Energy Policy 62 (2013) 1204–1211

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Public perceptions of climate change and energy futures before and after the Fukushima accident: A comparison between Britain and Japan

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HIGHLIGHTS

- We report data from 2005 to 2011 of British and Japanese attitudes towards nuclear power and climate change.
- The Japanese are less supportive of nuclear power as a solution to climate change than the British.
- Public support for and trust in nuclear power has collapsed in Japan after Fukushima.
- British public attitudes to nuclear power are remarkably robust in the wake of Fukushima.

ARTICLE INFO

Article history:
Received 5 December 2012
Accepted 2 August 2013
Available online 20 August 2013

Keywords:
Public attitudes
Fukushima accident
Cross-national comparison

ABSTRACT

The threats posed by climate change call for strong action from the international community to limit carbon emissions. Before the Fukushima accident that followed the Great East Japan earthquake and tsunami on 11 March 2011, both Britain and Japan were considering an ambitious expansion of nuclear power as part of their strategy to reduce carbon emissions. However, the accident may have thrown nuclear power as a publicly accep' energy technology into doubt. This study uses several nationally representative surveys from before and after the Fukushima accident to examine how it may have changed public perceptions of climate change and energy futures in Britain and Japan. The study found that already before the accident the Japanese public were less supportive of nuclear power than the British. While British attitudes have remained remarkably stable over time, the Japanese public appear to have completely lost trust in nuclear safety and regulation, and have become less acceptive of nuclear power even if it would contribute to climate change mitigation or energy security. In Japan the public are now less likely to think that any specific energy source will contribute to a reliable and secure supply of energy. The implications for energy policy are discussed.

1. Introduction

1.1. Background

The threats posed by climate change calls for strong action from the international community to limit Greenhouse Gas (GHG) emissions. Both the UK and Japan Governments have set themselves ambitious long-term domestic targets that go well beyond the Kyoto Protocol. The UK Climate Change Act of 2008 provides a legally binding GHG reduction target of 80% by 2050, with an interim target of 34% by 2020. Japan's policy is to achieve an emission reduction of 25% by 2020 and 80% by 2050. These targets necessitate fundamental changes to the way energy is used and produced, and are unlikely to be met without widespread engagement and approval from the general public. Not only does the public need to personally change their behaviour in order to reduce energy consumption and to comply with wider policies aimed at motivating these changes, they also need to accept new low-carbon technologies and facilities to de-carbonise the energy they are using (Spence and Pidgeon, 2009).

Within this context, nuclear power has in recent years been promoted as a low-carbon technology that may help to mitigate climate change and at the same time increase energy security (Bickerstaff et al., 2008). While arguments regarding the role of nuclear power in delivering a secure supply of energy have been made since the oil crises in the 1970s, it is only since the early 2000s that nuclear power has been framed explicitly as a means to

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http://dx.doi.org/10.1016/j.enpol.2013.08.015

address climate change (Pidgeon et al., 2008). Over the last decade various industry and government actors in the UK, as well as a number of prominent environmentalists, including Lovelock (2004) and Monbiot (2009), have expressed support for new nuclear built to help combat climate change. Previous studies suggest that this reframing argument has resulted in some changes in public attitudes towards nuclear power over the past decade. A significant proportion of the British public now '*reluctantly accept*' nuclear power as a means of addressing the greater threat of climate change (e.g. Pidgeon et al., 2008; Corner et al., 2011). However, while the public is willing to consider nuclear power, the energy technology is not embraced wholeheartedly. It has been suggested that this 'conditional support' is fragile in nature. Pidgeon et al. (2008) argued that, in the absence of any major accident since Chernobyl, the public may have become less attentive to the risks of nuclear power, and that latent concerns are likely to re-emerge in case of major accident, possibly amplified with considerable force.

Nuclear power has for a long time been a national strategic priority in Japan (MOE, 2008); and several government and industry actors have stressed the need for nuclear power to combat climate change (e.g. Hasegawa, 1999). The 2010 Strategic Energy Plan committed to radical reductions in GHG emissions through investments in renewable energy, the promotion of energy conservation, and an ambitious expansion of Japan's nuclear energy generating capacity from 26% in 2010 to nearly 50% in 2030 (METI, 2010). However, the accident at the *Fukushima Dai-ichi* nuclear power plant that followed the devastating *Tohoku earthquake and tsunami* on the 11th of March 2011 has thrown nuclear power as a publicly acceptable energy technology into doubt. Before the accident, public support and trust in the regulation of nuclear power had already been seriously tested following a series of accidents in Japan, most notably the criticality accident at the *Tokai-mura* uranium reprocessing facility killing two workers (and exposing many others to high doses of radiation), the steam explosion at *Mihama* nuclear power plant killing 4 workers and injuring 7 more, and the leakage of radioactive water from the *Kashiwazaki-Kariwa* nuclear power plant after the 2007 Chūetsu offshore earthquake (Cyranoski, 2010). Various scholars have argued that these accidents show that the Japanese Government and the nuclear industry have been far too lax in the development and operation of nuclear policies and facilities, and that public safety has not been their main priority (Nakamura and Kikuchi, 2011; NAIIC, 2012). Indeed, at the turn of the century public support for nuclear power reached an all-time low in Japan, as did trust in Japan's nuclear energy policy (OECD, 2010).

The investigations into the causes of the Fukushima disaster show that public distrust in the safety and management of nuclear power installations was to some degree warranted. Both the investigation of the privately-funded *Rebuild Japan Initiative Foundation* and the *NAIIC*[1]*investigation* ordered by the National Diet of Japan concluded that Fukushima was a man-made disaster rather than one caused directly by the earthquake and ensuing tsunami (Funabashi and Kitazawa, 2012; NAIIC, 2012). The reports conclude that, notwithstanding the complexity of the situation or the cascading effects of the unfolding emergency, the Fukushima accident was ultimately preventable (Funabashi and Kitazawa, 2012). All the direct causes of the accident were foreseeable prior to the accident and could have been responded to. However, the operator, Government, and regulators failed to meet the most basic safety requirements and did not implement appropriate procedures and training for an effective response to critical situations (NAIIC, 2012). This shows that that the pathology of catastrophic accidents can often be found in organisational and societal preconditions, such as a lack of safety culture (Pidgeon, 2012). The conclusions of the independent commissions are likely to have further eroded public trust in the safety and management of the nuclear power stations in Japan. Earthquakes and tsunamis are unpredictable but unavoidable events in Japan and should therefore have been central to any risk assessment and emergency planning in nuclear installations. However, even after a number of nuclear incidents and accidents in the 1990s and 2000s, some of which triggered by an earthquake, the industry and its regulators failed to ensure that appropriate emergency procedures were in place (NAIIC, 2012).

After the Fukushima accident all Japan's nuclear power plants have either closed or had their operation suspended for safety inspections and maintenance, leaving Japan temporarily without nuclear-produced electricity in 2012. The announcement of the decision to restart two nuclear reactors led to – for Japan – unprecedented demonstrations (BBC, 2012), showing the extent of public opposition and distrust in the safety and management of nuclear power in the wake of Fukushima accident. While there have been sizable and well-organised anti-nuclear movements in both Europe and US since the 1970s, the anti-nuclear movement in Japan has generally been smaller than its Western counterparts and tended to focus on military applications of nuclear technology rather than civilian nuclear power (Valentine and Sovacool, 2010; Hasegawa, 2011). While there has been successful opposition to the siting of new nuclear facilities in Japan (Takubo, 1997), the poor integration and marginalisation of environmental NGOs and civil society movements in policy-making networks limits its power to substantially influence environmental policies (Foljanty-Jost, 2005). The Fukushima accident and – perhaps more importantly – the subsequent loss of trust in Japan's nuclear industry and government, may have sparked the beginning of a better organised anti-nuclear movement resisting the use of civilian nuclear technology. This may have profound consequences for the future direction of Japan's energy policy, as shown by the relative success of anti-nuclear movements in the US and Europe to slow down the expansion of nuclear power (Hasegawa, 2011). Indeed, in a dramatic departure from its pre-Fukushima energy policy, the Japanese Government unveiled in September 2012 plans to phase out nuclear power before 2040 -although it declared a number of days later that Japan's future energy policy would be developed "*with flexibility based on tireless verification and re-examination*", leaving open the option of continuing Japan's existing nuclear power plants. This change in policy can of course not solely be attributed to the influence of public opinion. However, it is clear that Fukushima has fundamentally changed the debate on the role of nuclear power in Japan's future energy mix and strained the relationship between the general public and the Japanese Government.

The accident at the Fukushima Dai-ichi nuclear power plant has had ramifications beyond Japan, substantially reshaping nuclear agendas and policies across the world (Jorant, 2011). This is perhaps most dramatically shown in Germany's decision to phase out nuclear power by 2022, which was made in response to continuing public opposition and demonstrations in the wake of the accident—thereby revoking recent preceding policy decisions to continue its use (Pfister and Böhm, 2012). While Germany has already established itself as a leader in renewable energy technology and generation (Wittneben, 2012), it will still face challenges in replacing the lost capacity by other forms of low-carbon energy generation in order to meet its carbon reduction targets. In contrast, UK policymakers remain fully committed to their decision to increase the share of nuclear power in the energy mix. The UK Office for Nuclear Regulation concluded that "In considering the direct causes of the Fukushima accident we see no reason for

[1] National Diet of Japan Fukushima Nuclear Accident Independent Investigation Commission.

curtailing the operation of nuclear power plants or other nuclear facilities in the UK" (cited in Butler et al., 2011). Crucially, this was before the damning conclusions of the independent investigations that the Fukushima accident was a man-made rather than a natural disaster. UK policy makers however still consider nuclear power as an important part of the transition to a low-carbon economy (Schneider et al., 2012). These show very different policy responses to one of the most serious nuclear accidents in history.

If Japan is to phase out nuclear from its energy mix, it is imperative that the lost capacity is met by other low-carbon sources so that it still can meet its carbon reduction targets. Japan has seen a substantial increase in carbon emissions as it has been forced to import more oil, coal and natural gas to fill the energy gap created by the shutdown of its nuclear power stations. A continued reliance on oil and natural gas may call into question Japan's ability to reduce CO_2 emissions by 25% by 2020. On 27 October 2011, former minister for the environment Mr Hosono, stated at the committee for the environment of the Upper Diet that CO_2 emissions would increase by 150–170 million tons if all electric power generated by nuclear was substituted by oil or coals. This almost equals 12–14% of 1990 GHG emissions (National Diet Library, 2012). While there are a number of scenarios for a low-carbon Japan, including the large-scale deployment of renewable sources and energy demand reduction (e.g. Shimada et al., 2007; Fujino et al., 2008), these pathways would need to be supported by the general public. Case studies from around the world have shown that community opposition can lead to delays or even cancelation of the deployment and siting of low-carbon energy technologies (Pidgeon et al., 2008), while mitigating climate change through energy demand reduction requires serious commitment from the general public to change their own behaviour (Poortinga et al., 2012).

Box A–The Surveys.

GB2005: The first British survey was conducted between 1 October and 6 November 2005. A national representative quota sample of 1491 people aged 15 years and older was interviewed face-to-face in their own homes by the market and opinion research company MORI (see Poortinga et al., 2006 for more details).

GB2010: The second British survey was conducted between 6 January and 26 March, 2010. A nationally representative quota sample of the British population aged 15 years and older (i.e. England, Scotland and Wales; $n=1822$) were interviewed face-to-face in their own homes by trained Ipsos-MORI interviewers (see Spence et al., 2010 for more details).

GB2011: The third British survey was conducted between 26 August 2011 and 29 August 2011. Populus interviewed a random sample of 2050 adults online and subsequently weighted the sample to make it representative of the British adult population. The data were collected by the British Science Association (BSA) for the 2011 British Science Festival.

JP2007: The first Japan survey was conducted between 11 and 28 January 2007. This was within the 2006 Fiscal Year (FY) running from April 2006 to March 2007. The data was collected by Shin Joho Center Inc. The nationally representative sample of 959 people aged 20 years and older was interviewed face-to-face in their own homes.

JP2011: The second Japan survey was conducted between 7 and 24 of July 2011. A quantitative survey was undertaken nation-wide in Japan by Central Research Services Inc. A nationally representative sample of 1399 people aged 20 years and older was interviewed face-to-face in their own homes (Aoyagi et al., 2011).

1.2. The research

In this study we compare public perceptions of climate change and energy futures in Britain and Japan using a series of quantitative surveys that were conducted at different stages before and after the Fukushima accident. This comparison will show how the Fukushima accident may have changed public opinion on climate change and nuclear power in the two countries, as well as the acceptability of alternative energy options. The comparison between Britain and Japan is relevant, as nuclear power was part of both countries' strategy to achieve future carbon emission reductions. While the Fukushima accident is likely to have seriously affected Japanese public attitudes to nuclear power, its impacts on British public opinion are less clear. The studies that are included in this study all contained items that can be used for cross-national comparisons. The datasets include the "Public Risk Perceptions, Climate Change and Reframing of UK Energy" and "Public Perceptions of Climate Change and Energy Choices in Britain" surveys that were conducted in Britain in 2005 and 2010, respectively. The third British dataset is a survey commissioned by the British Science Foundation (BSA) as part of the 2011 British Science Festival. These British surveys are compared with a series of nation-wide public opinion surveys conducted in 2007 and 2011 in Japan. The surveys covered widely similar topics and items, although not each item was included in all surveys. We therefore only make cross-national and pre-post Fukushima comparisons where possible. Although these comparisons are admittedly crude – as the studies were not specifically designed to examine the impacts of the Fukushima accident – the surveys are the only nationally representative datasets available for that purpose. Box A provides details of the five datasets. The studies will be referred to as GB2005, GB2010 and GB2011, and JP2007 and JP2011, respectively.

2. Results

2.1. Public perceptions of climate change

Table 1 shows public perceptions of the reality of climate change in Britain and Japan, respectively. In 2005 an overwhelming majority (91%) of the British public thought that the world's climate was changing. This majority dropped significantly to 78% in 2010. At the same time, the group of individuals who expressed *trend sceptical* views, i.e. those who do not think that the world's climate is changing, grew from 4% in 2005 to 15% in 2010 (Poortinga et al., 2011). No major differences were found in Japan between 2007 and 2011. In 2007 an overwhelming majority (95%) of the Japanese public thought that the world's climate was changing. Only very few (3%) thought that the world's climate was not changing. A similar pattern was found when the question was repeated in 2011. More than nine out of ten (92%) thought that the world's climate was changing; only 5% thought it was not.

These results show that trend scepticism has gained some ground in Britain, but is still virtually non-existent in Japan. It has

Table 1
Responses to the question "As far as you know, do you personally think that the world's climate is changing" (in %).

		Yes	No	Don't Know
Great Britain	**2010 ($n=1822$)**	78	15	6
	2005 ($n=1491$)	91	4	5
Japan	**2011 ($n=1339$)**	92	5	3
	2007 ($n=911$)	95	3	2

Note: The percentages in the table may not always add up to 100% due to rounding.

to be noted though that, despite the increase, trend scepticism is still not very common in Britain either. Furthermore there are indications that the observed drop in public belief in climate change in 2010 is due to a unique convergence of circumstances, including '*climategate*' and the *economic downturn* (e.g. Scruggs and Benegal, 2012). The most recent evidence suggests that both belief in climate change and concern has stabilised since 2010 and not declined further (Demski et al., 2013).

2.2. Attitudes to different forms of electricity generation

Attitudes to different forms of electricity generation were assessed differently in Britain and Japan. Whereas respondents in Britain were asked how favourable or unfavourable their overall opinions or impressions are of the different forms of electricity generation, in Japan they were asked to what degree they agreed that the different forms of electricity generation will make a substantial contribution to reliable and secure supplies of electricity in Japan in the future. The results in Britain are therefore more likely to reflect a person's general affective evaluation of the different energy sources. In Japan responses are more likely to represent more cognitive representations regarding future electricity generation. As affective responses tend to be more stable over time than cognitive responses (e.g. Diener and Larsen, 1984), it can be expected that the Japan results are more changeable and will more closely track changes in energy policy. Despite these differences, we will report the findings for the two countries so that we will be able to track opinions regarding the different form of electricity generation over time in both Britain and Japan without claiming to make cross-national comparisons.

Fig. 1a shows that the overall patterns of favourability judgments were to a large extent comparable in 2010 and 2005. Overall, the renewable options were regarded most favourably (solar, wind hydroelectric), followed by biomass and gas. Nuclear and fossil fuels were by far the least favoured forms of electricity generation. Biomass was perceived slightly more favourably, while oil was perceived slightly less favourably in 2010 as compared to 2005. The GB2011 survey only asked for favourability judgements of nuclear power. Fig. 1a shows that only around a third of the British public had mainly or very favourable impressions of nuclear power in 2005, 2010, and 2011, and that these impressions remained surprisingly stable over the six year period. These results suggest that the Fukushima accident has had no substantive impact on the perceived favourability of nuclear power in Britain.

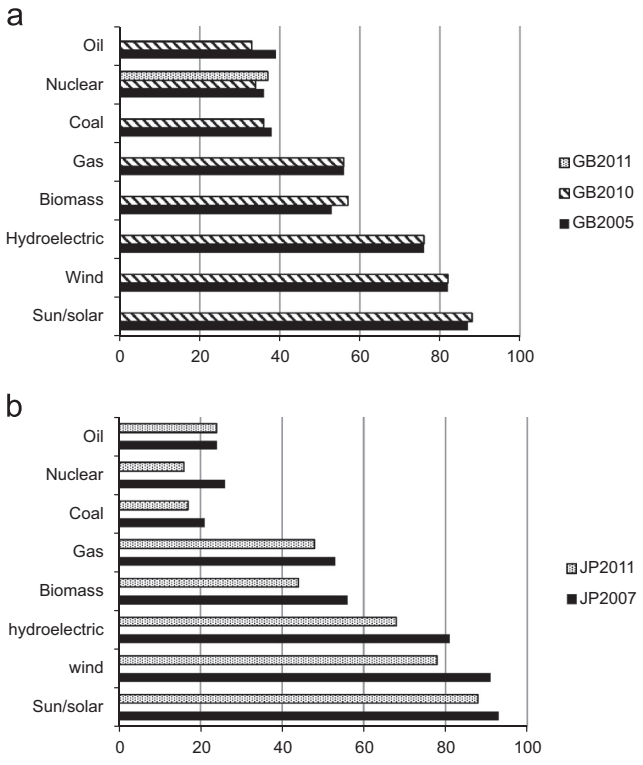

Fig. 1. (a) Responses to the question "How favourable are your overall opinions or impressions of the following energy sources for producing electricity currently" (% mainly or very favourable). (b) Agreement with the item "To what extent do you agree or disagree that the following energy sources will make a substantial contribution to reliable and secure supplies of electricity in Japan" (% tend to/strongly agree).

Fig. 1b shows the level of agreement that the different energy sources will make a substantial contribution to reliable and secure supplies of electricity in Japan in the future. The overall pattern of responses is comparable to the one observed for Britain. In 2007, a clear majority of the Japanese public thought that sun/solar, wind and hydroelectric power will make a substantial contribution to reliable and secure supplies of energy in Japan, followed by biomass and natural gas. A minority of less than 30% thought that nuclear, oil and gas will make a substantial contribution to energy security.

Fewer people in 2011 than in 2007 thought that any of the eight energy sources will make a substantial contribution to energy security in the future. The biggest decrease was found for renewable energy sources (in particular wind, hydroelectric and biomass) and nuclear power. The results regarding nuclear power are perhaps not surprising in the light of the Fukushima accident and the consequent shutdown of most nuclear power stations in Japan. However, the other changes are more difficult to interpret. The most likely explanation is that the Japanese public think that renewables may not be sufficient and/or cannot be developed fast enough to plug the energy gap left by the closure of nuclear power plants. It is also a possibility that the results reflect more generic concern regarding security of supplies of the whole energy system.

2.3. Attitudes to nuclear power

The surveys in Britain and Japan contained a variety of items to assess different aspects of public attitudes towards nuclear power, including 'conditional support' for nuclear power in the context of climate change and energy security (see Corner et al., 2011). Fig. 2 shows that more than half of the British population are willing to accept the building of new nuclear power stations if it would help to tackle climate change. In contrast, conditional support for nuclear power in Japan dropped from just over 30% in 2007 to just over 20% in 2011. These results suggest a number of things. First, in Japan there is a lower level of support for nuclear power

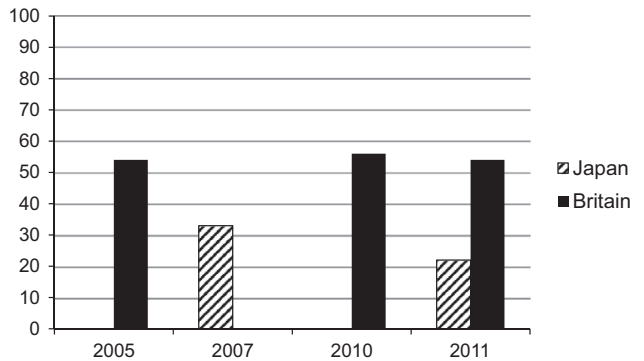

Fig. 2. Agreement with the statement "I am willing to accept the building of new nuclear power stations if it would help to tackle climate change" (% tend to/strongly agree).

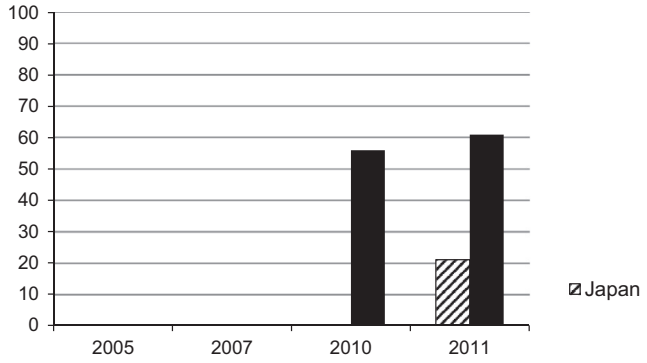

Fig. 3. Agreement with the statement "I am willing to accept the building of new nuclear power stations if it would help to improve energy security" (% tend to/strongly agree) (The item was not included in the GB2005 and JP2007 surveys.).

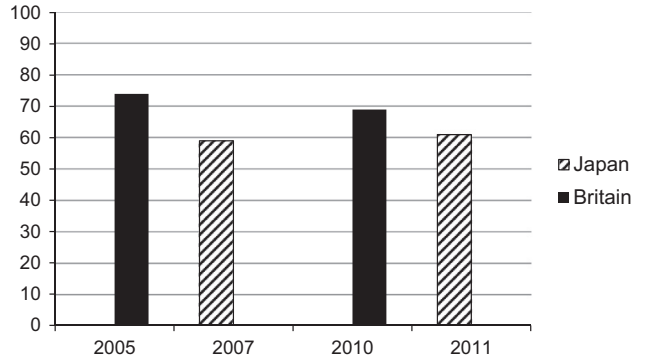

Fig. 4. Agreement with the statement "We shouldn't think of nuclear power as a solution for climate change before exploring all other energy options" (% tend to/strongly agree).

than in the UK. Already before the accident the Japanese public were less supportive of nuclear power than the British, even if it would contribute to climate change mitigation. This can best be explained by the series of nuclear incidents and accidents that took place throughout the 1990s and 2000s. Second, the British public appear more receptive to the reframing argument than the Japanese public. Third, while conditional support for nuclear power as a solution to climate change remained stable in Britain over a six year period, it decreased significantly in Japan in the wake of the Fukushima accident.

The GB2010, GB2011 and JP2011 surveys included a similar question on conditional support for nuclear power in the context of energy security (The question was not asked in the GB2005 and JP2007 surveys). Fig. 3 shows that more than half of the British public are willing to accept the building of new nuclear power stations if it would help to improve energy security. Only around 20% of the Japanese public agreed with this statement in 2011. This again shows that 'conditional support' for nuclear power is much higher in Britain than in Japan. Although no pre-Fukushima data is available for Japan, the similarities with the previous item suggest that the accident may also have dampened public Japan's enthusiasm for nuclear power, irrespective of its contribution to climate change and/or energy security. In contrast, conditional support for nuclear power the context of energy security even appears to have increased in Britain after the Fukushima accident.

Fig. 4 shows that a majority of both the British and Japanese publics agree that we shouldn't think of nuclear power as a solution for climate change before exploring all other energy options. This illustrates that, even if many people in Britain are willing to consider nuclear power to tackle climate change, they still think there are better alternatives. Overall, the responses to the different items suggest that many people in Britain still 'reluctantly accept' nuclear power (cf., Bickerstaff et al., 2008; Corner et al., 2011). Attitudes in Japan cannot be characterised as 'reluctant acceptance', as – in contrast to Britain – support for nuclear power is low, whether the questions are placed in the context of climate change and energy security or not. In Japan, agreement that all other energy options should be explored before considering nuclear power remained at the same high level after the Fukushima accident. No post Fukushima data on this item is available for Britain. Fig. 4 suggests that public preferences for alternative energy options over nuclear power are fairly stable in both Britain and Japan. Responses to other questions (not reported here) show that both the British and Japanese publics think that renewable energy sources and lifestyle changes/energy efficiency are better ways of tackling climate change than nuclear power.

Fig. 5 presents agreement in Britain and Japan with the statement "If we had safer nuclear power stations, I'd be prepared to support new ones being built" (the items was not included in

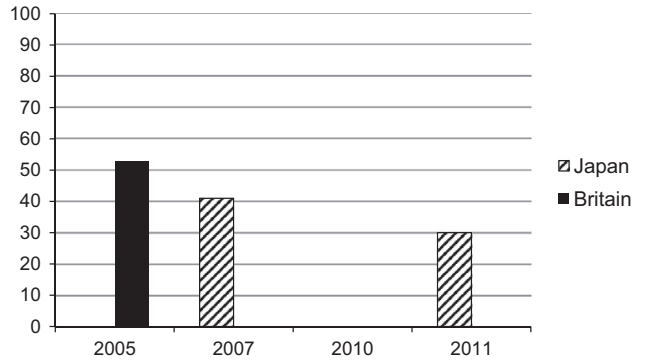

Fig. 5. Agreement with the statement "If we had safer nuclear power stations, I'd be prepared to support new ones being built" (% tend to/strongly agree) (The item was not included in GB2010 survey.).

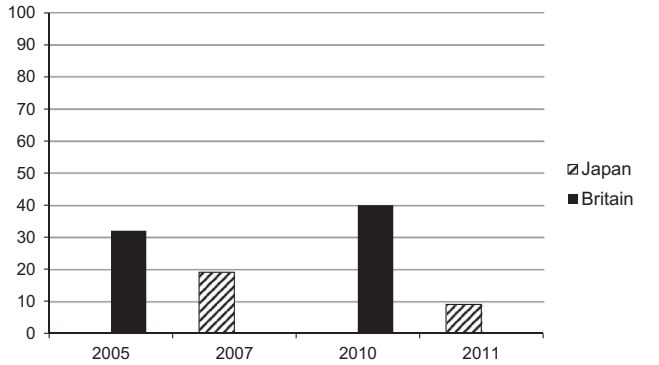

Fig. 6. Trust in risk regulation (% tend to/strongly agree) (Different questins were asked in Great Britain and Japan. GB: "I feel confident that the British Government adequately regulates nuclear power"; JP: "I feel that current rules and regulations are sufficient to control nuclear power".).

the GB2010 survey). Comparison between the GB2005 and JP2007 surveys shows that more people in Britain than in Japan are willing to support nuclear power if it is safe. In Japan, agreement with the statement decreased from 41% in 2007 to 30% in 2011, probably reflecting both a loss of trust in the safety of nuclear power and a drop in support for new nuclear built. No post Fukushima data is available for Britain.

Fig. 6 shows the responses to a number of items that were used to assess public trust in the regulation of nuclear power plants. Although different items were used in Britain and Japan, the results are presented to show changes over time in the two countries. The similarity in responses to the two items in the GB2005 survey

Table 2
Unconditional attitudes to nuclear power in Britain (in %).

	GB2005	GB2010	GB2011
Which of the following statements most closely describes your own opinion about nuclear power in Britain today?			
We should increase the number of power stations	9	17	23
We should continue using the existing NP stations and replace them with new ones when they reach the end of their life	34	29	21
We should continue using the existing NP stations but not replace them with new ones when they reach the end of their life	34	33	21
We should shut down all existing NP stations now and not replace them with new ones	15	13	11
Don′t know/none of these	7	7	14
From what you know or have heard about using nuclear power for generating electricity in Britain, which of these statements most closely reflects your own opinion?			
The benefits of nuclear power slightly/far outweigh the risks	32	38	41
The benefits and risks of nuclear power are about the same	20	17	16
The risks of nuclear power slightly/far outweigh the benefits	41	36	28
Don′t know/None of these	7	8	14
How concerned are you about nuclear power?			
Very concerned	28	16	12
Fairly concerned	31	38	35
Not very concerned	27	30	34
Not at all concerned	11	12	11
Don′t know/No opinion	3	4	8

($r=0.65$; Cronbach′s $\alpha=0.79$) suggests that the different items capture largely the same thing, and thus may tentatively be used to make cross-national comparisons over time.

Trust in the British government to adequately regulate nuclear power increased from 32% in 2005 to 41% in 2010. In contrast, trust in current rules and regulation decreased in Japan from 19% in 2006 to 9% in 2011. While trust in the regulation of nuclear power was already low in Japan before the accident, it collapsed to an even lower level after the Fukushima accident. Although no post-Fukushima data is available for Britain, responses to an alternative trust question ("How confident or unconfident are you that the UK is prepared to handle a major nuclear accident if one were to happen in one of our existing power facilities") suggests that there is still a considerable level of trust in the management of nuclear power after the accident (31% responded to be fairly or very confident).

The three British surveys included a number of additional questions that can be used to show changes in 'unconditional' attitudes to nuclear power over time. Table 2 shows that in 2005 and 2011 a similar number of people want to continue nuclear power in Britain. It also shows that, while overall support for the continuation of nuclear power stayed the same, more people *after* the Fukushima accident thought that the number of nuclear power stations should be increased. Overall, the number of people wanting to phase out nuclear power decreased from 2010 to 2011, with more people using the "don′t know" or "none of these" options. It has to be noted that GB2011 was the only online survey. It is possible that the online data collection has contributed to the higher percentages of "don′t know" and "none of these" responses. Table 2 further shows that concern about nuclear power has decreased substantially between 2005 and 2011. Fewer people are fairly or very concerned about nuclear power after the Fukushima accident as compared to before. Similarly, Table 2 shows that fewer people perceive the risks of nuclear power to outweigh the benefits of nuclear, while more people perceived the benefits of nuclear power to outweigh the risks after the Fukushima accident. These results paint a picture of attitudes to nuclear power having softened over time in Britain. In line with the other results presented here, the results suggest that Fukushima has not negatively impacted upon public attitudes to nuclear in Britain.

3. Discussion

This study used several British and Japanese surveys on public perceptions of climate change and energy futures that were conducted at different stages before and after the Fukushima accident to explore how the Fukushima accident may have changed public attitudes to nuclear power and climate change in the two countries. The comparison found that public belief in the reality of climate change is high in both Britain and Japan. While trend scepticism has increased substantially in Britain between 2005 and 2010 (also see Poortinga et al., 2011), it remained virtually non-existent in Japan. The study does however not include more recent (i.e. post-Fukushima) data on public perceptions of climate change for Britain. The most recent evidence suggest that both belief in climate change and concern has stabilised since 2010 and not declined any further (Demski et al., 2013). Further research should provide more clarity about how perceptions of climate change have developed over time, in particular in the wake of the Fukushima accident. Research by Nakayachi (2012) suggests that, notwithstanding the high level of belief in the reality of climate change, concerns about its risks may have taken second place to other more immediate risks and concerns relating to the earthquake and Fukushima accident. While it is unlikely that concerns about Fukushima will have replaced concerns about climate change in the UK, ongoing concerns about the economy may have diverted attention from environmental issues (cf., Weber, 2006; Scruggs and Benegal, 2012). Recent research suggests that elite cues and structural economic factors as expressed in news coverage have a substantial impact on the level of public concern about climate change (Brulle et al., 2012). Expanding the time series together with detailed media analysis would improve our understanding of the dynamics of public opinions about climate change in relation to other issues and concerns.

There were distinct differences in public attitudes towards nuclear power in Britain and Japan. The results show that the Japanese are generally far less supportive and trusting regarding nuclear power than the British. The differences between the two countries were already apparent before the Fukushima accident and have become even more pronounced after. The Japanese public are less willing to accept the building of new nuclear power stations, even if it would help to tackle climate change or improve energy security. They are more likely to consider renewable energy sources and lifestyle changes/energy efficiency as better ways to tackle climate change. It is likely that a history of nuclear incidents in Japan throughout the 1990s and 2000s has contributed to the lower levels of support and trust (Cyranoski, 2010). The Japanese nuclear industry and its regulators have not shown great regard for the safety of the general public, as concluded by the public

investigations into the causes of the Fukushima accident (e.g. NAIIC, 2012). Furthermore, despite nuclear power playing an important part in Japan's strategy to reduce CO_2 emissions before the Fukushima accident, the reframing argument has not been made as explicitly in Japan as in the UK media (cf., Doyle, 2011). In contrast, the lack of visible accidents in the UK and Europe may have made the British public less attentive to the risks of nuclear power, and, perhaps as a result, more open to the reframing argument. Research in Britain suggests that even environmentally concerned individuals are to some extent receptive to the reframing argument (Corner et al., 2011).

Although it is recognised that the available data are not sufficient to determine the long-term impacts of Fukushima on public opinion in the two countries, it is clear that the British and Japanese publics have responded very differently to the accident, just as their respective governments. British attitudes towards nuclear have remained remarkably stable over the years, and even appear to have softened somewhat in the wake of the accident. In contrast, Japanese attitudes have changed dramatically. The collapse in public trust in the safety and regulation of nuclear power may have far-reaching implications for Japan's energy and environmental policies. The demonstrations against the reopening of a number of reactors in 2012 show the challenges Japanese authorities are facing in re-establishing its nuclear energy generating capacity. The notion that trust is difficult to regain once it is lost (Slovic, 1993; Poortinga and Pidgeon, 2004) suggests that the Japanese public are likely to remain reject nuclear power for some time to come.

It is not clear as to why the Fukushima accident has not substantially impacted upon public attitudes in Britain. It was expected that latent concerns about the risk of nuclear power would re-emerge if a major accident were to happen (Pidgeon et al., 2008). However, these expectations did not materialise. A possible explanation is that some may think that the perceived causes of the accident are not likely to occur in Britain (cf., Butler et al., 2011), while a lack of radiation-related fatalities may have convinced others that nuclear technology is safe (cf., Monbiot, 2011). These explanation do however not take into account the loss of life as a direct result of the evacuation of vulnerable elderly patients (Tanigawa et al., 2012), the potential long-term effects of exposure to radiation (although the received doses are thought to be low; Tokonami et al., 2012), the conclusions of the independent investigations that Fukushima was a man-made disaster rather than a natural one (Funabashi and Kitazawa, 2012; NAIIC, 2012), and the observation from safety studies that complex engineering systems, such as nuclear power plants, are inevitably vulnerable to failure no matter how well managed (Pidgeon., 2012). There is a need to further explore the processes that can explain the robustness of British attitudes in light of one of the greatest nuclear accidents in history. Research conducted after the Chernobyl disaster provides some possible explanations. This research suggests that the public use various 'defensive attributions' in order to maintain their feelings of safety (Eiser et al., 1989; Van der Pligt, 1993). Eiser et al. (1989) found that post-Chernobyl attitudes were closely related to alternative interpretations of the accident (i.e. if the cause of the accident was attributed to specific aspects of the reactor, modes of operation, or context OR nuclear technology in general). Similar attribution processes may have contributed to the 'rebound' in public support for nuclear power in Britain (see Ipsos MORI, 2012).

Although different questions were used to assess public attitudes towards different forms of electricity generation in Britain and Japan, the pattern of responses were remarkably similar. Renewable sources were perceived most favourably and fossil fuels and nuclear power were perceived least favourably in the two countries. In Britain, favourability ratings of the different forms of electricity generation remained stable between 2005 and 2010. In Japan, however, the public were less likely to think that any specific energy source will contribute to a reliable and secure supply of energy in the future in the wake of the Fukushima accident. While the perceived reduced contribution of nuclear power may reflect the government's commitment to reduce Japan's reliance on nuclear power, it is less clear as to why the public are now less certain about the contribution of the other sources to energy security. The finding that *all* energy sources are now thought to be less able to contribute to a reliable and secure supply of energy suggests more generic concerns about fixing the energy shortfall in the short term and creating systemic energy security in the longer term.

Japan currently stands at an important crossroad that will determine its future in energy generation and use. Our research has shown that nuclear energy is no longer considered an acceptable option in Japan. The Japanese public have become wary of the risks of nuclear power in their earthquake and tsunami-prone region and appear to have completely lost trust in the government and industry to manage nuclear power plants safely. The question now is which alternative direction energy policy should take according to the general public. While there are several alternative pathways to a low-carbon Japan, these need to be supported and accepted by the public as well. Further quantitative and qualitative research is needed to assess public acceptance of the different energy futures, while public involvement in all steps of the decision-making process may help to create more socially acceptable solutions in the long term.

Acknowledgments

This research was initiated as part of the FY2012 Japan Society for the Promotion of Science (JSPS) Invitation Fellowship for Research in Japan (S-12008). Support for the earlier surveys was received from the Economic and Social Research Council (RES-062-23-1134; RES-152-25-1011) and the Leverhulme Trust (F/00 407/AG). We also would like to thank the British Science Association (BSA) for repeating some of the items in 2011. We also would like to thank the Global Environment Research Fund of the Ministry of the Environment Japan (1 ZE-1202) for their support, and Professor Michio Umino, Professor Yoko Niiyama and Professor Takehiko Murayama for their valuable comments on this project.

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