sustainability

MDPI

Article

Energy Poverty among College Students in Japan in a Survey of Students' Knowledge, Attitude and Practices towards Energy Use

Amin Nazarahari [1,*], Nader Ghotbi [2] and Koji Tokimatsu [1]

[1] School of Environment and Society, Tokyo Institute of Technology, Yokohama 226-8503, Japan; tokimatsu.k.ac@m.titech.ac.jp

[2] Graduate School of Asia Pacific Studies, Ritsumeikan Asia Pacific University, Beppu 874-8577, Japan; nader@apu.ac.jp

* Correspondence: ahari.a.aa@m.titech.ac.jp; Tel.: +81-45-924-5507

Abstract: In order to investigate the problem of energy/fuel poverty in Japan, we examined the knowledge, attitude, and practices towards energy usage of a random group of 447 college students in an international university in Japan. The majority of the students were living independently in private or shared accommodations, depended on portable heating/cooling appliances, and were billed directly for their electricity usage. The responses of 205 Japanese and 236 non-Japanese students to a detailed survey about energy consumption for daily living and its cost were collected. The examined variables included students' monthly income/allowance, energy bills, attributes of energy use including room temperature setting for cooling in summer and heating in winter, the students' awareness of energy fees, and their attitude towards energy use vs. saving in energy costs. The results indicate that energy bills were perceived as too high by most non-Japanese students as compared to Japanese students, while for both Japanese and non-Japanese students there was a positive correlation between monthly income/allowance and energy bills. The findings suggest that energy poverty is common among college students living independently in Japan, such that, in future research, they may be included in the category of vulnerable households with respect to energy poverty.

Keywords: college students; energy poverty; fuel poverty; Japan; room temperature setting; vulnerable households

Citation: Nazarahari, A.; Ghotbi, N.; Tokimatsu, K. Energy Poverty among College Students in Japan in a Survey of Students' Knowledge, Attitude and Practices towards Energy Use. *Sustainability* **2021**, *13*, 8484. https://doi.org/10.3390/su13158484

Academic Editors: João Pedro Gouveia and Ricardo Barbosa

Received: 27 June 2021
Accepted: 26 July 2021
Published: 29 July 2021

1. Introduction

This paper reports a study of energy poverty among college students in Japan who live away from their hometowns or home countries in private houses or school dormitories, many of whom have limited income for their basic needs and who often rely on portable heating and cooling devices to achieve thermal comfort.

As a developed country and the third largest economy in the world, Japan has an energy self-sufficiency ratio of only 9.6% [1], much lower than other developed countries and OECD nations. The Great East Japan Earthquake in 2011 severely damaged Japan's capacity to use nuclear energy as a solution to the scarcity of domestic energy resources; furthermore, a rise in global energy prices, along with a domestic decline of incomes, rising consumption taxes, and a sluggish economy in an aging population have contributed to the rise of energy prices in Japan [2].

Although Japanese households have easy access to energy through the national grid, its high cost limits its affordability, and studying the end-users' patterns of energy use can help with setting fair energy prices. In fact, the situation that led to the use of the term 'energy poverty', which is an important socio-economic issue linked with energy consumption, was an inability to afford adequate warmth at home in the late 1970s and early 1980s [3]. 'Energy poverty' or 'fuel poverty' generally describes the situation of households lacking access to commercial energy at an affordable price to meet their basic day to day needs [4]. Bouzarovski et al. (2012) define energy poverty as a condition in which households cannot access/afford energy services at a socially needed level [5]. In an overview of the issue of energy poverty, González-Eguino (2015) associated it to poverty in general, which is a common problem in poor developing countries with a low per capita energy and electricity consumption; he suggests that 'fuel poverty' may afflict some of the citizens in developed countries [6]. Galvin (2019) studied 28 developed countries and found a close relationship between economic inequality and energy poverty [7], while Walker & Day (2012) identify income as a key factor in energy poverty [8]. Reddy (2000) defined fuel poverty as "the absence of sufficient choice in accessing adequate, affordable, reliable, high-quality, safe and environmentally benign energy services to support economic and human development" [9]. Boardman (1991) defined energy poverty as having to pay more than 10% of the households' income to maintain a satisfactory indoor temperature and provide for basic energy necessities [10]; this definition is widely known as 'the 10% indicator' and is adopted by many researchers as well as governments for the recognition of energy poverty. One of the advantages of this indicator is its simplicity and potential application to various regions, with different local standards and norms.

The study of energy poverty is especially important due to recognition of its direct negative impact on human health [11]. In the UK, a series of respiratory, heart and circulatory diseases, and mental health problems, as well as illnesses due to living in cold and damp homes, have been linked to energy poverty, which cause millions of pounds in annual costs to the National Health Service [12]. In addition to physical and mental health problems, energy poverty can increase the mortality rate among the elderly in Japan due to exposure to the extreme temperature events associated with climate change. These events have led to an increased number of cases of heatstroke and cold-related deaths in Japan's aging population [13–16]. Reluctance to use air conditioning systems is common among this population group in Japan, and an insufficient income through the retirement pension system is the possible trigger to such behavior.

Literature studies on energy poverty in Japan began no earlier than 2016. Since then, a few national and regional studies proved the existence of energy poverty, suggested some potential factors, and described the types of households most vulnerable to it. However, a missing piece in the literature is the study of college students. Many Japanese college students live away from their hometowns in private houses or school dormitories and depend on a limited income/allowance for their study and living costs. Japanese studies suggest two factors among the most contributing to energy poverty, namely low income and high energy cost. With college students commonly living with a low income, it is questionable why they have been left out of these calculations.

In our research, we have examined a sample group of Japanese and non-Japanese independent college students who mostly lived in private houses in Beppu City, analyzing their incomes and costs while exploring their daily energy consumption practices and their perception of energy costs. First, an inclusive summary of the energy poverty studies conducted in Japan will be introduced in the following section, which also refers to a few studies conducted elsewhere on this type of household.

2. Literature Review

2.1. Japanese Studies (2013–2020)

Speculation of energy poverty in Japan was initially hinted at by Okushima & Okagawa (2013) in a conference proceeding [17], and the existence of energy poverty in Japan was first thoroughly described in a study by Okushima (2016) who referred to the trends in energy prices after the 2000s and portrayed energy poverty in relation to the differences in the income of various household categories [2]. He showed that lower income deciles were suffering from much higher energy poverty rates as compared with higher income deciles. Okushima (2016) refers to energy poverty in 21st century Japan as being "among lower income and vulnerable households" due to the escalation of energy prices and stagnating incomes [2]. He uses both 'energy poverty' and 'fuel poverty' as substitute terms with an almost equal meaning, and other scholars have also used 'energy poverty' and 'fuel poverty' interchangeably in the same context [7,18–20]. Likewise, in this paper, we refrain from focusing on terminological distinction between these two terms and use "energy poverty" to address this issue.

Okushima (2016) emphasizes that high energy costs may "prevent people from satisfying their basic energy needs" and refers to vulnerable households in Japan that include single parents, the retired elderly with little pension support, and single-aged households [2]. He elaborates that certain households such as single mother households, aged, or single and aged households faced higher energy poverty rates. In other countries also, single parents are reported to be in energy poverty or at the risk of becoming energy poor [21–24].

Mori et al. (2018) assessed energy poverty through surveys in three different regions of Hokkaido [25], which are among the coldest regions in Japan. They used the 'National Survey of Family Income and Expenditure' to assess spending for energy in different regions in Japan. The study showed that the risk of energy poverty was much higher among the elderly and lower income households living in aged dwellings as compared with younger households. Okushima (2017) extended his previous research by developing a new model for gauging energy poverty, the Multidimensional Energy Poverty Index (MEPI), composed of three dimensions: energy cost, income, and energy efficiency of housing [26]. In a later study, he examined a relatively different approach to studying energy poverty in Japan using calorific value as a testing method [27]. The calorific values of basic energy needs and income were used to examine the regional characteristics of energy poverty. The results suggest that kerosene plays a big role in northern Japan, as the amount used for heating is much higher and it is the cheapest option available. Tabata & Peii (2019) conducted a study on energy poverty in Japan's Kansai region in the form of a comparative analysis between elderly households (head of the household above 65) and other randomly selected households in the same region [28]. The study showed that the elderly households were at significantly higher risk of energy poverty.

Chapman & Okushima (2019) studied the role of energy poor households, as well as their awareness and behavior in the transition to low-carbon energy in Japan [29]. They emphasized the need to consider energy poor households in policies implemented for the low-carbon energy transition in Japan and the impact they can have in this transition through assistance in the provision of the primary capital for access to solar or renewable energy.

The ability to overcome the cold and to afford adequate warmth are common concepts in the definition of energy poverty, and thus there is frequently a focus on regions with a cold climate such as in northern Japan. Hokkaido is the northernmost and the coldest prefecture of Japan, with an annual mean temperature of 10 degrees Celsius [30]. Furthermore, 20.9% of the 5.63 million population of Hokkaido is over 65 years of age [31], who are in the vulnerable households category. Therefore, energy poverty is presumed to occur in Hokkaido and energy poverty studies in Japan often include this region [27,29,32], or specifically focus on this region [25,33,34].

In a different approach, Tabata & Peii (2020) investigated energy poverty during summer in Japan [35]. They found that while the energy poverty rates are much lower compared to winter, vulnerable households such as the elderly and single parent households are in higher risk of falling into energy poverty, affected by several factors such as the age and size of homes, efficiency of air conditioners, lower income, and higher utility costs.

Generally, energy poverty studies in Japan are severely limited in the number and variety of approaches compared to other countries, such as those in the European region. National scale governmental data such as the National Survey of Family Income and Expenditure conducted every five years provide a rich source of relevant national-scale information on households, from income to energy expenditure. The common approach to measuring energy poverty in Japan has been through analyzing such data and then identifying and introducing energy poor and vulnerable households. Although taking this top-down approach is crucial in shaping the image of energy poverty in Japan, supplementary studies through the investigation of other potential contributing factors and households at risk may enhance our understanding of the situation. We reviewed energy poverty studies in other countries and found that, in some studies, college students are among the vulnerable households in risk of energy poverty. In the following section, we elaborate on these findings in other countries, and introduce our approach to investigating the energy poverty condition of college students in Japan.

2.2. Indicator

The 10% energy poverty indicator defined by Boardman (1991) is often used to examine the actual energy poverty rates of households through income and energy expenditure [10]. However, in the absence of discrete household microdata, examining energy poverty becomes very challenging. In Japan, information on income is often perceived as a sensitive subject and is not easy to inquire about, and it is frequently left unanswered in survey questions. Moreover, students are not formally recognized as independent individuals, but are considered as a part of their family or household and are regarded as dependent on the head of the household. However, this has changed significantly in recent years, both for domestic students and international students who are often independent heads of single households in Japan; most of them have independent lives and jobs with low paying hourly wages that are time constrained and limited. Overall, the 10% indicator could be a fair criterion of energy poverty among the students in Japan.

Aside from the 10% indicator, there are several indicators that are used to examine energy poverty in European studies. These indicators, such as the low-income high-cost indicator (LIHC), double the median or mean indicator (2M), minimum income standard indicator (MIS), and the hidden energy poverty indicator (HEP), examine households' energy expenditure and incomes with respect to the national mean or median. However, these indicators are often used to examine large number of households at a national level, and the lack of data on student households in Japan, as well as the different income standards these households have compared to the ordinary households, may increase the inaccuracy in the results. Furthermore, there are only a handful of studies on energy poverty conducted in Japan, in which none of these indicators are adopted, and energy poverty is often examined using the 10% indicator.

Gauging energy poverty is a difficult task due to its multidimensional characteristic, which requires a consideration of the social, technical, and economic aspects. There are three general approaches: the expenditure approach, the consensual approach, and direct measurement [19]. The expenditure approach is generally based on the 10% indicator method, while the consensual approach looks for meaningful insights on household conditions and is based on the energy users' observations and understanding. Moreover, in the direct measurement approach, the assessment of energy poverty is based on a comparison of predefined standards with energy conditions inside the household. In the limited number of published papers on energy poverty in Japan, the expenditure approach is the dominant method used. The lifestyle of the household members is often not examined in the collected national data, which is another limitation of the expenditure approach for studying energy poverty in Japan. A strength of the consensual approach in Japan is the ability to assess household thermal comfort from the respondents' perceived energy shortages, which has often been neglected in national scale data collection. The consensual approach was therefore found to be suitable for this study.

2.3. College Students

In the few studies conducted in Japan about energy poverty, household 'types' are commonly considered as the units of study, so that households that, on average, show higher poverty rates may be included, for instance, elderly households and single mother households. However, there are no studies targeting independent college students, even though they are within the vulnerable household category elsewhere. It is a common and culturally acceptable expectation for students to live in an unpleasant residence and neighborhood with old and poor conditions [36]. Ntouros et al. (2019) investigated energy poverty due to housing tenure in the students' category [37]. Through a survey of 286 students, Morris & Genovese (2018) found that students' daily life practices qualify them as energy poor, even though the students themselves may not think so [38]. In a case study of fuel poor households in Scotland, Mould & Baker (2017) revealed that difficulties with the card meter payment system for a student flat is associated with "self-limiting behaviors and poor heating regimes" while also impacting their mental health [39]. A few surveys have been conducted at schools in Japan's Hokkaido region; however, the focus was not the students, but rather a comparison between households with children and elderly households [25,33].

Therefore, this study focuses on college students in Japan to examine whether students may be included in the vulnerable household category. As demonstrated in our study, it is common for college students in Japan to live in private households, while living on a limited income or allowance for their study and living costs. Hence, we decided to examine college students living away from their parents as a group of low-income individuals who may be under financial pressure. Ritsumeikan Asia Pacific University (APU), where the samples were collected, has an equal ratio of Japanese to non-Japanese students. In addition, most Japanese students come from other regions and live independently away from their families, making it a suitable population sample for our study.

Regulations in Japan allow college students to work up to 28 h per week [40]. This rule is set by the Japanese Ministry of Justice, specifically for non-Japanese students. Therefore, it may be interpreted as an official estimation by the Japanese government of the range of needed income for a college student in Japan. With the average hourly wage of USD 7.24 or 800 Japanese Yen, commonly abbreviated as JPY, (USD 7.24) at part time jobs in Beppu City, where our study was done, a student can earn a maximum of about JPY 1.16 million (USD 10,500) annually. Thus, JPY 1.16 million may be considered as the ceiling of income for a college student in Beppu City. However, students may often receive financial support such as parental allowances or scholarships. In comparison, the average income of a Japanese household is JPY 5.46 million (USD 49,400), and that of elderly households, also considered as low income and vulnerable, is JPY 3.08 million (USD 27,900) [35]. In another study of energy poverty in Japan, Chapman & Okushima (2019) refer to income levels of up to JPY 2 million (USD 18,100) as "very low income" households [29].

The average sum of a college student's monthly living costs including rent, utilities, food, transportation, and other essential expenditures tallies up to at least JPY 100,000 (USD 900), or JPY 1.2 million (USD 10,800) annually. Accordingly, we have classified our respondents into three income groups: 'low-income', 'medium-income' and 'high-income', as shown in Table 1. Then, there is the tuition cost, which is about JPY 1.4 million (USD 12,600) annually for Japanese students, but international students commonly get a tuition reduction of around 50%. It is almost impossible to afford these costs without other sources of income such as parental allowance, scholarships, loans, or savings.

Table 1. Student income categories selected for the study.

Category	Annual Income Level (JPY)
Low-income	<1,000,000
Medium income	1,000,000–1,200,000
High-income	>1,200,000

3. Materials and Methods

Original surveys were conducted for the purpose of this study. The survey questionnaires were distributed at the end of a few randomly selected lectures and other open platforms at APU campus in Beppu City. Survey results were collected between January 2019 and January 2021. The responses were channeled through an online system to facilitate an effective and reliable data collection. The survey included questions on demographics, financial status and expenditure, and the respondents' level of awareness and attitude towards energy consumption (Table 2). The Chi-square and independent samples t-test were employed at a significant level of 0.05 to assess and analyze the statistical significance of the results. IBM SPSS Statistics Version 26 was used for the analysis of the collected data.

Table 2. The data categories examined through the survey questionnaire used for the study.

Category	Question	Response Type	Results
Demographics	Gender	Dichotomous	Table 3
	Age	Ordinal	Table 3
	Nationality	Nominal	Table 3
	Type of housing	Multiple choice	Table 3
	Number of members in household	Multiple choice	Table 3
Energy consumption	Heating device *	Multiple choice	Table 3
	Cooling device *	Multiple choice	Table 3
	Summer temperature setting	Numerical	Table 4
	Winter temperature setting	Numerical	Table 4
Financial aspect	Monthly income (part-time jobs, full-time jobs, etc.)	Ordinal	Table 5
	Monthly income (scholarship, parental allowance, etc.)	Ordinal	Table 5
	Monthly electricity costs	Numerical	Table 5
	Monthly gas costs	Numerical	Table 5
	Difficulty in paying energy bills	Likert scale	Table 5
Awareness and behavior	Checking details and awareness of energy bills	Likert scale	Table 5
	Obstacle to needed energy consumption	Open ended	Table 5
	Actions taken to curb energy consumption *	Open ended	Table 5

* Multiple responses allowed.

Table 3. Basic characteristics of respondents (n = 447).

Characteristic		n	%
Gender	Male	194	43.5
	Female	252	56.5
Age group	<20	3	0.7
	20–30	443	99.1
	≥30	1	0.2
Nationality	Japanese	205	45.9
	Non-Japanese	236	52.8
	No response	6	1.3
Number of house residents	1	211	47.2
	2	91	20.4
	3	105	23.5
	4	31	6.9
	≥5	9	2.0
Type of house *	1K, 1DK, 1LDK	209	46.8
	2K, 2DK, 2LDK	76	17.0
	3K, 3DK, 3LDK	106	23.7
	4K, 4DK, 4LDK	7	1.6
	5K, 5DK, 5LDK	6	1.3
	Detached house	20	4.5
	Dormitory/Shared house	18	4.0
	No Response	5	1.1
Cooling device(s)	Air conditioner (AC)	400	89.5
	Electric fan	222	49.7
	Central cooling station	8	1.8
	None	1	0.2

Table 3. *Cont.*

Characteristic		n	%
Heating device(s)	Air conditioner (AC)	360	80.5
	Electric heater	104	23.3
	Electric carpet	76	17.0
	Kerosene heater	47	10.5
	Kotatsu	13	2.9
Income (job + allowance)	Low income	211	47.3
	Medium income	93	20.9
	High income	142	31.8

* Expressed by the number of rooms, followed by "L" as living room, "D" as dining space, "K" as kitchen.

Table 4. Household temperature setting recommended by the government vs. findings of the study.

Energy Price Impression	Winter Temperature Setting	Summer Temperature Setting
COOLBIZ/WARMBIZ	20	28
Mean household temperature setting	23.8	23.4

Table 5. Survey question results and basic data of the respondents (*n* = 447).

Question	Detail	Value	%
*Income per year (job + allowance) **	Mean	1,176,000	–
	Quartile 1	720,000	–
	Quartile 2 (Median)	1,200,000	–
	Quartile 3	1,440,000	–
	Std. deviation	628,000	–
*Utility cost per year (electricity + gas) **	Mean	71,100	–
	Quartile 1	39,300	–
	Quartile 2 (Median)	66,000	–
	Quartile 3	90,000	–
	Std. deviation	41,200	–
Income to utility ratio	Valid cases (79 did not report their income and/or utility costs)	368	–
	Mean	0.87	–
	Median	0.55	–
	Std. deviation	0.11	–
Energy poverty (10% threshold)	Not energy poor	283	75.9
	Energy poor	85	23.1
Do you find it difficult to pay for energy?	Yes, it is expensive	203	45.4
	No, it is cheap	25	5.6
	Neither	219	49.0
Do you check the details of your energy bill?	Always	194	43.5
	Never	252	56.5
What is stopping you from using more energy?	I cannot afford higher consumption	154	34.5
	Greenhouse emissions and climate change	130	29.1
	Spend most of the day outside	130	29.1
	Nothing, I don't mind spending more	33	7.4
What action(s) do you take to use less energy? (multiple choices allowed)	Spend more time outside (library, restaurant, café, etc.)	215	48.6
	Consciously take actions to reduce consumption (buy more efficient appliances, etc.)	172	38.9
	Wear more or less clothes	131	29.6
	Endure less consumption, even though I prefer to use more	64	14.5
	Insulate my house	28	6.3
	Others	67	15.2
	None	14	2.0

* Unit in JPY.

Four hundred forty-seven students answered the survey questions including 205 Japanese and 236 non-Japanese students from South Korea (37), Indonesia (31), Thailand (28), Vietnam (28), China (21), Bangladesh (20), Nepal (14), India (12), and a few from other countries such as Mongolia, Sri Lanka, Taiwan, Germany, USA, Kenya, Myanmar, Uzbekistan, France, Fiji, Finland, Ghana, Iran, Malaysia, Micronesia, Netherlands, New Zealand, Norway, Philippines, Russia, Samoa, Somalia, Switzerland, Tonga, Trinidad and Tobago, and Turkey. The Japanese vs. non-Japanese composition of the students allowed for a comparison of their knowledge and attitudes towards energy usage, while in some instances, the results of the whole group helped with a better understanding of the impact of relatively high energy cost on their use/saving practice.

4. Results

4.1. Respondents' Profile

A summary of the collected data on respondents' basic characteristics is provided in Table 3. Among 447 students who responded to the survey questions, there were 205 Japanese and 236 non-Japanese students; 6 students did not reveal their nationality. Nearly all students (443) were between the age of 20 to 30 years old; 194 were male and 252 were female; 221 students lived alone while 236 lived with at least one roommate in a relatively larger residence. The most common heating and cooling device used was the split air-conditioner that 400 (89.5%) of students owned and used especially for cooling in summer, though other heating devices such as radiant heaters (104 students), electric carpets (76 students), and kerosene fan heaters (47 students) were also commonly used to help save on electricity costs. This is quite different from European countries, where most houses, apartments, and student hostels have built-in heating devices. The average monthly income, including monthly allowance and scholarships, was quite modest at about JPY 95,900 (USD 868). Nearly half of the students were living on 'low incomes' (JPY <1.0 million), while 20.9% lived on 'medium incomes' (JPY 1.0–1.2 million), and 31.8% had 'high incomes' (JPY >1.2 million).

4.2. Household Temperature Setting

The data for home temperature settings in summer and winter are crucial for studies which focus on household ambient temperature control, as well as heating and/or cooling demand control of a household, and they may vary depending on countries and perhaps, regions within a country. However, it is possible to apply them to a close geographical range such as a city or at the prefecture level. Unfortunately, data on home temperature settings in Japan is limited as data collection through surveys is difficult and costly. Since 2005, the Japanese government has recommended specific temperature settings for the HVAC systems at closed spaces in residential and commercial sectors through its 'COOLBIZ' and 'WARMBIZ' campaigns designed to help save energy and reduce CO_2 emissions [41,42]. The campaigns were further promoted in the aftermath of 2011 Great East Japan Earthquake, with titles such as 'Super COOLBIZ' and 'Warm Share' [43]. Campaign regulations suggest a temperature setting of 20 degrees Celsius for winter and 28 degrees Celsius for summer and have been highly criticized for being uncomfortable [44]. This temperature setting is reportedly decided based on multiple criteria, such as a 1970 sanitary law for buildings, Industrial Safety and Health Act, and series of surveys. Many households do not follow these suggestions, regardless of government promotions.

In this study, we collected samples on home temperature settings, as portrayed in Table 4. The mean household temperature setting for summer and winter were 23.4 and 23.8 degrees, respectively, which are widely different from the government's recommended temperature setting of 20 degrees Celsius for winter and 28 for summer. It appears as if the COOLBIZ/WARMBIZ suggestions are unanimously ignored among many student households, and that these suggestions are too extreme to be practical, regardless of government promotions.

4.3. Energy Poverty and Household Characteristics

A summary of the basic data on income and energy expenditure as well as the responses to equations regarding consumption behavior and awareness is provided in Table 5. The average annual income of students was about JPY 1.2 million (USD 10,900), and the average annual cost of utilities was about JPY 71,100 (USD 643). On average, students spent 8.7% of their annual income on energy bills, but about 23% spent over 10% and may be considered energy poor based on the conventional 10% energy poverty indicator. When asked whether they found it difficult to pay for energy, 203 students responded "Yes, it is expensive", while only a few (25 students) claimed it to be cheap. When asked if they checked the details of their energy bills, most of the students (252) reported that they never checked the details, while 194 students said they did. The fact that energy bills are sent to users in Japanese language with technical terms may contribute to their negligence.

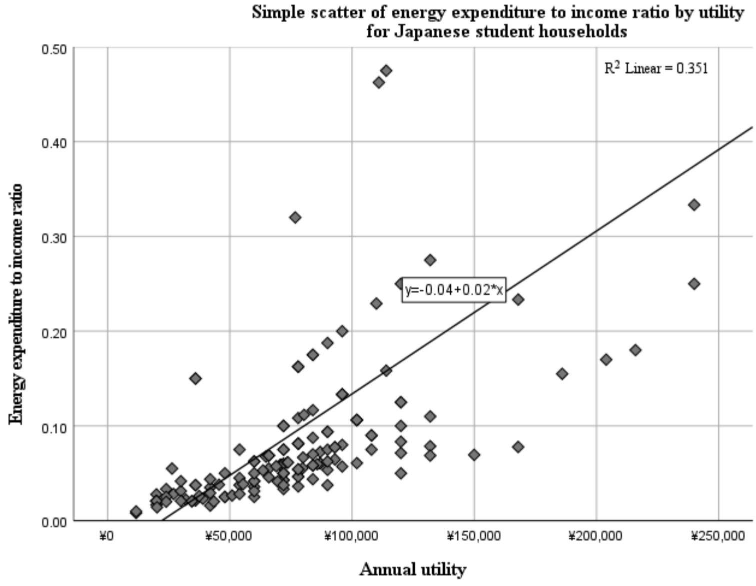
Out of all respondents, 34.5% mentioned that they lowered energy consumption at home because they could not afford to meet their energy needs; 29.1% claimed spending long hours outside home as a strategy to reduce energy consumption. In addition, 29.1% of respondents claimed to take environmental issues such as climate change and global warming into account for reducing domestic energy consumption. Only a small minority of students (7.4%) reported having no problem in consuming higher levels of energy if needed. Meanwhile, 38.9% of students took actions to reduce energy consumption by upgrading less efficient appliances to more efficient ones. In addition, 29.6% of students adjusted their clothes to feel cooler or warmer, while 14.5% of students simply endured or tolerated less consumption, though they would prefer to use more. Household insulation was not common (6.3%), as a large share of students did not own the house and thus would not make long term investments. Adjustment of temperature setting of air conditioners, saving in duration and instances of device usage, unplugging idle devices, and using smartphone applications to manage consumption were among the other less common practices, listed in the table as 'others'.

Low-income students in our study demonstrate higher energy poverty rates (Table 6). The average energy to income ratio for the low-income category was 14%, which surpasses the conventional 10% energy poverty threshold. While the results show a close proximity of the annual utility costs for all students, having a low income is a defining factor in their energy poverty status.

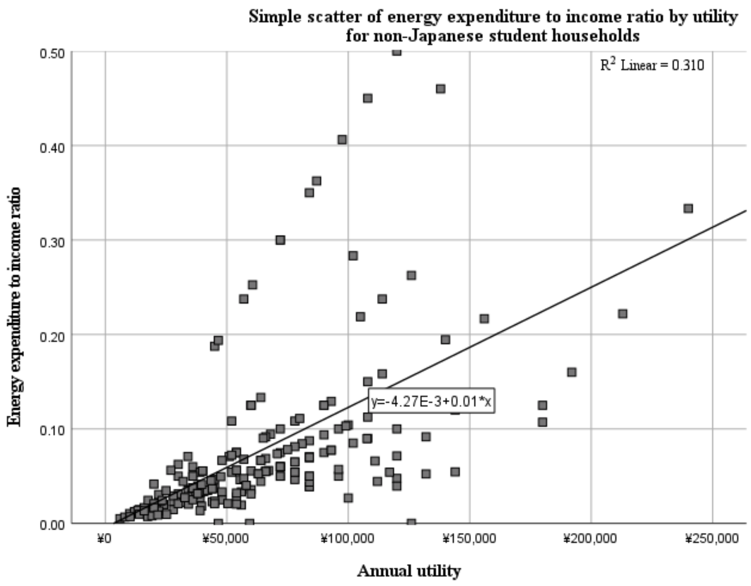
Table 6. Energy poverty ratio based on income category.

Income Category	Income (Annual Mean in JPY)	Utility (Annual Mean in JPY)	Energy Poverty Ratio (%)
Low income	699,384	72,122	14%
Medium income	1,198,710	69,658	6%
High income	1,870,732	70,545	4%

The energy poverty ratio by annual utility costs for Japanese students is portrayed in Figure 1a, while Figure 1b portrays that of non-Japanese student households. The calculated utilities costs are based on the reported costs of the households, divided by the number of its members. A positive correlation can be seen between energy poverty rates and utility for both Japanese and non-Japanese students. Overall, Japanese students seem to pay higher utility bills in comparison to non-Japanese students.



(**a**)



(**b**)

Figure 1. (**a**) Scatter diagram of energy energy poverty rate by utility for Japanese households. (**b**) Scatter diagram of energy energy poverty rate by utility for non-Japanese households.

4.4. Chi-Square and t-Test Results

Income is a crucial factor in energy poverty status. We conducted Chi-square tests to assess different categories of income and their energy poverty status (Table 7, (a)). A high chi-square value (Chi-square = 85.922) and a p-value bellow the significant level ($p < 0.001$) convey a significant correlation between income category and energy poverty status; many students in the low-income category are energy poor, while many students in the high-income category are not energy poor.

Table 7. Energy poverty status by income group.

(a)		**Energy poverty status**			
		Not energy poor		Energy poor	
		Observed	Expected	Observed	Expected
Income group	Low income	90	126.9	75	38.1
	Medium income	75	63.8	8	19.2
	High income	118	92.3	2	27.7
	Total	283	283.0	85	85.0
	Chi-Square	85.3922			
	p	<0.001			
(b)		**Nationality**			
		Japanese		Non-Japanese	
		Observed	Expected	Observed	Expected
Do you find it difficult to pay for energy?	Yes, it is expensive	80	93.1	123	109.9
	No, it is cheap	17	11.5	8	13.5
	Neither	108	100.4	111	118.6
	Total	205	205.0	242	242.0
	Chi-Square	9.391			
	p	0.009			
(c)		**Do you check details of your energy bills?**			
		Yes		No	
		Observed	Expected	Observed	Expected
Do you find it difficult to pay for energy?	Yes, it is expensive	101	88.3	102	114.7
	No, it is cheap	15	10.9	10	14.1
	Neither	78	94.8	140	123.2
	Total	194	194.0	252	252.0
	Chi-Square	11.286			
	p	0.004			

(d)		**No.**	**Mean**	**Std. deviation**	**t**	**df**	**Sig. (2-tailed)**	**Mean difference**
Income (annual)	Non-energy poor	283	1,371,035	573,220	11.213	366	0.000	733,623
	Energy poor	85	637,412	340,669				

Furthermore, we conducted independent samples t-tests to examine whether the difference in income rates among energy poor and non-energy poor households were significant (Table 7, (d)). The results confirm a significant correlation between income rates and energy poverty status (t = 11.213, $p < 0.001$).

There was a significant difference in the perception of energy costs by nationality (Table 7, (b)); more non-Japanese students felt it was difficult to pay for energy, while more Japanese students viewed the prices as affordable or cheap (Chi-square = 9.391, $p < 0.05$).

As shown in Table 7, (c), there was also statistical significance in the positive relationship between perception of energy costs and the habit of monitoring energy bills. This conveys that students' perception of energy costs were linked to awareness of their energy consumption (Chi-square = 11.286, $p = 0.004$).

5. Discussion

In this section, several aspects which ought to be considered in estimation of energy needs, specifically for the case of Japan, are discussed. Furthermore, we draw observations from our results based on the expenditure and consensual approach, and we highlight the importance of paying attention to the underestimation of energy poverty. We conclude this section by explaining the difficulties in identifying energy poor households, as well as the limitations of our study.

5.1. Estimation of Energy Needs

5.1.1. Required vs. Actual Energy Consumption

It is important to consider the 'needed' vs. the 'actual' energy expenditure, and the role of household daily practices and the built environment in securing adequate levels of domestic energy needs [19]. The results of our study, as presented in Table 5, show that although 34.5% of the students 'needed' more energy, they were burdened by financial constraints. However, the energy level mostly considered in studies is the 'actual' energy consumed, regardless of the burdens and/or savings in energy consumption. When assessing the actual amount of fuel used, Moore (2012) discovered that low-income households showed significantly lower spending on fuel than the estimated needs and endured the hardship [45]. The results of our study show slightly higher rates for average annual spending on energy among low-income households (Table 6), however it supports Moore's narrative of enduring hardships as it helps in discovering strategies to transfer energy use to outside the home, thus questioning studies that claim low energy poverty rates in Japan. Students in Japan often do this by spending long hours in libraries or restaurants and cafes where they can order a cheap drink and often stay as long as they like, while enjoying free Wi-Fi, heating, cooling, lighting, etc. The use of a single metric or aspect of household energy demand and consumption is not enough to draw conclusions on the actual status because some adaptive practices may be neglected. As revealed in this paper, poor households use financially motivated adaptations to reduce energy consumption, while energy needs remain and yet are often ignored in national or organizational energy poverty reports in Japan.

5.1.2. Space Heating and Cooling

Space heating is often one of the essential energy needs of a household; a quarter of the final energy consumed in Japan is for space heating [46]. Estimating the energy needed to maintain a comfortable temperature at home is important for the study of energy poverty. There are several methods to quantify the required amount of energy for space heating (or cooling) to maintain a desirable temperature inside commercial and residential buildings. A commonly applied method is the "Degree Day Method" introduced as early as 1895 [47]. This method has been applied to energy consumption estimations [48] and is used for the estimation of energy and fuel poverty in other studies [49]. Finding the base temperature usually selected for adjusting home temperature can help with the estimation of energy poverty level and aid in the discovery of underestimated energy poverty. One of the contributions of this paper is in taking the primary steps to find the average base temperature selected by this group of residents in the city of Beppu. For example, the average base temperature in England computed by the Department of Energy & Climate Change (2013) was between 18.1 °C in December and 21.5 °C in July and August [50], and the common temperature setting in the United States was reported to be 18.1 °C [51]. Our survey thus provides primary data to facilitate further studies in this field in Japan.

5.1.3. Considering Households Characteristics

For estimation of energy poverty using the 'Degree Day Method', it is important to consider the subjective nature and cultural characteristics of households with respect to temperature settings. In contrast to Hokkaido in northern Japan, the Okinawa prefecture, which is located in the southwest, has a tropical climate. Thus, within the same country, different standards and approaches ought to be considered for optimal solutions. It may be unreasonable to expect households living in two very different climates such as Hokkaido and Okinawa to follow a common set of standards. To agree to sacrifice some quality of life for environmental goals or financial gains is another issue worth consideration. However, thermal comfort is a complex concept to estimate, as it is a derivative of multiple perceptions of one's comfort and may not always be financially motivated [52,53]. For instance, following on the World Health Organization's recommendations, Scotland has set the standard temperature 2 degrees Celsius higher than the base for elderly and infirm households, stating that they need higher levels of a "satisfactory heating regime" in comparison to others [54].

5.2. Assessing Energy Poverty

5.2.1. Expenditure Approach

Based on the energy poverty calculations, we observed that the mean expenditure rate for students in Beppu is nearly within one standard deviation of the energy poverty threshold (10%), which suggests that many students may fall into energy poverty in case of an increase in energy needs or decrease in income. However, the energy poverty rates are based on the reported numbers, not the actual amount of energy needed, and does not take into consideration the impact of measures to reduce energy consumption. The results of Table 6 demonstrate that income plays a key role in energy poverty status, such that a decrease in income could push students closer to or over the energy poverty threshold.

Another strategy to alleviate energy poverty among students is sharing the living space with other students. It decreases the energy cost for space heating and cooling and helps save on expenditures for rent and other associated costs. In our study, 80% of the cases which surpassed the energy poverty threshold were students living in a non-shared single household alone, with nearly 60% of them living in small 1K or 1DK type houses.

5.2.2. Consensual Approach

In contrast with the conventional expenditure-based approach, which uses financial data to evaluate the affordability of energy services and the adequacy or inadequacy of energy consumption, there is also a 'consensual approach' for estimating energy poverty [55]. In this method, households self-report energy poverty based on their own cognitive knowledge of household standards and conditions. However, Morris & Genovese (2018) demonstrated that many students suffering from energy poverty had not declared serious energy hardships [38]. This may be due to the fact that behaviors associated with energy poverty are becoming the new norm among certain low-income households. The results from our survey showed that 203 students (45.4%) find it difficult to pay for energy costs, and only 25 students (5.6%) found electricity costs to be cheap. However, only 57.6% of the students in energy poverty reported difficulty in paying for energy.

5.3. Underestimation of Energy Poverty

Although 139 students were not categorically energy poor, they mentioned that energy was expensive, and they felt hardship in paying their bills; more than half of these students mentioned they would spend more time outside of their homes to reduce domestic consumption. This fact hints at the underestimation of energy poverty rates, since even though these students were not categorically energy poor, they were aware that energy costs were high, and they needed to acquire the required energy outside and refrain from energy consumption at home; this behavior may decrease the reported on-paper energy poverty rate.

Most of the non-Japanese students who responded to this questionnaire were from countries where energy prices are low and more affordable than in Japan. As shown in Table 7, there is a significant difference in the reported difficulty in paying for energy between Japanese and non-Japanese students, with more non-Japanese students finding it difficult to pay for energy. Non-Japanese students living in Japan reduce energy consumption for fear of high energy bills. On the other hand, students who did not monitor the energy bills would use other strategies such as moving energy consumption to buildings other than home.

5.4. Spotting and Identifying the Energy Poor

A factor contributing to the silent rise in the number of energy poor households in Japan is the difficulty in identifying them. This issue is further exacerbated due to the absence of government participation in energy poverty research, as there is no official indicator introduced to evaluate whether a household is energy poor or not. The energy poverty indicators used in other countries may not always suit the existing geographical and cultural differences in Japan. Some scholars have already proposed new methods for the calculation of energy poverty in Japan [2,26,35]. Other than a large-scale survey conducted by the Statistics Bureau of the Ministry of Internal Affairs and Communications of Japan every five years on households' income and expenditure [29], and a few other relatable surveys conducted in smaller scale, little information is gathered on household conditions and challenges with energy consumption. However, the results of our study (Table 7, (d)) show a strong relation between income and energy poverty status among college students who form an understudied household group. Therefore, examining income levels could be a starting point for finding households vulnerable to energy poverty.

The intervention of local governments to link energy suppliers and household service providers with national policy makers can help ameliorate this situation. Such a proposal has been reported in the UK, where EAS (2020) has proposed a "multi-organizational referral system" to facilitate the process of finding the energy poor through local organizations and companies that can help connect energy poor consumers to a national organization [12].

5.5. Study Limitations

In this study, we collected data on household base temperature. This information is essential for studies on households' ambient temperature control and heating/cooling demand control. However, the data was collected in the Kyushu region, which may not apply to other regions in Japan. Furthermore, most of the respondents were in their 20s, which is another limitation as the elderly and other vulnerable households were not included.

We have studied college students in Beppu City for this study. Living costs and part-time wages may vary in other regions. For example, part-time jobs in Tokyo pay an average of JPY 1,074 (USD 9.72) per hour in comparison to JPY 800 (USD 7.24) in Beppu [56]. Living expenses are proportionally higher in Tokyo as well. Although this study may not represent the national college student's energy poverty status, it is a fair representative of Japanese and non-Japanese students' experience with energy poverty in Japan. Further studies of students' experience with energy poverty in Japan are required to draw a better conclusion of this category of households. It is essential to consider vulnerable households such as students in future policies in transition to a low-carbon energy system.

The choice of indicator is an important factor in representing energy poverty. Although we have utilized the 10% indicator for this study, developing and adopting a multidimensional indicator may increase the accuracy of the results. However, in the absence of energy poverty studies and data on this household category, the 10% indicator may provide a fair assessment of the energy poverty rates among these households.

6. Conclusions

We examined the problem of energy poverty among a large sample of college students in Japan. Based on the results and the analyses conducted in this study, we can conclude that students in Japan may be considered as vulnerable to energy poverty in addition to the other categories of vulnerable households. On that account, reconsideration and adjustments to the categories of vulnerable households may be necessary in future studies of energy poverty in Japan. We examined the living costs and conditions related to energy consumption, as well as the actions taken by students to adjust their energy usage. While some answers varied between the Japanese and non-Japanese groups of respondents, such as awareness of energy costs, the overall responses confirmed that energy prices were relatively high. We found a positive correlation between energy poverty rate and energy expenditure for both groups. While nearly half of the students lived on low incomes, the costs of utilities were quite similar among all income levels. Meanwhile, the average energy poverty rate for these students was 14%, and the Chi-square tests showed a significant correlation between income categories and energy poverty status.

Data on household temperature setting was collected in this study, and we highlighted the role that such data can play in energy consumption estimations and future energy poverty studies. The results showed an average of 23.8 degrees Celsius temperature setting for winter and an average of 23.4 degrees Celsius for summer, which are different from the suggested temperature settings by the Japanese government.

A lack of proper knowledge on effective measures towards reducing/saving energy leads to improper and erroneous actions. We found that almost half of the respondents transfer energy consumption out of their home to save on consumption. More than a third (34.5%) of respondents reported saving on energy consumption because it would cost too much.

The lack of participation of the Japanese government in energy poverty studies is apparent. The participation of a governmental body in energy poverty studies such as by setting standards or ground rules such as a unified definition of energy poverty and a standard indicator can have a large impact on this field of study in Japan.

Moreover, this study draws attention to the importance of collecting microdata information. Asking qualitative questions to collect the insights of households, as done in this study, can help reveal households' conditions beyond large-scale national data. Actions and behaviors involving energy consumption are often left out of national-scale data, but they make meaningful contributions to energy poverty studies.

Any recommendations on energy pricing based on scientific data and governmental policies need to be checked for their social impact to ensure their effectiveness. As we observed in this study, there may be various types of households who are vulnerable to these changes. A number of adaptation strategies may be taken by such households to compensate for the new conditions, and such adaptive behaviors have the potential of becoming the new norm, thus making room for further underestimation of the actual levels of energy poverty.

The results of this study call for broader research in energy poverty and energy consumption patterns, with further focus on low-income and vulnerable consumers such as college students.

Author Contributions: Conceptualization, A.N.; Data curation, A.N.; Formal analysis, A.N., N.G. and K.T.; Funding acquisition, K.T.; Investigation, A.N.; Methodology, A.N., N.G. and K.T.; Project administration, K.T.; Resources, K.T.; Software, A.N.; Supervision, N.G. and K.T.; Validation, N.G.; Visualization, A.N.; Writing—original draft, A.N. and N.G.; Writing—review & editing, A.N., N.G. and K.T. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by JSPS KAKENHI Grant Number 20KK0106.

Acknowledgments: This research was supported by JSPS KAKENHI Grant Number 20KK0106.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Agency for Natural Resources and Energy, Government of Japan. 2019—Understanding the Current Energy Situation in Japan (Part 1). Available online: https://www.enecho.meti.go.jp/en/category/special/article/energyissue2019_01.html. (accessed on 21 May 2021).
2. Okushima, S. Measuring energy poverty in Japan, 2004–2013. *Energy Policy* **2016**, *98*, 557–564. [CrossRef]
3. Lewis, P. *Fuel Poverty Can be Stopped*; National Right to Fuel Campaign: New York, NY, USA, 1982.
4. Li, K.; Lloyd, B.; Liang, X.-J.; Wei, Y.-M. Energy poor or fuel poor: What are the differences? *Energy Policy* **2014**, *68*, 476–481. [CrossRef]
5. Bouzarovski, S.; Petrova, S.; Sarlamanov, R. Energy poverty policies in the EU: A critical perspective. *Energy Policy* **2012**, *17*, 76–82. [CrossRef]
6. González-Eguino, M. Energy poverty: An overview. *Renew. Sustain. Energy Rev.* **2015**, *47*, 377–385. [CrossRef]
7. Galvin, R. Letting the Gini out of the fuel poverty bottle? Correlating cold homes and income inequality in European Union countries. *Energy Res. Soc. Sci.* **2019**, *58*, 101255. [CrossRef]
8. Walker, G.; Day, R. Fuel poverty as injustice: Integrating distribution, recognition and procedure in the struggle for affordable warmth. *Energy Policy* **2012**, *49*, 69–75. [CrossRef]

9. Reddy, A.K. *World Energy Assessment: Energy and the Challenge of Sustainability*; United Nations Development Programe: New York, NY, USA, 2008; Chapter 2.
10. Boardman, B. *Fuel Poverty: From Cold Homes to Affordable Warmth*; Belhaven Press: London, UK, 1991.
11. Liddell, C.; Morris, C. Fuel poverty and human health: A review of recent evidence. *Energy Policy* **2010**, *38*, 2987–2997. [CrossRef]
12. Fuel Poverty and Health. Available online: https://www.eas.org.uk/en/fuel-poverty-and-health_50521/ (accessed on 21 May 2021).
13. Cold is Deadlier Than Heat in Japan, Often Striking Isolated Seniors. Available online: https://www.japantimes.co.jp/news/2018/02/03/national/science-health/heatstroke-star-japan-hypothermia-deadlier-experts-say/ (accessed on 21 May 2021).
14. Information on Heatstroke (In Japanese). Available online: https://www.fdma.go.jp/disaster/heatstroke/post3.html (accessed on 21 May 2021).
15. Tokyo Reports Record 193 Deaths from Heatstroke in August. Available online: http://www.asahi.com/ajw/articles/13693478. (accessed on 21 May 2021).
16. Risks of Heatstroke for the Elderly: Causes and Preventive Measures. Available online: https://www3.nhk.or.jp/nhkworld/en/news/backstories/966/ (accessed on 21 May 2021).
17. Okushima, S.; Okagawa, A. Energy poverty in Japan: How does the energy price escalation affect low income and vulnerable households? In Proceedings of the 32nd USAEE/IAEE North American Conference, Anchorage, Alaska, 28–31 July 2013.
18. Papada, L.; Kaliampakos, D. Measuring energy poverty in Greece. *Energy Policy* **2016**, *94*, 157–165. [CrossRef]
19. Thomson, H.; Bouzarovski, S.; Snell, C. Rethinking the measurement of energy poverty in Europe: A critical analysis of indicators and data. *Indoor Built Environ.* **2017**, *26*, 879–901. [CrossRef]
20. Kerr, N.; Gillard, R.; Middlemiss, L. Politics, problematisation, and policy: A comparative analysis of energy poverty in England, Ireland and France. *Energy Build.* **2019**, *194*, 191–200. [CrossRef]
21. The Impact of Fuel Poverty on Children. Available online: https://www.savethechildren.org.uk/content/dam/global/reports/hungerandlivelihoods/The_Impact_of_Fuel_Poverty_on_Children_Dec_08.pdf (accessed on 21 May 2021).
22. Galvin, R.; Sunikka-Blank, M. Economic Inequality and Household Energy Consumption in High-income Countries: A Chalenge for Social Science Based Energy Research. *Ecol. Econ.* **2018**, *153*, 78–88. [CrossRef]
23. Sunikka-Blank, M. Why are women always cold? Gendered realities of energy justice. In *Inequality and Energy*; Academic Press: Cambridge, MA, USA, 2020; Chapter 8; pp. 173–188. [CrossRef]
24. Sunikka-Blank, M.; Galvin, R. Single parents in cold homes in Europe: How intersecting personal and national characteristics drive up the numbers of these vulnerable households. *Energy Policy* **2021**, *150*, 112134. [CrossRef]
25. Mori, T.; Ozawa, T.; Tamakoshi, A. Research on Fuel Poverty in Japanese Cold Climate Region (in Japanese). *J. Hous. Res. Found. Jusoken* **2018**, *44*, 133–144. [CrossRef]
26. Okushima, S. Gauging energy poverty: A multidimensional approach. *Energy* **2017**, *137*, 1159–1166. [CrossRef]
27. Okushima, S. Understanding regional energy poverty in Japan: A direct measurement approach. *Energy Build.* **2019**, *193*, 174–184. [CrossRef]
28. Tabata, T.; Peii, T. Survey on fuel poverty among residents in the Kansai Region. In Proceedings of the 47th Environmental Systems Research Meeting, Tokyo, Japan, 26–27 October 2019.
29. Chapman, A.; Okushima, S. Engendering an inclusive low-carbon energy transition in Japan: Considering the perspectives and awareness of the energy poor. *Energy Policy* **2019**, *135*, 111017. [CrossRef]
30. Geography of Hokkaido. Available online: https://www.mlit.go.jp/hkb/en/geography.html (accessed on 21 May 2021).
31. Kojima, S.; Furuna, T.; Ikeda, N.; Nakamura, M.; Sawada, Y. Falls among community-dwelling elderly people of Hokkaido, Japan. *Geriatr. Gerontol. Int.* **2008**, *8*, 272–277. [CrossRef] [PubMed]
32. Okushima, S. Measuring Energy Poverty Via Energy Service Usage: The Japanese Case. USAEE Working Paper No. 18-352. 2018. Available online: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3225141 (accessed on 21 May 2021).
33. Konno, Y.; Mori, T.; Iwama, Y. Research on Actual Condition of Fuel Poverty in Hokkaido. *Environ. Eng.* **2018**, *83*, 729–736. [CrossRef]
34. Nakano, Y.; Omukai, A.; Taro, M.; Hayama, H. *Research on Deprivation Scale for Living Environment in Cold Climate Region*; SHASE: Tokyo, Japan, 2020. (In Japanese)
35. Tabata, T.; Peii, T. Fuel poverty in Summer: An empirical analysis using microdata for Japan. *Sci. Total. Environ.* **2020**, *703*, 135038. [CrossRef]
36. Homes Fit for Study—Research into Student Experiences of Energy in the Private Rented Sector. Available online: https://www.fuelpovertylibrary.info/content/homes-fit-study----research-student-experiences-energy-private-rented-sector-4. (accessed on 21 May 2021).
37. Ntouros, V.; Laskari, M.; Ioardache-Platis, M.; Assimakopoulos, M.; Romanowicz, J.; Lontorfos, V. Alleviating energy poverty experienced by students living in private rented accommodation: The role of the housing provider. *Proc. Int. Conf. Bus. Excell.* **2019**, *13*, 1009–1020. [CrossRef]
38. Morris, J.; Genovese, A. An empirical investigation into students' experience of fuel poverty. *Energy Policy* **2018**, *120*, 228–237. [CrossRef]
39. Mould, R.; Baker, K. Documenting fuel poverty from the householders' perspective. *Energy Res. Soc. Sci.* **2017**, *31*, 21–31. [CrossRef]

40. Immigration Services Agency of Japan. Available online: https://www.isa.go.jp/en/applications/guide/kanri_qa.html (accessed on 21 May 2021).
41. Tanabe, S.; Haneda, M.; Nishihara, N. Workplace productivity and individual thermal satisfaction. *Build. Environ.* **2015**, *91*, 42–50. [CrossRef]
42. About WARMBIZ for the Year 2012 (1st report) (Announcement). Available online: http://www.env.go.jp/press/press.php?serial=15780 (accessed on 21 May 2021). (In Japanese)
43. Nakashima, Y. Climate Change Policies in Japan/What are COOL BIZ and WARM BIZ? Available online: https://www.env.go.jp/en/focus/jeq/issue/vol03/feature.html (accessed on 21 May 2021).
44. Sato, T.; Nagai, H. Effect Inspection in CoolBiz/WarmBiz Air Conditioning. 2012. Available online: https://thesis.ceri.go.jp/db/files/GR0002900418.pdf (accessed on 18 July 2021). (In Japanese)
45. Moore, R. Definitions of fuel poverty: Implications for policy. *Energy Policy* **2012**, *49*, 19–26. [CrossRef]
46. Wang, J.; Matsumoto, S. Climate policy in household sector. In *Carbon Pricing in Japan*; Springer: Singapore, 2021; pp. 45–60. [CrossRef]
47. Technical Documentation: Heating and Cooling Degree Days. Available online: https://www.epa.gov/sites/production/files/2016-08/documents/heating-cooling_documentation.pdf (accessed on 21 May 2021).
48. Sarak, H.; Satman, A. The degree-day method to estimate the residential heating natural gas consumption in Turkey: A case study. *Energy* **2003**, *28*, 929–939. [CrossRef]
49. Papada, L.; Kaliampakos, D. A Stochastic Model for energy poverty analysis. *Energy Policy* **2018**, *116*, 153–164. [CrossRef]
50. Department of Energy & Climate Change (DECC), Government of the United Kingdom. *Report 2: Mean Household Temperatures*; Department of Energy & Climate Change (DECC): London, UK, 2013.
51. Walsh, P.J.; Miller, A.J. The relation between degree days and base temperature. *Appl. Energy* **1983**, *13*, 241–253. [CrossRef]
52. Healy, J.D. *Housing, Fuel Poverty and Health: A Pan-European Analysis*; Ashgate Publishing: Farnham, UK, 2004.
53. Healy, J.; Clinch, J. Fuel poverty, thermal comfort and occupancy: Results of a national household-survey in Ireland. *Appl. Energy* **2002**, *73*, 329–343. [CrossRef]
54. The Scottish Fuel Poverty Statement. Available online: https://www.webarchive.org.uk/wayback/archive/3000/https://www.gov.scot/resource/doc/46951/0031675.pdf (accessed on 21 May 2021).
55. Rademaekers, K.; Yearwood, J.; Ferreira, A.; Pye, S.; Hamilton, I.; Agnolucci, P.; Grover, D.; Karásek, J.; Anisimova, N. *Selecting Indicators to Measure Energy Poverty*; Trinomics: Rotterdam, The Netherlands, 2016. Available online: https://ec.europa.eu/energy/sites/ener/files/documents/Selecting%20Indicators%20to%20Measure%20Energy%20Poverty.pdf (accessed on 21 May 2021).
56. Part-Time Wages in Japan Rise on Back of Labor Shortage. Available online: https://www.nippon.com/en/japan-data/h00593/part-time-wages-in-japan-rise-on-back-of-labor-shortage.html (accessed on 21 May 2021).