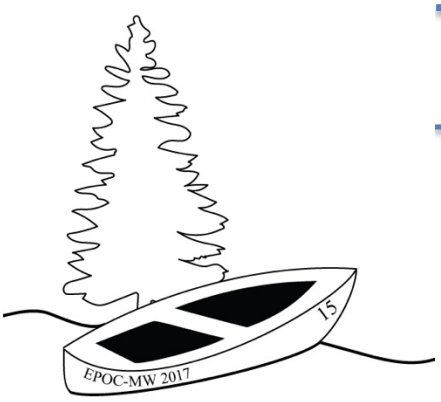

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Oh The Places You'll Go: How Renewable Electricity Is Constructed

Leigh Allison, University of Washington, USA

Jessica Kaminsky, University of Washington, USA

Proceedings Editors
Ashwin Mahalingam, IIT Madras, Tripp Shealy, Virginia Tech, and Nuno Gil, University of Manchester

OH THE PLACES YOU'LL GO: HOW RENEWABLE ELECTRICITY IS CONSTRUCTED

Leigh Allison[1], Jessica Kaminsky[2]

ABSTRACT

Widespread adoption and installation of renewable energy is vital to slowing climate change. This early stage research explores the statistical relationships between renewable electricity production and latent cultural dimensions embedded in the World Values Survey. Using principle component analysis, we discovered two latent cultural dimensions based on 51 nations: (1) secular-rational versus traditional values, and (2) survival versus self-expression. Both dimensions have significant inverse linear relationships with renewable electricity generation. Therefore, the data show that societies that hold more secular-rational values and promote self-expression tend to have more renewable electricity generation. Practically speaking, these findings can help guide industry professionals and policy makers as they engage, design, and implement projects within different societies.

KEYWORDS: Renewable Energy, World Values Survey, Culture, Social Sustainability

INTRODUCTION

This early stage research explores the statistical relationships between latent cultural dimensions embedded in the World Values Survey ("World Values Survey" 2016) and renewable electricity production. The development and installation of renewable energy infrastructure is essential to the continued production of power around the globe and to the fight against climate change. However, even with the reduced cost of construction and the advancements in storage and gird technologies, the construction of renewable energy is not yet widespread (EIA 2016). Recent research suggests that cultural factors affect the diffusion of renewable energy (Kaminsky 2016; Pierce et al. 2009). However, as our own previous studies have shown, culture is not consistently defined or measured (Allison and Kaminsky 2015). In this study, we define culture as beliefs held and behaviors by a group of people over time, and we use the World Values Survey to operationalize this definition. In conjunction with the World Values Survey, we use renewable electricity generation data from the World Bank as the operationalized renewable energy diffusion variable.

Building off of previous work (Kaminsky 2016), this study contributes to the literature focused on national values' impact on infrastructure design and construction. More specifically, we seek to answer the question: how do national cultural values influence the installation of renewable electricity generation around the world? In order to answer this question, we use statistical analyses to (1) measure latent cultural dimensions represented in the World Values Survey and

[1] University of Colorado Boulder, USA, allison.davis@colorado.edu

[2] University of Washington, USA, jkaminsk@uw.edu

(2) understand the relationship between latent cultural dimensions and renewable electricity generation.

POINTS OF DEPARTURE

THE SOCIAL REPRESENTATION OF RENEWABLE ENERGY

Renewable energy technologies are both a social and technological innovation. Therefore, not only do experts, developers and policy makers affect their adoption and implementation but so do the media and the public. For example, communication between the public and professionals shape how communities view renewable energy projects and how the experts view the communities (Batel and Devine-Wright 2015). To formalize the influences that each party has on the other, Walker and collaborators (2010) developed a framework for public engagement in renewable energy projects. The framework specifically focuses on (1) equalizing the role of the public and renewable energy actors (i.e. developers, promoters, etc) in project success, (2) understanding the expectations of both groups, (3) displaying how interactions change with time and finally (4) contextualizing the projects within the location. Using UK wind projects as case studies, the research team identified that both the public and renewable energy actors have project expectations, which influence their interactions. In particular, renewable energy actors have many established processes and expectations, which guide interactions with the public. For example, all the renewable energy actors in the study mentioned community hostility as though it was expected for every project. This led the wind industry to focus on community benefit packages (Devine-Wright 2010). On the other hand, the public (as a group and individually) has a different set of processes and expectations. They become aware of a project, interpret how it might impact their community, evaluate the actual proposal and finally respond to the renewable energy (Devine-Wright 2010). These expectations and interactions ultimately affect the project's success. In the UK, many of the project case studies were denied due to poor interaction and misunderstanding between stakeholders.

Social representation theory can explain the varying interpretations, expectations, and behaviors of renewable energy actors. A social representation is a system of "opinions, knowledge, and beliefs, particular to a culture, a social category or a group with regard to objects in the environment" (Rateau et al. 2012 p. 478). Social representation theory argues that people create social representations to understand the world around them (Batel and Devine-Wright 2015; Höijer 2011). These shared understandings are the foundation of culture within a society (Smith et al. 2013). Thus people within the same culture will have similar understandings of the renewable energy situation. While individuals may not agree on how to run a successful project, culture at national level could indicate if there is a general understanding supporting or rejecting the development of renewable energy technologies. Therefore, we argue that the national level cultural trends are able to adequately capture cultural values, which are more favorable to successful renewable energy projects.

MEASURING CROSS-CULTURAL DIFFERENCE: THE WORLD VALUES SURVEY

For this research, we focus on culture at a national level. While not all scholars agree that culture can be accurately measured at the national level, national cultural values provide a unit of analysis which is standardized (political national boundaries) and comparable across nations (Smith et al. 2013). Among the first and most influential to study culture at a national level was Geert Hofstede. In the 1960s and 70s, Hofstede surveyed thousands of IBM employees across

the world. From this data, he proposed four national cultural dimensions, which describe the relationship between (1) authority and social inequality, (2) individuals and groups, (3) masculinity and femininity, and (4) uncertainty and emotions. For each of these cultural dimensions, Hofstede created an index, where each country could be ranked on a scale of 0 to 100 (Hofstede et al. 2010). Later, Hofstede has added two more dimensions: long-term orientation and indulgence versus restraint. Hofstede defended these indexes through the study the regions within nations. Hofstede and collaborators demonstrated that even though national cultural parameters mask unique traits of regional (sub) cultures, these subcultures tend to cluster as a nation. Thus, Hofstede's national cultural indexes can indicate general trends and shared interpretation; his dimensions cannot provide specific cultural details about a single nation (Minkov and Hofstede 2012). In this study, we do not use the Hofstede dimensions as the basis for our regression model as this has already been done (Kaminsky 2016). Kaminsky found the preference for a nation to avoid uncertainty and encourage empathy – low masculinity – positively related to the amount of renewable electricity generated in those nations, implying that renewable energies are used to improve the reliability of electricity and to avoid dependence on a larger electrical grid (Kaminsky 2016).

We use a similar research approach as Hofstede and Kaminsky. However, due to the limited sample size and age of the Hofstede data, we choose to use World Values Survey data in order to create national cultural dimensions. We believe the World Values Survey is more comprehensive than Hofstede as well as other available cultural models because it has been distributed in seven waves over the last 37 years to nationally representative populations worldwide (WVS Association 2016). Furthermore, the survey asks about a much larger variety of issues. Therefore, we suspect that the cultural dimensions discovered will be more insightful and representative of the national cultures they are attempting to model. The World Values Survey has been analyzed by many researchers, but arguably the most influential findings are from Inglehart-Welzel cultural map (Inglehart and Welzel 2005).

A political scientist from the University of Michigan, Robert Inglehart the founding president of the World Values Survey Association, and Welzel, a political scientist from Leuphana Universitat, is currently the second vice-president of the World Values Survey Association. The Inglehart-Welzel cultural map shows two major dimensions that can summarize the majority of cross-cultural variation. First, the *traditional versus secular or rational* dimension studies how the nations range from traditional or those who emphasize the importance of religion, respect for authority, and strong family relationships to secular-rational or those who are accepting to alternative ideas such as abortion and divorce. Second, the *survival versus self-expression* dimension describes nations who focus on economic and physical security to nations who emphasize the importance of the environment, alternative lifestyles, and participation in decisions. Inglehart and Welzel have also demonstrated how these values have changed over time. With an increase in gross domestic product (GDP), nations tend to move from traditional survival values to secular-rational and self-expression values (Inglehart and Welzel 2005). These two dimensions do not come without criticisms, particularly with respect to the statistical analyses used to obtain these relationships. In 2016, a study attempted to replicate the Inglehart-Welzel dimensions with no success. The researchers largely blame this on the lack of variable (or question) equivalence between countries (Alemán and Woods 2016; Chen 2008).

For the present research, we use an exploratory statistical analysis to discover latent variables describing cultural dimensions embedded in the WVS. This inductive approach differs from

previous analyses of the WVS, which tend to use pre-selected questions to measure previously-defined theoretical constructs. In contrast, and as will be described below, our approach allows these constructs to emerge from the data itself. Next, we seek statistically significant relationships between these emergent cultural dimensions and the prevalence of renewable technologies in national electrical grids.

APPROACH

To answer the research question, we use a subset 69 variables from 2010-2014 WVS survey. These variables are reduced into five latent dimensions using principle component analysis. Next, the latent dimensions and renewable electricity generation data (measured as a percent of the total electricity produced in that country) are modeled using a multivariate linear regression. Please note that we do not seek a predictive model but only to test if there are relationships. Future qualitative research will explore the mechanisms described in the latent dimensions at the project level.

RESEARCH DESIGN

Unit of Analysis

This study aims to discover new relationships between national cultural characteristics and renewable energy generation. The authors do not believe that nations are culturally homogeneous; however, for this study, nations are the common unit of analysis and offer platform for understanding global trends. If renewable electricity production data were available at the region or city level, this analysis could be run at smaller levels since the World Values Survey data is available at the individual level. However, currently the data is limited to a national scale; and therefore, the relationships discovered are applicable only a national level and cannot be assumed to describe every project within a country (Piantadosi et al. 1988).

Latent Dimensions

Fundamentally, every analysis is biased upon the questions that are used as variables. For example, the original two dimensions created by Inglehart and Welzel were based on ten questions which were asked in all waves of the WVS up to 2004 (wave 4). They used principle component factor analysis, which is a statistical method whereby the variables are combined due to inter-variable correlations. The dimensions that result from these analyses are often latent variables. Unlike like manifest variables (i.e. age), latent variables cannot be directly measured (i.e. happiness). Therefore, latent variables or concepts are measured with a series of manifest variables. A principle component analysis is a descriptive way of combining variability into a smaller number of uncorrelated components while a factor analysis is a model-based technique used to reduce the number of variables into uncorrelated factors. Therefore, both methods are attempting to explain a latent concept by combining manifest variables based on the variability in the original variables. Since this research is exploratory, we use the descriptive statistical approach for variable reduction because it allows the theoretical constructs to emerge from the WVS dataset. In this study, the manifest variable are the politics and society questions from wave 6 of the WVS while the latent cultural dimensions are the principle components explained in the results and discussion section (Bartholomew et al. 2008).

DATA COLLECTION

This analysis uses data from two sources. The cultural dimensions are calculated from questions in Wave 6 of the World Values Survey (WVS). The WVS can be broken into nine categories as specified in the integrated WVS codebook (WVS 2014): (1) perceptions of family life, (2) work, (3) family, (4) religion and morale, (5) politics and society, (6) environment, (7) nation, (8) security, and (9) science. Only questions related to *politics and society* were included for this analysis. This is the largest subgroup of the WVS. Wave 6 was distributed to approximately ninety thousand people in 60 countries from 2010 to 2014 (*WORLD VALUES SURVEY Wave 6 2010-2014 OFFICIAL AGGREGATE v.20150418*. 2016).

The second data source is the World Bank. The national renewable electricity production and national gross domestic product are the indicators "Electricity Production from Renewable Sources, Excluding Hydroelectric (% of Total)" and "GDP (current US$)" respectively from the publicly available World Bank database ("World Bank. Indicators | Data" 2016). In this dataset, renewable energy is defined as electricity produced from geothermal, solar, tidal, wind, biomass, or biofuel. Figure 1 shows the distribution of the renewable electricity generation data. GDP was included as an indicator of national wealth and available resources to construct innovative renewable energy technologies.

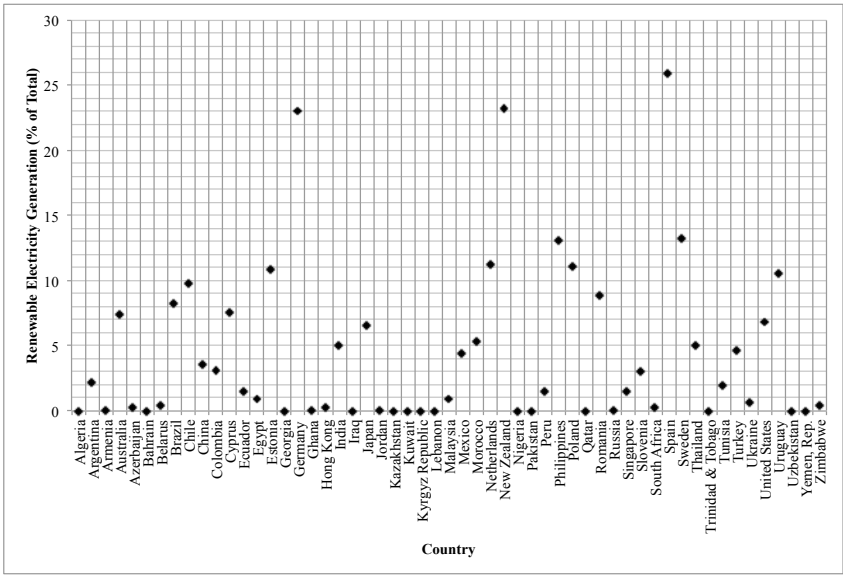

Figure 1: Renewable Electricity Generation Data

Renewable electricity generation data has been measured by the World Bank since 1960; however, after 2014 is sparse. Therefore, a combination of 2013 and 2014 data was used to create a data frame with the most recent available data. GDP is based on 2015 data. We merged and cleaned the collected data into three new data sets.

To reduce the Wave 6 data into country-level variables, the individual data was summed according to response to the question. For categorical questions, we broke each question into multiple variables – each variable representing a categorical response option, as shown in Table

1. Typically, this was five response variables per question. We then calculated the percentage of people in each country who choose that response. For the ordinal questions (i.e. Likert scale), we grouped pairs of responses. For example, 1-2 was considered one category for purposes of the percentage of people who choose that responses. This was done in order to keep the number of variables related to a single questions approximately the same. We also created dummy variables representing missing values. These dummy variables removed nine countries and 64 of 118 questions from the analysis due to large amounts of missing values. The resulting data set contains 51 countries with 54 questions (resulting in 225 variables).

Table 1: Expansion of Questions to Variables

Question 223: How often do you use the internet to obtain information about what is going on this country and the world?	
Variable Name	**Response**
223_Cat 1	Daily
223_Cat 2	Weekly
223_Cat 3	Monthly
223_Cat 4	Less than Monthly
223_Cat 5	Never

Moving forward this data set is called the *WVS data set*. The second data set merged the renewable electricity percentages with the WVS data set. This data set - *renewable data set* -, contains data for 49 countries. Finally, these data were merged with the 2015 GDP data to describe 48 counties. This third data set is referred to as the *control data set*.

DATA ANALYSIS

As downloaded, there are 117 coded questions associated with politics and society in the WVS data set. However, as mentioned above not all of those variables were measured for every respondent. Therefore, the WVS data set used in the principle component analysis has 225 variables and 51 countries. Figure 2 highlights the countries that are included.

Figure 2: Countries included in Analysis

Principle Component Analysis:

In order to reduce the number of variables in the *WVS data set*, principle component analysis was used. Principle component analysis (PCA) is a multivariate statistical method, which reduces the number of variables by linear combination into components, which account for the majority of the variability in the original variables. In other words, PCA converts a set of correlated variables into a set of uncorrelated components, as represented in the equations below as x_i and y_p respectively (Bartholomew et al. 2008). When the equations below are evaluated, the resulting values are called component scores.

$$y_1 = a_{11}x_1 + a_{21}x_2 + \cdots + a_{p1}x_p$$
$$y_2 = a_{12}x_1 + a_{22}x_2 + \cdots + a_{p2}x_p$$
$$\dots$$
$$y_p = a_{1p}x_p + a_{2p}x_2 + \cdots + a_{pp}x_p$$

Where a_{pp} is the loading of the variable of the component.

Typically, PCA starts with a correlation and covariance matrix. Since our data has more variables (p = 225) than observations (n = 51), we used singular value decomposition to calculate the loadings and scores. Singular value decomposition uses the matrix (n x p, where n is the number of observations, and p is the number of variables) to calculate three vectors – u_{ik}s, v_{jk}s, and singular values. The vector $u_{jk}\sqrt{n-1}$ holds the component scores; the vector $v_{jk}\sqrt{\lambda_k}$ holds the loadings; and finally, the singular values which are proportional of the eigenvalues, $\lambda_k s$. Eigenvalues are used to determine the importance of the components. Using the prcomp function in R, we analyzed the renewable energy data set. As can be seen in Figure 3, five principle components, explaining 59% of the original variance emerged. These five were retained because components five and up have small differences in the eigenvalues (Bartholomew et al. 2008).

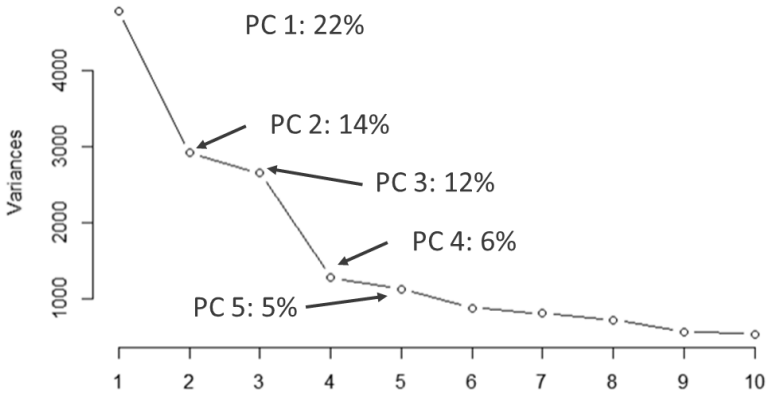

Figure 3: Scree plot of PCA with WVS Data Set

The coefficients or weights of each variable on the principle components are known as *loadings*. To simplify the interpretation, variables, which did not load on components one to five, were removed from the analysis. Loadings less than 0.1 (absolute value) were also removed from because it was assumed that they have a negligible effect on the component.

Regression Analysis

The five principle components showed a significant linear correlation (adj r^2= 0.37) with the renewable electricity generation data ($p<0.001$). The linear relationship is described in Figure 4. However, we can see that principle components three, four, and five do not significantly add to the relationship.

```
lm(formula = y ~ PC1 + PC2 + PC3 + PC4 + PC5 + Control)

Residuals:
   Min     1Q Median     3Q    Max
-9.184 -2.884 -0.546  1.868 16.005

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  4.9657928  0.8096009   6.134 2.79e-07 ***
PC1         -0.0487224  0.0112111  -4.346 8.92e-05 ***
PC2         -0.0471079  0.0138710  -3.396  0.00153 **
PC3          0.0149168  0.0144941   1.029  0.30943
PC4         -0.0150479  0.0210992  -0.713  0.47976
PC5          0.0226647  0.0220482   1.028  0.31000
Control     -0.0001974  0.0002683  -0.736  0.46620
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 5.171 on 41 degrees of freedom
Multiple R-squared:  0.4387,    Adjusted R-squared:  0.3565
F-statistic:  5.34 on 6 and 41 DF,  p-value: 0.0003787
```

Figure 4: Linear Regression – Five Principle Components

In figure 5, a simplified regression shows the relationship between the first two principle components and renewable electricity generation. In this model, we can see that principle components 1 and 2 are inversely correlated to renewable electricity generation.

```
lm(formula = y ~ PC1 + PC2)

Residuals:
    Min      1Q  Median      3Q     Max
-9.7101 -3.4882 -0.4758  2.0734 16.0584

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  4.72903    0.73718   6.415 7.54e-08 ***
PC1         -0.04663    0.01063  -4.388 6.83e-05 ***
PC2         -0.04544    0.01349  -3.368  0.00156 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 5.104 on 45 degrees of freedom
Multiple R-squared:  0.3998,    Adjusted R-squared:  0.3731
F-statistic: 14.98 on 2 and 45 DF,  p-value: 1.029e-05
```

Figure 5: Linear Regression – Principle Component 1 & 2

Using the component score for each country, we can use the simplified regression model to create a set of fitted values and compare them to the observed renewable electricity generation percentage. Thus, figure 6 shows how well the model fits the data. This model explains approximately 40% of the variation in the original renewable electricity data.

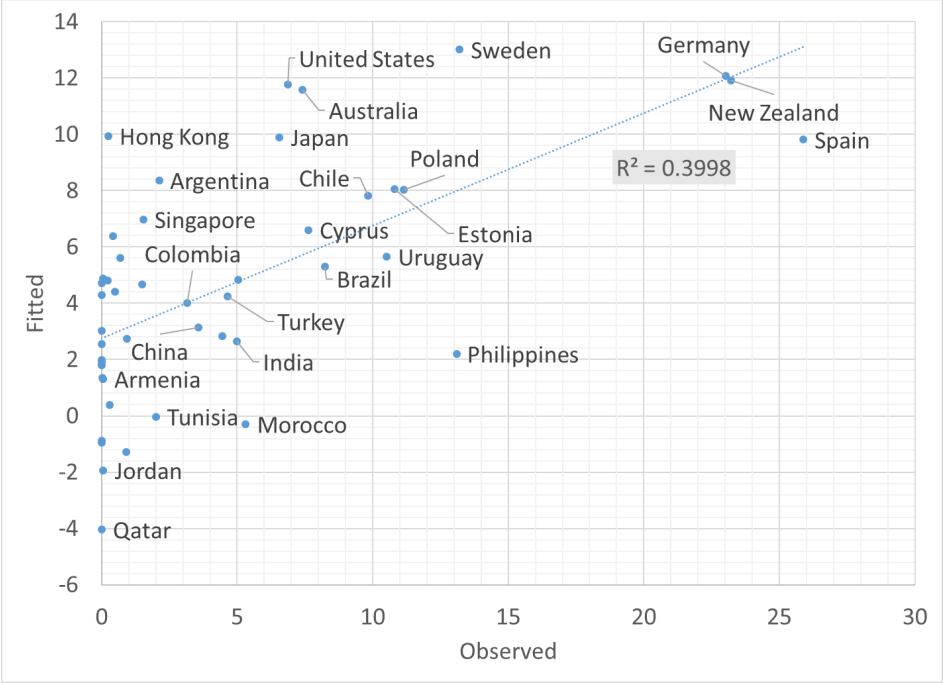

Figure 6: Fitted vs Observed Renewable Electricity Generation

Latent Dimensions

The regression model shows that only the first two principle components are significantly related to renewable electricity production. For this analysis, only principle components one and two are analyzed further as latent cultural dimensions.

Principle Component 1 - Survival-Self-Expression: As can be seen in Table 2, the majority of the loadings are positive, indicating that the variables listed support the same latent concept. Variables 85, 86, 87, 88, and 89 all represent respondents' involvement in politics while variable 223 show how respondents get their information about the world. More generally, the latent dimension shows a lack of involvement in political action and a tendency towards hard work in order to survive and be successful. From a cultural perspectives, these behaviors can be interpreted similarly to the survival vs. self-expression values presented by Inglehart and Welzel where self-expression is typically seen in postindustrial countries who are able to take survival for granted (Inglehart and Welzel 2005). Countries with high component scores (i.e. Armenia, Jordan and Tunisia) tend to have high political instability, limiting self-expression; while countries with low component scores (i.e. Australia, Germany, and New Zealand) tend to have lower political instability, allowing for self-expression (Kaufmann n.d.).

Table 2: Loadings on Principle Component 1

Variable	Description	PC1
V85_Cat_3	Would never sign a petition	0.311
V223_Cat_5	Never use the internet in order to get information about the world	0.226
V67_Cat_3	It would be a bad thing if less importance were placed on work in our lives	0.129
V69_Cat_1	It would be a good thing if there was greater respect for authority	0.128
V98_Cat_1	The government should take more responsibility to ensure that everyone is provided for.	0.128
V62_Cat_1	Maintaining the order of the nation is most important aim of the country	0.122
V100_Cat_1	In the long run, hard work usually brings a better life	0.112
V99_Cat_1	Competition is good it stimulates people to work hard and develop new ideas	0.11
V117_Cat_4	Have no confidence at all in parliament	0.1
V122_Cat_2	Quite a lot of confidence in environmental organizations	-0.101
V113_Cat_2	Quite a lot of confidence in the police	-0.106
V223_Cat_1	Use the internet daily in order to get information about the world	-0.148
V89_Cat_3	Would never join any other act of protest	0.292
V86_Cat_3	Would never join in a boycott	0.291

V87_Cat_3	Would never attend peaceful demonstrations	0.275
V88_Cat_3	Would never join strikes	0.269
V116_Cat_4	Have no confidence at all in political parties	0.11
V86_Cat_2	Might join in a boycott	-0.1
V132_Cat_1	Allowing religious authorities to interpret the laws is not an essential characteristic of democracy	-0.136
V85_Cat_1	Have signed a a petition	-0.178

Principle Component 2 - Traditional vs Rational: The second principle component focuses on respondents' confidence in various organizations, aspects of political governance as can be seen by the loadings in Table 3. Principle component 2 represents the support of respondents towards their countries national government and associated organizations. This component can be interpreted similarly to the traditional versus secular-rational values as defined by Inglehart and Welzel. Related to politics and society, traditional values include respect for authority and the church, strong national pride, and strong family connections. High positive scores will indicate more traditional countries (i.e. Qatar, Morocco, Kuwait), while countries with negative scores will be more rational as defined by Inglehart and Wetzel's construct. These countries (i.e. Germany, United States, and Argentina) place more importance on a stable economy and high economic growth. They are generally less confident in the ability of the government to provide for them.

Table 3: Loadings on Principle Component 2

Variable	Description	PC2
V113_Cat_1	Have a great deal of confidence in the police	0.155
V115_Cat_1	Have a great deal of confidence in the government in the nation's capitol	0.146
V117_Cat_1	Have a great deal of confidence in parliament	0.143
V66_Cat_1	Willing to fight for country	0.137
V109_Cat_1	Have a great deal of confidence in the armed forces	0.132
V111_Cat_1	Have a great deal of confidence in television	0.103
V60_Cat_1	A high level of economic growth should be an important country aim or the next ten years	-0.102
V66_Cat_2	Not willing to fight for country	-0.109
V118_Cat_3	Have not very much confidence in the civil service	-0.11
V117_Cat_3	Have not very much confidence in parliament	-0.125
V64_Cat_1	A stable economy is an important country aim or the next ten years	-0.126
V88_Cat_2	Might join strikes	-0.143
V133_Cat_5	People choose their leaders in free elections is definitely an essential characteristic of democracy	-0.149

V112_Cat_3	Have not very much confidence in labor unions	-0.155
V89_Cat_2	Might join any other act of protest	-0.157
V95_Cat_3	Moderate on the political scale	-0.174
V87_Cat_2	Might attend peaceful demonstrations	-0.186
V116_Cat_3	Have not very much confidence in political parties	-0.21
V89_Cat_3	Would never join any other act of protest	-0.23
V86_Cat_3	Would never join in a boycott	-0.259
V87_Cat_3	Would never attend peaceful demonstrations	-0.179
V88_Cat_3	Would never join strikes	-0.249
V116_Cat_4	Have no confidence at all in political parties	-0.109
V86_Cat_2	Might join in a boycott	-0.141
V132_Cat_1	Allowing religious authorities to interpret the laws is not an essential characteristic of democracy	-0.136
V85_Cat_1	Have signed a petition	-0.152

RESULTS & DISCUSSION

During this analysis, we found that two principle components have inverse correlations with renewable electricity generation. The multivariate linear regression model (shown below in equation 2) indicates that countries, which emphasize self-expression (negative values for PC1) and rationalism (negative values for PC2), tend to have more renewable electricity generation. For example Germany, which has approximately 23% renewable electricity generation excluding hydroelectric, measures -102.4 and -56.8 for principle component scores 1 and 2 respectively.

$$y = (-0.04663)PC1 + (-0.04544)PC2 + 4.729 \quad (2)$$

Where y is the fitted percentage of renewable electricity generation, PC1 and PC2 are the principle component scores for any particular country.

The relationship between survival and self-expression and renewable electricity generation shows that nations that tend towards self-expression also tend to have more renewable electricity generation. Negative survival and self-expression scores indicate high amount of not only self-expression, but also trust, tolerance and subjective well-being (Inglehart and Baker 2000). Of particular importance to the deployment of renewable energy technologies is trust and fairness. Societies judge both the technology and the actors implementing the technology. For example, if a community knows little about a technology, they will most likely make their judgments based on what they know about the implementers. If they view those proposals (technology and implementers) as fair, the project has a greater chance of success (Huijts et al. 2012). Therefore, the model presented in this research implies that societies which value self-expression, and trust are more likely to have renewable electricity projects, assuming the projects are in fact trustworthy and fair. As project teams start a new project, they should consider how to make the

project fair from all perspectives. For nations that tend to focus more on survival, the project team should emphasize the long-term benefits of renewable electricity such as the reduction of dependence on foreign resources and the new economic market.

The observed relationship between rational and traditional values and renewable electricity generation shows that nations that are more rational tend to have more electricity coming from renewable sources. This suggests that project developers see renewable electricity as the rational choice. In many ways, this is true since renewable electricity is reducing the emission of greenhouse gases and slowing climate change. In addition, renewable electricity projects have less risk of cost over-runs in comparison to other electricity projects (Sovacool 2014). In a study of 51 windfarms in 13 different countries, windfarms had the second lowest risk of cost overruns just behind solar facilities (Sovacool et al. 2017). Therefore, project teams should consider the values held by the countries in which they are working. According to this research, more rational leaning countries will be more accepting of the renewables due to renewable energy's infinite supply, economic potential and environmental benefits. This has the potential to make projects more successful; however, it is equally important that project teams consider how to make renewable energy projects more appealing to those who have values that are more traditional. Future research will expand on the existing literature (Mignon and Bergek 2016) related to challenges to incorporate how cultural values influence project success as well as project communication and stakeholder engagement.

Figure 7 shows the distribution of countries across the two components. Countries such as German, Sweden, New Zealand, and United States have more favorable values towards renewables while countries such as Jordan, Qatar, and Egypt have values on the traditional end of the constructs' scale. Future research will consider how renewable energy technologies have been integrated to support those values (Wilkin 2017) and how projects can be most successful in different cultural environments.

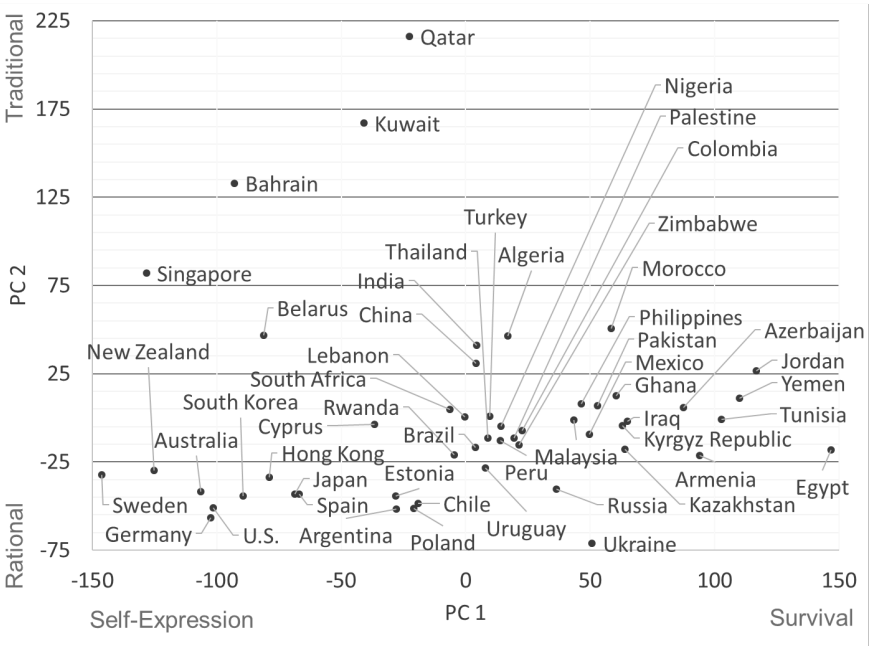

Figure 7: Latent Cultural Dimensions across Countries

CONCLSION & FUTURE RESEARCH

This exploratory study aimed to explore latent cultural dimensions within the WVS and determine if and how these values relate to renewable electricity production. A multivariate linear regression model was developed with two significant latent cultural dimensions (self-expression versus survival, and traditional versus secular). We discovered an inverse relationship between both latent dimensions and renewable electricity generation. Countries focused on self-expression and rational beliefs tend to have higher amounts of renewable electricity generation, implying that these contexts have more favorable conditions for renewable energy technology projects. For countries that are more traditional and focused on survival, this research begins to consider how project teams can alter communication and other strategies in order to deliver projects that are more successful.

Our continuing research focuses on expanding this analysis from the politics and society questions to all the questions of the WVS. While we do expect the same latent cultural dimensions found here to appear, we hope that more questions and resulting dimensions will provide a more comprehensive explanation about the relationship with renewable electricity generation. Furthermore, future research aims to provide insight into how to adapt engagement strategies. We also will seek the mechanisms by which these dimensions impact specific renewable electricity projects using qualitative research methods.

REFERENCES

Alemán, J., and Woods, D. (2016). "Value Orientations From the World Values Survey How Comparable Are They Cross-Nationally?" *Comparative Political Studies*, 49(8), 1039–1067.

Allison, L., and Kaminsky, J. (2015). "Culture in Construction Engineering." Canadian Society for Civil Engineering, 10.

Bartholomew, D. J., Steele, F., Moustaki, I., and Galbraith, J. (2008). *Analysis of Multivariate Social Science Data*. Chapman and Hall/CRC, Boca Raton.

Batel, S., and Devine-Wright, P. (2015). "Towards a better understanding of people's responses to renewable energy technologies: Insights from Social Representations Theory." *Public Understanding of Science*, 24(3), 311–325.

Chen, F. F. (2008). "What happens if we compare chopsticks with forks? The impact of making inappropriate comparisons in cross-cultural research." *Journal of Personality and Social Psychology*, 95(5), 1005–1018.

Devine-Wright, P. (2010). *Renewable Energy and the Public From NIMBY to Participation*. Taylor and Francis, Earthscan, Florence, London ; Washington, DC.

EIA. (2016). *International Energy Outlook 2016*. US Energy Information Administration.

Hofstede, G., Hofstede, G. J., and Minkov, M. (2010). *Cultures and Organizations: Software of the Mind, Third Edition*. McGraw-Hill, New York.

Höijer, B. (2011). "Social representations theory." *Nordicom review*, 32(2), 3.

Huijts, N. M. A., Molin, E. J. E., and Steg, L. (2012). "Psychological factors influencing sustainable energy technology acceptance: A review-based comprehensive framework." *Renewable and Sustainable Energy Reviews*, 16(1), 525–531.

Inglehart, R., and Baker, W. E. (2000). "Modernization, Cultural Change, and the Persistence of Traditional Values." *American Sociological Review*, 65(1), 19–51.

Inglehart, R., and Welzel, C. (2005). *Modernization, cultural change, and democracy: the human development sequence*. Cambridge University Press, Cambridge, UK ; New York.

Kaminsky, J. A. (2016). "Cultured Construction: Global Evidence of the Impact of National Values on Renewable Electricity Infrastructure Choice." *Environmental Science & Technology*, 50(4), 2108–2116.

Kaufmann, D. (n.d.). "Political stability by country, around the world." *TheGlobalEconomy.com*, <http://www.theglobaleconomy.com/rankings/wb_political_stability/> (Apr. 18, 2017).

Mignon, I., and Bergek, A. (2016). "System- and actor-level challenges for diffusion of renewable electricity technologies: an international comparison." *Journal of Cleaner Production*, New approaches for transitions to low fossil carbon societies: promoting opportunities for effective development, diffusion and implementation of technologies, policies and strategies, 128, 105–115.

Piantadosi, S., Byar, D. P., and Green, S. B. (1988). "The ecological fallacy." *American journal of epidemiology*, 127(5), 893–904.

Pierce, J. C., Steel, B., and Warner, R. L. (2009). "Knowledge, Culture, and Public Support for Renewable-Energy Policy." *Comparative Technology Transfer and Society*, 7(3), 270–286.

Rateau, P., Moliner, P., Abric, J.-C., and Moliner, P. (2012). "Social Representation Theory." *Handbook of Theories of Social Psychology*, SAGE Publications Ltd, 1 Oliver's Yard, 55 City Road, London EC1Y 1SP United Kingdom, 477–497.

Smith, P. B., Fischer, R., Vignoles, V. L., and Bond, M. H. (2013). *Understanding Social Psychology Across Cultures: Engaging with Others in a Changing World*. SAGE.

Sovacool, B. K. (2014). "What are we doing here? Analyzing fifteen years of energy scholarship and proposing a social science research agenda." *Energy Research & Social Science*, 1, 1–29.

Sovacool, B. K., Enevoldsen, P., Koch, C., and Barthelmie, R. J. (2017). "Cost performance and risk in the construction of offshore and onshore wind farms." *Wind Energy*, 20(5), 891–908.

Walker, G., Devine-Wright, P., Barnett, J., Burningham, K., Cass, N., Devine-Wright, H., Speller, G., Barton, J., Evans, B., Heath, Y., Infield, D., Parks, J., and Theobald, K. (2010). "Symmetries, expectations, dynamics and contexts: a framework for understanding public engagement with renewable energy projects." *Renewable Energy and the Public: from NIMBY to participation*, Earthscan, London, 1–14.

Wilkin, S. (2017). "Jordan to Award 300MW of Renewable Energy Projects by Year-End." *Bloomberg.com*.

"World Bank. Indicators | Data." (2016). <http://data.worldbank.org/ indicator> (Oct. 1, 2017).

"World Values Survey." (2016). <http://www.worldvaluessurvey.org/wvs.jsp> (Oct. 1, 2016).

WORLD VALUES SURVEY Wave 6 2010-2014 OFFICIAL AGGREGATE v.20150418. (2016). Aggregate File Producer: Asep/JDS, Madrid SPAIN.

WVS. (2014). *WV6 Codebook*. Madrid, Spain.

WVS Association. (2016). "What we do." *World Values Survey*, <http://www.worldvaluessurvey.org/WVSContents.jsp> (Nov. 7, 2016).