Engendering an inclusive low-carbon energy transition in Japan: considering the perspectives and awareness of the energy poor

Andrew Chapman*[1], Shinichiro Okushima*[2]
1. International Institute for Carbon-Neutral Energy Research, Kyushu University, Japan.
Email: chapman@i2cner.kyushu-u.ac.jp
2. Graduate School of Systems and Information Engineering, University of Tsukuba, Japan.
Email: okushima@sk.tsukuba.ac.jp

*Corresponding Author

Abstract

Engendering a low-carbon energy transition is necessary to limit climate change impacts and temperature rises. Ideally, this transition would be inclusive, incorporating all stakeholders, however, the issue of energy or fuel poverty is a major obstacle to this goal. This research investigates energy poverty in Japan using a subjective, multidimensional energy poverty measure, clarifying the linkages between energy poverty and an inclusive, just transition in terms of energy system and policy awareness, behavior and preferences. Through the analysis of an original survey, we uncover that there is a marked difference between low-income and energy poverty households' environmental awareness, and their subsequent attitude toward the low-carbon energy transition. Currently, the energy poor have a negative attitude toward the low-carbon energy transition in Japan, causing a lack of self-reported engagement which will not engender an inclusive, just transition. Our findings suggest that if the Japanese low-carbon energy transition were to be inclusive, a further 5 percent of households could participate in the low-carbon energy transition through access to solar or renewable energy capital. Findings identify the need for policies targeted at the energy poor, specifically promoting access to solar capital and low-carbon technologies, in addition to existing policies targeted at low-income households.

Keywords: Awareness, Climate Change Policy, Energy Poverty, Energy Transition, Renewable Policy, Stakeholder Engagement

JEL: D63, I32, Q49

1. Introduction

The need to transition to a low-carbon future is a well understood goal, particularly in developed nations who are signatory to the Paris Agreement, seeking to limit global temperature rises to below two degrees Celsius above pre-industrial levels (UNFCCC, 2018). While this need is well understood, the prevalence of energy or fuel poverty is an obstacle to an inclusive energy transition. Often, policies which advance the cause of energy transitions through climate change mitigation or the promotion of renewable energy exacerbate the issue of energy poverty and alienate a sector of society from participating in the energy transition (Urge-Vorsatz and Herrero, 2012, Bouzarovski, 2018).

In the case of Japan, since the Great East Japan Earthquake (GEJE), the amount of power generation from nuclear sources has reduced to almost zero, meaning that the role of imported fossil fuel-based generation has increased. Policies such as the feed in tariff (FIT) and carbon pricing have meant that energy prices for consumers have increased, and there is some evidence that energy poverty and vulnerability have increased following the massive earthquake and subsequent energy system changes (McLellan et al, 2016; Okushima 2016, 2017). Further, in light of Japan’s commitment to reducing greenhouse gases by up to 80 percent by 2050 under the Paris Agreement, the Japanese Government have shown a renewed interest in carbon pricing (Ministry of the Environment, 2018), which may further exacerbate domestic energy poverty levels.

Previous research has focused on the analysis of the deleterious impact of climate change mitigation policy on energy poverty outcomes. This study on the other hand investigates the previously unexplored interaction between energy poverty households and the low-carbon energy transition by clarifying their awareness and interest in climate change policy and the promotion of renewable energy deployment. This novel approach has applications in engendering a fair and inclusive low-carbon energy transition in Japan.

This study bridges two important energy concepts; energy poverty, and the notion of a just transition. The underpinning premise behind the combination of these two concepts is not only the need to engender a transition to a low-carbon future, but also to enable this transition to occur by involving all households, including those identified as the energy poor.

The aim of this study is to identify the prevalence of self-reported or subjective energy poverty in Japan - this is also the first attempt - to clarify the nature of this cohort, and to identify their level of energy system participation and awareness. Finally, based on the evidence uncovered through a novel survey and multidimensional energy poverty measure, this study aims to develop strategies for an inclusive, just energy transition in

Japan.

2. Background and Literature Review

Although a good deal of scholarship has been devoted to the problem of energy or fuel poverty in Europe (e.g., Bouzarovski et al., 2012; Thomson and Snell, 2013; Bouzarovski, 2018), and especially in the UK (e.g., Boardman, 2010; Hills, 2011; Robinson et al., 2018), very few studies have been conducted in Japan[1]. Among the only detailed studies, Okushima (2016) first analyzed the seriousness of energy poverty since the 2000's using the traditional 10% indicator (Boardman, 1991, 2010), demonstrating that energy poverty in Japan was aggravated in the 2000's, especially following the Great East Japan Earthquake and Fukushima nuclear accident of 2011. A follow-up study by Okushima (2017) developed a new type of measure, the multidimensional energy poverty index (MEPI), and suggested that mother-child and single-elderly households are specifically in a serious situation from the viewpoint of (multidimensional) energy poverty. The above studies utilized the governmental survey of household income and expenditure. The more recent study by Okushima (2019) developed a new approach to measuring energy poverty by assessing the amount of

[1] In this paper, the term 'energy poverty' is used synonymously with 'fuel poverty' as described in Bouzarovski and Petrova (2015) and Bouzarovski (2018).

heat utilized, with the data on household energy use, and examined the spatial or regional characteristics of energy poverty in Japan. It is of note that these studies all employ an objective measure, while this study first applies a subjective approach to measuring energy poverty utilizing original survey data, as detailed in the methodology section.

Along with the objective evaluations of energy poverty in Japan, a vulnerability index for energy poverty in Japan has also been established, as shown in Figure 1. The figure illustrates the historical trend in the level of vulnerability for energy poverty in Japan between 2000 and 2017. Here, vulnerability means the level of risk of falling into energy poverty, described at the macro level. This index is composed of domestic energy prices and household income.

The figure shows that the level of vulnerability has risen incrementally since 2000 and climbed sharply following the GEJE in 2011, subsequently experiencing a decline in 2015-16 due to a slump in international energy prices. However, in 2017, when the survey underpinning this study was conducted, the vulnerability level increases reflecting an upturn in international energy prices, and it can be observed that the vulnerability level is elevated when compared with the first decade of the 2000’s.

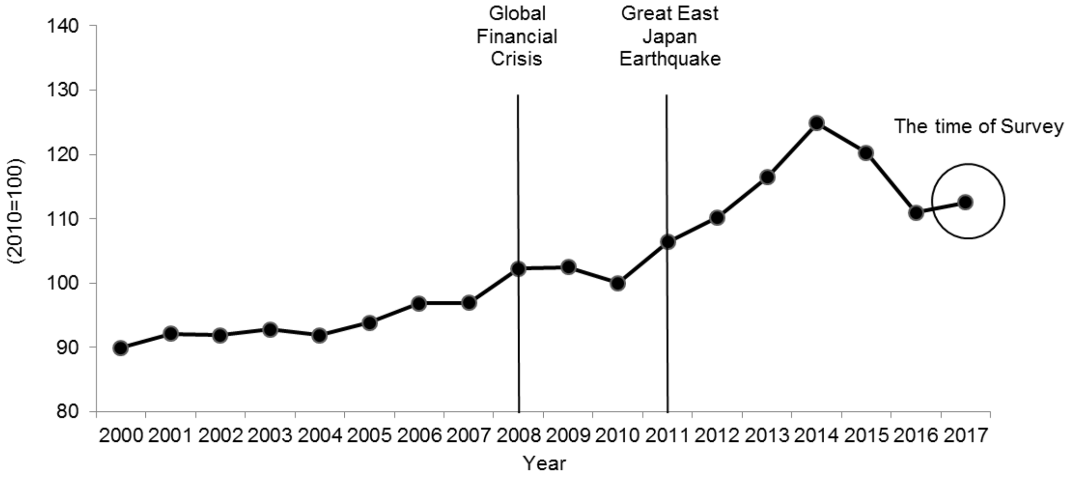

Figure 1. *Historical trend of 'energy poverty vulnerability' in Japan*[2]

In terms of the energy transition in Japan, full market liberalization which was begun in 2016 for electricity and 2017 for gas has meant that all households can now choose their energy retailer. Over the past 3 years, approximately 12% of households have chosen to switch energy retailer (NHK, 2019). Underpinning both liberalization and the energy transition is the Japanese Government's Strategic Energy Plan, which outlines the transitioning energy mix and priorities for meeting international carbon reduction targets (METI, 2018). The plan outlines a transition away from a fossil fuel dominated energy mix (approximately 79% fossil based; BNEF, 2019) to an energy mix containing 22-24% renewable energy, up to 22% nuclear, 26% coal and 27% natural gas by 2030. A longer-term energy mix for 2050 has not yet been decided, and debates are centered

[2]This index is the ratio of 'domestic energy prices' to 'household income'. 'Domestic energy prices' are shown by a composite index of CPIs for electricity, gas, and other fuels with 2010 weightings. 'Household income' is the annual average income of all workers' households in the Family Income and Expenditure Survey, Statistics Bureau, Ministry of Internal Affairs and Communications, Government of Japan. For more details on the index, see Okushima (2016).

on meeting carbon targets, the role of nuclear and the issue of energy security. In addition to the energy mix debate, the Japanese Strategic Energy Plan defines energy efficiency as a central pillar of reducing carbon emissions, backed by a reporting regime for industry, commercial and transport related operators. Moreover, strict measures for household devices, new building insulation and energy management procedures including demand response have been enacted since the oil crises in the 1970's (METI, 2018).

With regard to an inclusive energy transition which incorporates these vulnerable and energy poverty households, we use Heffron and McCauley (2018)'s definition of 'the just transition' as an inclusive framework which unites climate, energy and environmental justice to promote fairness and equity throughout the transition away from fossil fuels. A just transition aims to reduce inequality in society, allowing for engagement of all stakeholders in the transition process. Ideally, a just transition will help to restore normative concerns to energy policy making and engender a fair and just outcome for societal members, bringing the voice of disadvantaged groups as well as their participation into the transition process (Jasanoff, 2018). Previous research in Japan identified stakeholder's preference toward energy system participation in terms of early adoption, participation for financial gain, and non-participating sectors. Stakeholder preferences were measured through a survey identifying the types of participation (deploying solar panels, changing energy suppliers etc.) and the reasons for participation (financial benefit, improving the environment etc.; Chapman and Itaoka, 2018). Further, participatory preferences from this research were applied to a scenario-based investigation of energy system and social equity outcomes to the year 2050, identifying positive equity and renewable energy deployment impacts of a participatory approach (Chapman and Pambudi, 2018). However, this research did not investigate the underlying factors behind these preferences, nor did it identify groups who were perhaps unable to participate due to energy poverty or other factors. Complementary research focused on urban transitions has also identified that a diverse range of stakeholder perspectives and preferences leads to greater acceptance of transitions, and broader participation (Junghans et al., 2018).

3. Methodology

In order to uncover how energy poverty sidelines certain stakeholders from participation in the low-carbon energy transition in Japan, and to clarify the traits of this group, we undertake a national survey investigating the prevalence of energy poverty and associated characteristics of energy poverty households. Following on from the survey, we apply bivariate analysis to contrast the participatory and awareness characteristics of the energy poverty cohort when compared to (just) low income and other households.

3.1 National Survey

In March 2017, a nationally representative internet-based survey of 4,148 households in Japan was undertaken to identify the impacts of energy transitions and liberalization on householder's energy choice, knowledge and energy system generation source and participation preferences (Chapman and Itaoka, 2018). This precedential research identified the existence of energy system participatory tiers within Japanese society, with the majority of households not voluntarily participating in the energy system due to disinterest or a lack of information. In addition, for household participation in solar photovoltaic (PV) deployment, it was identified that excessive expense precluded a large portion of households (Chapman and Itaoka, 2018). Within this survey, the existence of self-reported or subjective energy poverty could also be measured using a multiple response question which asked respondents about their energy bills across the sources of electricity, gas (city network or liquid propane) and kerosene. Householders were asked to identify how they felt about the cost of their monthly bills ranging from 'inexpensive' to 'very expensive and difficult to afford'. Based on the responses to this question we identified self-reported ‘energy poverty’ and ‘severe energy poverty’ households. We then analyze this cohort alongside low-income households and all other respondents to identify specific traits, preferences and awareness of climate change related issues. Specifically, the survey questions shown in Table 1 are analyzed for each defined group (energy poverty and others) according to the methodology detailed in section 3.2.

Table 1. *Survey questions utilized for analysis*

#	Question
Used to define energy poverty and other cohorts	
12	Affordability of energy sources
30	Household income
Awareness	
4	Most important global issue
8	Knowledge about policies and international agreements
9	Knowledge about energy system liberalization
13	Consideration of changing electricity company post liberalization
Behavior and Energy Source Constraints	
10	Energy source used for heating
15	Change of electricity company post liberalization
20	Installation of household solar PV
Preferences	
19	Important factors for changing electricity company
23	Preferred energy mix
29	Preferred technological response to climate change

Questions are divided into the three categories of awareness, behavior and energy source constraints, and preferences for further analysis, detailed along with specific question elements investigated in Section 4.

3.2 Defining Multidimensional Energy Poverty

This section explains the methodology employed to identify the energy poverty households. In this study, we use the concept of multidimensional energy poverty (MEP), as developed by Okushima (2017). MEP is based on the multidimensional poverty measurement described in Atkinson (2003) or Alkire and Foster (2011) and can identify the energy poverty cohort from a multidimensional perspective.

In order to define MEP, we assume a population with *n* households $(i = 1, \cdots, n)$ and $d \geq 2$ dimensions (attributes) of energy poverty $(j = 1, \cdots, d)$ [3]. Also, we denote the achievement of household *i* in dimension *j* by y_{ij}. The achievement can be described by cardinal, ordinal, or even categorical types of data; it is enough to enable the partitioning of 'deprived' from 'not deprived' in the context of each dimension, using the given data. As seen below, we use ordinal or categorical type of data for the achievements, which are provided by the survey responses.

In this paper, we set two dimensions (attributes) of energy poverty in Japan. The first dimension is 'energy cost' or 'energy burden' and the second is 'income' or 'affordability'.

[3] See Okushima (2017) for more details on the methodology.

Deprivation (dimensional poverty) is defined as the shortfall from the given threshold (poverty line) z_j for each dimension (attribute) *j*; then, we can define dimension *j*'s poverty of household *i* if $y_{ij} < z_j$.

Multidimensional energy poverty in this paper can be defined as the intersection of two-dimensional poverty as follows:

Household *i* is energy poor $q \quad \Leftrightarrow y_{i1} < z_1 \,\&\, y_{i2} < z_2$.

(1)

For the first dimension, energy cost, we try to distinguish 'deprived' (dimensionally poor) from 'not deprived' (dimensionally non-poor) using the subjective assessment of each household on 'energy burden', instead of typically-used objective data such as the share of energy costs against income. In order to establish this dimension our survey asked respondents about the cost of their energy (Q12) ranging from inexpensive to unaffordable, causing issues in paying for energy (see Appendix A)[4]. Here, we define the households who answered 'unaffordable' for any energy source used in their home as 'deprived' (dimensionally poor) in the first dimension.

4 Several prior research efforts used the EU-SILC, considering only the affordability of heating (Meyer et al., 2018). On the contrary, this study considers the affordability of all energy services using this question.

This kind of subjective approach has been used on several occasions for comparative studies in European Union (EU) countries (e.g., Thomson and Snell, 2013) since suitable data such as the EU Statistics on Income and Living Conditions (EU-SILC) have been collected, providing an avenue for easier international comparison than objective measures. However, to the best of our knowledge, this is the first attempt utilizing a subjective approach to measuring energy poverty in Japan, providing a useful insight in a unique manner when compared to existing studies using objective (multidimensional) energy poverty measures (i.e. Okushima 2017, 2019)[5].

The second dimension of MEP is income, representing the level of affluence of households in general. At first glance, the income dimension seems redundant since the first dimension of our MEP represents so-called 'energy affordability'. However, the income dimension has a pivotal function in circumventing typical misidentification (false positive) that well-off households could be identified as energy poor through overconsumption of energy (Hills, 2011), or overly subjective views (McKay, 2004). For income, the survey data provides range-type information on annual income (see Table 2 and Appendix A). The seminal research of Boardman (1991) defines households in the lowest 30% income group as 'low-income households', and adapting this definition to

---

[5] It is known that the results given by subjective measures are considerably different from the results by objective measures (Hills, 2011; Waddams Price et al., 2012; Meyer et al., 2018).

Japan, the 30th percentile of annual (before-tax) household income is 3.04 million Japanese yen (￥) in 2014[6]. Hence, we define two income thresholds for further analysis: the threshold z_2 for 'energy poverty' of 4 million yen (i.e. respondents identifying within categories 1 or 2 for Q30 of the survey), while the threshold z_2' for 'severe energy poverty' is 2 million yen (i.e. respondents identifying only within category 1 for Q30).

We summarize the definitions of (multidimensional) energy poverty in this study thus:

Household *i* is energy poor $q \Leftrightarrow$ (Q12=1 for any energy source) & (Q30=1 or 2).

(2)

Household *i* is severely energy poor $q' \Leftrightarrow$ (Q12=1 for any energy source) & (Q30=1).

(3)

A complete response breakdown for Q12 and Q30 is provided in Appendix A. Analysis is conducted across 5 cohorts, as detailed in Table 2.

[6] The 2014 National Survey of Family Income and Expenditure. It is conducted every five years by Statistics Bureau, Ministry of Internal Affairs and Communications, Government of Japan.

Table 2. Survey Respondent Cohorts (n=4,148)

Cohort	Income Level	Energy Burden Awareness
1. Severe Energy Poverty (SEP)	￥0~2,000,000	Any energy source difficult to afford
2. Very Low Income	￥0~2,000,000	-
3. Energy Poverty (EP)	￥0~4,000,000	Any energy source difficult to afford
4. Low Income	￥0~4,000,000	-
5. Others	>￥4,000,000	-

4. Results and Discussion

The results are described in two sections. First, the energy poverty (EP) cohort is described in terms of region, householder age and housing situation from the survey findings. Second, comparative analysis of survey results pertaining to participation, preferences and awareness (detailed in Table 1) of severe energy poverty, energy poverty, low income and other household cohorts is undertaken.

4.1 National Survey Findings

Of the 4,148 households surveyed, 201 (approximately 4.8%) identified as EP households. A smaller group of 62 respondents (approximately 1.5% of the whole sample) were identified as severe energy poverty (SEP) households. This result is approximately at the same level as former literature, which estimated energy poverty levels after the GEJE using an objective type of measure (e.g., Okushima, 2017). As shown in Figure 2, the northernmost region of Japan, Hokkaido had the highest prevalence of energy poverty (~8.8%), due to having the coldest climate in Japan, followed by the two westernmost regions of Chugoku (~6.8%) and Kyushu (~5.4%). Although the measurement approach used considers different criteria, Okushima (2019) also estimated high energy poverty rates in the western regions due to lower income levels and a larger share of off-gas-grid population. In terms of householder age, those over the age of 60 showed the highest prevalence of energy poverty (~6.4%), followed by the youngest group, aged 20-29 (~4.4%). Previous studies using objective measures also stressed that the elderly are experiencing high levels of energy poverty in Japan (Okushima, 2016, 2017). Of all energy poverty households, approximately 56.7% own their home (detached house), and approximately 41.9% are rental properties.

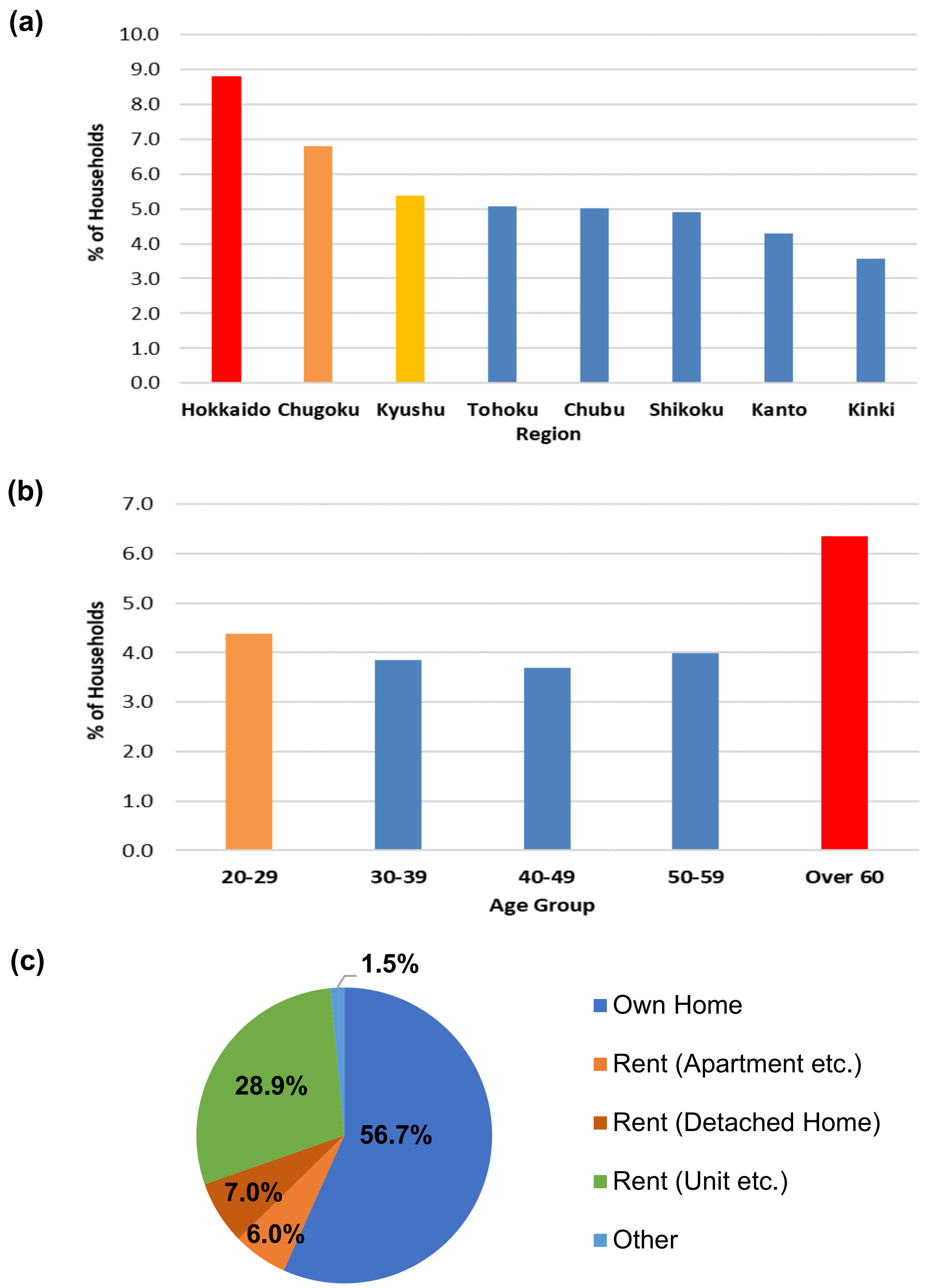

***Figure 2**. Percentage of Energy Poverty Households by (a) Region (n=4,148) and by (b) Age of Householder (n=4,148), and, (c) Housing Situation of Energy Poverty Households (n=201)*

4.2 Energy Poverty and Awareness

Four questions are analyzed for energy poverty and awareness, beginning with Q4 of the survey investigating respondent’s opinions on the most important current global issue.

Here we note a clear trend between EP and non-EP households in terms of issue importance. Global warming and climate change are valued at a comparatively lower level for EP households, a trend which is reversed for remaining issues considered important by Japanese households (described in detail in Appendix B).

Next, we investigated our cohort’s knowledge about policies and international agreements (Q8). The varying levels of household awareness of the key policies related to a low-carbon transition, the Paris Agreement and the FIT are detailed in Table 3.

__Table 3.__ Knowledge of Low-carbon Transition Policies (n=4,148)

Policy	Awareness	SEP	Very Low Income	EP	Low Income	Others
Paris Agreement	**High**	1.6%	1.5%	2.0%	2.6%	5.0%
	Moderate	24.2%	19.2%	27.4%	23.9%	27.7%
	Limited	56.5%	55.8%	50.2%	53.7%	51.0%
	None	17.7%	23.6%	20.4%	19.8%	16.3%
Feed-in tariff (FIT)	**High**	0.0%	0.8%	1.0%	1.4%	2.4%
	Moderate	6.5%	6.7%	7.0%	8.5%	11.7%
	Limited	27.4%	25.1%	26.9%	26.1%	24.8%
	None	66.1%	67.4%	65.2%	64.1%	61.1%

The knowledge of these policies is not high in general, though, EP and lower income households have a lower level of high awareness of both policies, which is more pronounced for the FIT. Here we note a connection between low income level and limited policy knowledge. Considering the results described for knowledge and awareness, we observe that EP and lower income households are not as engaged with the energy transition in Japan as other households. One important issue to note is that income and education are very strongly linked in our survey result, also likely impacting upon EP households' lower awareness of low-carbon transition policies. With regard to the FIT, currently in Japan there is no governmental program for solar investment specifically targeted toward low-income or EP households, likely further exacerbating the lack of awareness in these cohorts.

Two additional questions from the survey relating to energy system liberalization in

Japan are also investigated including knowledge about the liberalization (Q9) and consideration of changing power companies (Q13). The results of these investigations suggest limited linkage between EP and liberalization knowledge, and a higher propensity for EP households to seriously consider changing power companies. These results and the remainder of issues and policies tested for Q4 and Q8 are shown in Appendix B.

4.3 Energy Poverty, Behavior and Energy Source Constraints

Building on the findings in the awareness section, householder behavior and energy source constraints were also investigated. First, the energy source used for heating in the home, usually linked with energy and fuel poverty since the seminal study of Boardman (1991), was investigated (Q10). Variation between cohorts is shown in Table 4.

Table 4. *Energy Source Used for Heating in the Home (n=4,148)*

Issue	SEP	Very Low Income	EP	Low Income	Others
Electricity	61.3%	67.8%	68.2%	71.9%	77.8%
City Gas (On-network)	9.7%	11.2%	11.9%	12.6%	16.3%
Propane Gas (Off-network)	0.0%	1.3%	4.0%	2.3%	2.2%
Kerosene	54.8%	41.1%	49.8%	42.2%	36.2%

EP households are more likely to use kerosene than their non-EP counterparts who have a higher electricity and city gas usage level. With regard to energy source constraints, as shown in Table 4, even when compared with low income households, EP households show a lower level of city gas connection and a higher use of kerosene in the home. This trend is of interest, as the availability or ability to connect to the city gas network has a strong relationship with energy justice outcomes (Roberts et al., 2015; Bouzarovski and Simcock, 2017). Also, the future use of kerosene in Japan has been identified as a crucial consideration for both EP households and the engendering of a low-carbon energy transition in Japan (Okushima, 2019). If we consider the decarbonization of energy, and the likely introduction of an aggressive carbon pricing scheme, the relative price of kerosene will increase, and low-carbon alternatives will likely be promoted in its place. On the other hand, we know that EP households, particularly those in the northern regions of Japan rely on kerosene for their winter heating needs, meaning that the future reinforcement of carbon pricing is likely to exacerbate EP even further without alleviation measures.

An assessment of post-liberalization change of electricity company (Q15) was also made, identifying that EP households in our survey have changed energy companies post liberalization at a much higher rate than their non-EP counterparts (approximately

16-17% of EP/SEP households compared to approximately 11.5% of others). This trend is an opposite trend to that which was identified for other countries (e.g., Boardman, 2010)[7]. These results are detailed in Appendix C and underpinning reasons for changing energy companies are discussed in section 4.4.

Finally, the installation of solar PV at the home was investigated (Q20), a key low-carbon energy transition behavior able to be undertaken by households. There is a strong linkage between EP, household income and the deployment of solar PV, with a much lower deployment level in EP households than their non-EP counterparts, as described in Figure 3.

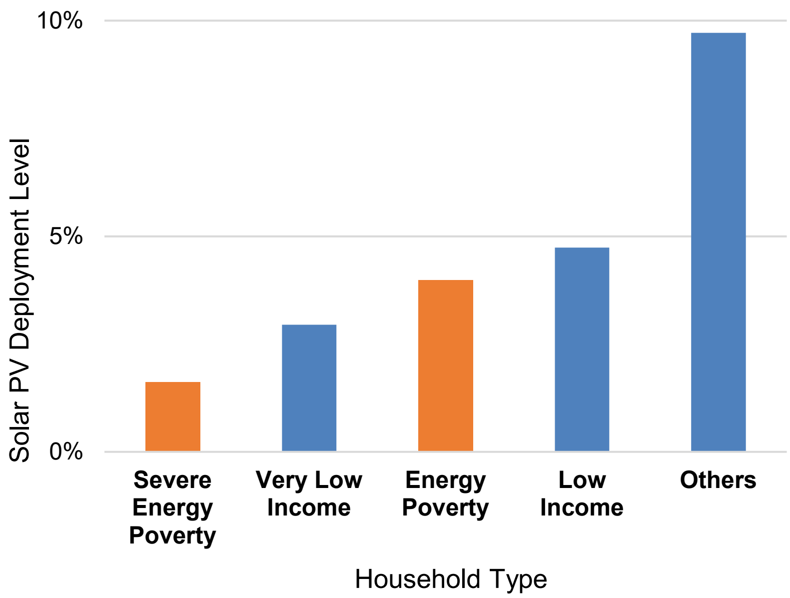

Figure 3*. Household Type and Solar PV Deployment Level (n=4,148)*

[7] However, Boardman (2010) pointed to the inaccessibility of the internet in EP households as one of the reasons for not switching. As this survey is internet based, there is the potential for some bias to be introduced.

For households who have solar panels installed, under the current Japanese low-carbon energy transition regime, the prominent FIT policy allows them to generate profit and to reap an economic benefit. Although the FIT purchase price has been reduced over the past few years, for those who were able to take advantage of this policy immediately after the GEJE, they have locked in a large benefit, over at least a 10-year contract period (Agency for Natural Resources and Energy, 2017). In order to reap the benefits of the ongoing energy transition in Japan, access to solar panels or solar technology is of utmost importance. Considering the results shown in Figure 3, EP households' access to solar technology is lower than their low-income counterparts, and significantly lower than households above the average income level. This trend in the Japanese energy transition makes EP households' energy affordability the lowest overall and distributes the lowest level of economic benefits to those households which need them most, causing an energy injustice. In addition, the charges arising from the FIT, which are calculated per kilowatt hour (kWh) consumed in each household (2.95 Japanese yen/kWh in Fiscal Year 2019), put a larger burden on low income and EP households as these households spend a higher proportion of their income on energy compared to more affluent households. The current Japanese low-carbon energy transition policies are exacerbating the level of energy poverty in Japan, as well as the level of inequality experienced.

4.4 Energy Poverty and Preferences

In terms of household preferences toward behavior and the energy system, three survey questions were analyzed. First, the important factors underpinning a change of electricity company (Q19) was investigated, as shown in Table 5.

Table 5. *Important Factors for Changing Electricity Company (n=4,148)*

Issue	SEP	Very Low Income	EP	Low Income	Others
A Lower Tariff	59.7%	58.3%	62.7%	52.3%	50.0%
Green Energy	3.2%	5.7%	5.5%	5.9%	6.6%
Ability to Choose Energy Mix	1.6%	1.1%	1.5%	1.4%	1.9%
Stable Supply	22.6%	24.2%	23.9%	30.7%	33.6%
Other	3.2%	0.8%	1.5%	0.9%	0.9%
Nothing	9.7%	9.9%	5.0%	8.8%	7.0%

Although this factor is more contingent on the liberalization of the energy market, generally speaking a lower tariff and stable supply were considered important, however, a lower tariff (cheaper electricity) was found to be markedly more important to EP households, while aspects such as green energy (environmentally friendly energy) and a stable supply were considered less important. These findings are also relevant to the energy transition more generally.

Next, the issue of preferred energy mix (Q23) was assessed. Respondents preferences toward three prominent, current technologies considered instrumental to a low-carbon energy transition are detailed in Table 6.

Table 6. *Low-Carbon Transition Energy Mix Preference (n=4,148)*

Energy Source	Preference	SEP	Very Low Income	EP	Low Income	Others
Coal	Increase	1.6%	1.1%	2.0%	1.2%	1.3%
	Maybe Increase	3.2%	4.2%	7.5%	4.7%	5.0%
	Neither	37.1%	47.8%	35.3%	45.5%	44.2%
	Maybe Decrease	27.4%	25.9%	28.9%	29.1%	29.1%
	Decrease	30.6%	21.1%	26.4%	19.4%	20.3%
Solar	Increase	37.1%	30.5%	40.8%	35.1%	36.5%
	Maybe Increase	35.5%	36.8%	36.8%	40.0%	41.6%
	Neither	19.4%	29.5%	18.4%	22.6%	19.9%
	Maybe Decrease	3.2%	1.9%	2.5%	1.5%	1.3%
	Decrease	4.8%	1.3%	1.5%	0.7%	0.7%
Nuclear	Increase	8.1%	2.3%	5.5%	3.5%	3.3%
	Maybe Increase	4.8%	4.4%	5.5%	5.7%	6.5%
	Neither	24.2%	31.4%	27.4%	27.9%	29.0%
	Maybe Decrease	19.4%	20.2%	17.9%	21.0%	22.5%
	Decrease	43.5%	41.7%	43.8%	41.9%	38.7%

For EP households, a higher relative preference for both the increase and decrease in the use of coal is observed. As detailed in the background section, the current energy mix debate in Japan is centered in the Strategic Energy Plan, with a focus on economic efficiency, environmental improvement, energy security and safety. The reduction of coal fired power will improve the environment, while it’s replacement with renewable sources of energy will aid in improving energy security. In terms of solar, the same trend is observed, however in terms of a preference for the decreased use of solar, SEP/EP households are particularly high at 4.8%/1.5% (Decrease) and 8.0%/4.0% (Decrease + Maybe Decrease), both are much higher than even low-income households. This trend identifies a negative attitude toward solar promotion policy, including the FIT. It is likely that this preference is linked to the increased burden imparted on EP households in terms of proportional energy spend, even though an increase in renewable energy will meet the tenets of improved energy security and environmental outcomes. For other household income groups, the ratio of opposition to solar is low, and the difference between low-income households and others is relatively small. In this case, we observe that the level of energy burden experienced in the households has a higher level of impact than a low-income level.

In addition, SEP/EP households identify a relatively high preference for the increase in nuclear generation (8.1%/5.5%). The reason for this response can be traced back to the impact imparted on EP households by the GEJE, where nuclear generation was halted, and domestic energy prices increased rapidly due to the need for additional expensive imports and use of fossil fuels (Okushima, 2016). Although the Japanese energy transition is planned to occur via a reduction in nuclear power and an increase in renewable energy deployment due to the FIT, EP households are not accepting of this direction, and there is a suggestion of exclusion occurring as a result.

While it appears that there is a contradiction between stakeholders' preference to reduce nuclear and increase solar, while at the same time desiring a lower tariff (cheaper electricity) as shown in Table 5, in Japan, notably after the GEJE, support or opposition toward nuclear power is becoming more a matter of value judgement and there is a group of people who oppose nuclear power irrespective of its impact on energy affordability. For this reason, EP households' opinions will also be separated incorporating value-driven considerations and a singular trend cannot be extracted in this case.

Results detailing the energy mix preference for all technologies in use in Japan is shown in Appendix D. In addition, householder's preference for implementation of climate change mitigation approaches was tested (Q29). Nine potential approaches were tested including energy efficient devices, solar power generation, fuel efficient vehicles, wind power generation, biomass power generation, nuclear power generation, CCS, planting more trees to absorb CO_2, and low-carbon fuels (complete responses are shown in Appendix D). Of these approaches, we show the results for solar power generation, nuclear power generation and energy efficient devices in Table 7, which are most important in the Japanese energy transition context and representative of near-term solutions for Japan.

Table 7. Climate Change Mitigation Policy Approach Preference (n=4,148)

Approach	Preference	SEP	Very Low Income	EP	Low Income	Others
Solar Power Generation	Not Use	8.1%	2.7%	3.0%	2.0%	1.5%
	Maybe Not Use	3.2%	6.9%	5.5%	5.3%	5.1%
	Neither	38.7%	38.1%	31.3%	32.4%	32.6%
	Maybe Use	33.9%	37.9%	40.8%	42.2%	43.6%
	Definitely Use	16.1%	14.3%	19.4%	18.1%	17.2%
Nuclear Power Generation	Not Use	30.6%	27.4%	29.9%	29.2%	23.7%
	Maybe Not Use	12.9%	20.6%	21.4%	21.4%	23.7%
	Neither	40.3%	40.2%	33.8%	36.2%	38.9%
	Maybe Use	8.1%	8.4%	10.0%	9.8%	10.9%
	Definitely Use	8.1%	3.4%	5.0%	3.4%	2.8%
Energy Efficient Devices	Not Use	4.8%	2.1%	1.5%	1.2%	0.9%
	Maybe Not Use	8.1%	6.3%	5.0%	4.9%	4.7%
	Neither	30.6%	39.8%	32.3%	32.6%	31.8%
	Maybe Use	43.5%	40.6%	48.3%	48.9%	49.5%
	Definitely Use	12.9%	11.2%	12.9%	12.4%	13.2%

SEP/EP households' preference to not use solar is significantly higher than other cohorts at 8.1%/3.0%, a similar trend to what was found in Table 6. In terms of the low-carbon energy transition, EP households demonstrate a negative attitude toward the use of solar energy driven by the FIT. Additionally, these cohorts show relatively strong support for the use of nuclear power as a climate change mitigation strategy.

Considering the results from Tables 6 and 7, we can see that EP households display a negative attitude toward the ongoing low-carbon energy transition in Japan. From the survey results, it is likely that a generally low level of awareness of low-carbon transition policies and unaffordability of solar panels for EP households underpin this response. Energy transition policy (incorporating nuclear cessation, carbon pricing and the promotion of RE through the FIT) impacts adversely on EP households. Accordingly, if the low-carbon energy transition is further promoted without policy changes, negative impacts will be increasingly felt by EP households, further excluding them from what should be an inclusive national energy transition. Considering the official Japanese approach to the low-carbon energy transition, i.e. the use of more renewables (including solar) and less nuclear, we can see that EP households are experiencing exclusion from mainstream trends.

For SEP/EP households there is also a relatively strong trend away from using energy efficient devices, 4.8%/1.5% for 'Not Use' and 8.1%/5.0% for 'Maybe Not Use'. With regard to energy efficiency, different from nuclear power, value judgement plays only a small role in opposition, and usually energy efficiency approaches garner broad support (Kerr et al., 2017). The discovery of an opposing trend here is of note.

One explanation which accounts for EP households' opinions could be that policies which support the enhancement of energy efficiency are largely driven by industry standards (METI, 2018) and are not targeted to EP households, making them unattractive, as EP householders do not anticipate an economic benefit, making their general stance pessimistic. This pessimism further exacerbates their exclusion from the low-carbon energy transition.

In the same way, regarding the costs and benefits of a low-carbon energy transition for EP households, it is generally accepted that low-carbon energy transitions adversely impact upon energy poverty levels (e.g., Okushima, 2019). When considering how the current Japanese energy transition is impacting upon EP, we observe that not only are there adverse impacts, but that the level of inequality is increasing.

5. Conclusions and Policy Implications

This investigation of subjective energy poverty, awareness, behavior and preferences identified two key conclusions. Firstly, the necessity for an energy poverty agenda was identified. Although low-income policy exists in Japan, there is currently no policy agenda to address energy poverty. According to our results, there is a clear distinction between (just) low-income and energy poverty households, especially evident in their respective self-reported levels of awareness and attitude toward the low-carbon energy transition. Accordingly, basic low-income policy will not engender an inclusive low-carbon energy transition in Japan, and the policy agenda must be expanded to achieve this goal.

Secondly, we identified that for energy transitions in the Japanese context, solar power will play a prominent role (Agency for Natural Resources and Energy, 2017). In this study it was shown that the benefit of solar is not distributed to incorporate energy poverty households. Possibly due to this, households experiencing energy poverty have a negative attitude toward the use of solar power driven by the FIT. Ideally, other sources of energy could also be considered in a low-carbon energy transition, specifically natural gas and nuclear power. As Japan already uses natural gas for in excess of 40% of energy generation (BNEF, 2019) and is heavily reliant on imports, this quantity is not likely to be easily increased. Further, with regard to nuclear power, as detailed throughout this paper, the GEJE reduced nuclear generation to almost zero, and engendered a strong opposition to this power source. Even today, 8 years after the GEJE, nuclear has not been reinstated at a significant level.

For an inclusive Japanese energy transition to occur, there is a need for solar benefits to be more evenly distributed. Further in terms of defining an inclusive energy transition, we propose that energy access in developed countries (such as Japan) should include access to ‘solar capital’ or ‘low-carbon technology’, and resultant benefit distribution (Sovacool et al., 2019). Additionally, the concept of distributive justice within energy justice considerations should also be cognizant of the access to such ‘capital’ in the context of energy poverty in developed countries.

Following from these conclusions which are grounded in our analysis, we identify that EP households are less likely to be interested in the low-carbon energy transition in Japan, and as a result, less likely to engage in the transition process. In order to rectify this situation, we identify several potential policy approaches which could alleviate the negative attitude and exclusion being experienced by EP households to engender an inclusive transition.

The first practical policy suggestion for Japan is to re-distribute the costs and benefits of solar power deployment more progressively. One way to achieve this is to excuse EP households from the payment of the RE surcharge on electricity bills (the amount currently added to all electricity bills to cover FIT payments, Agency for Natural Resources and Energy, 2018). An alternative approach would be to collect the RE surcharge from all households and then distribute a proportion back to EP households in the form of an income support or energy subsidy. Currently no such approaches exist in Japan among the incumbent energy suppliers or as targeted approaches from the government such as those in Germany (whereby an allowance is provided for basic necessities including electricity and heating for the disadvantaged; Cludius et al., 2015) or Australia (whereby assistance or relief is provided by state government bodies for those having trouble paying energy bills; Energy Australia, 2019), for example. While these approaches directly address energy poverty and seek to redress its exacerbation through current renewable energy deployment approaches, the determination of EP household criteria would need to be clearly defined and may cause an ongoing administrative burden (Dubois, 2012).

A simpler approach which does not currently exist in Japan is the provision of low cost or even completely subsidized solar panels for EP households who fulfil criteria, i.e. direct distribution of solar capital such as state funded rural utility cooperatives in the state of Colorado, or the 75 megawatts per year community solar projects in New Jersey which dedicates 40% of these projects to low or moderate income customers (Grist, 2019). Alternatively, EP households could be supported in obtaining solar capital through a government subsidized ‘initial investment cost’ scheme, whereby the upfront cost of solar panels is provided by government subsidy, and then recuperated through monthly pro-rata payments which do not increase the monthly cost of energy for the EP household. This approach is similar in some respects to zero-interest loan schemes, but with a more nuanced repayment regime. This approach may be both effective and socially palatable as the onus for the supply of solar capital does not place a burden on non-EP households. Further, EP households pay back their solar panels over time under a preferential repayment scheme which meets their needs and does not require specific technical or economic prowess on their part[8].

As not all EP households' living situation will allow for the deployment of solar (i.e. those who live in an apartment, those whose houses are not suited to solar deployment and those who are unable to deploy solar panels due to rental clauses etc.), alternative measures will need to be considered[9]. One such idea which has precedents internationally is the distribution or financial assistance for the installation of energy efficient devices to reduce energy costs (appliances, LED light bulbs, low-flow shower heads etc., i.e. Department of the Environment and Energy (Australia), 2018; Duke Energy (US), 2018). Alternatively, community solar deployment could be undertaken, whereby local councils could provide solar facilities for the benefit of EP households, who could then benefit from the FIT[10]. There are international precedents for such an

---

[8] As the issue of economic efficiency is also important here, when undertaking the distribution of solar capital to EP households, appropriate targeting and qualification regimes are necessary.

[9] Considering renewable sources other than solar, we note one example of biomass use in Japan, that is applicable to addressing energy poverty. Shimokawa, Hokkaido provides public housing for lower income households which utilizes a district heating system using locally- produced woody biomass (Okushima, 2019). As locally- produced biomass is typically preferred over imported biomass for such schemes, the number of regions in which they could be deployed is severely limited when compared to solar power.

[10] An example pertinent to Japan is the recent phenomenon of local government established PPS (Power

approach in the US, whereby 12 states and the District of Columbia are developing a variety of financial incentives and programs to enable access to shared solar for low-income participants (Grist, 2019).

The energy justice debate includes consideration of distributional justice aspects, including the redistribution of benefits, in this case access to solar capital, or access to energy through financial means (Jenkins et al., 2016). In the case of the proposed subsidization of solar panels (or provision of access to community based solar facilities) for EP households, the system design would need to be cognizant of each household's need for energy and means to pay for it.

A successful policy will likely draw from a number of options which are fit-for-purpose in each locale. Should these policy recommendations be implemented it is likely that the current situation can be improved, a positive attitude toward energy transition generated and an inclusive transition realized, as shown in Figure 4.

Producers and Suppliers) following the full liberalization of retail electricity markets in 2016. PPS arrangements generally aim for local production and consumption of energy and stimulation of the local economy. Theoretically, it is possible to either facilitate the distribution of low-cost energy generated from community solar energy farms to financially disadvantaged households or to invest profits into energy poverty alleviation efforts. Building on these kinds of measures, we can achieve both an inclusive low-carbon energy transition and energy poverty countermeasures.

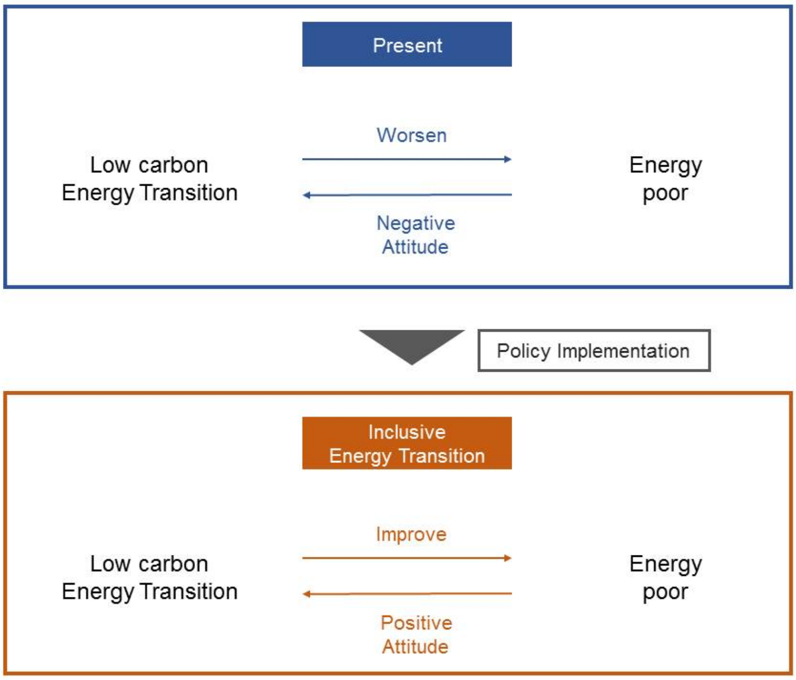

***Figure 4**. Improving Energy Transition Inclusivity Through Policy Intervention*

According to our results, by making the low-carbon energy transition inclusive in Japan we can expect to incorporate an additional ~5% of households, a significant number. There are some limitations and areas for further improvement of this research, firstly in terms of sample size and time-series based analysis. This research analyzes outcomes from a survey sample of 4,148 Japanese households, conducted in March of 2017. Within this sample, 201 households are identified as EP households. In order to verify the trends established in this research, future surveys will enable a time-series analysis. Regarding the energy poverty measure proposed in this paper, the first dimension of (multidimensional) energy poverty is based on subjective or self-reported assessment of household 'energy affordability' or 'energy burden'. This study is the first attempt at such an approach to measure energy poverty in Japan, presenting valuable information, differing from the results gained through objective energy poverty measures (e.g., Okushima, 2017). Several studies have suggested there is limited overlap between subjective and objective EP results, and there is the likelihood that a different kind of energy poverty is being measured (Hills, 2011; Waddams Price et al., 2012; Meyer et al., 2018）. Therefore, a standalone subjective assessment may be insufficient to make a holistic energy poverty evaluation, and a combined subjective and objective evaluation may provide more effective policy responses, indispensable for dealing with the energy poverty issue (Hills, 2011; Waddams Price et al., 2012).

Further, in order to maximize respondent understanding and participation, this survey is focused on supply-side issues and self-reported outcomes most relevant to householders. The internet survey approach introduces some bias according to the proficiency of internet users, especially the elderly, and excludes those without internet access (Pew Research Center, 2015).

With regard to the issue of EP, and the future progress of the low-carbon transition in Japan, these will both be undoubtedly influenced by a number of uncertainties and external factors. For example, the movement of future (international) energy prices will be very influential. As we described in Section 2, current energy prices are lower than previous peak levels (although they are still relatively high overall), however, if they vary significantly, they will impact heavily upon both the low-carbon energy transition and energy poverty outcomes in Japan. Moreover, as this study's policy implications focus on the FIT, they are likely to be time sensitive and subject to change, in line with changing energy transition policy approaches such as anticipated future carbon pricing regimes.

Finally, in order to dig deeper into stakeholder preferences and the specific nature of a desirable, inclusive low-carbon energy transition, a future task remains to design and implement a survey which can accurately capture these factors.

References

1. Agency for Natural Resources and Energy, 2017. Energy White Paper 2017. http://www.enecho.meti.go.jp/en/category/whitepaper/
2. Agency for Natural Resources and Energy, 2018. The Renewable Energy Feed in Tariff: Renewable Energy Surcharge. http://www.enecho.meti.go.jp/category/saving_and_new/saiene/kaitori/surcharge.html
3. Alkire, S., Foster, J., 2011. Counting and multidimensional poverty measurement. Journal of Public Economics, 95, 476-487.
4. Atkinson, A.B., 2003. Multidimensional deprivation: contrasting social welfare and counting approaches. Journal of Economic Inequality, 1, 51-65.
5. Bloomberg New Energy Finance (BNEF). (2019). Japan Country Profile: Electricity Mix, Generation (GWh). https://www.bnef.com/core/country-profiles/jpn?tab=Tableaus
6. Boardman, B., 1991. Fuel Poverty: From Cold Homes to Affordable Warmth. Belhaven Press; London.

7. Boardman, B., 2010. Fixing Fuel Poverty: Challenges and Solutions. Earthscan; London.
8. Bouzarovski, S., Petrova, S., Sarlamanov, R., 2012. Energy poverty policies in the EU: a critical perspective. Energy Policy, 49, 76–82.
9. Bouzarovski, S., Petrova, S., 2015. A global perspective on domestic energy deprivation: overcoming the energy poverty-fuel poverty binary. Energy Research and Social Science, 10, 31-40.
10. Bouzarovski, S., Simcock, N., 2017. Spatializing energy justice. Energy Policy, 107, 640-648.
11. Bouzarovski, S., 2018. Energy Poverty: (Dis)Assembling Europe's Infrastructural Divide. Palgrave Macmilan; Switzerland.
12. Chapman, A., Itaoka, K., 2018. Curiosity, economic and environmental reasoning: public perceptions of liberalization and renewable energy transition in Japan. Energy Research and Social Science, 37, 102–110.
13. Chapman, A. J., Pambudi, N. A., 2018. Strategic and user-driven transition scenarios: toward a low carbon society, encompassing the issues of sustainability and societal equity in Japan. Journal of Cleaner Production, 172, 1014–1024.
14. Cludius, J., Beznoska, M., Schlomann, B., Forster, H., Hunecke, K., Loreck, C., Schumacher, K., Kenkmann, T. 2015. The distribution of renewable energy policy cost amongst households in Germany – and the role of energy efficiency policies. ECEE Summer Study – First Fuel Now, Panel 2: Energy Efficiency Policies – How do we get it right? 2-259-15.
15. Department of the Environment and Energy, 2018. Appliance purchase loan assistance: No Interest Loans Scheme (NILS). https://www.energy.gov.au/rebates/appliance-purchase-loan-assistance
16. Dubois, U., 2012. From targeting to implementation: the role of identification of fuel poor households. Energy Policy, 49, 107-115.
17. Duke Energy, 2018. Products and Services: Free LEDs. https://www.duke-energy.com/home/products/free-leds
18. Energy Australia. 2019. Government Assistance. https://www.energyaustralia.com.au/home/bills-and-accounts/hardship-policy/government-assistance
19. Grist. 2019. Energy equity: Bringing solar power to low-income communities. April 14, 2019. https://grist.org/article/energy-equity-bringing-solar-power-to-low-income-communities/

20. Heffron, R. J., McCauley, D., 2018. What is the ‘Just Transition’? Geoforum, 88, 74–77.
21. Hills, J., 2011. Fuel Poverty: The Problem and its Measurement. Department of Energy and Climate Change, Government of UK, London.
22. Jasanoff, S., 2018. Just transitions: a humble approach to global energy futures. Energy Research and Social Science, 35, 11–14.
23. Jenkins, K., McCauley, D., Heffron, R., Stephan, H., & Rehner, R. (2016). Energy justice: A conceptual review. Energy Research & Social Science, 11, 174–182. https://doi.org/10.1016/j.erss.2015.10.004
24. Junghans, L., Kreft, S., Welp, M., 2018. Inclusive visions for urban transitions: lessons from stakeholder dialogues in Asian medium sized cities. Sustainable Cities and Society, 42, 512–520.
25. Kerr, N., Gouldson, A., Barret, J., 2017. The rationale for energy efficiency policy: assessing the recognition of the multiple benefits of energy efficiency retrofit policy. Energy Policy, 106, 212-221.
26. Mckay, S., 2004. Poverty or preference: what do ‘consensual deprivation indicators’ really measure? Fiscal Studies, 25(2), 201–223.
27. McLellan, B. C., Chapman, A. J., Aoki, K., 2016. Geography, urbanization and lock-in – considerations for sustainable transitions to decentralized energy systems. Journal of Cleaner Production, 128, 77–96.
28. Meyer, S., Holzemer, L., Delbeke, B., Middlemiss, L., Maréchal, K., 2018. Capturing the multifaceted nature of energy poverty: lessons from Belgium,” Energy Research and Social Science, 40, 273-283.
29. Ministry of the Environment, 2018. 9th Meeting of the Committee for the Consideration of a Carbon Pricing Approach, meeting outcomes. https://www.env.go.jp/earth/cp09_gijigaiyou.pdf
30. Ministry of Economy, Trade and Industry (METI). (2018). Strategic Energy Plan July 2018, Provisional Translation. https://www.meti.go.jp/english/press/2018/pdf/0703_002c.pdf
31. Nippon Hoso Kyokai (NHK, Japan Broadcasting Corporation) News Web. (2019). 3 years since liberalization, switching rates remain around 12% (in Japanese). https://www3.nhk.or.jp/news/html/20190428/k10011899461000.html
32. Okushima, S., 2016. Measuring energy poverty in Japan, 2004–2013. Energy Policy, 98, 557-564.
33. Okushima, S., 2017. Gauging energy poverty: a multidimensional approach. Energy, 137, 1159-1166.

34. Okushima, S., 2019. Understanding Regional Energy poverty in Japan: A Direct Measurement Approach. Energy and Buildings, 193, 174-184.
35. Pew Research Center. 2015. Coverage in Internet Surveys, Who Web-Only Surveys Miss and How That Affects Results. http://www.pewresearch.org/2015/09/22/coverage-error-in-internet-surveys
36. Roberts, D., Vera-Toscano, E., Phimister, E., 2015. Fuel poverty in the UK: is there a difference between rural and urban areas? Energy Policy, 87, 216-223.
37. Robinson, C., Bouzarovski, S., Lindley, S., 2018. 'Getting the measure of fuel poverty': the geography of fuel poverty indicators in England. Energy Research and Social Science, 36, 79–93.
38. Sovacool, B.K., Lipson, M.M., Chard, R., 2019. Temporality, vulnerability, and energy justice in household low carbon innovations. Energy Policy, 128, 495-504.
39. Thomson, H., Snell, C., 2013. Quantifying the prevalence of fuel poverty across the European Union. Energy Policy, 52, 563-572.
40. United Nations Framework Convention on Climate Change (UNFCCC), 2018. The Paris Agreement. https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement
41. Ürge-Vorsatz, D., Tirado Herrero, S., 2012. Building synergies between climate change mitigation and energy poverty alleviation. Energy Policy, 49, 83–90.
42. Waddams Price, C., Brazier, K., Wang, W., 2012. Objective and subjective measures of fuel poverty. Energy Policy, 49, 33-39.

Appendix A. Energy Poverty Cohort Identification Factors

Q12. Monthly Energy Bill Affordability (n=4,148)

	1	2	3	4	5
	Unaffordable	**Expensive**	**Affordable**	**Inexpensive**	**Don't Use**
Electricity	5.6%	61.5%	29.5%	2.8%	0.7%
City Gas	2.5%	33.2%	25.4%	2.9%	36.0%
LP Gas	4.7%	25.2%	11.4%	1.0%	57.7%
Kerosene	3.7%	34.7%	16.8%	1.7%	43.2%

Q30. Household Income Level (n=4,148)

Response	Income Level	Households
1	**< 2 Million Yen**	11.5%
2	**2 - 4 Million Yen**	29.3%
3	**4 - 6 Million Yen**	25.6%
4	**6 - 8 Million Yen**	14.8%
5	**8 - 10 Million Yen**	9.8%
6	**10 - 15 Million Yen**	6.8%
7	**15 - 20 Million Yen**	1.3%
8	**> 20 Million Yen**	1.0%

Appendix B. Energy Poverty and Awareness Survey Results

Q4. Most Important Global Issue (n=4,148)

Issue	SEP	Very Low Income	EP	Low Income	Others
Global Warming (Climate Change)	27.4%	35.8%	33.3%	38.2%	39.7%
Stable Energy Supply	11.3%	7.6%	10.4%	8.5%	8.8%
International Terrorism	4.8%	10.3%	8.0%	10.7%	12.1%
Poverty (Lack of Food and Water)	11.3%	10.1%	10.0%	9.8%	8.2%
Transmission of Infectious Diseases	3.2%	1.1%	2.5%	2.0%	2.8%
Economic Issues	16.1%	12.8%	11.9%	11.3%	10.8%
Nuclear Weapon Proliferation	14.5%	7.4%	10.4%	7.2%	5.7%
Armed Conflict	1.6%	5.7%	6.0%	5.1%	5.2%
Increasing World Population	4.8%	4.2%	3.5%	4.0%	4.5%
Other	1.6%	0.4%	1.5%	0.5%	0.4%
Unsure	3.2%	4.6%	2.5%	2.8%	2.0%

Q8. Knowledge About Policies and International Agreements (n=4,148)

Policy	Awareness	SEP	Very Low Income	EP	Low Income	Others
Paris Agreement	High	1.6%	1.5%	2.0%	2.6%	5.0%
	Moderate	24.2%	19.2%	27.4%	23.9%	27.7%
	Limited	56.5%	55.8%	50.2%	53.7%	51.0%
	None	17.7%	23.6%	20.4%	19.8%	16.3%
Feed-in tariff (FIT)	High	0.0%	0.8%	1.0%	1.4%	2.4%
	Moderate	6.5%	6.7%	7.0%	8.5%	11.7%
	Limited	27.4%	25.1%	26.9%	26.1%	24.8%
	None	66.1%	67.4%	65.2%	64.1%	61.1%
Intended Nationally Determined Contributions (INDC)	High	0.0%	0.0%	0.5%	0.4%	1.0%
	Moderate	3.2%	3.8%	3.0%	3.6%	5.7%
	Limited	14.5%	15.8%	18.4%	18.9%	19.6%
	None	82.3%	80.4%	78.1%	77.0%	73.8%
Conference of Parties (COP)	High	3.2%	0.8%	1.0%	1.0%	2.4%
	Moderate	4.8%	6.7%	7.5%	7.6%	11.9%
	Limited	22.6%	27.6%	27.4%	31.7%	30.6%
	None	69.4%	64.8%	64.2%	59.7%	55.1%
Kyoto Protocol	High	8.1%	5.5%	9.5%	7.2%	9.8%
	Moderate	27.4%	26.1%	30.8%	31.8%	35.2%
	Limited	45.2%	51.8%	46.3%	48.7%	45.0%
	None	19.4%	16.6%	13.4%	12.4%	9.9%
Intergovernmental Panel on Climate Change (IPCC)	High	1.6%	1.1%	2.0%	1.4%	2.6%
	Moderate	6.5%	6.1%	7.5%	8.5%	11.3%
	Limited	21.0%	27.2%	26.4%	29.1%	28.3%
	None	71.0%	65.7%	64.2%	61.0%	57.8%

Q9. Knowledge About Energy System Liberalization (n=4,148)

Knowledge Level	SEP	Very Low Income	EP	Low Income	Others
High	19.4%	24.2%	30.8%	28.1%	31.6%
Moderate	54.8%	51.4%	52.7%	54.3%	55.3%
Low	25.8%	21.3%	14.9%	15.8%	12.1%
None	0.0%	3.2%	1.5%	1.8%	1.0%

Q13. Consideration of Changing Electricity Company Post Liberalization (n=4,148)

Consideration Level	SEP	Very Low Income	EP	Low Income	Others
Serious Consideration	21.0%	10.4%	18.7%	12.2%	13.0%
Moderate Consideration	35.5%	33.0%	40.4%	33.6%	38.2%
No Consideration	43.5%	56.5%	40.9%	54.2%	48.8%

Appendix C. Energy Poverty, Behavior and Energy Source Constraint Survey Results

Q15. Change of Electricity Company Post Liberalization (n=4,148)

Changed Electricity Provider	SEP	Very Low Income	EP	Low Income	Others
Yes	16.1%	8.3%	17.2%	11.0%	11.5%
No	83.9%	91.7%	82.8%	89.0%	88.5%

Appendix D. Energy Poverty and Preference Survey Results

Q23. Preferred Energy Mix (n=4,148)

Energy Source	Preference	SEP	Very Low Income	EP	Low Income	Others
Coal	Increase	1.6%	1.1%	2.0%	1.2%	1.3%
	Maybe Increase	3.2%	4.2%	7.5%	4.7%	5.0%
	Neither	37.1%	47.8%	35.3%	45.5%	44.2%
	Maybe Decrease	27.4%	25.9%	28.9%	29.1%	29.1%
	Decrease	30.6%	21.1%	26.4%	19.4%	20.3%
Solar	Increase	37.1%	30.5%	40.8%	35.1%	36.5%
	Maybe Increase	35.5%	36.8%	36.8%	40.0%	41.6%
	Neither	19.4%	29.5%	18.4%	22.6%	19.9%
	Maybe Decrease	3.2%	1.9%	2.5%	1.5%	1.3%
	Decrease	4.8%	1.3%	1.5%	0.7%	0.7%
Nuclear	Increase	8.1%	2.3%	5.5%	3.5%	3.3%
	Maybe Increase	4.8%	4.4%	5.5%	5.7%	6.5%
	Neither	24.2%	31.4%	27.4%	27.9%	29.0%
	Maybe Decrease	19.4%	20.2%	17.9%	21.0%	22.5%
	Decrease	43.5%	41.7%	43.8%	41.9%	38.7%
Natural Gas	Increase	9.7%	7.8%	13.4%	8.4%	8.4%
	Maybe Increase	32.3%	28.6%	38.3%	36.4%	35.5%
	Neither	41.9%	50.7%	34.8%	43.8%	43.2%
	Maybe Decrease	9.7%	9.1%	8.5%	8.4%	10.0%
	Decrease	6.5%	3.8%	5.0%	3.0%	2.8%
Oil	Increase	3.2%	1.7%	5.0%	2.2%	2.6%
	Maybe Increase	9.7%	10.9%	15.4%	13.9%	13.3%
	Neither	48.4%	56.6%	42.8%	52.2%	53.4%
	Maybe Decrease	27.4%	22.9%	29.4%	25.6%	24.9%
	Decrease	11.3%	7.8%	7.5%	6.1%	5.8%
Wind Power	Increase	38.7%	26.7%	35.3%	29.2%	31.3%
	Maybe Increase	32.3%	36.6%	38.3%	41.4%	41.6%
	Neither	21.0%	33.1%	22.9%	26.7%	25.0%
	Maybe Decrease	4.8%	2.3%	2.5%	1.9%	1.5%
	Decrease	3.2%	1.3%	1.0%	0.8%	0.7%
Hydropower	Increase	27.4%	22.5%	28.4%	23.4%	25.2%
	Maybe Increase	43.5%	36.4%	44.8%	40.7%	40.9%
	Neither	25.8%	38.5%	23.9%	33.3%	32.0%
	Maybe Decrease	1.6%	1.9%	2.5%	2.1%	1.5%
	Decrease	1.6%	0.6%	0.5%	0.5%	0.4%
Biomass	Increase	25.8%	21.3%	29.4%	21.9%	24.0%
	Maybe Increase	29.0%	26.5%	31.3%	33.9%	35.4%
	Neither	40.3%	47.6%	36.8%	41.1%	38.3%
	Maybe Decrease	3.2%	2.7%	2.0%	2.0%	1.6%
	Decrease	1.6%	1.9%	0.5%	1.1%	0.7%
Geothermal	Increase	33.9%	28.4%	32.8%	29.2%	30.0%
	Maybe Increase	37.1%	36.6%	42.3%	41.2%	41.3%
	Neither	25.8%	33.1%	22.9%	27.9%	27.5%
	Maybe Decrease	3.2%	1.3%	2.0%	1.2%	0.9%
	Decrease	0.0%	0.6%	0.0%	0.5%	0.3%

Q29. Preferred Technological Response to Climate Change (n=4,148)

Approach	Preference	SEP	Very Low Income	EP	Low Income	Others
Solar Power Generation	Not Use	8.1%	2.7%	3.0%	2.0%	1.5%
	Maybe Not Use	3.2%	6.9%	5.5%	5.3%	5.1%
	Neither	38.7%	38.1%	31.3%	32.4%	32.6%
	Maybe Use	33.9%	37.9%	40.8%	42.2%	43.6%
	Definitely Use	16.1%	14.3%	19.4%	18.1%	17.2%
Nuclear Power Generation	Not Use	30.6%	27.4%	29.9%	29.2%	23.7%
	Maybe Not Use	12.9%	20.6%	21.4%	21.4%	23.7%
	Neither	40.3%	40.2%	33.8%	36.2%	38.9%
	Maybe Use	8.1%	8.4%	10.0%	9.8%	10.9%
	Definitely Use	8.1%	3.4%	5.0%	3.4%	2.8%
Energy Efficient Devices	Not Use	4.8%	2.1%	1.5%	1.2%	0.9%
	Maybe Not Use	8.1%	6.3%	5.0%	4.9%	4.7%
	Neither	30.6%	39.8%	32.3%	32.6%	31.8%
	Maybe Use	43.5%	40.6%	48.3%	48.9%	49.5%
	Definitely Use	12.9%	11.2%	12.9%	12.4%	13.2%
Fuel Efficient Vehicles	Not Use	6.5%	3.8%	2.5%	2.4%	1.6%
	Maybe Not Use	4.8%	6.5%	6.5%	7.0%	5.7%
	Neither	32.3%	36.6%	29.4%	30.4%	30.1%
	Maybe Use	35.5%	40.2%	47.3%	45.7%	47.1%
	Definitely Use	21.0%	12.8%	14.4%	14.4%	15.4%
Biomass Generation	Not Use	4.8%	2.1%	1.5%	1.6%	1.1%
	Maybe Not Use	8.1%	8.4%	9.0%	7.2%	6.2%
	Neither	45.2%	44.8%	42.3%	40.0%	40.5%
	Maybe Use	21.0%	33.1%	32.8%	39.7%	41.5%
	Definitely Use	21.0%	11.6%	14.4%	11.5%	10.7%
Low Emission Fuel Use	Not Use	4.8%	2.7%	2.5%	2.1%	1.3%
	Maybe Not Use	4.8%	6.5%	5.5%	5.4%	5.2%
	Neither	48.4%	44.6%	39.3%	39.8%	39.0%
	Maybe Use	33.9%	38.9%	44.8%	44.4%	45.7%
	Definitely Use	8.1%	7.2%	8.0%	8.3%	8.7%
CO_2 Absorption Through Tree Planting	Not Use	3.2%	2.9%	1.5%	2.3%	1.2%
	Maybe Not Use	3.2%	5.9%	6.0%	5.2%	5.7%
	Neither	46.8%	46.3%	40.3%	39.6%	40.2%
	Maybe Use	25.8%	30.5%	38.8%	38.9%	39.3%
	Definitely Use	21.0%	14.3%	13.4%	14.0%	13.5%
Carbon Capture and Storage/ Utilization (CCS/CCU)	Not Use	3.2%	3.2%	1.5%	2.5%	1.4%
	Maybe Not Use	0.0%	7.2%	5.5%	5.7%	5.9%
	Neither	54.8%	57.5%	51.2%	53.5%	53.7%
	Maybe Use	32.3%	24.4%	33.8%	31.3%	31.6%
	Definitely Use	9.7%	7.8%	8.0%	7.0%	7.4%
Wind Power Generation	Not Use	6.5%	2.7%	2.0%	1.9%	1.5%
	Maybe Not Use	4.8%	6.7%	6.5%	6.5%	6.8%
	Neither	38.7%	41.9%	34.3%	35.9%	36.1%
	Maybe Use	32.3%	37.1%	40.3%	41.8%	42.9%
	Definitely Use	17.7%	11.6%	16.9%	14.0%	12.7%