes grow. Of course, the inputs of this system, like almost any modern industry, are dependent on intensive operations that are unlikely sustainable in their current form.

In particular, Tokunaga expressed some sense of difference about biogas as renewable energy. Unlike solar power or hydroelectricity, biogas relied on dairy farming and all the labour that went into it. The substance for biogas comes from living things, but moving the waste and taking care of the cows still used inputs and labour that were not from the farm. I was surprised at how electricity production was less the focus for Tokunaga than using waste and re-using heat, but it made sense given the origins of biogas development in Hokkaido. Tokunaga did want to contribute to reducing emissions and allowing the local community to have energy independence, but biogas itself was more focused on the bioremediation of animal waste and re-use of heat to grow profitable side-products than electricity production. Even cows themselves seemed at a distance from this entire process, as their movements were minimized and controlled by the process and technologies of milk extraction. Whereas in other contexts, the experiences of livestock have served as boundary objects for the use and efficiency of electrical technologies (Sayer, 2023), on Hokkaido dairy farms, the relations of sharing heat between plants, bacteria and people are at the centre of the ecologies of heat practices and waste I survey here.

In drawing on Stengers' (2005) *ecology of practices*, I am attempting to approach the practices of making biogas greenhouses and re-using heat from biogas generators at their divergence from the practices of FIT. Much of this ecology of heat, visible in the energy flow, happens outside or at the margins of the electricity grid, co-existing with the sale of electricity by burning biogas. The question of heat was not one I had initially considered in imagining this research, but taking inspiration from Stengers, I took interest in the relationships that were developing on dairy farms between methanogenic bacteria, cows, generators, biogas producers, sensors, and plants through heat.

The way this biogas experiment initially started to manage waste has evolved to create new relationships to waste, and to re-use heat to reduce dependency on imported fertilizer and fuel is remarkable. The emergence of large biogas projects has become a focal point for a movement that includes farmers, academics, activists and community members to increase Hokkaido's energy independence, invest in its energy infrastructure, and think more about heat in energy policy, as I have discussed in the previous chapter. As Stengers (2005) also notes, an ecology of practices eschews the ideal of progress, and does not seek to describe things as they are, but to remain open to how things are becoming differently. For all that the dairy industry may be hopelessly reliant on cheap imports, exploitative labour arrangements, and colonial land relations to keep going, biogas can also at the same time tell us that energy (especially in the form of heat) is already all around us, and that we need not be so beholden to the materiality of oil that creates and enables distant decision makers and distant power plants to shape human and non-human lives. Is there hope for alternatives in these biogas experiments for a *Stadtwerke*-like local reclamation of energy ownership and circulation in Tokachi?

5.4 Biogas Microgrids

In the town in which Great Hopes was located, I did not encounter any grassroots movement to develop renewable energy projects or infrastructural independence. However, the local government has been active in trying to attract attention and investment into the town by using biogas experiments as models for local independence. Most notably, they used the success of the biogas plants and the concerns following the 2018 Iburi earthquake about such a key industry being paralyzed by another blackout to try to convince the Ministry of Economy, Trade and Industry to invest in a townwide microgrid. The effort was not successful. I visited the local city office in the summer of 2019 to find out more about the city's role and the apparent mismatch between local government priorities and the central government model of local production, local consumption.

I sat down with the town's renewable energy officer called Muramata-san to the side of their workplace in a small waiting area. He looked to be in his mid-thirties, and had a relaxed demeanour. He had worked at city hall for the majority of his life after graduation from university. I focused on the issue of the microgrid and renewable energy, but also asked about the town's experience of the earthquake, its surprising demographics, and what challenges Muramata-san was facing recently. I told him what I knew about the microgrid project, and asked him to tell me if my understanding was correct. In July 2019, the Ministry of Economy, Trade and Industry launched a subsidy to help private organizations develop storage and local microgrid capacities that could supply renewable energy even through a disaster. The program allocated sums of up to 20 million yen to help develop 'master plans' for and to conduct feasibility studies for microgrids, with a potential for up to 600 million yen for the construction of these microgrids. I had heard that a company called Bridge had applied to make the microgrid plans in the town, but was unsure what their history and relationship to the municipality were.

Muramata-san explained that Bridge was founded in 2018 to manage regional promotion, tourism, amenities and energy works. The main investors were the municipality, Hokkaido Gas, a travel company and two regional credit unions. At the time, the business seemed like a semi-private arm of the municipality that even had its offices in the town hall. Bridge was given a METI grant to develop a master plan, which they submitted in summer 2019. The plan detailed a local, independent microgrid fed into by the existing biogas plants that would only be used in emergencies. However, Muramata-san said they were unable to receive a grant to build it, as the ministry was cautious to give funding to projects that would only be used in emergencies. Connecting even critical areas of the town to an independent microgrid would be a tremendously costly affair, with the installation cost of all three parts of the microgrid costing over 10 billion yen, and the annual operating cost being over 30 million yen per year (approximately 2 million yen per inhabitant for the installation alone in a town of less than 5000 people). Despite these issues, Bridge represented an increased awareness of the area's existing renewable energy development, and the willingness of the municipality to help manage new renewable projects as a semi-public resource.

However, the ownership structure of Bridge as a private company with a principal investor that is a public entity differs from the *Stadtwerke* communal companies that have re-municipalized energy in Germany, often cited as a model for Japan to follow to achieve local energy independence in METI's presentations and documents (e.g. METI, 2019; 2020). The town itself only owns one of 5 of the existing large biogas plants in the area, with one belonging to Great Hopes, and the other three being operated by biogas plant companies. Bridge sold electricity, but its main holdings were tourist facilities, not owning any power-producing facilities itself. Given that government subsidies and policies like FIT had focused on private over public development, companies like Bridge were the most likely product of such policies.

I asked Muramata-san if he felt there was still hope for building more independent energy infrastructure given the success story of the biogas plants, but the apparent mismatch between . “There are many difficulties, particularly with funding, but I think something like a regional microgrid is possible. For projects like ours, the ministry perhaps sees it mostly in terms of infra[structure] for disaster-prevention. This is important, but as the office responsible for renewable energy, we would also like to see broader changes in society from renewable energy that require more investment. There is also the potential for it [investment] to come from many regions working together, but our resources are more limited than the ministry”. The microgrid project reflects desires similar to those of the farmers experimenting with biogas: not just preventing disasters and creating resilience with regards to the grid, but creating better feedback loops throughout the ecological and social spheres of the region. The possibility of localizing energy production and infrastructure, and of re-imagining of energy that comes from the grid as heat that can be captured and redirected from natural or existing processes. These have in turn invited speculation about different kinds of productive ecological arrangements such as small-scale fruit production throughout the year heated by residual heat from burning biomethane, and heating other spaces in the farm housing other species, human and otherwise.

Stated this way, biogas and microgrid projects may sound like local actors are merely realizing or going along with the ministry's local-production, local-consumption plans. However, we should be attentive to the local desires that formed these experiments in biogas infrastructure that would power the microgrid (Larkin, 2013). It was biogas as a means of processing local waste to avoid environmental damage and smells that preceded much of this planning (as discussed in previous chapters). The experience in the 2018 earthquake in Hokkaido has also become formative in pushing local governments and the ministries to act on feelings of vulnerability from local constituents, and in particular the fear of deaths and damages from cold in the event of a disruptive event in winter. Both the microgrid plans from rural areas in Hokkaido in 2019 made reference to the 2018 Eastern Iburi earthquake, and the threat of another blackout. Feelings about heat, and where it comes from, are being contested by local governments and actors that are more aware of their level of infrastructural dependence and vulnerability[38].

Microgrids are not a new technology, but their re-emergence is significant within the context of the contestation of the future of energy infrastructure in Hokkaido. Japan has been relatively early in its adoption of microgrid experiments. There were several early microgrid projects in Japan by 2005: in Sendai at Tohoku Fukushi Daigaku, an integrated microgrid run on fossil fuels (which is said to have performed well during the 2011 earthquake), and in Hachinohe, in Aichi and in Kyotango (Marnay, 2017; METI, 2019). Despite the success of the Sendai microgrid, these technologies have not seen widespread implementation. Instead, as we have seen in Hokkaido, the reinforcement of the national electricity grid has been the focus of

[38] Hokkaido Precture actually included a Energy/New Energy Promotion Clause on the 27th of March 2011, following the 3.11 triple disaster. Clause 108 notes that Hokkaido, as a land of cold and snow, needs energy for its economy and the lives of its inhabitants, but must leave nuclear power generation behind and use new energies within Hokkaido. These energies should be environmentally friendly, allowing people and nature to coexist (Hokkaido, 2011)

resilience-building, with microgrids only more recently being given more attention as a cost-saving, resilience-building infrastructure by the New Energy and Industrial Technology Development Organization, which is largely funded by the Ministry of Economy, Trade and Industry (NEDO, 2019). The ministries, then, are simultaneously investing heavily in increasing Hokkaido's dependence on the existing infrastructural mode (through higher capacity undersea cables, and a new LNG terminal that were already planned) while opening small, specific grants for experimentation towards local production, local consumption (NEDO, 2019).

In 2021, more than double the number of microgrid plans in 2019 were funded and produced (SII, 2021). Many of the towns I visited have been selected by the Ministry of Environment for grants for renewable energy projects in the first round of selection for the "Decarbonization Preceding Regions" program (E-Kenshin, 2022). The town in which Great Hopes Farm is located has put out more detailed plans for the microgrid even after it was rejected for funding. It includes the criteria for biogas plants to be able to supply power in an emergency, and to which buildings emergency power would be routed for each biogas plant. It even included a basic revenue model, whereby the biogas plant operators benefit from paying out less to their utility company for electricity but would pay the microgrid operator for use of battery storage, and the municipality would contribute a business continuity plan[39] measures fee to the microgrid operator.[40] While the cost of such infrastructure remains prohibitive, it has not stopped municipalities from pursuing these projects of infrastructural autonomy, and microgrids in

[39] 事業継続計画 *Jigyou keizoku keikaku*.
[40] Business continuity plan (BCP) seems to come from managerial and logistics studies, and is a version of resilience thinking, whereby planning is made to continue operations after a certain disruptive event.

particular, as a result of the funding available for planning and the local imperative to become more resilient to disasters.[41]

Recent surveys reinforce the idea that local municipalities are for more locally focused energy systems. A survey by REOH from 2017 to early 2018 mentioned in passing earlier asked 179 municipalities in Hokkaido about their opinions on renewable energy introduction in Hokkaido. It showed that 20% of the respondents want increased connection to Honshuu, but around 30% of respondents emphasized the need to allow regions to take leadership and receive the benefits, while asking the government to extend FIT with amendments. 62% wanted policies promoting local production for local consumption. The same survey also showed that 40% of municipalities had experienced some kind of trouble with their renewable energy projects, even though the majority had not and did not foresee any problems in the future (REOH, 2018).

Another survey by the Hokkaido Prefectural Committee on Promoting Energy Saving and New Energy (2019) conducted in February 2019, the winter after the earthquake, gave a portrait of the various issues facing businesses and municipalities. While the motivations of most businesses for introducing renewable energy were distributed among reducing waste, marketing, contributing to emission reduction and advancing local production for local consumption, biomass projects involving farm animals answered mostly advancing local production for local consumption and 'other' (presumably re-using waste to make fertilizer and save money). The survey also supported what I had discussed in that they indicated that the initial costs and difficulties with maintenance because of the nature of working with bacteria and machinery they may not have

[41] Interestingly, NEDO's documents will more often refer to レジリエンス (*rejiriensu*), while local actors and the microgrid plans have more often used the term 防災 (*bousai*).

experts on-site to fix, as well as 'other' worries such as the recurring cost of the equipment and bureaucratic hurdles are important issues for biogas producers (Hokkaido Prefectural Committee on Promoting Energy Saving and New Energy, 2019: 11).

This survey also gathered interesting answers about their ability to use renewable energy during the earthquake. Most municipalities and one assisted living facility in a rural area that answered said that they did not have any battery storage to use energy, and given that their systems were connected to the grid, could not make use of any of it. This left more than one town unable to use their schools as emergency evacuation areas.

One town in Tokachi specifically commented that during the years of the RSP policy, they used energy they needed first and sold only what was left, but that FIT incentivized selling energy through the grid first, making them unable to use the energy when they most needed it. Half of the businesses surveyed similarly were unable to use the renewable energy they were producing. Only one dairy farm in the survey was able to use one milking machine. For many rural areas in Hokkaido, the central government's policy of FIT and the grid itself had betrayed their expectations of resilience rather than renewable energy itself.

5.5 Biogas Infrastructures and Thermoception

Returning to the idea of revolutionary infrastructure proposed by Boyer (2016), we can see that here too, biogas plants fall far short of the revolutionary repurposing ideal: reliant on fossil fuels, feeding into the grid, and operated on privately held farms designed for capitalist value creation from exploiting labour and animals on land taken from indigenous people. To end the analysis here, however, would flatten the way renewable energy has brought together activists, farmers, corporate engineers, utilities, government leaders, and academics, and brought back into focus the problem of dwindling public trust faced by the government and utilities. As Tokunaga and Muramata both expressed, the government and HEPCO are suggested to be difficult to work with and a bit complacent, despite being aligned on the desire for local production and consumption of energy and resources. Bridge and its emergency grid plan shows that the desire voiced by some activists at the REOH meetings to bring ownership of the grid under the public rather than a utility company (or many companies, under the new liberalization laws) is not so extreme, and could have support from parties that might otherwise be assumed to be too conservative to implement a Stadtwerke-like re-municipalization or public reclamation of energy infrastructure.

Moreover, and more importantly for the rest of this chapter, focusing on how biogas experiments in Hokkaido fail to present any kind of revolutionary potential risks wasting the valuable perspectives given by those interviewed here. Though undoubtedly guided by my interest and questions in matters of energy (labour supply and bureaucratic hang ups were clearly more important to the day-to-day of the farm managers I spoke to), the interviewees spoke of their own reconceptualizations of heat and energy emerging from multispecies energy production through biogas, and the sensorial and affective dimensions that are involved in building out rural energy infrastructure following the 2018 earthquake.

Heat-sharing on dairy farms makes heat part of a sensorially and technologically managed ecology. While there are backup heaters for when biogas is not emerging consistently from the vats, in normal conditions, plants, cows and people rely on bacteria to digest waste and the generators to supply excess heat to the system of pipes that redirect the heat through the facilities. In this way, excess heat also exists at the margins of grid electricity, and has become a focal point for renewable energy proponents seeking survival strategies outside merely relying on the government to strengthen electrical infrastructure. Technologies for sharing and conserving heat from *natural* processes posit an alternative to the centralized electrical systems that create more distance between living beings and energy, and have been built around maximizing and intensifying energy production. I think this is the difficult, unruly political possibility of bioheat in particular: in tying the well-being of others to the biological processes of one species, it challenges the assumptions (along the lines of Leslie White) that more energy production creates more societal well-being (for humans), that using fossil fuels can free us from ecological relations, and that modern society must now depend on complex, centralized systems that increase caloric efficiency for its continuation, which undergird of the modern mode of energy production.

Vannini and Taggart (2014a) offer the concept of *hot energy* (as opposed to the cold, machine-managed energy of the grid) to discuss the practices of off-grid homeowners in managing the socio-technical and spatiotemporal processes required to produce energy more self-sufficiently on a small scale. By using their senses to understand the state of energy (heat) around them, which Vannini and Taggart call *thermoception*, people not only create different systems, they are themselves transformed by the repetitive use of their bodies to become attuned to heat. Drawing on Ingold (2000, 2011) and Latour (2007), Vannini and Taggart (2014a) argue for an embodied and technologically mediated conceptualization of off-grid heat practices. While not off-grid, biogas plant management demands more attentiveness and bodily attunement to variations in heat. Biogas infrastructure is closer to hot energy in this sense, and requires a sensitivity to heat that modern energy systems have not.

Social scientists have long argued that heat (and cold) are more than just a matter of individual sensory experience. Classen (1993), building on the earlier work of Redfield and Villa Rojas (1934), argues that the thermal order is the social order for Tzotzil in Mexico, with days corresponding to heat cycles, rituals allowing people to become warmer, and geographies being named based on their relative experience of heat. Hot and cold are used across the world in medical conceptualizations and the effects of food, herbs and other substances on bodies (Logan, 1977; Manderson, 1987). Energy also finds uneasy equivalents in Chinese medicine through *qi* and concepts of flows and blockages in Rwandan traditional medicine (Mayor and Micozzi, 2011). I bring these distant examples up not to suggest there is any direct connection between them and Hokkaido, but rather to point to the ways thermoceptions have always existed and influenced social organization of space, time, and embodied existence[42].

More recently, concern about heat mitigation and adaptation, and the costs to society and human life for failing to mitigate and adapt, have figured more in both media and social science in Japan and elsewhere. Recent articles in the New York Times (Goodell, 2023) and the Guardian

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[42] Sean Hsiang-lin Lei (2012) has written an interesting article on how the steam engine changed at least one school of traditional Chinese medical interpretation of the body, in that it inspired Tang Zonghai's reconceptualization of Chinese medicine through the understanding of *qi* as steam. This at once separated the functions of Western and Chinese medicine (the former for anatomy, the latter for *qi* transformation) while bringing their understandings of the body closer epistemically.

(Lakhani, 2023) have covered a long term journalistic project attempting to capture the gap of delusion between the apocalyptic scenes of climate collapse *driven by heat* already around us, and the failure to reorganize society around protecting those that will suffer the most: people and ecosystems that have been deprived of the resources to survive. Mabon et al. (2021) have written about mitigation methods taken by people in Fukuoka, and how senses of heat are linked to desires for environments that tend to be less centred around cars (e.g. parks with shade). Luggauer, Martín and Farías (2022)[43] have explored Madrid using bodily sensations of heat and visual media as guides for understanding hot spots and urban heat infrastructure.

From the cracks left from the 2018 earthquake, in biogas plants, in the hopes of autonomous microgrids for rural municipalities, and in renewable energy conferences, different kinds of practices and ways of becoming around heat are emerging that have a shared sensitivity to the potential for losing and wasting heat in a disaster. Heat can make *unthinkable* disasters thinkable. By extending Vannini and Taggart's ideas of thermoception and hot energy to the broader movement for local heat-based energy projects and independent infrastructure for rural areas in Hokkaido, we can see that a different kind of thermal subject is emerging that is not quite hot or cold. They are reluctant experimenters and tinkerers. Nowhere is this emergence more obvious than in the way I have tried to trace the short but multifaceted and compounding history of biogas plants in Hokkaido as they adapt to public matters of concern: first emerging as waste disposal in response to local environmental concerns, then becoming enrolled in electricity production and heat ecosystems, and now being re-imagined as backup generators for a future blackout and potential sources of liquid fuel for local consumption. It has been one of the most

[43] Farías is currently leading another project which also has a component on heat in Fukuoka being conducted by Margherita Tess.

interesting findings of this research that biogas plants on dairy farms have become, in such a short period of time, a site of such active contestation and speculation on energy infrastructure.

Rather than focus on a critique of this imagination of biogas farms as living generators and emergency energy infrastructure and the material conditions that underlie it, I draw on the work of Stengers (2010), Gabrys (2015) and Jensen (2020; 2022) to instead make room to speculate with my participants about the potential of their thermoceptions and experiments to transform the politics, infrastructure and ecology of energy in Hokkaido. To better understand the potential of biogas infrastructure and its related thermic subject, comparison with other modes of infrastructure and their subjects from the reviewed literature is helpful. I do so here with attention to what Bridge et al. (2018) call energy landscapes, the constellation of practices, and natural as well socio-technical relations that make up energy production and consumption in a given place.

Recalling the discussion from earlier in this chapter, Nader's (1981) nuclear power technocrats produced and maintained centralized systems of power production and used their knowledge as power to overrule democratic concerns. In this landscape, Nader's anti-democratic nuclear scientist cuts the network so as to exclude the broader society, the afterlife of the fissile materials, and the risk of centralized energy production (Strathern, 1996). Morita's (2017) discussion of aquatic infrastructure in the Chao Phraya Delta centres the multispecies relationships of farmers growing floating rice moderating flood waters and sediment. This represents an alternative landscape to the terrestrial logic of roads and flat concrete imposed on the delta by hubristic modern urban planners. On the other hand, Boyer imagines a revolutionary subject (2016), or perhaps a hyposubject (Boyer and Morton, 2021), emerging from the practices of squatting and repurposing existing metabolic energy represented in modern energy infrastructure. Biogas plants in Hokkaido are not highly technical and fortified systems like nuclear power plants, but neither are the multispecies relationships of biogas themselves transformative to the entire dairy farm ecosystem as they are in floating rice farming.

Chandler and Reid (2019; 2020) criticize this ontological or speculative imagination when it is applied to indigenous methods and practices by Western academics, as it has ironically tended to reduce these to a mere foil for white Western academic imaginaries, and reaffirm governmental approaches rather than challenge them. I agree that histories of indigenous struggles do not exist for the gratification or revitalization of a discipline mired in the ongoing crimes of colonialism. Given the planetary crises we are confronted with, one would hope that the search for analytics or the trope of a future after modernity in *non-modern* indigeneity would be set aside, and that any engagement with indigenous practices would come with material support to indigenous peoples' struggles. Chandler and Reid (Chandler and Reid, 2019; Chandler and Reid, 2020; see also Farai and Chandler 2023) suggests that the speculative exercises of Western academics are only possible because they largely assume that modernity has failed, the Human and its promise of progress are already dead. I, for one, am not convinced that Stengers, Latour, Viveiros de Castro and others, for all their possible faults, assume modernity to be over[44]. I engage Stengers and the ontological literature not from the assumption that modernity has ended, or that indigeneity is the inevitable future following modernity. Instead, I make the small deviation from

[44] Chandler and Reid (2019; 2020) while critical of ethnographies from the ontological turn also do not make mention of the work of anthropologists like Maria de la Cadena (2015), who have added nuance and in my opinion avoided some of the tropes they point out. Moreover, they rely throughout on Bessire and Bond's (2014) 'Ontological Anthropology and the Deferral of Critique' without examining its possible overreliance on equating ontology with the works of much older structural anthropologists, and without examining the problems of critique as a program for social science as has been pointed out by the likes of Latour (2004).

the logic of modern energy megasystems I see in biogas plants the place I speculate from: within the conditions of modernity, but potentially representing one area where one of its engines of support begins to fail and may be replaced by alternative infrastructures and their ecologies of heat practices (Stengers, 2005).

In doing so, I draw on readings of Spinoza, and Deleuze's reading of Spinoza, as well as Marx and Negri by suggesting that the forces of production (the living worlds that allow constitution and production) are not a priori subjected to the relations of production (the state, the market, the logic of the grid). Spinoza's *Ethics* has served as inspiration for many looking to understand how to break out of philosophies of idealism and teleology (Read, 2022: 208). Negri (2000) argues in *The Savage Anomaly* that Spinoza's writing was defined by a crisis that we are in many ways still living through today, as it extends and repeats itself, of subjecting new productive forces like science and technology to the mediating order of the market. By seeking the transformative power in the material and immanent, we may become more attuned to radical possibilities emerging from unexpected places.

Cara Daggett makes the point that the language around energy doing "useful work" that comes from engineering physics undermines the way that the redistribution of energy through entropy also creates new reactions and kinds of work. In her writing on physics, energy and petromasculinity, she puts forward the idea that the very history of language and thought surrounding energy is married to the history of a particular masculinist subject (Daggett, 2018). Paying attention then to the work of ambient energy, and becoming attuned to the risks of petromasculine infrastructure can be a step towards a more feminist energy system and a different kind of thermic subjectivity.

5.6 Speculating About Biogas Futures

Though they represent an infinitesimal fraction of the electricity generated in Hokkaido, these farms are microcosms of a different set of possible energy practices and relationships that challenge the idea of the grid as an omnipresent, modern machine. They are made up of a small system of wires, water pipes and heat, a generator plugged into cow waste (and whatever else the workers had thrown in the mix) being eaten by bacteria, which in turn leaves fertilizer to feed crops, and heat that allows fruits to grow through the winter. The energy is not just flowing through wires into the homes and offices of people around the island, and the eastern half of the country through the grid, it is also slowly but surely circulating around the farm site through heated water pipes in and above the ground. Bacteria, cows, sensors, generators from Germany, workers from Vietnam, melons were all participating in the heat ecosystem enabled by government subsidies, farm equipment companies, dairy industry development, and the grid's own capacity problems as a result of Hokkaido's uneven development.

Moreover, dairy farms are paragons of scalable projects, requiring the flattening of local ecology and human and animal well-being (Tsing, 2015), but biogas infrastructure is less clearly scalable, requiring attention to local conditions on an ongoing basis, cultivating thermoceptions, and might provide different, *hotter* modes of relating to energy than with the electricity grid. Even if they are reproducible, and caught between the logic of the grid and the logic of the dairy farm, they also unsettle these modernist projects in their potential to change thermoceptions and thermic subjects.

Making space for alternative ways of being in the infrastructures of modernity could lead to more arrangements like biogas plants: less reliance on fossil fuels, and more decentralized power production, using heat, insulation, water and waste to replace electricity. To borrow from Stengers (2016), slowing down modern energy infrastructures before they are forced to by global energy markets' incessant demand for stable output and optimization would seem the more prudent option to ensure human and ecological well-being. In this sense, over-engineering resilience holds the greater risk for those that conventional resilience has left feeling vulnerable.

If, as Papadopoulos (2011) suggests, "the point of departure for grounded politics is how experience of the involved human and non-human actors is collectively produced" and negotiations of radical difference "constitute the processes of social and ecological world making" (190), then there is in biogas and the mediated management of dung and heat in Hokkaido the potential for a more grounded and more-than-human politics of energy and resilience based on shared vulnerabilities.

The politics of biogas experiments and their ecologies of heat are still somewhat undetermined, even though they are built within a capitalist and colonial history of factory farming. While unsustainable, they do point towards energy formations that may allow places like central Hokkaido to better survive ecological polycrises. Similarly, the concern over infrastructural independence and disaster readiness speaks to a desire for breaking away from the unnecessary dependencies on Tokyo built into the development of Hokkaido. There is no guarantee that this will translate into a more decolonized world on its own. However, if public attention turns to land use and ecological restoration as global heat patterns get *sensed* as disrupted, new politics of ecological well-being that, for instance, advance returning land to indigenous people could gain traction.

Whatever energy futures they may continue to build, thermoceptions in biogas plants and practices to share heat against the collapse of the grid contribute to expanding the way we can *do* energy beyond thermodynamics, mechanistic resilience, and neoliberal subjectivity. As Mirowski (1991) argues, neoclassical ideas of humanity impose restrictions on what it means to be human. Value is assumed to be like energy in its purely thermodynamic sense. By unsettling practices of energy, we might also continue to unsettle these structures of value, time and humanity that are furthering the polycrisis.

6. Making Off-grid Solar Systems, Senses and Futures

I had, in early 2019, aimed to focus this research on the changes to energy production and its impact on Hokkaido's electric infrastructure as at least two competing logics of resilience, and different groups enacted different energy futures. This remains an important element of the findings of this research. By focusing only on electricity production, I was following a certain thread of recent energy anthropology focused on electricity production and the grid (Bakke, 2017; Howe, 2019; Jensen, 2020; Özden-Schilling, 2020). As I gained greater awareness of the responses to the 2018 earthquake and in particular biomethane projects, I realized heat-centric practices were also important to the way alternative energy infrastructures were being imagined. I gradually found my way into biogas plants and the more sensory and ecological aspects to the changes in energy infrastructure that was perhaps just as important to understanding why and how actors in Hokkaido were diverging from the goals of energy policy, and attempting to creating autonomy and resilience outside the electricity grid.

In the course of writing this thesis, I have come to learn of other projects that show a growing concern over matters of heat in the midst of worsening outcomes in the climate crisis. Jamie Cross leads the *Cool Infrastructures: Life with Heat in the Off-Grid City* project mentioned previously, aimed at studying and sharing information on infrastructures of cooling in large cities in the Global South (UKRI, 2023). Another project carried out by Ignacio Farías, Indrawan Prabaharyaka, and Margherita Tess examines the strategies of micro-adaptation to heat in two leading cities, Stuttgart and Fukuoka. This one also notes the creeping thermal stress placed on human and non-human life by climate change and how spaces are being reconfigured by this change and by climate policies. These and other projects focus attention on energy and infrastructure in a way that is more attuned to heat and the way local adaptations of infrastructure produce thermal, sensory configurations that affect human and non-human life.

In many cases, thinking with heat forces our attention away from the grid to the *off-grid* practices of those outside the realm of electrical expertise, and outside the concentrated centres of energy production. As previously discussed, Vannini and Taggart (2014b) have studied the embodied and affective aspects of heat in off-grid homes. During the course of this research, I had the opportunity to talk to some activists in Hokkaido who gave off-grid workshops to help people set up solar arrays in their homes. One noted the impact that the Fukushima disasters had on them, and their awareness of the grid as a machine that gave electricity but took away power from people. This matched what I had read from a collective of off-grid proponents (Ito, Goto and Takeuchi, 2017): 3.11 had cemented for many of them the idea that food could disappear from supermarkets, and infrastructure they relied upon for their lives could fail. As such, what was needed was not just energy efficiency in the current energy system, but new, material ways of living with disaster and mediating sense (Ihde and Malafouris, 2018).

In Japanese popular culture too, the impact of the Fukushima Daiichi disaster on Japan's relationship to electricity can be felt in films like *Sabaibaru Famirii* (Survival Family) (Yaguchi, 2017), which depicts an urban society (and nuclear family), whose social fabric has been built on easy and plentiful energy access at home, suddenly plunged into a state where no electricity is available. Even before 3.11, Japanese pop culture imaginations of the grid as a fossil fuel and nuclear machine propped up by corporations and empire had their rare appearances. In the popular video game, *Final Fantasy 7*, a group of outcasts battles the Shinra Corporation that is essentially using the life of the planet to create energy and make bioweapons out of people. Popular culture products, as well as the work of off-grid proponents, point to the domestic sphere as both a nexus for fears about surviving a breakdown in grid infrastructure, and a starting point for rethinking modern living arrangements that contribute to a worsening climate crisis.

In the following sections, I refer to my experience using critical making (Ratto, 2016) to build a DIY solar array at home, and to the off-grid solar projects of others, to argue that the co-constitutive process between off-grid practices and technologies can enable a rethinking of modern energy subjectivity and senses of energy. I turn the idea presented earlier of grids as machines of contradictions embodying a theory of how the world is or should be, to the world-making and sense-making of off-grid solar projects. In particular, I interrogate the usefulness of Morton and Boyer's (2021) concept of the hyposubject to think through the fractal or less-than-systemic reorganization of energy that might be possible not through photovoltaic technology alone, but through relationships they mediate between photovoltaic arrays, the Sun, heat, communities and ecology.

6.1 Finding Methods at Home

Thinking through the future (or present) of collapse means also thinking about the purpose of research in such a time, and problems of methodology. In a way, every work cited here has its own answer formulated for the way it identifies problems and the value of its contribution at the time it was written. Finding continued purpose in an academic project, even one studying the forefront of the supposed solutions to climate change, has not been easy. If only perhaps because it is painfully clear to me how these solutions and the way they are being implemented are leaving people woefully underprepared for any kind of *unthinkable* shock. As political mechanisms for change become moribund, and both the economics and ethics of research grow more difficult, it is difficult to imagine researching contributing to change outside the personal alliances and reach achieved at the margins of research projects. Even some of the writings of Chakrabarty and late Latour risk falling back on universalism or proposing a central organizing concept for life in the Anthropocene (that is also at once supposed to be not unified and anti-systemic while also mediated through systems theory)[45] in the face of the climate crises (Boscov-Ellen, 2020; Junges, 2021).

I am, however, encouraged by some attempts to combine social science with speculative fiction and direct action (Haraway, 2016a; Haraway, 2016b; Auld and Jensen, 2023) as well as recent thinking on living in damaged places (Tsing, Bubandt and Gan, 2017). Engagements with speculative realism are helpful for understanding difference through emergence and co-creation between systems and stories, making place for the possibility of other worlds (Jensen and Kemiksiz, 2019; Stengers, 2018). Through participation in the speculative fiction project FICT (2023)[46], and following commentary on pluriversal politics (Garcia-Arias and Schöneberg, 2021;

[45] Even more confusingly, even the critique of Latour's Gaia and the Anthropocene sometimes invokes a revolutionary universalism, reflected through historical decolonial struggles, as a better mode for a pluriversal politics (Tornel and Lunden, 2021; Tornel and Lunden, 2022). There has been ongoing scrimmage of this kind between (eco)socialists and the ontological turn authors, with the former seen as trapped in old binaries and ineffective programs of critique, and the latter as divorced from reality and unable to generate a realistic political program. For instance, Andreas Malm (2018) critiques Latour and Bennett mainly for attributing intention to matter. Jensen et al. (2017) argues against Bessire and Bond (2014) that not a priori adopting terms of critique like gender, race and class being taken as a sign of lacking politics is actually potentially a failure to imagine politics and modes of description with terms not limited to the standard Western modes of critique applied almost universally. While I am mostly sympathetic to the ideas of the ontological thinkers, I believe they can hopefully agree that ecosocialists are not generally the primary obstacles to the possibility of their kinds of politics. In this moment of crisis, there is hopefully more to be shared and learned from than through critique and debate. Indeed, the social sciences in general are only increasingly under threat as the concepts of traditional social science have reached more people.

[46] A small project that soon snowballed into a sprawling mass of small projects with Asli Kemiksiz's power of persuasion. It was an attempt to imagine a different 2020 without the influence of European colonialism, inspired by

Tornel and Lunden, 2021; Tornel and Lunden, 2022) through the pandemic, I was pushed to ask myself questions about the direction of post-pandemic energy transitions in Japan, and how individual actions from within capitalist and colonial contexts could meaningfully unsettle the one-world gridworld.

Given the circumstances of the pandemic, and the demographics of participants in my research, I chose to pursue online and distanced methods following February of 2020. Most of my participants were over 60 years old, and were located in places that required me to take public transit to go to their offices or place of work. The uncertainties around the mechanisms of spread of COVID-19, and the well-known age-based risks to my participants made me feel I could not ethically justify increasing the risks to myself and others for the sake of the methodological integrity of this research. While I believe the pandemic had various deleterious effects on the work and lives of almost everyone, I believed in my case the fieldwork I had already conducted provided me with sufficient data to build upon using other methods. One such method was an experiment with critical making I conducted at my home in Hokkaido with my supervisor, Professor Morita.

Like many during the pandemic, my attention turned to my own environment at home. Professor Morita had suggested a small collaborative project to build solar arrays using a guide and the ideas of critical making by Ratto (2011; 2016). I had already been thinking of setting up my own

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speculative fiction. While I believe many of the tensions in the project around the idea of *decolonization* as something that can happen in a thought experiment mostly in universities by taking inspiration from indigenous cultures remains unresolved, the project was a success in bringing together groups of people that would otherwise not have had the opportunity to interact, and creating interesting works of art.

solar panel, and accepted. I had help from my supervisor, and later a friend who used the system in their home.

I also took inspiration from a branch of research between energy and place has centred around homes, and emerges from material culture studies. Using the work of scholars associated with material culture studies, Kerstin Leder Mackley and Sarah Pink (2012) approached energy consumption within the home through video tours of the home. This builds on Pink's (2004) previous work of the home as a multi-sensory environment that shapes everyday practices that constitute self-identities, itself based on Miller's (2001) material culture approach to the home and consumption. Energy is discussed as a flow, something consumed indirectly by users through the mediation of sockets and appliances to make refrigerated, tumble-dried, electrically lit patterns of living possible.

In later work, Strengers, Pink and Nicholls (2019) have also engaged with concepts of energy futures[47] and sociotechnical imaginaries, but remain focused on practices of energy use and engagement with technology in the home. Noortje Marres (2010) has explained this focus on the home as part of a new form of citizenship, where the home is the centre of *green* actions like changing light bulbs and buying less energy-intensive appliances that allow one to participate in global change to protect the common good of the climate and environment. These technologies become material linkages to energy infrastructures and green energy citizenship as a form of subjecthood.

[47] See also Ballo, 2015.

Similarly, Alex Wilkie and Mike Michael (2018) have explored the connections between community and energy via experimental devices. While it may seem a bit distant from the energy literature's historical focus on the way energy shapes society as a whole, moral and political problems, and energy experts, this branch of literature is interesting for breaking down the usual scale of energy (geological eras, country-crossing pipelines, national groups of experts, globally significant projects) and focusing on the sensory and the material within more familiar environments.

6.2 Making Off-Grid Solar Systems

The early stages of this project began in the summer of 2020. I was able to keep staying in Yubari during this period, but had stopped conducting interviews and meeting in person with people outside of masked gatherings with my small social circle. It felt like a time of both grim hopelessness and radical possibility, with the hope for a different kind of life that might be possible after the pandemic. Around this time, the initial planning for the speculative fiction FICT project was underway. Massive protests for racial justice had shaken the United States. There was talk of a green recovery, albeit from the conservative forces of the Bretton-Woods cartel.

Professor Morita and I had previously discussed the relationship between making as a material process of assembling and adjusting to the environment and energy infrastructure. With some funding from the Toyota Foundation, he advanced the idea of attempting to follow the instructions in Tenda's (2015) *Wagaya Denryoku*[48]. We generally followed these instructions

[48] This would literally translate to *My House's Electric Power*, but the title *Powerhouse* would sound better.

with some adjustments and patching together knowledge from videos online like oral traditions. We also made use of the process of critical making proposed by Ratto (2011; 2016). Critical making helps create more in-depth and practical experiences of technical systems in doing science and technology studies by making researchers take on the role of amateur technologists to think about materials, bodies, environments, and technologies through direct and experimental engagement. Critical making focuses on the processes of making, rather than finished objects. Objects themselves point back to processes of making and carry with them theories of how the world works, translating (and often failing to translate) between differences.

Ratto also addresses the limitations of work in social science by asking how we can do more to think more broadly about the impact of research beyond impact factors and publications: "Performed within the safe walls of academic conferences and journals, and in a few cases brought into forms of public debate through artistic exhibition, what effects can this kind of work have?" (Ratto, 2016: 31). Ratto argues that the largely indirect effects it can have on policymakers, engineers, financiers and the more direct impacts on other scholars' understanding is not enough to address the critical issues of society. In this way, critical making is also proposed as a kind of methodological exploration through collaborative, often smaller-scale or DIY creation.

Putting together the solar system involved planning the locations of the panel and the battery, as well as choosing the battery, panel, cables, soldering kit, tester, and assorted items for fixing the panel and cables. In my case, the location of the panel had to be within 10 metres of the battery to match the length of the cable, allow for the cable to pass through without affecting the insulation and heat of the house (no holes, no open windows), and allow for as much electricity as possible to be generated. This left the roof of the first floor of the house, near a small window that led into the living room as the only logical emplacement. However, this meant finding fixation clamps that could attach to the zinc-coated steel sheet roof[49] to ensure that no holes were drilled that would cause leaks and rust. To provide better grip, I added bits of cardboard between the clamp and the panel's metal frame. This was an improvisation, as gap tape would likely have proven more resistant to rain. Additionally, insulatory padding was needed to block the rest of the small opening in the window once the panel was installed and the cable was sent through to connect to the battery.

Even with one small 100kW solar panel, I had to consider my immediate environment and the panel's impact on it, which exceeded my expectations. I had considered installing it out in the yard to provide shade for plants, but Hokkaido's winter conditions would have risked damaging the cables. As snow melts and falls as packed snow or ice on warmer winter days, it would have been more likely to create small cuts and water infiltration into the wires. Despite my efforts to consider the qualities of the materials and forces involved, this still occurred, as the edge of the roof wore into the cable over time. Professor Morita's roof, as it was not in snowy Hokkaido, allowed for the panel to be installed to provide partial shade for plants in a kind of solar sharing. Solar sharing is increasingly used in Hokkaido in flat agricultural lands where thin solar panels with gaps in between the arrays are installed on tall beams to provide cover for crops and plants on land that is still in use (Hokkaido Shimbun, 2022; Tabata, 2018). Even on my metal roof, I noticed that I had not properly thought of the panel's location as it would get covered in ice from the snow melt from the second floor's roof.

[49] トタン屋根 *totan yane*

Additionally, birds –and particularly crows– that would previously land on the roof and hang on the electric wires would now avoid the roof, and even once tried to drop a small rock onto the panel. When this happened, I was reminded of conversations I had with the managers of a solar plant in Osaka and electric pole repair crew in Hokkaido about crows. Crows were probably the most frequently mentioned animal in regards to maintenance costs: they liked to build their nests in higher areas, were curious and mistrustful of reflective surfaces, and learned to adapt quickly to many measures taken. Recently, the potential for crows nest-making to cause power outages and the use of AI to identify nests in Fukushima prefecture has made headlines (FNN, 2023). Even outside this DIY project, making and moving energy always involves some negotiation with other species and ecologies.

The choice of panel and battery also involved research and discussions about the properties of these components. The panel had to be commensurate to the capacity of the battery to avoid regular overcharging, and be relatively cheap and durable. Tenda's (2015) instructions involved using a regular lead-acid battery. While cheaper and offering more opportunities for soldering and tinkering to connect to an inverter and controller that would give data on output, these batteries were easier to manage and tended to have a shorter or equivalent life to a lithium-ion battery. A lithium-ion battery offered a gauge to measure how charged it was, and was also less likely to create damages in an accident, was more easily transportable, had an in-built MPPT adapter, as well as offering different ports for charging.

It also involved research and discussion into the history of making of these parts, and the supply chains involved in producing them. While lithium-ion batteries were at the forefront of electric cars, grid storage and home energy management systems, they still required a large supply chain involving lithium mining and refinement (as well as smaller electric components for the screen, internal converter and USB plugs). They also sometimes require silica and semiconductors, which are also used in solar panels. Individual solar cells in the panel are made of silica material (like semiconductors) that have atoms with missing electrons, allowing the cell to take electrons from incoming lightwaves. Both lithium and semiconductors experienced a supply crunch in this period, and both materials have diverse sources, qualities, and associated environmental and political networks they affect. In the end, given that the supply chain and life-cycle considerations for the battery skewed towards lithium-ion, that I knew I was likely to use the battery outdoors, and that I would lend both the panel and battery to a friend nearby while I was away from Hokkaido, I chose a more easy-to-connect lithium-ion battery made in Shenzhen that could store about 384Wh.

Once installed, I began gaining a better sense of my hourly electricity use and the flow of light and heat in my environment through the battery. The level of the charge in the battery became my main measuring tool. I observed that during an hour of regular laptop computer use, I could use as much as 15-20% of the battery’s charge, while charging my smartphone for the day often required only 5%. My sense of the charge and the battery also changed with the season. 10% of the battery in the summer could be made up in less than two hours of direct sunlight. Meanwhile, it could take 3 or more hours to charge that much in the winter. After using the battery and on hot days, I would check for temperature anomalies to ensure there would be no spontaneous combustions, and ensure the battery's level did not go below 50% for very long in order to maximize the battery's life. By thinking more about heat in this way, I also began to slightly heat water for dishwashing and house cleaning in the summer using ambient heat and reflective surfaces.

Upon leaving Hokkaido for a prolonged period of time, I lent the system to my friend, V. V is a man in his 40s, who has a hobby of repairing old, empty houses and I frequently help him with renovations. He was also interested in solar power, and energy more broadly. He was at one point selling small little burner devices and also bought an old stove that he burns dead wood from the area in and uses the heat to roast coffee. I asked him to tell me about his experiences using the off-grid solar system. His living space did not allow for the same kind of installation, so he simply propped up the panel outside at a slight angle and connected it to the battery. Despite changing the position and angle of the panel slightly, he often found that in winter he could barely charge more than 7% of the battery's capacity in a day (less than half of what I would get). However, he said he was glad to use something he could monitor directly, and rely on in a blackout even if the battery was not up to the task of powering a fridge or a heater.

This idea of a *sense* of energy in the home becoming closer or more bodily mediated was also something that came up in my discussions with an off-grid educator in Hokkaido. He was a man in his 60s who retired slightly early and decided to teach people how to build off-grid systems after the 3.11 disasters[50]. This included not just energy production, but getting better insulation,

[50] This was a fairly common reference point for the renewable energy advocates and few off-grid advocates I met. Even though no one I met claimed they were directly affected by the disaster, it now punctuated a period in their lives where they saw themselves as complacent about how their electricity was being made and managed, and their relationship to the environment.

heat pumps, and making reflective paint to manage heat in homes. He mostly taught small off-grid solar workshops in a communal space in central Hokkaido, but also sometimes invited small groups to his home so they could feel the difference. "I don't usually use much heating if I can. Many visitors are surprised when I say that. It feels like a normal house where the heat is set to 26 [degrees Celsius]. By getting a sense on their skin of what is possible with insulation, a heat pump and a bit of heating, mostly from solar… I think this changes their perspective on the energy they are using every day." He added that some people he knew with good insulation and off-grid solar would be able to dry their clothes outside the main heated room and create a more agreeable level of humidity that way, extending practices of energy saving to an awareness of their house as a kind of ecosystem of heat[51].

By inviting people to feel to use their bodies a different way about the heat in their house, the off-grid educator was performing a tactical oscillation (Schick and Winthereik, 2016): this was at once a kind of eco-fix for modern houses, but also a way to invite people through an everyday experience of heat into a post-Fukushima world where heat is the basis for more action and infrastructural change. The smooth politics of changing consumer habits was also an invitation to be affected differently by something both so mundane and life-or-death as the dynamics of heat in a house in Hokkaido. One could compare this tactical oscillation between the mundane and the vital or cosmopolitical to the destabilizing experience of infrastructural inversion of the grid during the 2018 earthquake. Indeed, many joined a seminar of his following the earthquake in order to learn about heat pumps and installing off-grid photovoltaic arrays.

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[51] The word for heat in these demonstrations often also oscillated between thermodynamic and affective worlds. Throughout, I have not attempted to differentiate between kinds of heat, but there is a world of difference between *netsu* (熱) used analogously with thermodynamic heat, and words like *atatakasa* (暖かさ・温かさ) or even *nukumori* (温もり) which are more affectively charged words similar to the idea of warmth.

The oscillation towards the cosmopolitical, if there is one here, is to cast practices of off-grid energy into practices of sense-making and world-making. In other words, insulation, heat pumps and photovoltaics can enable practices that grow a thermoception of one's body, devices, the earth below and the air outside as part of a wider ecology of heat around the home (Ingold, 2000; Vannini and Taggart, 2014a). Over time, these configurations and practices become infrastructural to ways of being or worlds outside the gridworld (Boyer, 2016; Keiichi, Otsuki, Satsuka and Morita, 2018; Winthereik, Maguier and Watts, 2019).

Thinking about the consumption end of energy through sensory experience at home as a kind of ecosystem of heat was not initially part of my research design, but I believe it did help me understand the changes in thermoceptions happening as a result of biogas and off-grid solar in Hokkaido. I was reluctant to include this bit of self-ethnography, as the practice has been somewhat maligned. However, Strathern's (2004) response to the critical turn –arguing against simply making the *self* into the *object* of critical analysis in a reproduction of the Western metaphysical reliance on objects– suggests we should not exclude ourselves in thinking about how we are becoming and changing along with what we do. Subjectivity is then not just a position we occupy but a process we act in. By relating my experience to others acting in their environments at home who are also being affected by energy use in the midst of climate crises (Morita and Suzuki, 2019) I extend this becoming to more than some narrow idea of self, and beyond a reliance on analogies to systems.

Using critical making as a method, I was able to reflect more carefully on the subjectivities and ideas of a future energy transition produced through off-grid practices. Biogas infrastructure implies different concepts of the grid, and relationships to the grid, than FIT or the increased connections to Honshu. Similarly, off-grid solar, even when following a simple instruction manual, can also demand a kind of thermoception and awareness of sunlight, precipitation, insulation, frequencies and the characteristics of many different materials. Though coal and oil infrastructure are built on the ideals of constant, maximum output, they have implied different material configurations which required mass labour in the case of the former, and extensive, specialized infrastructure in the form of pipelines in the latter (Mitchell, 2011).

6.3 Hyposubjects in the Ruins of the Grid

Off-grid solar, though varied in its forms, often offers practices for a transition not as modern[52] energy maximalists, but instead what Morton and Boyer (2021) call hyposubjects. The hyposubject is a bit of a messy and weak concept, by their own admission (Morton and Boyer, 2021: 61). Hyposubjectivity attempts to talk about subjectivities possible from renewable energy arrangements outside of the grid:

[52] The word *modern* is often used in more-than-human scholarship (Morton, 2013) and STS (Latour, 1993) in a way that more often refers to a certain paradigm of thinking of the relationship between natural objects and human subjects. A surface read could lead one to criticize them for belief in the same kind of modern exceptionalism that affects archaeology (Dawdy, 2010). Rather, they attempt to criticize the belief in this exceptionalism as part of Western metaphysics from the times of Kant and Marx. However, they are less attentive to the use of modernity in other disciplines, or translations into other languages and contexts (Chakrabarty, 2011; Ferguson, 1999; Ferguson, 2006; Melvin-Koushki, 2018). I am attentive to these interrelated and multiple uses, and have tried throughout to use context to indicate whether I am using the word modern to refer to the process of negotiating Western-style economic growth delivered through infrastructure and globalization as I am here, or the philosophy of the relationship between nature and humans as I do below in the paragraph. I have tried to avoid using it to refer to a period of time to avoid creating additional confusion over this term.

> "Meanwhile the thing about solar energy— solar meaning solar but also wind, biomass, etc.—is that their supply chains are much shorter. They don't need a centralized grid infrastructure to operate, in fact they don't work best in a grid world. They have a different material politics which could enable a different human politics to emerge. Right now grid engineers hate solar energy because they see it as parasitic and weird and intermittent. They view renewable energy as a virus in the grid world, endangering the health and stability of the system. And it is!" (Morton and Boyer, 2021: 45).

As a heuristic concept, it searches for a kind of subversive, subtractive emergence from the world of hyperobjects (which defy understanding through the vastness of the things they bring together) and hypersubjects (who bring hyperobjects into being through projects of extraction, liberal politics, domination and rationalization). In *Hyperobjects,* Morton (2013) argues that the vastness of human-made phenomena like climate change break down the modern patterns of thought that allowed there to be a background *nature* that could hold the mess of human activity. There is no background environment or place *away* from human objects like plastic and radiation: that world has ended.

As discussed in the previous chapter, I believe grid engineers and even the government in Japan do not see renewable energy as something like a virus, even if utilities have defended the pre-existing grid rules of hard stability by blocking large numbers of solar projects at the peak of FIT-subsidized profitability and forced the suppression of renewable energy output at peak production times (Cusick, 2014). Kyocera and other large companies have also shifted their business models to support self-consumption and local consumption, something the central government has increasingly supported on paper (Goode, 2017). The complexity and carbon intensity of dairy farm biogas and solar panels are also significantly different, making one united attitude to renewable energy, even within a single government body or organization, hard to imagine. However, the basic premise of energy hyposubjectivity that in the face of crises, the material arrangements of off-grid solar and biogas can create less maximalist[53] ways of being and thinking of heat and ecology matches at least some of my findings.

Morton has suggested in *Hyperobjects* (2013) that the collapse is in a sense already all around us. There has been growing commentary on the combination of climate change, war, economic exploitation, and rising fascism as a *polycrisis*, variably characterized as an emergent divergence from world-market liberal status quo (Tooze, 2022) or as a compounding acceleration towards catastrophe as part of the evolution of capitalism that is not any more likely than before to result in radical social transformation (Mezzadra, 2022). While the latter points to the difficulty in pointing to a single moment of collapse via comparison to a previous state of normality, they both suggest that the sum of these crises is creating difficulties in imagining a return to even the imagined status quo of a few years ago (Ayers, 2023; Heidemann, 2023; Jiménez and Pabón, 2023; Lawrence, Janzwood and Homer-Dixon, 2022).

Hyposubjects are imagined in relation to a future where modernity as both the imagination of nature as background for human activity, and as the material conditions and infrastructure of global capitalism, has reached a breaking point or even a collapse. In this new mode of existence,

[53] One latent tension in the concept of the hyposubject for me is the reliance on Deleuzian language of excess and abundance with the "hypo" and the subtractive imagination of its subject's belonging to a larger world. Viewed critically and simplistically, one could say it might imply a Human-centric need to act against some intrinsic excess to allow the excess flourishing of Nature. I have no direct resolution for this question of the concept of excess or its relationship to a kind of modernist maximalism, but address some of these ideas obliquely a bit further below in reference to Strathernian dividuality and complexity theory.

humans must find ways to become hyposubjects (again, they say) as a way of surviving this collapse (Morton and Boyer, 2021: 14-15)[54]. As it relates to energy, I interpret this as sacrificing the *anytime, anywhere* of the industry-centric energy subject of modern electricity grids for increased ability to live through coming disasters by relying on ambient energy (from the snow, from the earth) and active dependencies on other species (methanogenic bacteria) and local environments (rivers, the Sun, wind).

By allowing new ecologies of energy practices to unsettle the flattening frame of time and space laid by the gridworld, hyposubjectivity might also help in getting out of some of the pitfalls of Anthropocene discourse. Notably, the idea of a universalism in the Anthropocene mentioned earlier mirrors the ecomodernist arguments for greening the grid and other eco-fixes (Curley and Smith, 2023). Rather than engage with the transcendental assumptions of universalism to build a commons (even a multispecies one), we might instead turn to the potential of the hyposubjective and to the making of undercommons that resist discipline through enlightenment structures of time and humanity that render others less than (Coulthard, 2014; Houdek, 2023; McKittrick, 2015). Once again, I also do not argue that the off-grid solar projects presented here would end colonialism and capitalism. Rather, I see in them a challenge to the technologies that allow energy to be *cold* (Vannini and Taggart, 2014a) and invisible, and similarly disappear the possibility of living with disasters into the hinterlands of the gridworld (Boyer, 2016; Law, 2004; Morton, 2013). Off-grid activists in Japan often point back to the 3.11 disasters (and the future of climate change) in the way they understand time, living with or within the hyperobject that is the disaster and its lingering effects.

[54] I believe the implication is not that we must return to a pre-modern state, but that we will take what we can out of -or 'squat' in- the ruins of modernity. There are strong similarities to revolutionary infrastructure here too.

The provocation of the hyposubject that is the most significant, is that it is not so much emergent (more than the sum of its parts) as something like a fractal or dividual subject living with the failing conditions of modernity. It should be noted that in speaking of emergence, and of the relationships between parts and wholes, I am using the terms of complexity theory. Marilyn Strathern (2004, 2005), also thinking with complexity theory, draws on Roy Wagner's (1991) idea of *fractal person* in the Melanesian context to express how people exist relationally rather than be assumed to exist as individuals. Wagner's (1975) *The Invention of Culture*, coming out of a moment of reflexivity and focus on the ethnographer's subjectivity and gaze, was also an early intervention into how people make their worlds: not as culture as understood in ethnographic theories, but as lived worlds that have their own theories. Strathern's ideas of complexity are hard to summarize, but rely on the idea of nesting comparisons as making scales (with the level or scale assumed to be the larger often shown to be reversible to the smaller), and relations not just being parts of infinite networks, but being cuts that do not reduce complexity, instead giving form to that complexity (Strathern, 2004; Stathern, 2005; Holbraad and Pederson, 2009; Jensen, 2007).

Hyposubjectivity might align with Strathern's (1988) use of the category of dividual as a heuristic to understand relational ways of being in Melanesia that are not captured by the idea of the individual. Since its introduction, the heuristic of the dividual has been extended to many other contexts, critiqued, as well as erroneously associated with tradition and inescapable social structure (Smith, 2012). Much like the idea of the Western individual itself, and the idea of Japanese groupist conformism (which gets extended broadly to East Asia), these are stereotypes that have become packaged in theory (Smith, 2012; Sugimoto, 2003). Others like Hess (2006) writing about Christianity in Vanuatu have made arguably better use of the dividual to argue against the assumption that modernity, Christianity and individuality inevitably arise together. The legacy of Wagner and Strathern is also brought out in the way Sneath, Holbraad and Pedersen (2009) argue for technologies of imagination, in which imagination is developed through technologies rather than merely the source of individual invention.

What then might these ideas of complexity have to say about the kinds of systems that make up modern energy infrastructure, and the logic of the grid that has become the logic for cybernetics and ecology? Edgar Morin (1977), an influential thinker on complexity, notes that a system can be impoverishing, and antagonism can take place instead of synergy (or contains forces antagonistic to its perpetuation). As discussed with regards to Fisch's (2019) ethnography of the Tokyo train system making use of disorderly deaths on the tracks, adaptive systems can rely on disorder. The hyposubject points to the possibility of a future where modern systems will be or already are unable to manage disorder (within machine systems, ecologies, and people). It remains a provocation more than a theory with an associated literature and examples of its practices. Additionally, the idea of reducing systems and complexity to an addition or subtraction of parts which do or do not produce emergence is likely not the intention of anyone cited here. However, the idea of the hyposubject, through dividuality and complexity, can unsettle the naturalization of adaptation with regards to systems. It offers a slightly different way of thinking about emergence, complexity, the relationship between humans and systems, and energy futures by thinking through antagonism within systems and the *hypo*-systemic rather than synergy[55].

[55] Thinking of relationships and systems through fractals and disorder also brings us back to energy. An important problem posed by Schrödinger posited life's tendency towards organization in the face of the second law of thermodynamics (the tendency towards entropy) was paradoxical (Kauffman, 2020). More recently, the idea of *free*

Recalling earlier discussions of Simondonian philosophy of systems, the efforts to rethink energy and its infrastructure through solar, rather than adapt it to the grid is one that proposes a co-evolution and co-constitution[56] with a different kind of technical system or life object (Keating, 2023; Letiche and Moriceau, 2017; Simondon, 2005). We can also think of this as a less-than-systemic technological and sensory mediation of a relationship between people and ecologies with the Sun (Morita and Suzuki, 2019). A recent attempt at exploring some of these relationships is *Solarities* (Howe, Diamanti and Moore, 2023). Notably, *Solarities* does not shy away from the affective dimensions of these relationships as the Sun tends to bring together the same affective qualities as heat has in this research: dependence, fear, empathy. Indeed, if there is to be hope in the photovoltaic mediation and co-evolution or co-constitution of our relationships to the Sun, it is perhaps less in the technology's ability to reduce emissions, and more in the way it can bring together people and ecologies to leave behind the systems and conventions built around the gridworld and fossil fuels.

Both Simondonian and Strathernian thinking about complexity help in understanding how this can be hyposubjective. Simondon's ideas of societies and machines as self-generating and self-differentiating life objects, and his challenge to things just being as they are instead of evolving and becoming, opposing and breaking down offer a way to think processually about how we can become something different or be affected differently by doing things differently

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energy has been used and combined with information theory to think of living organisms as connected, non-equilibrium open systems using things like sunlight and nutrients to create their internal order (and return heat to their surrounding system). This in turn allows fractal mathematics to isolate and compare the structural complexity of different living processes, even theoretical life that would not be on Earth (Azua-Bustos and Vega-Martinez, 2013).

[56] Co-constitution differs from Jasanoff's co-production (Jasanoff and Kim, 2015: 6) as it does not assume a baseline reality being observed (i.e. by an ethnographer) that weaves in an imagined or social *native* reality.

(Letiche and Moriceau, 2017; Simondon, 2005). Though I question the usefulness of his idea of transduction as a pre-individual and encompass force or pervasive energy of becoming, the attention to the instability and complexity of one machine or one person is useful for rethinking the influence of modern machines, even as they seem to be all-encompassing. The latter in particular is a point in common with the fractal philosophy of Strathern.

Much like with biogas, although the future remains uncertain, the materiality of becoming for off-grid solar projects offers some idea as to the direction of the future or world being made possible in co-constitution with them. It is perhaps less a world of cold energy and maximum production than one where becoming affected by disaster and making energy more critically allows humans to create different, hypo-systemic, multi-species dependencies.

6.4 Degrowth Futures?

Very recently, conversations about degrowth, the limits of ecomodernism (see Morita and Suzuki, 2019), and the inevitability of the transformation of capitalism into socialism in ecologies killed by capitalist extraction have become more mainstream. One example of this from Japan is Saito's (2023) surprise bestseller *Marx in the Anthropocene*. Saito argues that the ecomodernist program of promising continued abundance and growth has failed to halt the destruction of ecosystems or meaningfully solve problems of capitalism. Degrowth communism, from my reading, imagines a mostly municipal or locally led cooperative re-organization into a stable-state economy (implying the elimination, reduction and increase of different sectors in order to at least meet all needs). While this idea did not strike me as offering anything particularly novel, its filtration into mainstream discussion could signal something of a shift in the popular thinking about economic growth and the calcification of mainstream party politics in Japan[57] (Dooley and Ueno, 2023).

Degrowth communism replaces ecomodernism's green growth with a future of a stable, sustainable system. Returning to the ideas of resilience explored in chapter 4, we might question the idea of relying on so-called stable systems. Off-grid solar proposes a local reorganization of energy that realizes shared ecological vulnerabilities to the Sun and to heat. It may also recognize the inability of modern systems to manage or survive climate disorder.

As mentioned throughout this chapter, it is difficult to say with conviction whether this necessarily qualifies these practices as something sub-systemic or hyposubjective. However, to the extent that relations to ecologies and to time through adaptive systems become disciplinary and managerial, they may lose sight of the transformative sensory and affective dimensions of relations between people, other species, lived environments and technologies living with disaster. The history of energy infrastructure in Japan, and indeed the history of energy anthropology from Nader's work, shows that modern, centralized grid management has disempowered democratic control and environmental movements. Biogas producers have shown me how even within an industry operating out of colonial land management, cheap labour, and automated extraction, experiments with off-grid heat infrastructure that create new more-than-human dependencies

[57] Some might wonder if there is something particularly about Japan and its responses to nuclear disaster, climate change and crises of capitalism that attracts imagination of a degrowth future. In some sense, the attention to Japan as a vanguard of demographic and economic possibility is nothing very new. Japan has been at the forefront of demographic aging and demographic decline discourse for decades, and has been the object of financial experimentation with high debt, low growth and negative interest rates, with the risks of these number games being treated much like nuclear waste put out to some place *away* (Hoshi and Ito, 2014; Morton, 2013; Zenios, 2022). Towns like Yubari have been taken up as emblematic of the dark future that awaits the rest of Japan through demographic decline (St-Pierre, 2017).

(and autonomies) through relationships with bacteria and sensing heat are taking place. Off-grid solar activists are, on their end, living closely with the idea of a future grid collapse, changing their lived environment to use ambient energy as much as possible, rather than the grid or other inputs.

The idea of energy futures as paths or ways of life under different scenarios of energy use that has become more prevalent lately seems to have existed from at least as far back as the 1970s oil shocks (Herman and Cannon, 1976; Cook, 1976). As early as 1986, Midttun and Baumgartner (1986) pointed to the act of energy forecasting by scientists as a form of political negotiation shaped by professional priorities and organizational structures[58]. This analysis has recently received more attention, particularly as forecasts for nuclear power continue to disappoint every wave of optimism (Braunger and Hauenstein, 2020; Lounasmeri, 2022; Sgouridis et al., 2022; Urhammer, 2017; Weibezahn et al., 2022).

The assumption that the future could be worse, or even disastrous, perhaps represents an important turning point in Japanese energy futures. In many parts of the world already, the modern idea of progress, particularly in the form of Western capitalism, has already lost its persuasiveness (Alsayyad and Roy, 2006; Ferguson, 1999; Mbembe and Roitman, 1995). I do not mean to say that off-grid solar projects in Japan imply some Malthusian vision of the next 30-50 years. Nevertheless, the difference between the futures being imagined at the time of high

[58] Grunwald (2011) notes that the sheer diversity of future energy scenarios even now makes it difficult to orient policy. The components and weighting given to different variables and infrastructures result in very different possibilities, requiring an understanding of energy futures as informed by norms and cognitive aspects of the producers of such energy future models. Some, like Nersesian (2016: 17) advocate simplifying energy forecasts to macroeconomic drivers, but these rely on layers of abstraction that risk making the forecast into yet another black box.

economic growth and nuclear power expansion in the 1970s and those being imagined in living with climate change and nuclear disaster grows starker.

As previously discussed, nuclear development in Japan emerged from a period where the risks of resource scarcity and limits to growth were at the forefront of discussions of sustainability. The promise of nuclear power has been painstakingly propped up by successive governments in Japan, but the 3.11 disasters and the increase in costs of maintenance have most likely dealt a serious blow to this optimistic mirage of the future. While the promise of continued growth and technological solutions to problems like climate change and depopulation remain perhaps the dominant form of sociotechnical imaginary for many in Japan[59] (Jasanoff and Kim, 2015), off-grid solar projects attest to the kind of alternative and marginal imagination of the future where these promises are also going unfulfilled. Elsewhere, ecological modernization and sustainable development are already used to reinforce ongoing colonial occupations that deny basic human rights to millions and worsen desertification (Alkhalili, Dajani and Mahmoud, 2023; Hughes, Velednitsky and Green, 2023). Things look bleak under a feed-in future of gridworlds[60].

In thinking about justice in transitions and how cybernetic systems fed by economic forecasts tend to minimize or distance the damages of climate change (Jasanoff, 2018), making tactical oscillations with systems of liberal politics, grid infrastructure and climate accountability may be important. However, those making efforts to live with disaster and develop ecologies of heat

[59] Or at the very least it can be said to remain so for those in government espousing Society 5.0.
[60] I have attempted to use *futures* when describing speculative thinking about a particular trajectory of co-evolution, and world to mean the immanent becoming and embodied practices in the context of energy. However, such a distinction is not always clear to me in the literature (see Maguire, Watts, and Winthereik, 2021; and Winthereik, Maguire andWatts, 2019).

practices in the present can potentially teach people (or hyposubjects) to more profoundly change our senses and relations to time, ecologies and energy.

Conclusion

In conclusion, I have argued that by living with disasters thought unthinkable within the resilience framework of existing energy infrastructure, biogas producers and renewable energy proponents are re-making energy infrastructure in ways that co-constitute alternative senses of energy in ecologies of heat practices. Ecologies of heat practices can help to understand the potential of even quotidian modifications, but in being affected by heat and disasters, also raises the question of the limits of the analogy of systems to describe ecologies. I have reviewed the origins of electrical systems and their gridworld in Hokkaido and the alternate possibility of community utilities that they supplanted. FIT has emerged as a response to the previously unthinkable failure of nuclear future-making projects after 3.11, and FIT has caused problems of resilience and hopes for infrastructure to diversify in the face of the seismic inversion of the 2018 East Iburi earthquake. Biogas producers who benefit from FIT are re-using heat in green houses and other facilities, creating ecologies of heat-sharing practices between species that require them to actively sense heat as well as use sensors to monitor its flow. Finally, I have extended this idea of ecologies of heat practices to off-grid solar projects, offering some reflections on how making energy outside of the gridworld can change our senses of heat, time and self.

This thesis leaves open questions about multispecies aspects of resilience to disaster. There has been increased attention to the role of other species and wider ecologies with regards to preventing disasters (Morita, 2017; Wakefield and Braun, 2019). The ecology of biogas heat sharing is complicated by its integration into a wider and similarly controlled ecology of the farm. Perhaps most interesting is the relationship between waste and methanogenic bacteria, upon which the entire sub-ecosystem relies. The category of waste, the relationships between waste and bacteria, and the indeterminacy or lack of knowledge of this interaction within the life-world of bacteria despite our dependence on them has received some attention (Hird, 2013). While I have dealt with some aspects of how post-2018 feelings of vulnerability have played a role in how practices and attitudes have changed in Hokkaido, there is an important ethics of vulnerability at play in between the failings of the electricity grid and Hokkaido's dairy farm waste itself that merits further study.

However, along with this comes the problem about sustainability and the material mix of biofuels. I have tried to address how transitions are contested, future-making projects, and made references to the dependency on fossil fuels not being undone by biogas. Recent reviews of life cycle analyses of second-generation biofuels like biogas suggest they have a slightly greater potential to reduce greenhouse gas emissions than other generations of biofuels provided land use does not change (Jeswani, Chivers and Azapagic, 2020). A more in-depth discussion of energy futures, their concepts of sustainability, and practices of heat and fuel are necessary to get at the problem of sustainability and bio-fuels in Hokkaido in the face of the magnitude of mitigating the climate crises. I have attempted to speculate with experts, biogas producers and municipal officials about the potential outcomes of biofuel technology and heat-sharing practices after the earthquake, but am personally not optimistic about their impact on greenhouse gas emissions. Biogas can nonetheless be a modest adaptation tactic to avoid some methane release, with the potentially more important effect of contributing to changing practices of heat and the relationships between localities and national governments on energy infrastructure in Japan.

In this way, while being deeply skeptical of the ability to meaningfully reduce emissions by greening industrial capitalism, we might also broaden the question of sustainability beyond just direct emission reduction. The Japanese government's plan to reduce emissions by replacing coal with natural gas, for instance, does nothing to meaningfully end the reliance on imported fossil fuels, redistribute the concentration of power enabled by such fuels, or make rural Hokkaido safer from grid blackouts. I urge us to think more carefully about the relationship between the application of systems thinking to emissions and the practices that make ecologies. Critical making can perhaps also offer a way to bring together the theoretical concerns of critical social science with post-ANT approaches: much like the electricity grid existed before theoretical formulations of systems theory, materiality and practices of making renewable energy worlds outside of gridworld could lead to better theoretical collaborations between worlds.

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