The Just Transition in Japan: Awareness and Desires for the Future

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Abstract

As with many advanced economies, Japan is currently undergoing an energy transition, aiming to deploy the maximum amount of renewable energy in order to reduce reliance on energy imports from abroad. Ideally, this transition will not only increase energy security for Japan, but will also improve the living standards of its people and be representative of a 'just' transition. In order to determine the nature of the Japanese energy transition, it is important to recognize the awareness of concepts such as the Just Transition, and to understand people's desires for the future. This research investigates the relationship between these factors, i.e., uncovering whether or not awareness of the Just Transition concept affects peoples desired outcomes, personal behaviors or preferences toward energy policies which engender a transition. Here we analyze a large sample survey (n=6,000) of the Japanese public to understand desires, behaviors and preferences, to attempt to extract policy implications and effective strategies to promote desirable behaviors which promote a Just Transition. Our results show that demographics impact upon Just Transition knowledge levels, and that these knowledge levels themselves then impact upon propensity to undertake desirable behaviors, or to allow for the deployment of conducive technologies at the local or regional level. We surmise that a greater level of understanding of the concept of a Just Transition, perhaps via targeted education may help to align people's behavior, desires and expectations toward the development of a fairer future energy system in Japan and expect that these findings will translate well for other advanced economies.

Keywords: Just Transition, Awareness, Socio-Technological Analysis, Fairness, Energy Transition

1. Introduction

Energy is indispensable in our lives and significantly influences modern society. Coal, which underpinned the industrial revolution, was eclipsed by oil in the 20th century and gas has in turn taken a larger share of the energy mix in the early 21st century. It is also clear that current policy and investment is moving towards an energy transition toward renewables [1]. Japan's energy supply is extremely vulnerable as it is highly dependent on energy imports to meet the majority of its primary energy supply [2]. Two major events– the oil shocks of the 1970s and the 2011 Fukushima accident have strongly shaped the energy policy and the energy transition in Japan [3]. Following the oil crises of the 1970s, Japan embarked on an ambitious program to diversify its energy mix through increased use of nuclear energy and alternative energy to bolster the country's energy security [4,5]. The public largely came to accept nuclear power due to the benefits of nuclear reactors in terms of economic benefits, climate advantages, and access to reliable baseload power that were promoted by industry and government. However, the 2011 Fukushima accident led to a total shutdown of all nuclear power plants and reawakened a division of opinions on the future role of nuclear energy from both the public and politicians [6]. It quickly became apparent that a new energy strategy was needed to balance economic growth and energy security with environmental and safety concerns [7]. Although an opportunity for a rapid energy transition presented itself to Japan as a result of the Fukushima disaster, renewables did not replace nuclear power as the major contributor of energy in Japan. At present, nuclear and fossil sources are slated to make up a large portion of future energy generation in Japan according to the Basic Energy Strategy, in which the transition to a majority share by renewables is not envisaged in the short term. However, due to the Fukushima disaster, the government envisages a shift away from both fossil and nuclear sources of energy in preference for renewables in the long term [8].

The concept of a Just Transition is important for Japan to ensure the energy transition to a net-zero carbon energy system is equitable, accessible, sustainable, and managed for all communities, in addition to remediating the burdens on those historically harmed by the fossil fuel-based energy system. In moving toward a net-zero carbon energy system, Japan has included the concept of a Just Transition as part of a long-term development strategy to reduce greenhouse gas emissions under the Paris agreement, albeit largely focused on economic and employment transition priorities [9]. The strategy calls for companies and financial institutions to provide supporting resources for transitioning local economies and workforces to reform their business models under a decarbonized society. However, practical policy measures or analyses are lacking to support this movement. This is evident as the Japanese government has yet to clearly reflect just transition policies in the latest revision of the strategic energy plan [8]

Energy transitions typically unfold over long timespans and involve a broad range of stakeholders[10]. Thus, ensuring the transition toward a net-zero carbon energy system is inclusive

and fair while minimizing trade-offs among stakeholders is crucial. The concept of such a "Just Transition" has been gaining attention in recent policy [11,12] and academic discussions [13,14]. Research on just transitions has been conducted globally on the topics of addressing inequalities in energy policy [14–16] and notably providing supportive resources for coal communities to transition from the current carbon-intensive energy system toward a clean energy era [17–19]. In Japan, the concept of a Just Transition is at the relatively early stage of discussion, with Non-Government Organizations (NGOs) [20], media [21], political actors [22], and researchers [23,24] beginning to explore what a “Just Transition” means in the Japanese energy transition context.

Nevertheless, considering the post-Fukushima energy and economic challenges [25,26], difficulties faced by former coal-mining municipalities [27,28], liberalization of the electricity market [29,30], and public preferences for energy technologies [31,32] have revealed concerns for Just Transition issues and how energy transition may disproportionately affect less empowered people, especially in places whose livelihoods are reliant on carbon-intensive activities. Work promoting the energy transition from fossil fuels to renewable energy often frames energy justice, energy democracy, and energy poverty as a broader "Just Transition" to a net-zero carbon and sustainable economy that is inclusive in its decision-making and fair in its distribution of emerging opportunities [33]. NGO Climate Integrate illustrates the importance of consensus-building and dialogue to achieving a Just Transition in Japan [34]. Understanding of the concept and importance of a Just Transition among the public is thus an important step in developing a Just Transition for Japan.

The aim of this study is to clarify the level of knowledge in Japan of the concept of a Just Transition, to uncover some of the drivers of this understanding, and to elucidate people’s desires for the future, and the kinds of behaviors that they feel align with these desires. The remainder of this study is structure as follows, section 2 details the literature review to elucidate the gap in research which we seek to fill, section 3 details the methodology utilized to analyze and interpret our results, section 4 provides the key results of this analysis, section 5 discusses these results and their broader implications, while section 6 provides the conclusions.

2. Background and Literature Review

Considering the broad scope behind the definition of a Just Transition, a literature review has been undertaken to evaluate the academic scholarship devoted to Just Transition issues and principles which are most prominent in Japan. This literature review assessed recent peer reviewed articles from the year 2013, i.e., considering the most recent 10-years of research, to form the background of the study using Scopus document analysis. The papers were classified into three thematic groups and their principles, i.e., the purpose of these studies and are summarized in Table 1: Just Transition and Energy Justice s; Table 2: Energy Democracy; and Table 3: Energy Poverty.

Table 1: Just Transition and Energy Justice studies

Year	Purpose of Study	Description of Study	Ref
2019	To have an inclusive transition incorporating all stakeholders	Clarify the linkages between energy poverty and an inclusive just transition in terms of energy system and policy awareness, behavior, and preferences.	[23]
2021	Knowledge gap between Just transition concept and implementation	Analyze the decarbonization of the power sector using three aspects of just transition to quantify local employment impacts.	[24]
2018*	The rise of renewable energy transition	Analyze social equity impacts of mega-solar power policy for host communities	[35]
2019*	Resistance to phasing out coal power plants	Examines narratives employed by government and industry to sustain Japan`s domestic and international coal industry	[36]
2020*	The rise of renewable energy transition	Explore technical & socioeconomic variables on why some municipalities choose to adopt more renewables than others	[37]

* Indicates Energy Justice studies

Among the few detailed studies in Japan, Chapman & Okushima [23] investigate the linkage between energy poverty and a just transition using a national household survey to understand public preferences on the energy system and policy awareness. The results highlighted that low-income and energy poor households tend to have a negative attitude toward a net-zero economy in Japan. Accordingly, the current basic low-income policy should be expanded to address energy poverty and extend the economic and social benefits to everyone. On the other hand, Kuriyama & Abe [24] analysed the decarbonization of the power sector using the three aspects of energy justice classified by McCauley et al. [38] as distributional justice, recognition justice, and procedural justice. Kuriyama and Abe's study shows that achieving decarbonization of the power sector can revitalize the local economy by increasing domestic employment in rural areas with national or local government support [24].

Numerous studies have highlighted the benefits of local renewable energy communities [39,40]. However, many mega-solar projects in Japan have resulted from industry-led initiatives instead of community-engaged renewable energy. Fraser and Chapman [35] analyze the social equity impacts of mega-solar project siting processes using distributive energy justice perspectives. Their results show that the availability of underutilized land decreases community bargaining power compared to historical power plant siting agreements based on the existing Feed-in Tariff and sufficient solar irradiation. A follow-up study by Fraser [37] investigated renewable energy adoption in different Japanese cities and concluded that institutional support is needed for poorer cities to adopt more renewable energy. The aftermath of the Fukushima accident has led to a rapid uptake of renewables in Japan but has also prompted the expansion of coal-based energy to fill the baseload capacity gap.

Trencher et al. [36] investigated the narratives employed by fossil fuel regimes to sustain and expand the current coal-based energy system. Their findings show that the fossil fuel regime frames Japanese coal technology as the most efficient and clean in the world and promotes how coal-fired electricity is compatible with climate policy and energy security. The above findings indicate that Japan needs to consider various policy pathways and institutional reform to encourage wider diffusion of renewables while reducing fossil fuel dependency.

Table 2: Energy Democracy studies

Year	Purpose of Study	Description of Study	Ref
2013	Fukushima Accident	Examines public perceptions of climate change before and after the Fukushima accident in Japan	[41]
2017	Fukushima Accident	Examines the willingness of two set of citizens: (A) prefectures that have nuclear power plant (B) prefectures that do not have nuclear power plant to participate on post-disaster energy and environmental policy.	[25]
2017	Public preference for energy technology	Estimates peoples' willingness-to-pay (WTP) for renewable, nuclear, and fossil fuels in electricity generation in post-Fukushima Japan.	[32]
2017	Fukushima Accident	Examines how geographical distance, nuclear energy production status, freedom of the press, and the building of new nuclear reactors influence the support for nuclear energy after the Fukushima accident	[42]
2018	Liberalization of electricity market	Identifies user preferences within the liberalizing energy system of Japan based on social and environmental issues, energy knowledge, energy use, energy choice, and the future energy system.	[43]
2018	Public preference for energy technology	Compares energy transition scenarios between the strategic Japanese policy approach and a user driven approach	[31]
2019	Fukushima Accident	Measure the willingness of individuals (affected/not affected by Fukushima accident) to participate in deliberations on energy and environmental policy	[44]
2020	Fukushima Accident	Investigate public preferences on nuclear power in Japan after the Fukushima nuclear accident and the role of four sets of factors: (1) household/individual socioeconomic characteristics, (2) psychological status, (3) geographical aspects, and (4) Fukushima accident-related experiences.	[26]
2022	Liberalization of electricity market	Investigate how household consumers' preferences and behaviors affect their decision in choosing energy supply company	[29]

A Just Transition means restructuring the energy system in a way that benefits all or most of the people, particularly taking into account issues of increased burden due to engaging energy generation methods which are more expensive than their traditional counterparts, impacting unfairly on lower income groups [45–47]. This research approach argues that people should play an active role in the decision-making process on the transition to renewable energy and the redistribution of benefits

within the energy system. The 2011 Great East Japan Earthquake and the subsequent Fukushima nuclear accident sparked widespread discussion on the usage of nuclear power and the option to use alternative energy - both in Japan and globally. An internet-based survey by Nakamura examined Japanese citizens' willingness to participate in post-Fukushima energy and environmental policy deliberation [25]. The survey showed that more than one-third of respondents are willing to join citizen dialogue, and more than two thirds of respondents have a strong interest in understanding various energy and environmental policies. A follow-up study by Nakamura further revealed that the willingness of Japanese citizens to be involved in participatory energy and environmental governance has either remained steady or increased, even six years after the Fukushima accident [44]. A global survey conducted by Latré, Perko, and Thijssen [42] shortly after the accident reveals that support for nuclear energy decreased as the geographical distance between a country and Fukushima increased. By comparing survey results before and after the Fukushima accident, Poortinga, Aoyagi, and Pidgeon [41] found that the Japanese were not supportive of nuclear plants even before the accident and became less accepting of nuclear plants after the accident. In addition, three national surveys conducted in Japan show that public acceptance of renewable energy has been increasing, and people are more willing to pay for renewables rather than nuclear energy after the Fukushima accident [25,31,32]. The Fukushima accident in 2011 revealed the weaknesses in the system of that time, which prompted thorough market reforms for the Japanese Electricity Market, one of which was the full liberalization of the retail market and power generation in 2016 [48,49]. Using a survey-based approach, Chapman and Itaoka identified household preferences within the liberalizing energy system of Japan [43]. Their survey results showed that economic factors were most important when making energy choices, while only a tiny portion of the population made energy decisions based on environmental reasoning. A further study by Itaoka, Chapman, and Farabi-Asl reveals that the rate of energy company switching is still low even after five years of full liberalization of the electricity market [29]. The current liberalized market is not appealing enough to household owners as they have not identified sufficient economic or environmental drivers to encourage widespread change. The above findings show a level of uncertainty for the post-Fukushima Japanese energy system, and policymakers have yet to find the right balance between public interest, energy security, and sustainability.

Table 3: Energy Poverty studies

Year	Purpose of Study	Description of Study	Ref
2016	Neglect of energy poor household	First analysis of energy poverty in Japan from the period of 2004 to 2013 using traditional 10% indicator	[50]
2017	Neglect of energy poor household	Seasonal analysis of energy poverty in Japan using a new multidimensional energy poverty index (MEPI)	[51]
2019	Neglect of energy poor household	Examine regional characteristics of energy poverty in Japan by measuring energy service usage	[52]
2021	Neglect of energy poor household	Investigate the relationship between energy poverty and an individual carbon dioxide emission based on social demographic data	[53]
2021	Energy poverty knowledge among college student	Investigate the vulnerability of college students in respect to energy poverty by examining the knowledge, attitude, and practices towards energy usage of college students	[54]
2021	Neglect of energy poor household	Examine energy poverty vulnerabilities in Japan by examining issues of affordability, accessibility to different forms of energy, and the effects of new technologies on the risk of energy poverty	[55]
2021	Aging population and energy demand	Investigate the relationship between aging and energy demands to identify methods for reducing energy consumption in aging societies	[56]

The transition to renewables needs to be inclusive, with policy and financing to ensure the most vulnerable households have access to basic energy needs such as heating and lighting without being penalized for the switch from fossil fuels to renewables. The just transition principles will help to consider vulnerable households when setting future energy policies, lifting people out of energy poverty. In Japan, Okushima [50] evaluated regional energy poverty from 2004 to 2013 using a 10% indicator by which households are considered to be in energy poverty when they must spend more than 10% of their income to have adequate energy services such as heating, lighting, appliances, and cooking [57]. In a follow-up study, they [51] developed a multidimensional energy poverty index (MEPI) and discovered that energy price escalation after the Fukushima accident has greatly affected vulnerable households such as mother-child and single-elderly households. As Japan has one of the fastest-aging populations in the world, there is a need to address the relationship between the aging society and their energy consumption. Yagita and Iwafune [54] utilized national statistical survey data and interviews to reveal that elderly households tend to have older and less energy-efficient housing equipment. In addition, older adults spend more time at home, increasing energy consumption. It is noted that people in energy poverty often require greater high-carbon energy to fulfill their basic energy needs, leading to higher carbon emissions [53]. With this perspective, Okushima [52,53] evaluated energy poverty in Japan using direct measuring approaches comparing energy usage and basic carbon needs (BCN) of different households' demographic and regional characteristics. Castaño-

Rosa and Okushima [55] extended Okushima's [50] previous work by utilizing a new theoretical framework to analyze energy poverty vulnerability in Japan. Their results show that northern regions (with more extreme winter conditions) experience a higher rate of energy poverty during winter, and southernmost regions experience a higher rate of energy poverty during summer due to the need for additional heating or cooling during these seasons. Another vulnerable group to energy poverty is college students who live independently in Japan. Nazarahari, Ghotbi, and Tokimatsu [54] surveyed a local group of college students in Japan and indicated that most students saw energy bills as too high.

Overall, the principles of the just transition encompass inclusive decision-making, addressing energy poverty, considering social equity, promoting public participation, particularly in energy system design and meeting carbon reduction targets, and ensuring access to basic energy needs, all aimed at achieving a sustainable and equitable energy transition.

A knowledge gap remains between just transition concepts and policy implementation that considers important factors for each stakeholder based on demographic features and their desires for the progression of the energy transition in terms of preferential technologies, concepts, distribution of benefits and costs, and the elucidation of trade-offs. This study seeks to elucidate these important factors in the nation of Japan, which have not been assessed in the extant literature to date. In filling this gap through the analysis of a national survey of people's understanding of the just transition and their desires for the future energy system, we hope to provide policy implication for the realization of a just energy transition in line with people's desires and behavioral preferences.

3. Methodology

This study utilizes a survey of Japanese adults, undertaken in January 2022 (n=6,000) to uncover the level of understanding of (i.e., self-reported familiarity with) the concept of a just transition, and to extract the key factors which are associated with or affected by this level of understanding or conceptual familiarity (survey sample representativeness is detailed in Appendix A, a list of all questions and groupings is provided in Appendix B). Further, people's lived experience and preferences for the energy transition were examined in terms of desirable energy sources, locations, and deployment regimes. Finally, people's future desires were investigated regarding the energy system, and trade-offs inherent in these choices were clarified. The survey design process included workshops consisting of small groups of respondents to test the language of the survey, the consistency of response regimes and to avoid any leading questions. The survey was conducted online,

administered by a survey company who also provided feedback on design and consistency for deployment and response screening criteria to ensure representativeness within the Japanese population, particularly with regard to the necessity for 6,000 samples to enable objective analysis of all 47 prefectures cognizant of population distribution.

Both bivariate and multivariate analyses were undertaken, utilizing appropriate analytical models at the regional, local, and individual levels.

The methodology is presented in two parts. First, bivariate analysis was conducted to examine the relationship between the knowledge level of Just Transition and socio-demographic and regional variables as well as some Just Transition related behaviors of interest. Second, multivariate analysis is performed using a binary logistic regression model to identify the determinants of Just Transition knowledge and the actions that are required to achieve a fair transition to a sustainable decarbonized society, as well as clarifying stakeholder expectations from the Just Transition.

3.1 Bivariate Analysis

Bivariate analysis was undertaken using a chi-square test to examine the relationship between the knowledge or familiarity level of the Just Transition concept and socio-demographic and regional variables. This analysis was followed up by an assessment of acceptable behavioral changes which respondents would be willing to undertake, the acceptability of the deployment of certain energy types at the local and regional level, and what respondents anticipated with regard to their lifestyles due to the progression of a Just Transition.

3.2 The Binary Logistic Regression Model

In this study, knowledge or familiarity with the Just Transition concept is categorized as either having no knowledge or familiarity (i.e., “I have never heard of it”) or having some knowledge or familiarity with the concept (via the responses “I know it well”, “I know it”, and “I have heard of it”) as a binary outcome variable (the rationale for using a binary variable here is due to the very low level of familiarity with the Just Transition concept overall for analysis purposes). As the dependent variable is dichotomous or binary, we cannot use simple linear regression. In this situation, a binary logistic regression model, a statistical technique, is used to predict the relationship between predictors (our independent variables) and the dependent variable (e.g., Knowledge of the Just Transition).

Let P_i be the probability of having knowledge of Just Transition of i^{th} $(i = 1,2, \dots ,6000)$ respondent, Y_i be the Just Transition knowledge, and X is the vector of predictors such as gender, age, type of household, household ownership, period of living in the prefecture, education, employment status, and region. Therefore,

$$P_i = \Pr(Y_i = 1|X = x_i) = \frac{exp(\beta_0+\beta' X)}{1+ exp(\beta_0+\beta' X)} \quad (1)$$

From Eq. (1), the log of odds of having knowledge on Just Transition can be written as follows

$$log\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \beta' X \quad (2)$$

Now, the odds can be calculated using Eq. (3).

$$Odds = \frac{P_i}{1-P_i} = exp(\beta_0 + \beta' X) \quad (3)$$

Where, β_0 indicates the intercept and β' denotes the vector of regression coefficient. The odds ratio (OR) can be estimated taking the ratio of the two odds presented in Eq. (3). Similarly, variables such as moving to another prefecture, changing job type, limiting electricity usage within government-designated budgets, installing a solar power generation system, switching to a fuel cell vehicle, and changing to telework, etc. are utilized as dependent variables. The complete list of variables considered are detailed in Table 4.

Table 4. Variables Considered in Multivariate Analysis

Dependent variables (Y)	**Independent variables (X)**
Knowledge/familiarity with the Just Transition concept	Gender
Move to another prefecture	Age
Change job type	Household type
Limit electricity usage within government-designated budgets	Household Ownership
Install a solar power generation system	Period living in the Prefecture
Switch to a fuel cell vehicle	Academic Background
Demand response	Employment Status
Change to telework	Region
Stop using the car	
Switch power plans	
Deploy a nuclear power plant (city/prefecture)	
Deploy a solar power plant (city/prefecture)	
Deploy wind turbines (city/prefecture)	
Deploy Carbon Capture and Storage (city/prefecture)	
Close coal-fired power plants	
Import renewable energy	
Expansion of the new energy industry	
Increased employment	
Healthy environment	
Realization of a fair society	
Increased assets	
Cheaper energy	
Reduction of natural disasters	
Maintaining living standard	

4. Results

Results are described consistent with the order of investigations detailed in the methods section, beginning with bivariate analysis of our survey sample. Table 5 details the summary statistics

and significance levels of selected variables' impact upon knowledge of, or familiarity with the concept of the Just Transition (hereafter summarized as 'Knowledge of the Just Transition).

Table 5. Summary statistics of the significance of demographic factors on knowledge of the Just Transition concept

Variable	Frequency (%)	Knowledge of the Just Transition (%)		p-value
		No	Yes	
Gender				
Male	57.5	77.4	22.6	<0.001
Female	42.5	83.2	16.8	
Age				
< 30 years	8.3	76	24	
30-40	16.7	84.6	15.4	
40-50	26.7	80.9	19.1	<0.001
50-65	35.3	79.3	20.7	
65+	13	75.6	24.4	
Household Type				
Detached House	58.6	78.8	21.2	
Apartment etc.	39.8	81.1	18.9	0.047
Other	1.6	84.5	15.5	
Household Ownership				
Own Home	68.8	79.2	20.8	
Rented	28.8	81.4	18.6	0.150
Other	2.4	80.7	19.3	
Years Living in Prefecture				
< 10	23.6	79.1	20.9	
10-20	14.8	77.4	22.6	
20-30	15.8	80.1	19.9	0.114
30-40	14.2	82.5	17.5	
40-50	14.2	81.3	18.7	
50+	17.5	79.3	20.7	
Academic Achievement				
High School or Lower	30.6	80.8	19.2	
Vocational School	13.1	82.1	17.9	<0.001
Junior College	9.2	85.8	14.2	
University	47.2	77.4	22.6	
Employment Status				
Unemployed	15.1	81.3	18.7	
Self-employed	8	76.3	23.7	
Homemaker	10.8	85.3	14.7	0.001
Part-time	13.7	79.9	20.1	
Full-time	52.3	78.8	21.2	
Region				
Hokkaido	4.2	82.9	17.1	
Tohoku	6.9	79.6	20.4	
Kanto	35.2	79.6	20.4	
Chubu	16.7	80.5	19.5	0.220
Kansai	17.6	77.4	22.6	
Chugoku	5.7	83.5	16.5	
Shikoku	2.9	82.9	17.1	
Kyushu (inc. Okinawa)	11	79.8	20.2	
Total	**6,000**	**79.8**	**20.2**	

We note a significant difference in knowledge of the Just Transition due to gender, age,

household type, academic achievement, and employment status.

It is also worth noting that there are geographical differences in understanding of the concept of a just transition. Although not significant, as per Table 5, across 8 geographical regions of Japan there were differing levels of understanding. This was true also when the responses were broken down into Japan's 47 prefectures (a scale of government in-between municipal and national government). Fukushima and Wakayama Prefectures showed a better level of understanding. Figure 1 details the national situation regarding understanding of the concept of a just transition at the 95% confidence interval (CI).

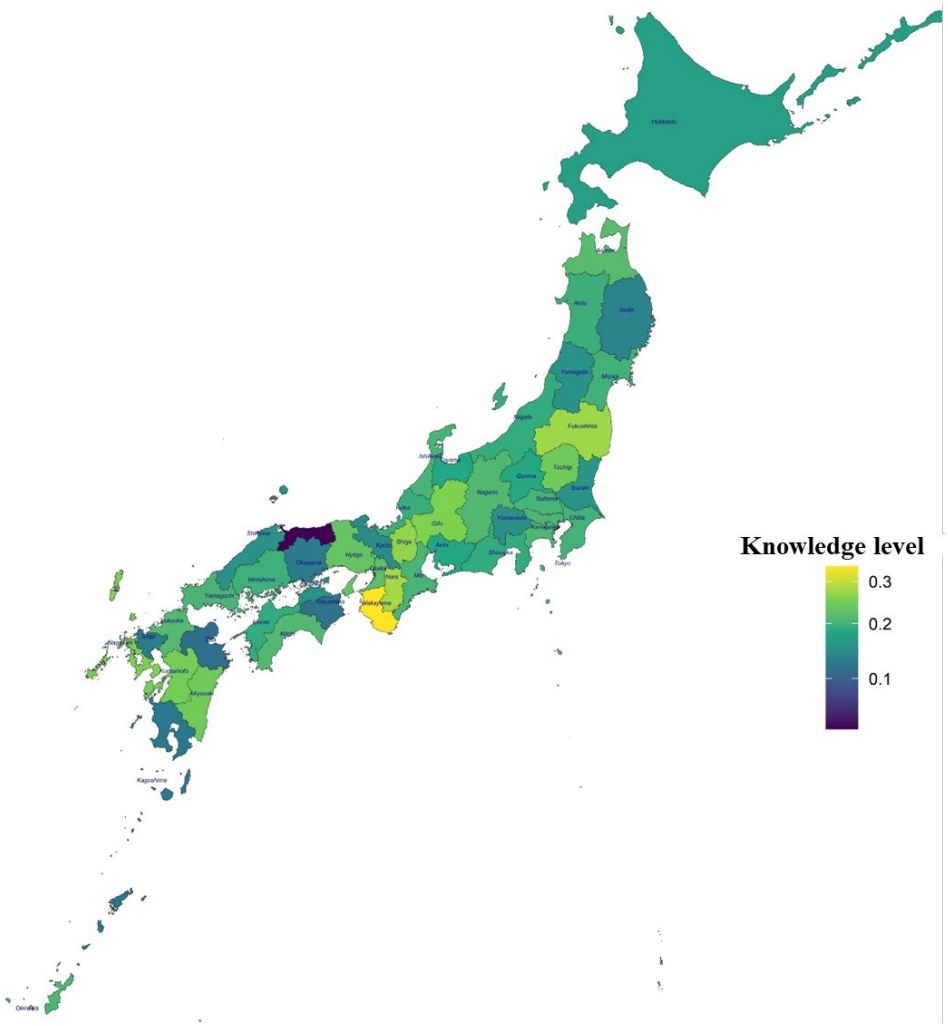

Figure 1. Overall knowledge level of the Just Transition in Japanese Prefectures

We observe overall that the level of understanding of the concept of a just transition in Japan is currently very low.

The behavioral changes that people would be willing to undertake to engender a Just Transition by 2050, the changes they would be willing to accept at the town or prefectural level, and what they anticipate from the realization of a Just Transition vary from person to person. A summary

of our sample for these three factors is presented in Figure 2.

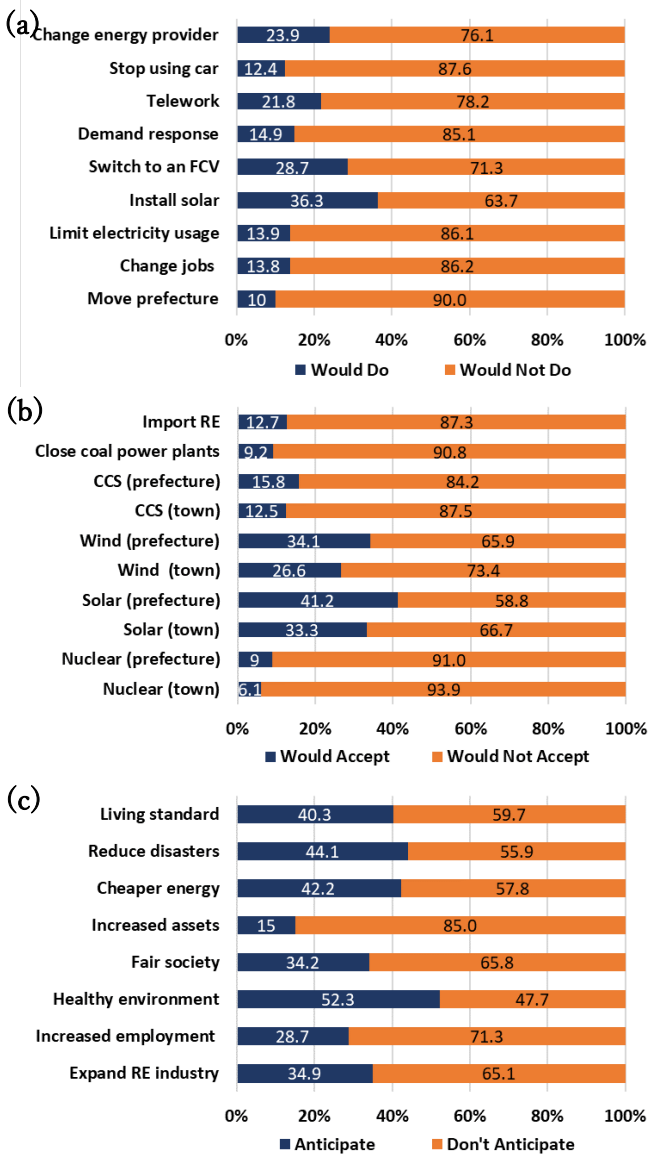

Figure 2. (a) Acceptable behavioral changes, (b) local and regional actions, and (c) anticipated benefits due to the Just Transition

The most acceptable behaviors were found to be installing solar panels on the home, followed by a switch from the current household vehicle to a fuel cell vehicle (FCV) and changing energy providers. Compared to a previous study from 2016 [58] in which switching to electric vehicles (EVs) was used, the stated willingness to switch to FCVs, which have been heavily promoted in Japan is much stronger in this survey. The least likely behavior identified among the options presented was moving to a different prefecture. In terms of acceptable local and regional actions, installing renewable energy (solar and wind), and carbon capture and storage (CCS) were the most acceptable, in all cases

these were more attractive at the prefectural level, rather than within one's own town. While deploying new nuclear power was the most unacceptable, closing coal power plants and importing renewable energy were not highly supported by respondents. In terms of people's anticipated changes in their life as a result of a successful energy transition, a healthy environment was the most highly anticipated, followed by reduced disasters, cheaper energy, and an improved standard of living overall.

In order to better understand the underpinning influencers of just transition understanding in Japanese society, multivariate analysis utilizing the binary logistic regression model was applied, which describes results via an odds ratio (OR) to compare variables within a category to a reference group, which has the value 1. In this way we can evaluate the level of significant difference between variables in each assessed category. For example, the comparative difference in Just Transition knowledge can be understood between male and female respondents in our cohort, whereby the female OR is 0.789 compared to the reference value of 1 for male respondents. This implies a difference in knowledge level of 21.1% between the genders. Table 6 presents the results of our logistic regression analysis for all demographics.

Table 6. Logistic Regression Results for Knowledge of the Just Transition by Demographics

Variable	OR	Std. Error	p-value	[95% CI]	
Gender					
Male	1.000				
Female	0.789	0.067	0.005	0.667	0.932
Age					
< 30 years	1.000				
30-40	0.524	0.077	0.000	0.393	0.701
40-50	0.654	0.090	0.002	0.499	0.856
50-65	0.728	0.099	0.020	0.558	0.951
65+	1.029	0.167	0.862	0.748	1.414
Household Type					
Detached House	1.000				
Apartment etc.	0.810	0.073	0.019	0.679	0.967
Other	0.667	0.203	0.184	0.367	1.212
Household Ownership					
Own Home	1.000				
Rented	1.001	0.101	0.995	0.822	1.219
Other	1.004	0.231	0.987	0.639	1.575
Period Living in Prefecture					
< 10 years	1.000				
10-20	1.033	0.112	0.767	0.834	1.279
20-30	0.802	0.090	0.049	0.644	0.999
30-40	0.820	0.098	0.097	0.649	1.037
40-50	0.818	0.100	0.099	0.645	1.039
50+	0.799	0.096	0.063	0.631	1.012
Educational Achievement					
High School or Lower	1.000				
Vocational School	0.952	0.107	0.664	0.763	1.188
Junior College	0.790	0.112	0.096	0.599	1.043
University	1.151	0.089	0.070	0.989	1.340
Employment Status					
Unemployed	1.000				
Self-employed	1.591	0.229	0.001	1.200	2.109
Homemaker	1.158	0.180	0.347	0.853	1.570
Part-time	1.534	0.205	0.001	1.182	1.993
Full-time	1.469	0.164	0.001	1.181	1.829
Region					
Kanto	1.000				
Hokkaido	0.897	0.161	0.544	0.631	1.275
Tohoku	1.013	0.139	0.922	0.775	1.325
Chubu	0.945	0.094	0.566	0.778	1.147
Kansai	1.136	0.106	0.171	0.946	1.362
Chugoku	0.791	0.125	0.137	0.580	1.078
Shikoku	0.877	0.185	0.535	0.580	1.326
Kyushu (inc. Okinawa)	1.033	0.117	0.776	0.827	1.289

As was noted in the bivariate analysis, there is a significant difference in knowledge of the Just Transition by gender, whereby female respondents are 21% less likely to express that they know of the Just Transition than males, and for age group, whereby people under the age of 30 have a significantly higher level of knowledge than their older counterparts, except for those over the age of

65. Apartment dwellers were some 29% less aware of the Just Transition than those who lived in a detached house, while home ownership or property rental did not significantly affect level of knowledge. Living in a prefecture for a long period of time did not increase knowledge of the Just Transition, however university level education led to approximately 15.1% greater levels of knowledge of the concept. Employment status and region of residence did not significantly affect levels of knowledge.

Considering the effect of respondent's level of knowledge on their propensity to undertake actions which would engender a Just Transition by the year 2050, we also note a significant difference in behavioral propensity between those who report an understanding of the concept of a Just Transition and those who do not, as shown in Figure 3.

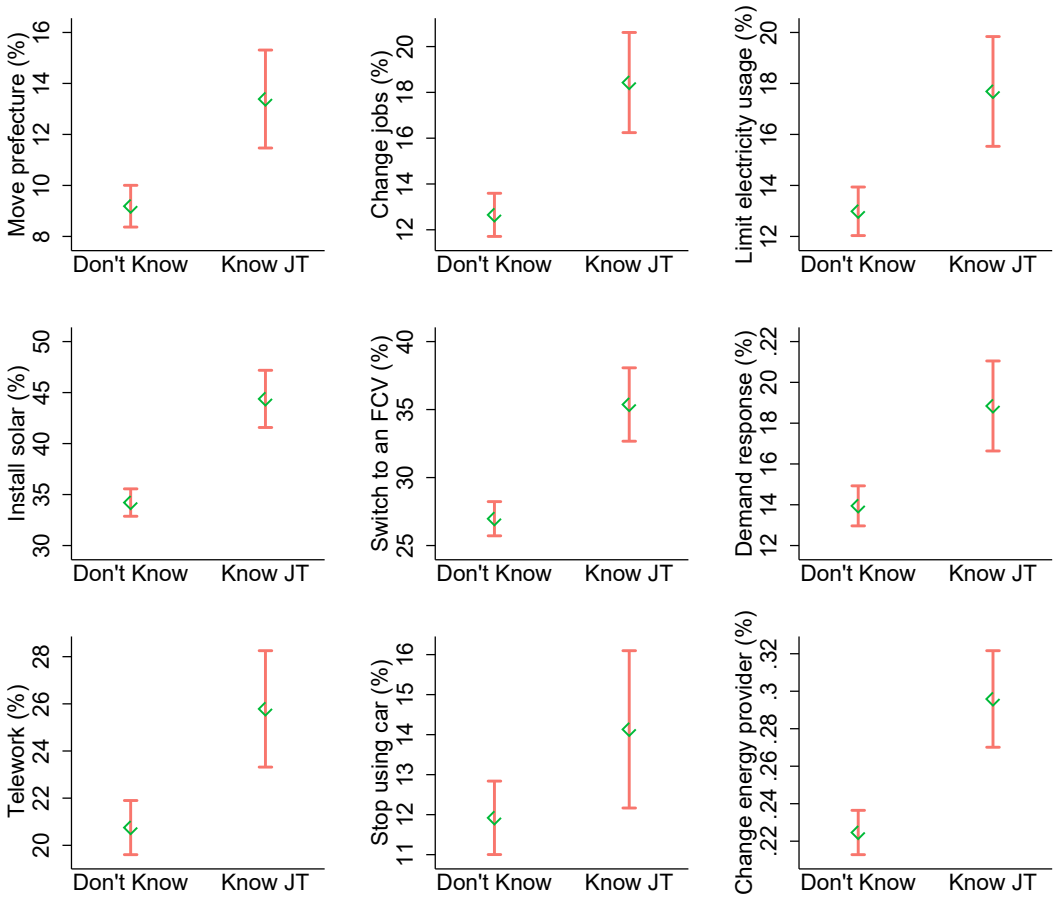

Figure. 3. Prevalence of actions by just transition (JT) knowledge status in Japan

Here we note that all Just Transition engendering actions are more likely to be undertaken if respondents have a higher level of knowledge of the Just Transition.

Further, for local and regional acceptable actions, we note a similar trend, i.e., more people are likely to approve of the installation of solar, wind, nuclear, CCS and the import of renewable energy if they have a higher level of knowledge of the concept of a Just Transition, as detailed in Figure 4. This difference is less clear for the approval of the closure of coal power stations.

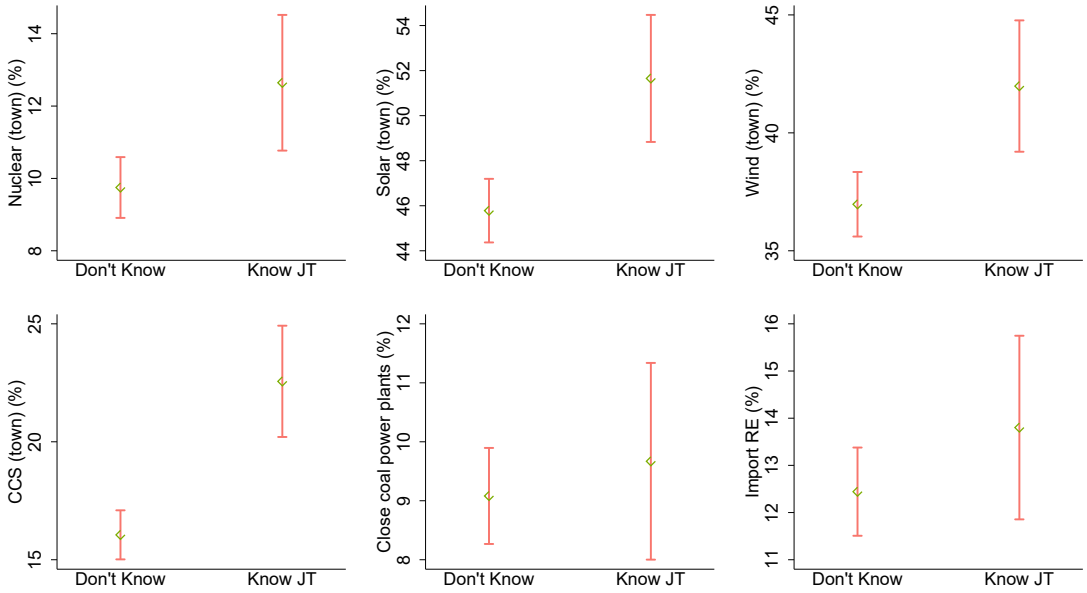

Figure. 4. Prevalence of acceptance of installing power plants in own town by Just Transition (JT) knowledge status in Japan

Respondents' expectations arising from a Just Transition according to their level of knowledge are detailed in Figure 5.

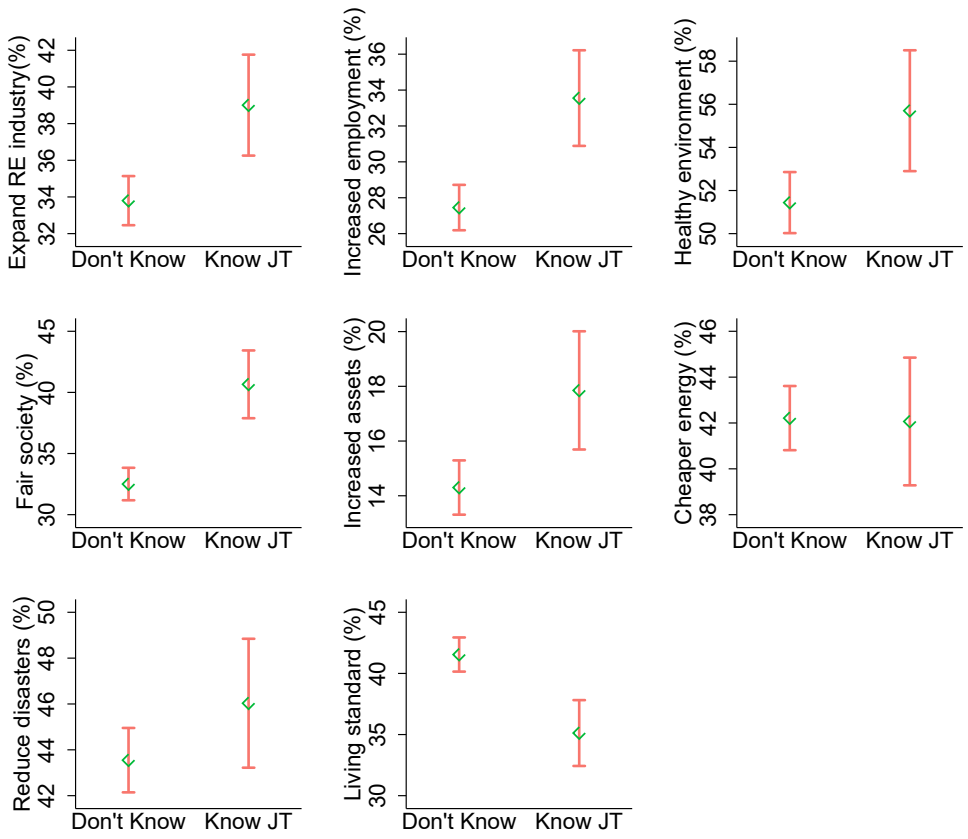

Figure. 5. Prevalence of anticipated benefits from a Just Transition by Just Transition (JT) knowledge status in Japan

For the aspects of expanding the new energy industry, increased employment, a healthy environment, the realization of a fair society, increased wealth and a reduction in natural disasters, knowledge of the Just Transition was critical. However, the maintenance of living standards was anticipated at a higher level for those who did not know what a Just Transition was, perhaps linked to an assumption by respondents that the any change in the status-quo might impinge on their standard of living. The expectation of cheaper energy prices (bearing in mind that this outcome is not always shared by all stakeholders, and that some income groups may see an unfair outcome) was not heavily influenced by knowledge of the Just Transition.

5. Discussion and Policy Implications

Through our analysis, we note that although overall knowledge of the Just Transition is relatively low among the population, there are some specific demographic factors which affect overall awareness levels (i.e., those who have at least heard of the concept of a Just Transition). For example, men were generally more aware of the concept than women, however mixed results were identified

for other significant demographic factors including age, household type, education, and employment status, as show in Figure 6.

Figure 6. Statistically Significant Just Transition Knowledge Difference among Demographic Groups

Younger people are more aware of the concept of a Just Transition than those in their 30's, 40's and 50–65-year-olds, with a gradual increase in knowledge level between those in their 30's and those above 65 years of age. The oldest group was the most familiar with the concept of a Just transition. Those who lived in detached houses had the highest level of knowledge by household type, which may be related to the long-term commitment to an area required by building and living in a detached home, or indeed by the increased income level required to do so. For educational achievement, interestingly, those who completed their education up to the high school level were better informed about the concept of Just transition than those who went to vocational school or junior college, however those who completed university level education had a much better knowledge level that their peers. It is important to note that those who are currently attending university would indicate their highest level of education achievement as high school, so some cross-over is expected here. Employment type also had an impact on the level of Just Transition conceptual knowledge, with part-time workers, full-time workers and the self-employed more well-informed than homemakers or the unemployed.

The regional and prefectural effect on Just Transition knowledge was not found to be significant, however, some prefectures had an overall higher level of understanding of the concept of a Just Transition. Among them, Wakayama and Fukushima stand out. The rationale behind Fukushima

Prefecture respondents having a higher level of knowledge is understandable, as the events of the great eastern Japanese earthquake and subsequent nuclear disaster have led to a re-invigoration of the region, with social aspects prominent among aims [59]. The increased comparative awareness observed in Wakayama Prefecture may be due to the G7 summit held in 2016 in Ise, Wakayama. This summit brought international heads of state together to discuss many issues, among them climate change, and a commitment to the SDGs [60]. Further, Wakayama City was selected in the first round of SDGs Future Cities initiative in Japan in 2019 with a strong commitment to achieving the SDGs led by city officials cognizant of all three aspects of sustainability, the economy, environment and society [61]. Moreover, at the same time as the survey was being conducted in January 2022, ENEOS announced plans to close their Wakayama oil refinery, at which 450 people were employed [62]. Although ENEOS stated the workers would be redeployed elsewhere, this may have focused local attention on the implications of climate and energy responses for the local economy. This reasoning is not exhaustive and due to the non-statistically significant difference in knowledge levels among prefectures, these differences may also be explained by the existence of some sampling bias. For example, Nagano prefecture hosted a G20 Ministerial Meeting on Energy Transitions and Global Environment for Sustainable Growth in 2019, and although we see a slightly higher level of Just Transition knowledge, we do not observe as big a difference as we see for Fukushima or Wakayama. Although our sample is representative of prefectural populations, some variance exists with regard to age, particularly for the age groups between 40 and 60 years old.

In terms of personal actions relevant to engendering the Just Transition, installing solar panels, switching to an FCV, followed by changing energy providers were the behaviors identified as the most preferable. Installing solar panels is often linked to the personal benefit of reduced energy bills and receiving feed-in tariff payments, while switching to an FCV, identified by 28.7% of respondents as a potential action was significantly higher than previously found in a 2016 survey in Japan [58], suggesting that people's resistance to change in terms of mobility is reducing over time. Regarding a change of energy provider in order to engender the Just Transition, 23.9% of respondents identified this as an acceptable behavior to undertake, a marked increase over the previously reported level of change of 14.2% in a 2018 Japanese national survey [29], however slightly lower than the current level of change reported by the Japanese Government as of 2023 of 26.8% in the household sector [63]. It is important to note here that in previous investigations [29] , people identified the main motivation for changing electricity providers to be influenced by economic benefits followed by environmental awareness and concern. Here we are assessing what portion of respondents would change energy companies to engender a Just Transition, i.e., through the ability to change to an energy provider which provides a higher proportion of renewable energy in their energy generation mix, mostly due to their environmental and social awareness. Our study found that knowledge of the Just Transition was not necessarily influenced by an expectation of lower energy prices, which could be

achieved through both an additional influx of low-cost renewables or through the simple action of changing energy providers. This finding identifies an opportunity for the provision of education regarding the merits of low-cost renewables and their link to engendering an energy transition in a just manner.

Considering actions at the local and regional level, people's level of knowledge of the Just Transition tended to influence their approval of specific energy interventions (renewables, nuclear, CCS etc.), however for the cessation of energy provision from coal fired power, this connection was not so clear, suggesting that respondents are critically aware of the need for stable energy provision in resource-poor Japan. This finding has been elucidated regarding 'preferable' sources of fossil fuels including natural gas in future energy system design in previous national-level investigations of desirable energy systems. Although respondents prefer renewables, an understanding of the need for fossil fuel-based stability on the way to a desirable energy system is well understood, and given as a reason for choosing non-renewable sources in desirable energy mixes in Japan [31]. Again here, education regarding the positive impacts of the energy transition and the establishment of the technical feasibility of stable provision of energy from a renewables dominated energy grid remains relevant both for the energy transition itself, and realization of the energy transition in a just manner.

Conclusions

This study identified that overall, the level of understanding of the concept of a Just Transition in Japan is relatively low, with some variation accounted for by demographic or regional factors. The energy transition which is unfolding in Japan is mostly driven by a transition away from fossil fuels in favor of renewable energy, and as a result, many people expect that a Just Transition will bring environmental improvements, while a smaller cohort expressed a willingness to act in certain ways to encourage such a shift, including through consumer and environmentally aware behaviors. Even recognizing the need to shift to a low-carbon future energy system, people are less likely to support the deployment of renewables and other low carbon alternative locally, opting for deployment at the prefectural rather than the town level. Although the focus of our research was to identify the awareness and expectations related to the Just Transition, people overall expected improved environmental outcomes, living standards and cheaper energy, however, overall, they did not anticipate that society would become fairer at the same level as these other expectations. In terms of the trade-offs required to achieve a Just Transition, i.e., changing non-trivial behaviors, it was identified that as people's awareness of the concept of a Just Transition increased compared to their peers, they were more likely to accept these behaviors or changes. Some key examples identified in our analysis included a higher level of acceptance of local level deployment of renewables, changing jobs, restricting energy use, or changing to an alternative vehicle or ceasing use of a vehicle altogether.

Future applications deriving from this study could include the development of a desirable

future energy system which aligns with people's preferences, achieves carbon reduction goals, and ushers in an energy transition fairer than the current energy regime.

Appendix A: Survey Representativeness

Demographic	Survey Sample	National Demographics	Reference
Average Age	49.95 years old	48.6 years old	[64]
Percentage of women	42.5%	51.3%	[65]
Age 20-29	7.13%	9.93%	
Age 30-39	16.4%	11.57%	
Age 40-49	25.2%	14.84%	
Age 50-59	26.1%	12.66%	
Age 60-69	17.9%	13.41%	
Age 70-79	6.3%	11.99%	
Age 80-89	0.9%	7.01%	
Age 90-99	0.1%	1.67%	
University Graduates (inc. Graduate School)	56.4%	41.8%	[66]
47 Prefectures	Samples consistent with the population distribution across Japan for each Prefecture		

Appendix B: Survey Questions

Section 1: Demographics

1. How long have you lived in your current prefecture?
2. Please indicate the category of housing you currently reside in (detached home, apartment/unit, other).
3. Please indicate the status of your current residence (owned, rented, other).
4. Please indicate your employment status (full time, part time, home maker, unemployed, self-employed, student).
5. Please indicate your industry of employment? (Agriculture, forestry and fisheries, mining, quarrying etc., construction, manufacturing, electricity, gas, heat supply, and water supply, information and communication, transportation and postal services, wholesale and retail trade, finance and insurance, real estate, academic research, professional and technical services, lodging, food and beverage services, lifestyle-related services and entertainment, education and learning support, medical care, welfare, service industry, public service, other).
6. Please indicate your highest level of education (elementary, junior high, high school, technical college, 2-year university, university, graduate school).

Section 2: Key Concept, Technology and Policy Familiarity

7. How familiar are you with the concept of a 'Just Transition'? (know it well, know it, have heard of it, never heard of it).
8. If you answered 1 to 3 in the previous question, please answer the following. Where did you hear of the term "Just Transition"? (the internet, family or friends, the news, other).
9. How familiar are you with the following power generation technologies? (know it well, know it, have heard of it, never heard of it)
    A) Solar PV
    B) Wind
    C) Biomass
    D) Geothermal
    E) Hydropower
    F) Nuclear
    G) Fossil Fuels (Coal, Oil, Liquid Natural Gas etc.)
    H) Carbon Capture and Sequestration
    I) Hydrogen-based generation
    J) Biomass Energy with Carbon Capture and Sequestration
10. How familiar are you with the following energy policies, agreements, and organizations? (know it well, know it, have heard of it, never heard of it).
    A) Paris Agreement
    B) Japan's Basic Energy Strategy
    C) Intended Nationally Determined Contribution (INDC)
    D) Feed in Tariff (FiT)
    E) Prefecture level renewable energy portfolio

F) Conference of Parties (COP)
G) Kyoto Protocol
H) Intergovernmental Panel on Climate Change (IPCC)
I) Sustainable Development Goals (SDGs)

11. Do you know the energy mix of the electricity you consume in your home? (know it well, know it, have heard of it, never heard of it).

Section 3: Lived Experience, Policy Importance and Technology Preference

12. Do you own any of the following energy-related equipment? (Solar panels, storage battery, Eco-Cute water heater, Fuel cell vehicle, Electric vehicle, none).
13. How do you feel about your monthly energy bills? (cheap, about right, expensive, extremely expensive (unable to pay)).
14. Please rate the importance of the following energy policy issues to you. (not important at all, a little important, somewhat important, very important, the most important).
    A) Environmental Protection
    B) Climate Change Response
    C) Preserving Limited Resources
    D) A Healthy Economy
    E) Reducing Energy Costs for Consumers
    F) A Safe and Reliable Energy System
    G) Social Equity
15. Please tell us your opinion on the following energy sources and technologies and whether you would like to see more or less of each type in the overall energy mix? (should reduce extremely, should reduce, neither, should increase, should increase extremely)
    A) Coal without CCS
    B) Coal with CCS
    C) Natural Gas without CCS
    D) Natural Gas with CCS
    E) Nuclear
    F) Oil without CCS
    G) Oil with CCS
    H) Solar
    I) Wind
    J) Hydropower
    K) Biomass without CCS
    L) Biomass with CCS
    M) Geothermal

Section 4: Just Transition Considerations, Priorities and Trade-offs

16. Whose opinion should be taken into account when considering moving away from fossil fuels? (Household energy consumers, neighbors of retiring power plants, neighbors of newly constructed power plants, small and medium-sized enterprises, fossil fuel workers, electric power companies, automobile manufacturers, local governments, prefectural governments, economists, environmental organizations, research institutes/think tanks, no one's opinion should be taken into account).

17. Whose interests should come first when considering divestment from fossil fuels? (coal miners, oil drillers, oil refinery workers, coal power plant workers, automobile manufacturers, electricity consumers, large consumers of electricity, no one's interests should be considered, other).
18. Which segment of society should be considered first and foremost when thinking about divesting from fossil fuels? (the poor, the wealthy, households with children, married couples, single-person households, elderly households, other).
19. Which generation's interests should come first when we think about getting rid of fossil fuels? (children – the future generation, the current generation, the elder, other).
20. If investments in new energy infrastructure are needed, who should bear the burden? (collected from taxes, power producers (i.e., via a carbon tax), large companies, added to electricity bills).
21. In the past, people have lost their jobs as a result of the energy transition. Which of the following options do you think it is inevitable that people will lose their jobs as a result of the energy transition? (Coal Mine Personnel in Japan, Coal Mine Personnel Overseas, Coal-fired power plant personnel in Japan, Coal-fired power plant personnel Overseas, Gas & Petroleum workers in Japan, Gas and petroleum workers Overseas, Nuclear power plant-related personnel in Japan, Nuclear power plant-related personnel overseas, haven't considered this issue).
22. Which of the following actions would you consider taking to achieve a just transition to a sustainable decarbonized society in Japan by 2050? (Relocation to another prefecture, changing jobs to another occupation, limit electricity use to within a government-designated budget, install a solar power generation system, switch to a fuel cell vehicle, reduce energy output to enable demand response, switch to teleworking, stop using your car, switch to an electricity plan that includes more renewable energy (at a higher cost), other, don't want to take any action).
23. What are you willing to accept in your community to achieve a just transition? (Install a nuclear power plant in your town, install a nuclear power plant in your prefecture, solar power plant in your town, solar power plant in your prefecture, wind power plant in your town, wind power plant in your prefecture, close a coal-fired power plant in your town or prefecture, closing a mine in Japan, closing a mine in another country, deep-sea mining in Japan to extract deep-sea mineral resources (rare metals and gases), deep-sea mining in Okinawa to mine deep-sea mineral resources, deep-sea mining in other countries to mine deep-sea mineral resources, deep-sea mining in international waters to mine deep-sea mineral resources, install CCS in your town, Install CCS in your prefecture, shut down industries with high energy use, import renewable energy from other countries, I am not willing to accept any of these options).
24. What benefits do you expect to gain from a Just Transition? (expansion of new energy industries, increased employment through new energy industries, a healthier environment, fairness and a correction of societal imbalance, an increase in assets, cheaper energy, a decrease in natural disasters, maintenance of living standards, other).

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