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ENERGY SECURITY: INSIGHTS FROM A TEN COUNTRY COMPARISON

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ABSTRACT

The article explores the extent to which energy security concerns differ between countries from the perspectives of energy users. It relies on a survey distributed to more than 2,100 energy consumers across Brazil, China, Germany, India, Kazakhstan, Japan, Papua New Guinea, Saudi Arabia, Singapore, and United States, facilitated through its translation into seven languages (English, Mandarin, Portuguese, Russian, Arabic, German, and Japanese). The article first discusses the survey methodology and then presents a discussion of the results according to four key components of energy security, namely availability, affordability, energy efficiency and stewardship. In addition to analyzing the survey results by different demographic and country levels, the authors compare the results to country-level data indicators. They find that energy security is a multi-dimensional concept with different priorities for different countries that can often be explained by the country's inherent circumstances.

Keywords: energy security; security of supply; energy poverty

1. INTRODUCTION

To get a sense for the urgency and scope of the energy security threats facing society, consider three recent events. In May, 2006, exploratory natural gas drilling in East Java, Indonesia, ignited mud laced with methane and induced a volcano that continues to grow as an “apocalyptic, flammable sea” engulfing dozens of villages [1]. Some days enough mud erupts to fill 50 Olympic Size swimming pools, nearby sewers have caught fire, unwitting residents tossing their cigarette butts in surrounding towns have ignited seeping methane, more than 50,000 people have lost their homes and been displaced, and \$400 million in damages has occurred. Secondly, in early 2010, the

International Energy Agency updated its energy poverty statistics and reported that 1.4 billion people lack access to electricity, 85 percent of them in rural areas, and that by 2030 the number will remain 1.2 billion. They also reported that the number of people relying on traditional biomass will rise from 2.7 billion today to 2.8 billion by 2030. Household air pollution from the use of biomass in inefficient indoor stoves will cause 1.5 million premature deaths per year, more than 4,000 per day by 2030, greater than premature deaths from malaria, Tuberculosis, and HIV/AIDS [2]. Finally, in September 2010, the Stuxnet computer worm, a highly sophisticated piece of malicious software, was found to in fact be a “directed cyber weapon” aimed at infecting electricity grids, power plants, pipelines, and refineries. The worm was designed to cause “serious damage” and had the potential to destroy gas pipelines, force nuclear power plants to malfunction, and induce explosions at power plant boilers [3].

These anecdotes reveal the diffuse nature of common energy security threats, ranging from communities forcibly relocated due to energy accidents to the thousands of women and children dying daily from energy poverty to the intentional targeting of energy infrastructure by hackers. But the extent to which energy security concerns may fundamentally differ within and between countries is rarely discussed. Relying on a survey distributed to more than 2,100 energy consumers in ten countries, this article answers the following research question:

Do notions of energy security differ by institution, training, and particular country, or do “universal” elements exist that transcend individual people and countries?

To answer this question, the article begins by articulating its research methodology, consisting of a four-part survey, translated into seven languages (English, Mandarin, Portuguese, Russian, Arabic, German, and Japanese) and then distributed to ten countries: Brazil, China, Germany, India, Kazakhstan, Japan, Papua New Guinea, Saudi Arabia, Singapore, and United States. These countries were chosen because they represent a mix of energy exporters and importers, developed and developing economies, large and small energy producers, and varying population densities and geographic sizes. The second part of the article discusses the results from the survey, organized according to four components of energy security – availability (related to diversification), affordability (related to equity of supply and its affordability), efficiency (related to innovation, education, energy intensity of use) and stewardship (both environmental and governance related).

2. RESEARCH METHODS

Our research tool, a survey, was a structured questionnaire consisting mainly of multiple choice questions that we have used previously to assess national energy security issues [18-22]. We first conducted three focus groups (including one international workshop with more than 30 international experts) to determine the appropriate dimensions of energy security and then properly phrase the questionnaire. It was then made available online to respondents across all ten countries through a survey hosting website, and also distributed physically in four countries (Kazakhstan, India, Papua New Guinea and Japan) to improve response rates. A total of 2,167

responses were collected. Details of the sample sizes across the countries are provided in Figure 1. One-hundred-and-four respondents did not provide their country of residence when filling the survey online. We have included their responses when analyzing the overall results, but excluded them when analyzing results by country. The sample size by country is not proportional to the country's population, nor has data been weighted to mirror each country's proportional size. To ensure more representative distribution rates, researchers in various countries were recruited to help distribute the survey to people representing a mix of occupations. These included government officials, businessmen, employees of non-governmental organizations, and university employees, who were not necessarily experts in the field of energy. Those who chose to respond did so only based on their willingness to participate; they were not compensated.

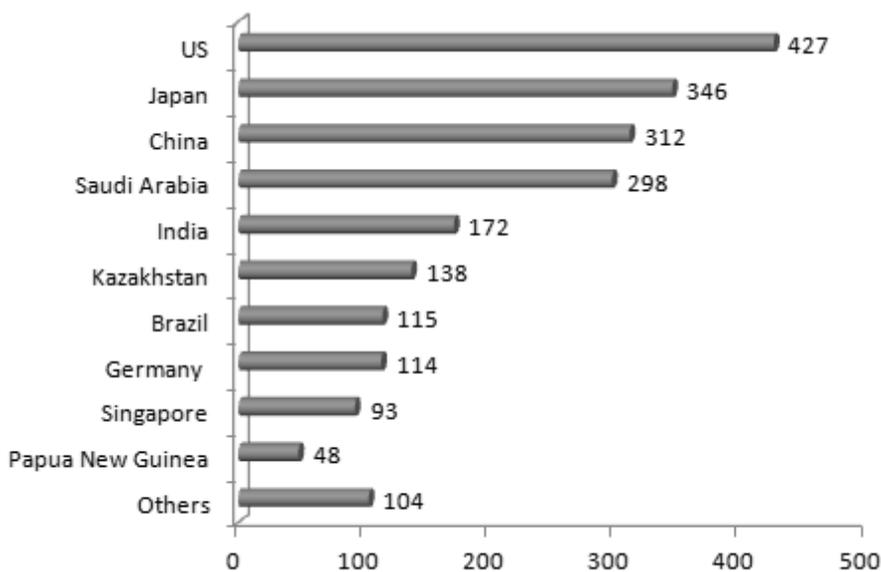


Figure 1. Sample size of survey respondents by country

The survey consisted of three parts with nineteen questions. The first section asked for demographic information about respondents, including their country of residence, nationality, age, level of education, gender, occupation sector, name of employer and job title. The second section asked participants to rate sixteen dimensions of energy security according to a five point scale: extremely important, somewhat important, neither important nor unimportant, somewhat unimportant, or extremely unimportant. We call this method of questioning "rating". The third section asked respondents to rank each of the sixteen dimensions against each other, choosing only the five most important and ranking them in order of importance from first to fifth. We called this method of questioning "ranking". The sixteen dimensions resulted from (a) three focus

group discussions with more than 60 experts on energy security, and (b) our review of the academic and policy literature, including synthesis from the useful meta-surveys and reviews offered by [4 - 6]. The final question was an open ended one asking respondents to add any energy security dimension that they thought was missing in the survey, and asking them to rate it on the importance scale previously mentioned. Appendix 1 provides a copy of the survey in English.

Our aim was not to generalize the survey results to any population. Instead, the results represent the opinions of an informed audience with a mix of demographic characteristics. As Figure 1 reveals, nearly half the respondents are post graduates in our sample, i.e. better educated, something not representative of the general population, especially in the less developed countries. In terms of occupation, more than a third worked at universities, which is proportionately higher than in actual national populations. The respondents do span a wide range of age groups, and 43% are female.

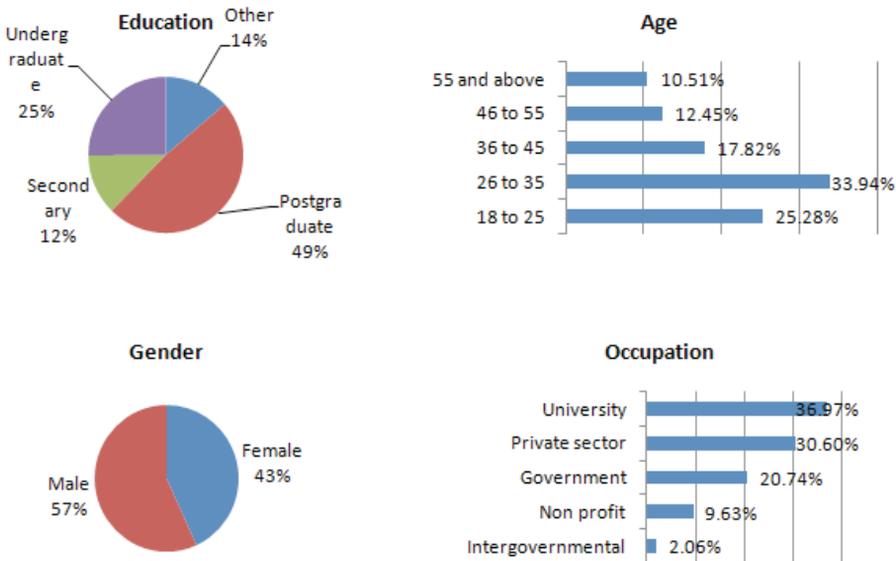


Figure 2. Demographic characteristics of our energy security survey sample
Education and gender figures expressed in percentage, 100% = 2167 respondents

3. DISCUSSION AND RESULTS

This section distills the results from our survey into four key components of energy security, which are defined according to Sovacool and Brown [5] and Sovacool and Bulan [7], and summarized by Table 1.

Table 1: Key components of energy security

Criteria	Underlying Values	Explanation
Availability	Independence and diversification	Diversifying the fuels used to provide energy services as well as the location of facilities using those fuels, promoting energy systems that can recover quickly from attack or disruption, and minimizing dependence on foreign suppliers
Affordability	Equity	Providing energy services that are affordable for consumers and minimizing price volatility
Efficiency	Innovation and education	Improving the performance of energy equipment and altering consumer attitudes
Stewardship	Social and environmental sustainability	Protecting the natural environment, communities and future generations

Source: [7]

Accordingly, we have grouped the results of our survey in these four components:

- **Availability:** Under this component, we capture the security of supply of fossil fuels and nuclear energy, decentralization of energy systems and minimizing the depletion of energy resources
- **Affordability:** Under this component, we capture affordably priced energy services, and equitable distribution of energy to all citizens
- **Energy Efficiency:** Under this component, we include energy research and development and low energy intensity
- **Stewardship:** In this component we group the environmental and governance dimensions of energy security. These include water availability, air pollution, land degradation, climate change (both mitigation and adaptation) and energy governance (transparency and participation in energy permitting, citing, and decision-making).

To give readers a sense of the survey results before we discuss them according to these four dimensions of energy security, Table 2 presents the results from the rating component of our survey for all questions and dimensions, broken down by each of the ten countries as well as providing results in aggregate across the entire sample. The scores represent the mean given by respondents to each dimension of energy security, with a 1 indicating “extremely unimportant” and a 5 “extremely important.” Table 3 provides the highest and lowest rated dimensions of energy security by country, Table 4 show results across the entire sample for energy security ratings and rankings.

Table 2: Energy Security Ratings by Country and Entire Sample

	Entire Sample (n=2,167)	USA (n=427)	India (n=172)	Singapore (n=93)	Germany (n=114)	China (n=312)	Japan (n=346)	Saudi Arabia (n=298)	Brazil (n=115)	Kazakhstan (n=138)	Papua New Guinea (n=48)
(Range: 1 = extremely unimportant; 5 = extremely important)											
secure supply of coal, gas, oil and/or uranium	4.50	4.14	4.86	4.34	3.75	4.82	4.42	4.79	4.70	4.68	4.66
promote trade in energy products, technologies, and exports	4.27	4.19	4.57	4.16	4.23	3.99	4.14	4.49	4.70	4.47	4.53
minimize depletion of domestically available energy fuels	4.33	4.08	4.61	3.54	4.07	4.57	4.37	4.40	4.68	4.54	4.40
stable, predictable, and clear price signals	4.38	4.34	4.47	4.24	4.15	4.27	4.27	4.55	4.75	4.49	4.67
affordably priced energy services	4.37	4.10	4.67	4.28	4.15	4.21	4.34	4.61	4.82	4.51	4.79
small-scale, decentralized energy systems	4.02	3.97	4.17	3.53	4.34	3.62	3.99	4.47	4.47	3.76	4.50
low energy intensity	4.41	4.49	4.52	4.16	4.57	4.44	4.36	4.41	4.59	4.14	4.45
R&D on energy technologies	4.71	4.83	4.83	4.37	4.89	4.68	4.50	4.78	4.98	4.66	4.60
equitable access to energy services to all of its citizens	4.44	4.53	4.49	4.33	4.24	4.36	4.11	4.72	4.79	4.39	4.79
transparency and participation in energy permitting, citing, etc.	4.32	4.47	4.58	4.01	4.15	4.21	4.00	4.46	4.65	4.36	4.77
inform consumers and promote social / community education	4.42	4.56	4.74	4.23	4.41	4.04	4.11	4.72	4.82	4.37	4.77
minimize the destruction of forests & degradation of land /soil	4.66	4.73	4.82	4.18	4.52	4.79	4.48	4.64	4.90	4.71	4.81
provide available and clean water	4.72	4.83	4.89	4.66	4.47	4.75	4.35	4.91	4.88	4.79	4.84
minimize air pollution	4.71	4.75	4.80	4.53	4.46	4.76	4.57	4.84	4.86	4.71	4.60
minimize the impact of climate change (i.e., adaptation)	4.47	4.56	4.59	4.33	4.22	4.54	4.23	4.55	4.84	4.29	4.69
reduce greenhouse gas emissions (i.e. mitigation)	4.58	4.65	4.76	4.33	4.74	4.62	4.36	4.62	4.88	4.51	4.66

Note: Green shows comparatively high ratings, red low ratings. "Entire Sample" sum is more than individual country sums due to respondents reporting "other."

Table 3: Highest and Lowest Rated Dimensions for Each Country*

Country	Highest rated	Second highest rated	Third highest rated	Fourth highest rated	Lowest rated	Second lowest rated	Third lowest rated	Fourth lowest rated
Singapore	Water availability	Air pollution	Energy R&D	Security of supply	Energy decentralization	Domestic fuel depletion	Transparency in energy decisions	Energy intensity
India	Water availability	Security of supply	Energy R&D	Land degradation	Energy decentralization	Price stability	Equitable distribution	Energy intensity
Japan	Air pollution	Energy R&D	Land degradation	Security of supply	Energy decentralization	Transparency in energy decisions	Education and equitable distribution (tie)	-
China	Security of supply	Land degradation	Air pollution	Water availability	Energy decentralization	Trade	Education	Transparency in energy decisions
Kazakhstan	Water availability	Land degradation and Air pollution (tie)	-	Security of supply	Energy decentralization	Energy intensity	Climate change adaptation	Transparency in energy decisions
Saudi Arabia	Water availability	Air pollution	Security of supply	Energy R&D	Depletion	Energy intensity	Transparency	Decentralization
US	Water availability & Energy R&D (tie)	-	Air pollution	Land degradation	Energy decentralization	Domestic fuel depletion	Affordability	Security of supply
Brazil	Energy R&D	Land degradation	Water and Climate change mitigation (tie)	-	Energy decentralization	Energy intensity	Transparency in energy decisions	Domestic fuel depletion
Germany	Energy R&D	Climate change mitigation	Energy intensity	Land degradation	Security of Supply	Domestic fuel depletion	Transparency in energy decisions and Price stability (tie)	-
Papua New Guinea	Water	Land degradation	Affordability and -	-	Domestic fuel	Energy	Energy	Trade

* Where there was a tie between two dimensions, the next dimension was skipped

Table 4: Energy Security Ratings and Ranking Across All Dimensions and Respondents (n=2,167)

	Ratings (Range: 1 = extremely unimportant; 5 = extremely important)	Rankings (% Ranking criterion as 1 st , 2 nd in importance)	
To provide available and clean water	4.72	31%	To have a secure supply of coal, gas, oil and/or uranium
To minimize air pollution	4.71	22%	To conduct research and development on new and innovative energy technologies
To conduct research and development on new and innovative energy technologies	4.71	21%	To reduce greenhouse gas emissions (i.e. mitigation)
To minimize the destruction of forests and the degradation of land and soil	4.66	18%	To provide available and clean water
To reduce greenhouse gas emissions (i.e. mitigation)	4.58	15%	To minimize depletion of domestically available energy fuels
To have a secure supply of coal, gas, oil and/or uranium	4.50	15%	To minimize air pollution
To minimize the impact of climate change (i.e., adaptation)	4.47	14%	To minimize the impact of climate change (i.e., adaptation)
To assure equitable access to energy services to all of its citizens	4.44	14%	To have low energy intensity (unit of energy required per unit of economic output)
To inform consumers and promote social and community education about energy issues	4.42	14%	To have affordably priced energy services
To have low energy intensity (unit of energy required per unit of economic output)	4.41	13%	To minimize the destruction of forests and the degradation of land and soil

3.1 Availability

For this study, availability of energy includes not only concerns about the security of supply of fossil fuels, but also the depletion of domestic fuel resources, as well as the decentralization of energy supply.

3.1.1 Secure supply of fossil fuels

Survey respondents rated supply of fossil fuels sixth among the sixteen dimensions. However, when we look at rankings instead of ratings, Table 4 reveals that this dimension is ranked at the top position by a majority of respondents. To those of us in the energy policy community studying energy security, these results may come as no surprise. Security of supply is one of the most crucial components of energy security and one most readily associated to energy security in literature reviews [6, 8 – 11]

Interestingly, however, our survey results revealed a difference between Asian and Middle Eastern respondents on the one hand, and Western respondents on the other, in terms of how they prioritized security of supply. Those from China, India, Japan, Kazakhstan, Saudi Arabia, Singapore and Papua New Guinea, the Asian and Middle Eastern countries among the sample placed security of supply among the top four rated dimensions, as Table 3 depicts. However, this was not the case amongst Brazil, Germany, and the United States. This is further confirmed by comparing the normalized ratings on security of supply across all countries, data presented by Figure 3. The process of normalization involved dividing all the country level dimension ratings by the country's average rating, and then multiplying by the total cross-country average rating. This recalibrated the ratings at a country level and removed cultural biases between countries – for example – it corrected for the tendency of Brazil residents to give higher scores to all dimensions in comparison to residents of countries such as Singapore and Japan.

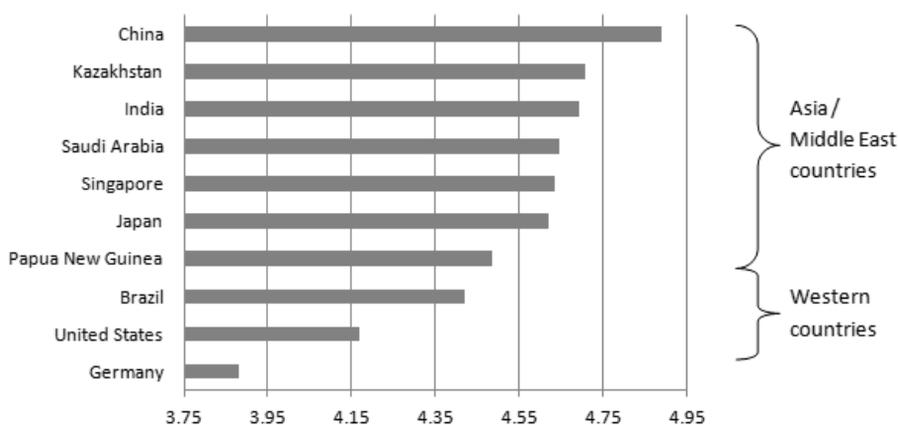


Figure 3. Normalized rating on the dimension “Secure supply of fossil fuels” across the ten countries

3.1.2 Depletion of domestic fuel reserves

Depletion of domestic reserves was another dimension that we asked respondents to rate. On this dimension, China, Japan and Kazakhstan emerged as countries with comparatively greater concern about domestic depletion, and Singapore, Germany and USA emerged as ones with the least concern, data reflected in Figure 4. Interestingly, Figure 5 shows that government employees were the most conscious of fuel security. They have the highest scores on security of supply of fossil fuels, and on minimizing the depletion of domestic fossil fuels.

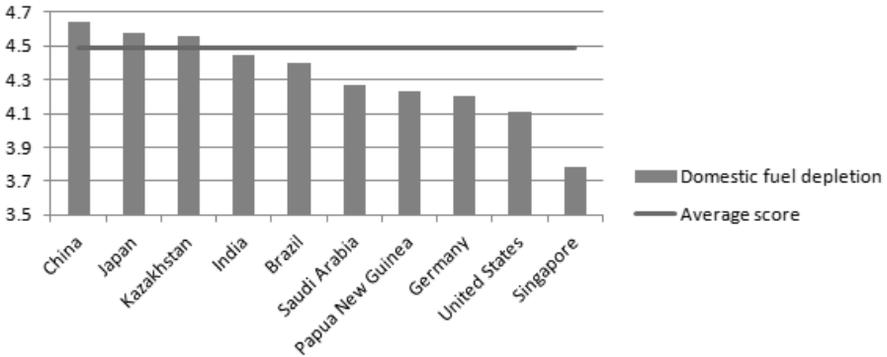


Figure 4. Normalized rating on the dimension “depletion of domestic fuel reserves” across the ten countries, compared to a normalized average score

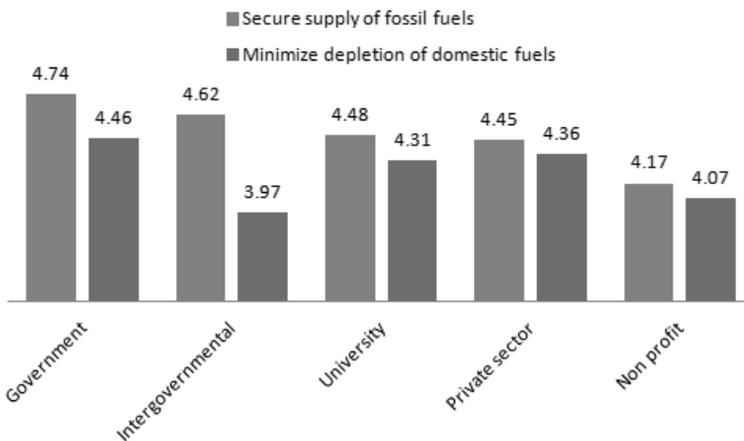


Figure 5. Average scores on two dimensions across occupation categories

3.1.3 Decentralised and small scale systems

Also, we asked respondents to rate and rank the importance of decentralized and small scale energy systems. As a sign of favor against decentralization and towards large-scale, capital intensive infrastructure, Table 4 above shows how lowly rated decentralized supply was among respondents. When normalized, Figure 6 shows that China scored the lowest on this ‘decentralization’ dimension, underscoring the importance it gives to centralized systems. At the other end of the spectrum was Germany, which gave this dimension the highest score, perhaps reflecting the growing recognition there about small scale renewable systems.

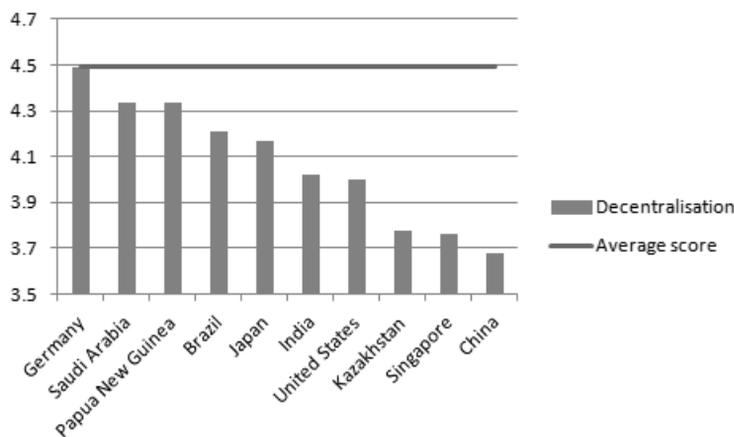


Figure 6. Normalized rating on the dimension “small scale, decentralized systems” across the ten countries, compared to a normalized average score

3.2 Affordability

Our survey captured this dimension through questions on the importance of affordably priced energy services, as well as that of equitable energy distribution to all citizens.

Both affordability and equity came out as ‘middling’ dimensions in importance, even for poorer countries, underscoring by Tables 2 – 4 above. Apart from Papua New Guinea, no country put these dimensions in their top four rated dimensions. This is surprising for poorer countries in the list such as India where energy access is highly unequal between income groups. In Figure 7, we compared the scores on the two dimensions of ‘affordability’ and ‘equity’ to actual per capita electricity consumption in that country. We found that in the United States– the country with the highest per capita electricity consumption - the normalized score for affordability was the lowest. This may be due to the already affordable prices of electricity there, partly contributing to the high levels of consumption. At the other end of the spectrum, in India, where electricity consumption is one of the lowest per capita, affordability was more highly rated compared to other countries. So although the affordability dimension is not significantly important compared to other energy security dimensions in India, it

emerges as important relative to other countries. In terms of energy equity, again India and the US showed diametrically opposite patterns. In the US, which has high electricity consumption, a high level of importance placed on equity, whereas in India, with lower electricity consumption, equity was given a lower level of importance. The pattern represented by the US and India seems to suggest that with rising consumption levels, equity concerns start to rise whereas affordability concerns begin to fall.

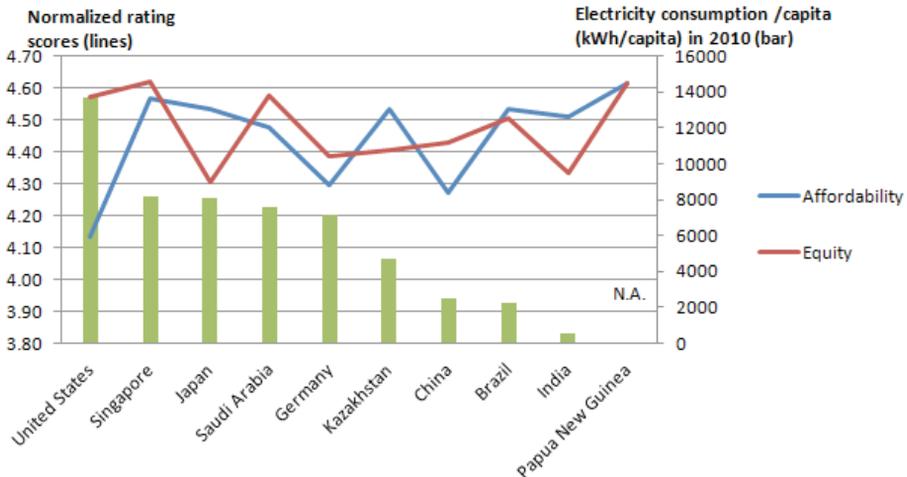


Figure 7. Comparison of Energy poverty dimensions with energy consumption

3.3 Energy Efficiency

Energy efficiency was captured through two questions in our survey: low energy intensity (i.e., unit of energy spent per unit of GDP produced), and the importance to research and development in new and innovative energy technologies.

3.3.1 Low energy intensity

As Figure 3 depicted above, this dimension is not an energy security priority in most countries. Other concerns are viewed as more pressing on energy security compared to low energy intensity. In six of the ten countries (Singapore, India, Brazil, Papua New Guinea, Saudi Arabia and Kazakhstan), low energy intensity was rated amongst the bottom four dimensions (see Table 3). Even when normalized scores were compared to the normalized average score, Figure 8 shows that only Germany, Japan, US and China gave it above average ratings.

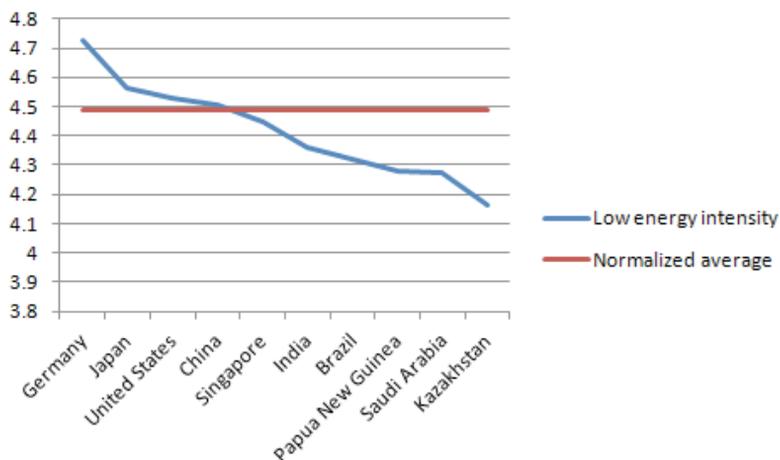


Figure 8. Normalized scores on low energy intensity when compared to the average score

Perhaps three factors play a role in explaining these results, and diminishing the importance of low energy intensity. First, there are quite a few impediments to investments in energy efficiency measures when compared to returns on other infrastructure. For example, in India, a World Bank study in collaboration with the Indian Renewable Energy Development Agency [12] found that there were several barriers to implementation of such measures, including perceived technical uncertainties in new technological solutions, or the inability of government or municipal energy users to raise the required capital. Second, there is a rebound effect of energy efficiency measures which reduces their effectiveness. According to Jin [13], in South Korea the effectiveness of energy efficiency measures was reduced by 38% at the macro level in the short run, due to rebound effects, i.e., the tendency of consumers to consume more energy due to the economic benefits from efficiency improvements. Third, the energy efficiency market is typically plagued by the 'principal-agent' problem, i.e., the mismatch of incentives to save energy due to costs accruing to one party (landlords or builders), and benefits accruing to another (tenants or residents). This leads to a lack of motivation for landlords to invest in energy efficiency measures, unless policy actions are undertaken by governments to mandate such measures. A study conducted by Sathaye and Murtishaw and coordinated by the IEA [14], found that over a quarter (25.8%) of primary residential energy use related to space heating, water heating and refrigeration and lighting in the US in 2003 was vulnerable to principal-agent problems.

3.3.2 Research and development (R&D)

Almost all countries, with the exception of Papua New Guinea, gave above average importance to conducting R&D on new and innovative energy technologies (see

Figure 9). The countries giving it the highest importance were Germany, US, China and Japan. Also, six of the ten countries – namely USA, India, Germany, Japan, Brazil, and Singapore – have rated R&D as among their top three dimensions, and a seventh - Saudi Arabia - among the top four. We also tried to compare R&D ratings to the economy-wide R&D spending as a proportion of GDP by the particular country, available from World Bank’s World Development Indicators [15]. Figure 10 shows that countries with stronger R&D expenditures as a percent of GDP (Japan, US, Germany and Singapore) together had higher scores on the R&D dimension in the survey than others.

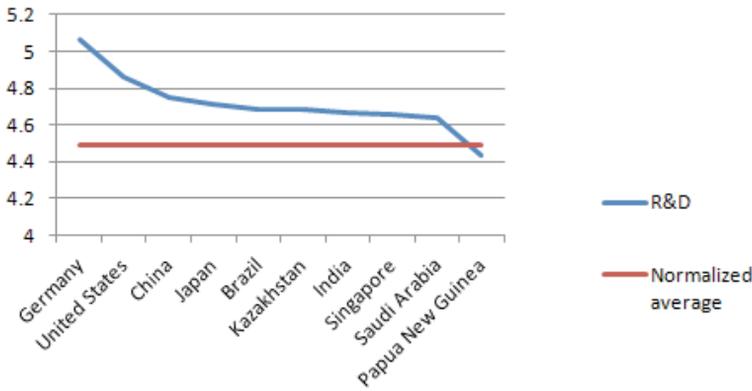


Figure 9. Normalized scores on R&D compared to the average score

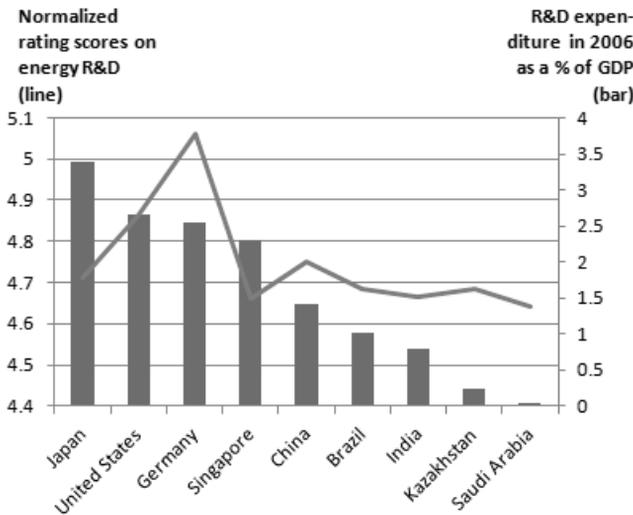


Figure 10. Ratings on energy R&D compared to actual country R&D spending as a percentage of GDP

As a final intriguing point, the link between energy R&D and low energy intensity scores was very high. The ratings of these two variables aggregated at the country level had a Pearson's correlation coefficient¹ value of 0.76. This indicates a high degree of positive linear dependence between the two variables. Figure 11 below illustrates this relationship visually. The results imply that although R&D spending on average is far more important than low energy intensity to the survey takers, countries that prioritize R&D spending also seem to prioritize low energy intensity. These are perhaps the countries that realize that energy security is more than just a supply side problem – it needs demand reduction and technology spurts in equal measure.

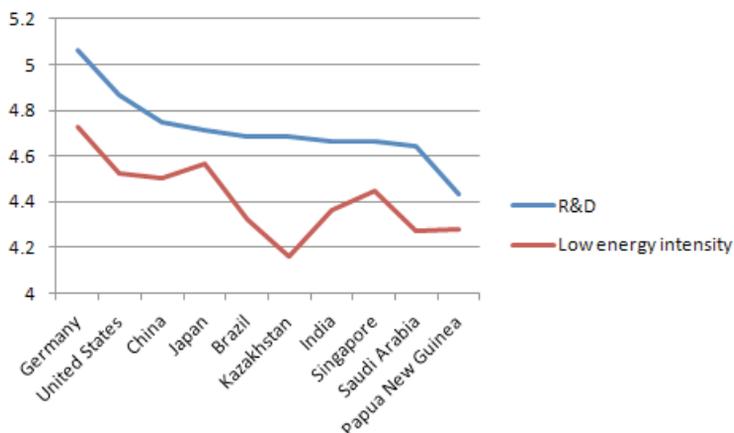


Figure 11. Correlation between ratings on low energy intensity and energy R&D

3.4 Stewardship

For our survey, stewardship consists of several aspects – local environmental factors such as water pollution, air pollution and land degradation, climate change and energy governance.

3.4.1 Water availability

Water availability is a concern closely linked to energy security due to the requirement to cool temperatures in thermal and nuclear power stations, and for generating hydroelectricity. Unexpectedly, water availability emerged as the most highly rated concern across all respondents when results are presented in aggregate. At a country level, in seven of the ten countries water availability was among the top three criteria. Only in three countries (China, Japan and Germany) was it not featured amongst the top ten.

¹ The Pearson correlation coefficient is obtained by dividing the covariance of two variables by the product of their standard deviations. It ranges from +1 to -1, depicting the two extremes between perfect positive or perfect negative linear relationship.

3.4.2 Air pollution

Also unexpectedly, air pollution emerged as the second highest rated dimension in our survey). Figure 12 shows that Singapore and China were the most concerned about air pollution, whereas Papua New Guinea and Brazil were the least concerned. We compared the air pollution ratings to actual air pollution levels in the country, by using the World Bank’s latest PM10 indicators. The World Bank defines this indicator as follows:

“Particulate matter concentrations refer to fine suspended particulates less than 10 microns in diameter (PM10) that are capable of penetrating deep into the respiratory tract and causing significant health damage. Data for countries and aggregates for regions and income groups are urban-population weighted PM10 levels in residential areas of cities with more than 100,000 residents. The estimates represent the average annual exposure level of the average urban resident to outdoor particulate matter. The state of a country’s technology and pollution controls is an important determinant of particulate matter concentrations.”

Our comparison in Figure 12 does not show a strong relation between actual air pollution levels and the ratings that air pollution received in the survey.

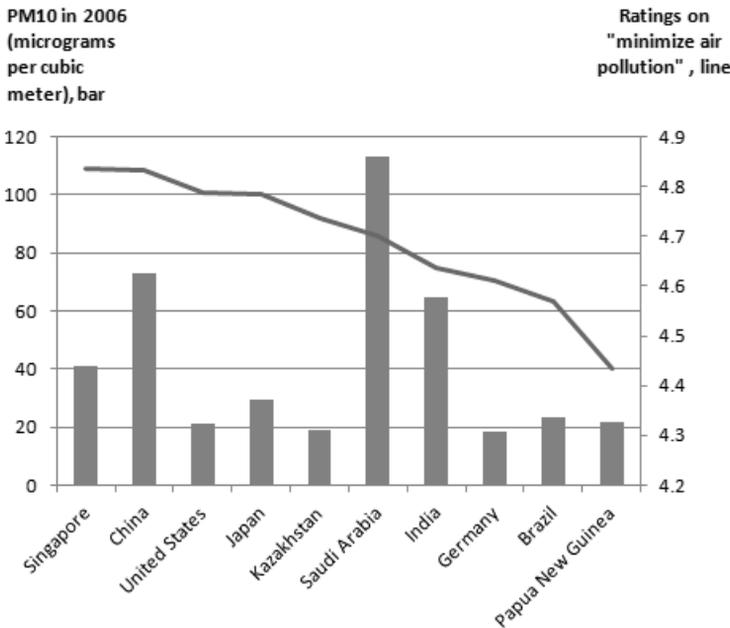


Figure 12. Normalized rating on the dimension “minimize air pollution” across the ten countries

3.4.3 Climate Change adaptation and mitigation

In general, climate change mitigation and adaptation were not amongst the top few dimensions – they were rated fifth and seventh rated across all dimensions. Local environmental factors such as water availability, air pollution and land degradation were rated above climate change mitigation. This leads us to hypothesize that although people are conscious of environmental degradation, they are perhaps more conscious of their local environment than a global problem like climate change which does not have immediate perceived repercussions to them.

However, in Brazil, Germany, and Papua New Guinea, Figure 13 illustrates that climate change mitigation showed up as more important than air pollution. Brazil has long been a supporter of action on climate change, in a large part to encourage action to reduce Amazonian deforestation, and it perhaps links climate change closely to local action on deforestation. Germany, as the only EU country among the ten, is also a forerunner in action on climate change. In Papua New Guinea as well, local air pollution is not a great concern due to reasonable air quality (21.4 PM10 micrograms per cubic meter in 2006, according to [15]), and in comparison, by virtue of it being a Pacific island country subject to rising sea levels, climate change is a pressing political and environmental problem. Our results from Figure 14 also suggest that climate change mitigation is more important for the government compared to private sector employees in the US, India, Germany, Saudi, Brazil, Kazakh, and Papua New Guinea, but that in Singapore, China and Japan, climate change mitigation is more important for the private sector

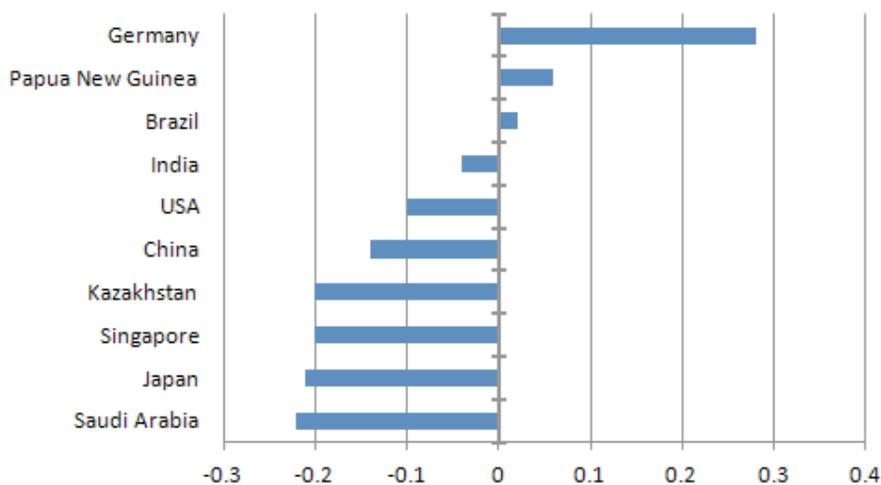


Figure 13. Difference between the average ratings of “climate change mitigation” and “minimize air pollution” dimensions, by country

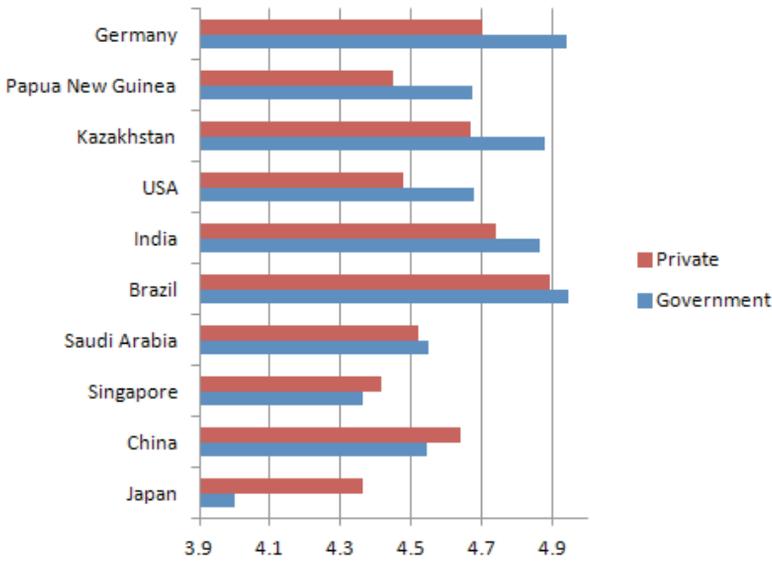


Figure 14. Average rating on climate change mitigation between respondents working for government versus private sector

We also asked respondents about climate change adaptation. Figure 15 illustrates that adaptation scored lower ratings than mitigation in almost all countries except for Papua New Guinea and Singapore. Adaptation is most important for China, United States, Singapore, Brazil and Papua New Guinea on normalized scores. These are countries that are moderately or highly vulnerable to the impact of climate change by 2020 [16] – see figure 16. However, what is surprising is that India and Saudi Arabia, which are categorized in the referenced report as highly and moderately vulnerable to climate change respectively, do not rate adaptation as highly.

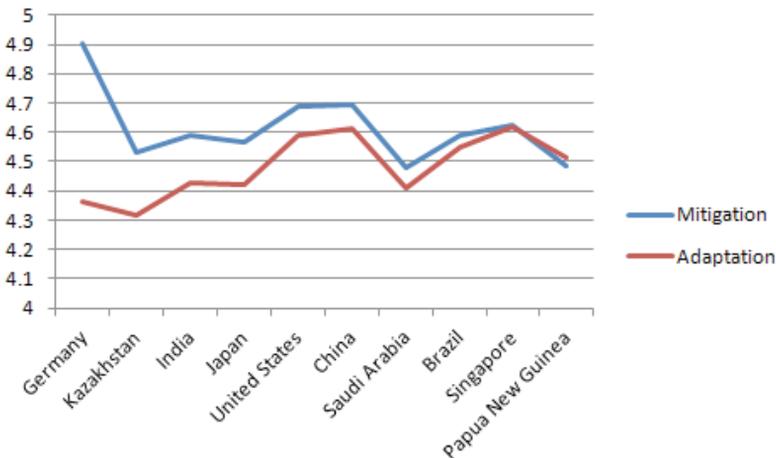


Figure 15. Normalized scores on climate change mitigation and adaptation

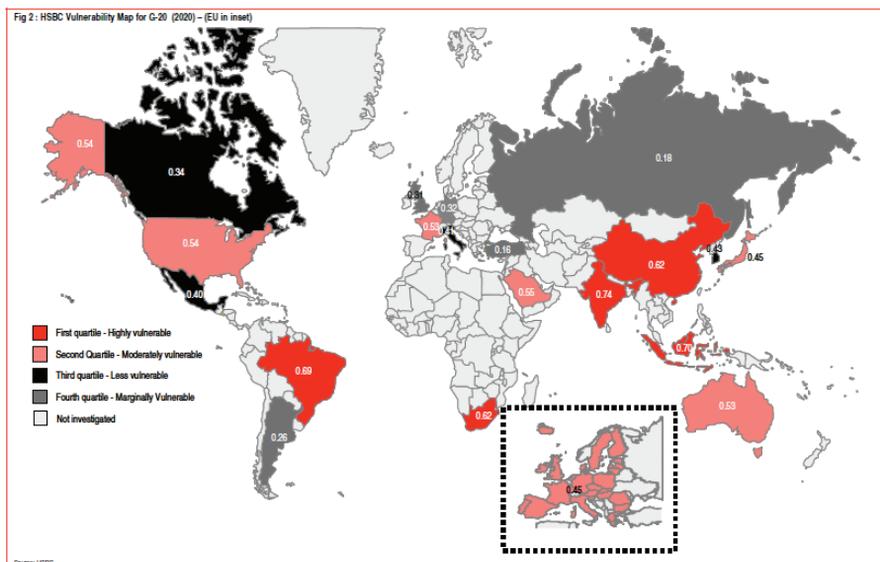


Figure 16. HSBC’s Vulnerability Map for G-20 by 2020

3.4.4 Energy Governance

Lastly, on energy governance, we asked questions relating to the importance of transparency and participation in citing of energy infrastructure. Interestingly, the overall scores of this dimension are third from last. Seven of the ten countries (rated transparency as one of their bottom four dimensions). These ratings are loosely related to the level of corruption in the country. Transparency International’s Corruption Perceptions Index 2010 [17], for example, rates countries based on assessments and business opinion surveys carried out by independent institutions. The scale runs from 10 (highly clean) to 0 (highly corrupt). Figure 17 shows that Singapore and Japan are amongst the least corrupt nations on the Corruption Perceptions Index, and they also have amongst the lowest rating scores on transparency from our survey. Similarly, Papua New Guinea and India have high levels of corruption, and also rate transparency highly – energy consumers perhaps identifying an energy security dimension they desire, yet is currently lacking within their country. The only exceptions to this trend rule seem to be the US and China – US respondents rated transparency highly but the country has low levels of corruption, and Chinese respondents rated transparency lowly but the country has relatively high levels of corruption.

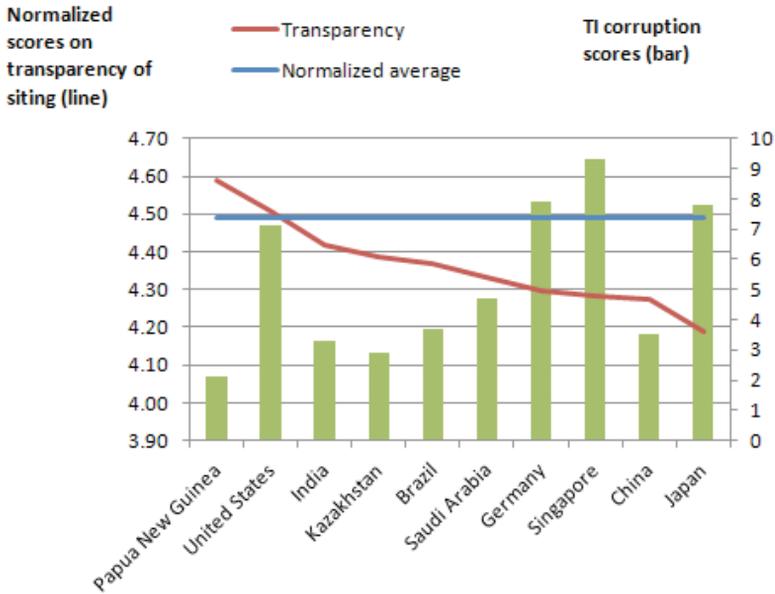


Figure 17. Comparison of energy governance with country corruption

4. CONCLUSION

Our study asked over two thousand respondents in ten countries to rate the importance of sixteen dimensions linked to four components of energy security. We offer four conclusions related to each of these four components: availability, affordability, energy efficiency, and stewardship. In terms of availability, we found that security of supply was amongst the top ranked dimensions. There was also a notable difference between Asian and other countries regarding the importance placed on the security of supply. In addition, government employees seemed to place a premium on fuel security dimensions compared to private sector employees. Decentralized energy systems were not considered important in increasing energy security, and decentralization emerged as the lowest rated across all dimensions. Within countries, it scored the lowest in China, and the highest in Germany.

In terms of affordability, dimensions relating to prices and equity were moderately rated. Our results suggest a link between conceptions of affordability and per capita energy consumption. The US, which was the highest per capita consuming country, showed a high regard for equitable distribution, but a low regard for affordability. In direct contrast was India, the lowest energy consuming among the ten, showing a low regard for equitable distribution but a high regard for affordability.

In terms of energy efficiency, the two dimensions of energy R&D spending and low energy intensity had a high correlation coefficient of 0.76. However, between these two attributes, R&D was more highly rated than low energy intensity. Among countries, those that showed higher ratings on both these dimensions were those that

typically had a higher percent of their GDP spend on R&D. These were Germany, Japan and the US.

In terms of stewardship, local environmental factors emerged as some of the most important dimensions across all the sixteen. Water availability came out as the most important, and air pollution was the second most important. Climate change mitigation and adaptation were less important than local environmental factors in nearly all countries. Within climate change, mitigation was rated more highly than adaptation in almost all countries. Stewardship also included governance issues of transparency. The transparency dimension was typically rated low in importance. We also found that countries with low levels of corruption (such as Singapore, Japan and Germany) rated transparency as lower in importance compared to countries with higher levels of corruption (such as India and Papua New Guinea).

Our study is the first we know of to survey the energy security opinions of citizens across multiple countries. However, it does signify the need for further research. One would be looking in future surveys not at national background, but demographic characteristics such as age or gender. Analysts could explore, for example, how perceptions differ between 50-year-old males from the university sectors in all the countries, or between 30-year-old females in the NGO sector across the countries. Or they could analyze responses between the less educated and the more educated respondents to determine if more education has a significant influence on respondent's ratings and rankings of the dimensions of energy security. Another would be breaking down aspects of energy security according to sectors (such as residential consumers, transportation, agriculture, etc.) to see if concerns and perceptions differ within or between them. Still another would be relying on qualitative instruments to collect data on energy security where respondents can ask for feedback rather than quantitative ones such as the survey, which was administered online (so participants could not ask for clarification).

Notwithstanding these shortcomings, perhaps the most salient lesson from our results is energy security is a multi-dimensional concept, where different people put different priorities on its various components, often depending on their inherent circumstances. Figure 18 shows that security of supply is only one aspect of energy security, and environmental stewardship is, perhaps surprising to many experts in the field, considered even more salient. If that is true, then policymakers and planners might be wise to start reconsidering their conceptions of what energy security is, and how it can be improved.

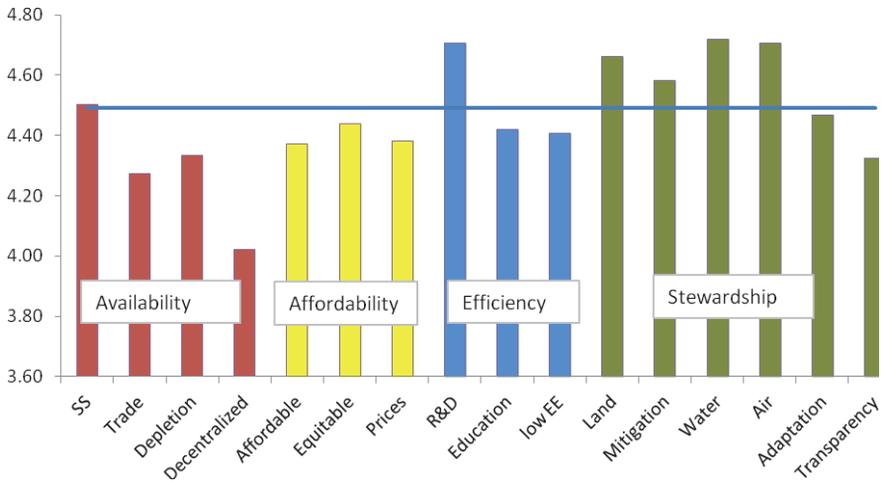


Figure 18. Comparison of average scores of the sixteen dimensions, sorted into four components

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Annex: The Energy Security Survey**ENERGY SECURITY SURVEY**

This is a short survey on the different dimensions and challenges of energy security. Please think about the key energy-related challenges facing your country of residence when filling out this survey.

SECTION 1

1. Please tell us about yourself:

- a. Level of education: Postgraduate Undergraduate Secondary Other
- b. Age: 18 to 25 26 to 35 36 to 45 46 to 55 55 and above
- c. Gender: Male Female
- d. Country of residence:
 - United States
 - Brazil
 - Russia
 - China
 - India
 - Kazakhstan
 - Papua New Guinea
 - Saudi Arabia
 - Singapore
 - Japan
 - Germany
- e. Nationality:

- f. Type of Occupation:
 - Private sector / industry / business / for-profit organization
 - Non profit, non-governmental organization / civil society
 - Government / national institute / regulatory agency
 - University / school / academic institution
 - Intergovernmental organization
- g. Name of Primary Employer (optional):

- h. Job Title (optional):

SECTION 2

2. When you think about energy security for your country of residence in the next five years, how important is it

...to have a **secure supply of oil, gas, coal, and/or uranium**

Extremely important	Somewhat important	Neither important nor unimportant	Somewhat unimportant	Extremely unimportant
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

...to promote **trade** in energy products, technologies, and exports

<input type="checkbox"/>				
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...to **minimize depletion** of domestically available energy fuels

<input type="checkbox"/>				
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...to have **stable, predictable, and clear price signals**

<input type="checkbox"/>				
--------------------------	--------------------------	--------------------------	--------------------------	--------------------------

...to have **affordably priced energy services**

<input type="checkbox"/>				
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...to have **small-scale, decentralized** energy systems

<input type="checkbox"/>				
--------------------------	--------------------------	--------------------------	--------------------------	--------------------------

...to have **low energy intensity** (unit of energy required per unit of economic output)

<input type="checkbox"/>				
--------------------------	--------------------------	--------------------------	--------------------------	--------------------------

...to conduct **research and development** on new and innovative energy technologies

<input type="checkbox"/>				
--------------------------	--------------------------	--------------------------	--------------------------	--------------------------

...to assure **equitable access** to energy services to all of its citizens

<input type="checkbox"/>				
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...to ensure **transparency and participation** in energy permitting, citing, and decision-making

<input type="checkbox"/>				
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...to inform consumers and promote social and community **education** about energy issues

<input type="checkbox"/>				
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...to minimize the destruction of Land degradation and the degradation of **land** and soil

<input type="checkbox"/>				
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...to provide available and clean **water**

...to minimize **air pollution**

...to minimize the impact of **climate change** (i.e., adaptation)

...to reduce **greenhouse gas emissions** (i.e. mitigation)

SECTION 3

3. Given the sixteen dimensions of energy security discussed here, select the five that you think are most important for your country of residence, and rank them from 1 (the most important) to 5 (5th most important), without allowing for ties. Please rank only 5 dimensions:

- Secure supply of oil, gas, coal, and uranium
- Bolstering trade
- Minimizing rates of depletion
- Predictable and clear price signals
- Affordably priced energy services
- Decentralization and small-scale supply
- Low energy intensity
- Research and development
- Equitable access
- Transparency and participation in citing and decision-making
- Education and information
- Preservation of land
- Availability and quality of water
- Minimal air pollution
- Responding to climate change/adaptation
- Reducing greenhouse gas emissions/mitigation

4. Did we miss any dimension that you consider important for the energy security of your country of residence in the next five years? Please enter below (or if we didn't, then leave blank)
-

If you did provide an answer, when you think about energy security for your country of residence in the next five years, how important is this above dimension?

- Extremely Important
- Somewhat Important
- Neither Important nor Unimportant
- Somewhat Unimportant
- Extremely Unimportant