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Social and ecological effects of biomass utilization and the willingness to use clean energy in the eastern Qinghai–Tibet plateau

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HIGHLIGHT

- Rural household survey is done in 19 villages on the Qinghai–Tibet plateau.
- Biomass collection and utilization cost time and are bad for health and ecosystem.
- Price is the main determinant of fuel choice.
- Most households are willing to use clean energy but pay no attention to the environment.
- Future development should focus on finding new ways to utilize biomass and exploring renewable energy.

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ABSTRACT

We conducted surveys in 19 villages on the Qinghai–Tibet plateau to explore the social and ecological effects of household biomass utilization and local people's willingness to use clean energy. Results showed that biomass was commonly used on this plateau. Dung combustion generated heavy indoor smoke in pastoral regions. Women were main dung collectors, who spent 1.8 h per day on dung collection. Crop residues and firewood were mainly collected by adults. Most respondents would like to rest while few chose to entertain or study when the time for biomass collection was saved. Tree numbers decreased in agricultural regions and grasslands deteriorated in pastoral regions recently according to most respondents. There were significant differences in the willingness to use modern energy, but no significant difference in the willingness to use clean energy among households from regions with different livelihoods. Almost all the respondents would like to use clean energy when there was no economic constraint but paid no attention to the environmental impact of fuel choice. Livelihood and region were main determinants in modern energy utilization, and energy price was the main determinant of fuel choice. Future energy development should focus on finding new ways to utilize biomass and exploring renewable energy.

1. Introduction

Having access to modern energy (e.g. electricity or gasoline) is important to human beings for reducing health and safety risks (Barnes, 1988; IEA, 2010), optimizing time budget constraints especially for women and children, and increasing household labor productivity and income (Dutta, 2003; Rath, 2005). Meanwhile, after the Kyoto Protocol, renewable energy development has aroused interest all over the world for their lower greenhouse gas emission compared with fossil energy (Haberl et al., 2012). Since the oil crisis in the 1970s, various dimensions of household energy use have been explored and many strategies have been designed and implemented to solve problems on access to energy services, transition to modern fuels, energy poverty, environmental concerns and greenhouse gas (GHG) emission (Joon et al., 2009; Kowsari and Zerriffi, 2011). Among them, the social and psychological analyses of residential energy consumption and energy conservation are attracting more and more attention (Owens and Driffill, 2008; Stern, 1992). Given that the use of energy sources is strongly related to public willingness and acceptance, a better knowledge of household willingness and consumer behavior are important for policy makers to achieve energy development goals (Kowsari and Zerriffi, 2011; Owens and Driffill, 2008; Viklund, 2004).

Willingness is the behavioral intention, which is crucial in shaping the consumer's demand for goods. Studies on people's willingness to use renewable energy and the determinants of

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willingness are gradually acknowledged. Kostakis and Sardianou (2012) present some insights into the determinants of tourists' willingness to pay for renewable energy in green hotels in Greece. Hansla et al. (2008) explore the willingness to pay for green electricity in Sweden and show that the willingness increases with positive attitude toward green electricity and decreases with electricity cost. Roe et al. (2001) find that many individuals in the United States are willing to pay for decreased air emission, especially when emission reductions stem from increased reliance upon renewable fuels.

Biomass has been used for cooking and heating for thousands of years on the Qinghai–Tibet plateau. Overgrazing and utilization of biomass as fuel have been proven to result in grassland degeneration, soil fertility reduction, desertification and the weakening of the ecosystem's function (Abegaz et al., 2007; Cai and Zhang, 2006; Liu et al., 2008; Ping et al., 2011; Wei et al., 2004). Besides that, collection of biomass costs much time and energy, and the combustion of biomass releases heavy smoke which might pose health hazards to consumers, especially to women and children (AIR, 2002; Liu et al., 2008). On the other hand, the Qinghai–Tibet plateau is rich in renewable energy like solar energy, wind energy and hydropower for its special geological position and climate.

Given the particular role it plays in climate regulation and social–economic welfare, the energy issues of the Qinghai–Tibet plateau have attracted much interest from researchers and policy makers (Liu et al., 2008; Qie et al., 2003; Wang, 2009; Wang and Qiu, 2009; Wei et al., 2004; Xiang et al., 2009). However, our understanding of the people's willingness to use renewable energy and the determined variables of renewable energy choices on the plateau have not been fully assessed. Here, we present results from a survey designed to assess local people's willingness to use clean energy with regard to present energy consumption and future energy choices in different counties in the eastern part of the plateau. We seek to investigate the following issues: (1) whether rural residents realize the social and ecological effects of fossil and biomass utilization; (2) what their favorite energy type is; (3) whether they want to use clean energy or not; and (4) what the most important determinant of fuel choice is. Lastly, based on the energy situation and the willingness local people hold, we give some suggestions on future energy development.

2. Methods

2.1. Study area

With an area of 2.57 million km^2 and average altitude of over 4000 m above sea level (asl), the Qinghai–Tibet plateau (26°00′12″N-39°46′50″N, 73°18′52″E-104°46′59″E) is recognized as the third pole of the earth. Alpine meadow, alpine steppe, alpine shrub and alpine desert are the main types of landscapes on the plateau. Qinghai Province (31°40′N-39°15′N, 89°20′E-103°05′E) lies in the eastern part of the Qinghai–Tibet plateau with an area of 720,000 km^2 and population of 5.68 million in 2011 (Qinghai Bureau of Statistics, 2012). Pastoral lands account for 59.1% while farmlands and woodlands account for 0.8% and 3.9% of the land area of Qinghai respectively. This area is characterized by strong solar radiation with long, cold winters, short, cool summers and short frost-free periods. The mean annual temperature is 0.17 °C and annual precipitation varies from 14.9 mm in the northwest to 774.3 mm in the southeast with most of the rain falling between June and September. Annual evaporation is about four times greater than annual precipitation (Natural Geography Chronicles Compiling Committee of Qinghai Province, 1998). Qinghai Province can be divided into three parts according to livelihood (Table 1).

2.2. Data collection

We carried out our survey in 19 villages in seven counties: Xunhua, Huzhu, Wulan, Gangcha, Gonghe, Tianjun and Dulan from April to August 2009 and 2010. Xunhua and Huzhu are located in an agricultural zone; Gonghe, Tianjun and Dulan are located in a pastoral zone; Wulan and Gangcha are located in an agro–pastoral transitional zone (Fig. 1).

We chose household as the survey unit since household was the basic unit of decision-making and consumption. We randomly selected survey households in each of these 19 villages based on social and economic conditions of households with the help of a local guider. The economic status of a household was determined in terms of pasture or farmland held, livestock owned, employment type and total income. We took the highest education in a household as the education level of the household. Household size only included those people who lived in the family during the last six months before the investigation.

Altogether, 691 households were sampled. Among them, 12 households gave incomplete information. We discarded the incomplete questionnaires and the valid number of households sampled was 679. These seven counties differed in altitude and

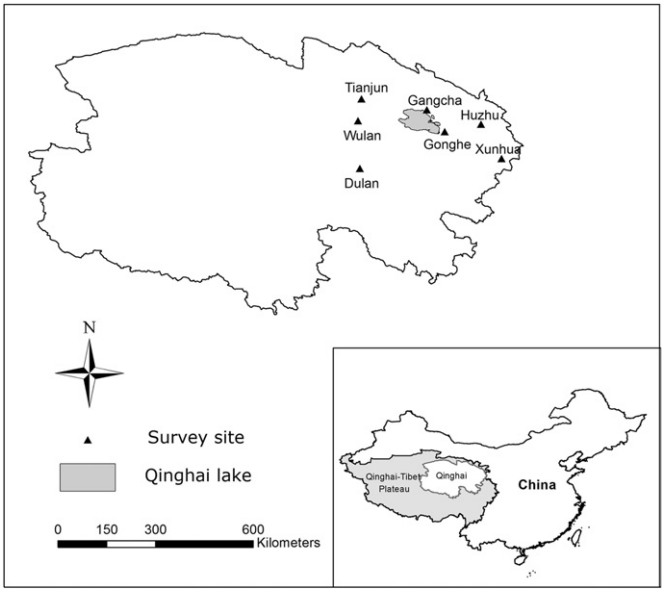

Fig. 1. Survey sites in seven counties in Qinghai Province, China.

Table 1
Three parts of Qinghai Province according to the livelihood.

Part in Qinghai	Livelihood	Altitude (m)	Population	Ethnicity
Eastern part	Agricultural zone	1700–2500	3,500,000	Han, Hui, Tu, etc.
Qinghai lake area	Agro–pastoral transitional zone	2500–4500	100,000	Majority are Tibetan
Western part	Desert and pastoral zone	above 3000	Sparse	Majority are Tibetan

distance to the town, and households in these seven counties differed in education, income, and household size (Table 2).

Open-structural questionnaires and interviews were used in the investigation. Our questionnaire included three aspects: (1) basic information of respondents and the household (income, household size, livestock, farmland, education, energy using appliances, etc.); (2) social effect of household energy consumption, indicated by the chance of cough during the burning of fuel and the time cost of biomass collection; moreover, the ecological effect of energy consumption, indicated by changes in numbers of trees or the grassland around the villages; and (3) the willingness to use clean energy and modern commercial energy, and main determinants of modern commercial energy utilization. We used the questionnaire as a guide but followed the thinking of respondents with no constraint on those questions. We took the guider as the first interviewee to ensure he understood all the questions. Each interview took 30–60 min to complete in agricultural regions where mandarin could be understood, and 60–90 min in pastoral regions where Tibetan is the universal language with the guider as the translator. All questionnaires and interviews were conducted face to face.

2.3. Data analyses

Education levels and different answers to questions were quantified as different numbers to facilitate the following analyses (Table 3). These data were not normally distributed and could not be transformed into normally distributed data. Therefore, we used non-parameter test (Kruskal–Wallis H) to compare the differences in household willingness to use clean energy among seven counties. After the variables were dumbed, we used stepwise logistic regression to find out the determinants of willingness to use modern energy. All the statistical analyses were done in SPSS 15.0 (SPSS Inc., Chicago) and two-tailed with significance of $P < 0.05$.

3. Results

3.1. Social effects of biomass combustion among different regions

Majority of dung piles were less than 500 m away from tents or houses in the pastoral region. Women were the main dung collectors (95.9%), who spent 1.8 h on average in dung collection each day. Crop residues were collected more than 3 h per year by adult members of the family. The collection of firewood cost 2.55 h per month mostly by adults (81.7%) and few by elders and children (19.3%). The majority of respondents wanted to take rest while some wanted to entertain or study when time for biomass collection was saved (Table 4).

Many households in agricultural regions used improved stoves and the combustion of biomass generated less smoke while many households in pastoral regions used traditional stoves with no chimney to drive smoke outside, leading to heavy indoor air pollution. Heavy smoke could be found in 31.8% households in Gangcha, 55.7% households in Gonghe and 36.4% households in Tianjun. About 4.1% of respondents in Gonghe often got cough during the burning of fuels and 75.6% of coughers were women (Table 4).

3.2. Ecological effects of biomass combustion among different regions

Very few ashes were used as fertilizer in agricultural regions while all ashes were thrown away in pastoral regions after biomass combustion. Both the livestock numbers per household and the whole village have not change much in recent years. The numbers of tree declined in Xunhua and Huzhu, and increased in Wulan, while pastures owned by both households and the whole village degenerated in Gangcha, Gonghe and Tianjun in recent years according to the respondents. The majority of interviewees sensed the warming of winters but did not know about any global change (Table 5).

Table 2
Socio–economic conditions of the surveyed households from seven counties (Mean ± SE).

County	Altitude (m)	Education*	Household size*	Annual income (Yuan)*	Distance to town (km)	*N*
Xunhua	1873.12 ± 0.73	3.03 ± 0.075	4.77 ± 0.12	11,184 ± 701	3	154
Huzhu	2597.44 ± 8.74	3.05 ± 0.72	4.47 ± 0.14	9,872 ± 488	5	96
Wulan	2965.00 ± 0.28	3.14 ± 0.74	4.28 ± 0.12	11,611 ± 770	5	120
Gangcha	3295.78 ± 8.53	2.83 ± 0.98	4.32 ± 0.099	11,284 ± 1,940	27	110
Gonghe	3336.57 ± 16.93	1.88 ± 0.78	4.86 ± 0.18	12,435 ± 980	40	97
Tianjun	3800.81 ± 16.01	2.67 ± 1.05	4.67 ± 0.27	21,964 ± 2,351	50	55
Dulan	3907.65 ± 9.45	2.11 ± 0.14	5.43 ± 0.29	16,936 ± 1,509	80	47

Notes: Education level was divided into five types: illiterate, primary school, junior high school, senior high school, college and university, which were recorded as 1, 2, 3, 4 and 5, respectively. Education here is the highest education level in each household. Household size only includes people who have lived in the family in the last six months before the investigation. $1 USD=¥6.31 (2012/1/6).

Table 3
Questions and codes for answers when analyzing data.

Questions	Codes for answers
Education	Illiterate (1), primary school (2), junior high school (3), senior high school (4), college and university (5)
What to do with the ash after combustion	As fertilizer (1), throw away (2)
Is there any smoke when burning	Yes (1), no (−1)
Is the smoke heavy or not	Heavy (1), not heavy (−1)
Cough or not when burning fuel	Yes (1), no (−1)
Want to use same fuel or not	Yes (1), no (−1)
Want to use clean energy or not	Yes (1), no (−1)
Consider the environmental effect or not when choosing fuel	Yes (1), no (−1)
Change in number of trees around the village	Increased (1), decreased (−1), unchanged (0)
Livestock number change	Increased(1), decreased(−1), unchanged(0)
Pasture change around the village	Better (1), worse (−1), unchanged (0)
Heard of global change or not	Yes (1), no (−1)
Source of knowledge of global change	Television or internet (1), other people (2), books or class (3)

Table 4
Social effect of biomass combustion in the seven counties in Qinghai.

Xunhua (%)	Huzhu (%)	Wulan(%)	Gangcha(%)	Gonghe (%)	Tianjun (%)	Dulan (%)
Indoor air smoke when burning fuel						
87.7	97.9	93.3	73.6	82.5	61.8	87.2
Heavy smoke when burning fuel						
0.0	0.0	3.3	31.8	55.7	36.4	2.1
Often cough when burning fuel						
0.6	0.0	0.0	0.0	4.1	0.0	0.0
Sex of cougher (male/female)						
100.0/0.0	–	–	–	24.4/75.6	–	–
What to do when time for biomass collection is saved?						
Rest 86.4	Rest 96.9	Rest 89.2	Rest 53.6	Rest 84.3	Rest 100.0	Rest 72.8
Entertain 0.0	Entertain 1.0	Entertain 9.1	Entertain 5.5	Entertain 15.7	Entertain 0.0	Entertain 19.1
Other 13.6	Other 2.1	Other 1.7	Other 40.9	Other 0.0	Other 0.0	Other 8.5

Table 5
Ecological effect of biomass combustion in the seven counties in Qinghai.

Xunhua (%)	Huzhu (%)	Wulan (%)	Gangcha (%)	Gonghe (%)	Tianjun (%)	Dulan (%)
Change in number of trees around the village						
Increased 3.2	Increased 20.8	Increased 83.3				
Decreased 94.2	Decreased 76.0	Decreased 0.0	–	–	–	–
Unchanged 2.6	Unchanged 3.1	Unchanged 16.7				
Change in number of livestock owned						
			Increased 1.8	Increased 10.3	Increased 9.1	Increased 0.0
–	–	–	Decreased 0.0	Decreased 19.6	Decreased 3.6	Decreased 0.0
			Unchanged 98.2	Unchanged 70.1	Unchanged 87.3	Unchanged 100.0
Change in number of livestock in whole village						
			Increased 0.9	Increased 14.4	Increased 3.6	Increased 0.0
–	–	–	Decreased 0.0	Decreased 11.3	Decreased 1.8	Decreased 0.0
			Unchanged 99.1	Unchanged 74.2	Unchanged 94.5	Unchanged 100.0
Change in situation of pasture owned by yourself						
			Better 0.0	Better 0.0	Better 10.4	Better 0.0
–	–	–	Worse 3.6	Worse 36.1%	Worse 31.6	Worse 0.0
			Unchanged 96.4	Unchanged 63.9	Unchanged 58	Unchanged 100.0
Change in situation of pasture in whole village						
			Better 0.0	Better 0.0	Better 10.4	Better 0.0
–	–	–	Worse 3.6	Worse 36.1	Worse 31.6	Worse 0.0
			Unchanged 96.4	Unchanged 63.9	Unchanged 58	Unchanged 100.0
Use ash as fertilizer after biomass combustion						
0.0	1.1	0.8	0.0	0.0	0.0	0.0
Heard of global change						
15.6	20.8	25.0	9.3	16.4	15.1	10.6
Source of knowledge of global change						
Television 100.0	Television 94.9	Television 96.7	Television 100.0	Television 40.0	Television 66.7	Television 0.0
Other people 0.0	Other people 5.1	Other people 3.3	Other people 0.0	Other people 60.0	Other people 33.3	Other people 100.0

3.3. Willingness to use energy types among different regions

There were highly significant differences in the willingness to use electric appliances ($\chi^2=75.57$, $df=2$, $P<0.001$), liquefied petroleum gas (LPG) ($\chi^2=138.07$, $df=2$, $P<0.001$) and coal ($\chi^2=341.94$, $df=2$, $P<0.001$) among households in regions with different livelihoods. There was no significant difference in the willingness to use clean energy among households from different counties, counties with different livelihoods or counties with similar livelihoods ($P>0.05$).

Most households from Gonghe and Tianjun wanted to use LPG, while most households in pastoral regions wanted to use coal. Almost all the respondents took price as the first factor to consider when choosing fuel types while few considered availability of energy or fuel-using habits first. Most respondents would like to use clean energy when there was no economic constraint but took no consideration of environmental impact when choosing energy types. Majority of households chose electricity and some households chose LPG as their favorite fuel when there was no economic constraint for cleanliness and convenience. Some households in pastoral regions chose dung as their favorite energy type even if there was no economic constraint (Table 6).

3.4. The determinants of willingness to use energy type

We included altitude, livelihood, region, respondent's education, respondent's age, household size, household income and household education into our regression model to assess the household willingness to use electric appliance, LPG and coal. We found that livelihood and region were determinants of willingness to use electric appliances; livelihood, region and respondent's education were determinants of willingness to use LPG; and livelihood, region, respondent's education, household size and household education were main determinants of willingness to use coal (Table 7).

4. Discussion and policy implication

4.1. Social and ecological effects of biomass utilization

This empirical study indicated that the utilization of biomass reduced rest or education time, and increased the possibility of suffering from respiratory disease for women. The ashes of biomass combustion did not return to farmland or pastures

Table 6
Willingness to use energy types in the seven counties in Qinghai.

Xunhua (%)	Huzhu (%)	Wulan (%)	Gangcha (%)	Gonghe (%)	Tianjun (%)	Dulan (%)
Want to use LPG						
16.9	3.1	8.3	12.2	90.7	67.3	2.1
Want to use coal						
0.0	4.2	13.2	88.9	85.6	54.4	83.0
Favorite fuel when there is no economic constraint						
Electricity 87.7	Electricity 88.5	Electricity 83.3	Electricity 93.9	Electricity 82.1	Electricity 60.0	Electricity 51.1
Coal 9.7	Coal 6.3	Coal 11.7	Dung 3.1	LPG 11.2	Dung 24.9	Coal 38.3
LPG 2.6	LPG 3.1	LPG 5.0	Coal 1.5	Coal 4.5	Coal 15.1	Dung 10.6
			LPG 1.5	Dung 2.1		
Care about the environment when choosing fuel						
1.3	3.1	0.8	0.0	0.0	0.0	0.0
Want to use clean energy when there is no economic constraint						
100.0	100.0	99.2	100.0	100.0	100.0	100.0

Table 7
Stepwise regression results of willingness to use energy type.

	Dependent variable=electric appliance use		Dependent variable=LPG use		Dependent variable=coal use	
Variable	***B***	***P***	***B***	***P***	***B***	***P***
Altitude	0.003	0.957	0.985	0.321	−0.002	0.072
Livelihood	3.267	**<0.001**	5.145	**<0.001**	2.494	**0.004**
Region	2.974	**<0.001**	4.502	**<0.001**	2.573	**<0.001**
Respondent's education	0.045	0.833	−0.346	**0.028**	−0.553	**0.017**
Respondent's age	−0.198	0.061	1.065	0.302	0.323	0.570
Household size	0.291	0.590	0.188	0.081	0.303	**0.013**
Household income	0.069	0.793	0.097	0.755	1.068	0.301
Household education	0.626	0.429	0.072	0.788	−0.677	**0.002**

Note: The data with statistical significance ($P<0.05$) are shown in bold.

properly. Most interviewees sensed the change of winter temperature and saw the deterioration of pastures and the decrease of tree numbers in recent years but knew little about global change and did not take environmental effects into consideration when choosing fuel types, indicating that the rough and irrational utilization of biomass might bring something negative to both the health of people and the ecosystem around.

Most women in pastoral regions were illiterates, whose lives were full of housework, and they barely had any time to rest and not to mention the time for study, and most of them could not understand mandarin, which might constrain their knowledge of the world and then the way of energy utilization. They knew little about new things, and many interviewees did not know how to use LPG, wind turbines and electric applications, and considered it was dangerous to use LPG. The lack of knowledge of what clean energy is and how to use it might constrict the spread of clean energy.

4.2. Willingness to use energy type and determinants of energy choice

The results also showed that households in rural Qinghai mainly used biomass and fossil energy at present, but they were willing to use clean energy when there was no economic constraint. Energy price was the main determinant of fuel choice, besides that, some socio–cultural factors like fuel using habits and availability of fuels were equally important in decision-making preferences of fuel at a household level. Most respondents chose electricity as their favorite energy type with some choosing coal or dung, indicating that clean energy had large room for development in rural Qinghai while biomass and fossil energy would still be used in the short run.

Contrary to our expectation, household income was not the main determinant of willingness to use energy in rural Qinghai, while many studies confirmed the importance of income in shaping the willingness to use renewable energy (Ek, 2005; Zarnikau, 2003). Both household education and respondent's education were important determinants of willingness to use energy which was consistent with previous studies that higher education levels were associated with higher probability of modern fuels use (Heltberg, 2003; Swofford and Slattery, 2010; Zarnikau, 2003).

4.3. Policy implication

Given that biomass will be the main energy resource in rural Qinghai in the near future, the improvement of energy-using efficiency is an effective way of energy saving and emission reduction. Old stoves have low burning efficiency and release much smoke and noxious gas while improved stoves could double the burning efficiency and have chimneys to direct smoke out of houses (Bhattacharya and Salam, 2002). Thus, the expansion of improved and energy-saving stoves is a good way to reduce energy consumption. Furthermore, new ways of biomass utilization like biogas, biomass electricity, and straw briquette could also improve the energy efficiency. Qinghai Province has launched sets of programs in the past 30 years to advance solar energy applications and biogas. However, the lack of technical know-how and follow-up obstructs the utilization of solar cookers and biogas. Thus, the training of local technicians for management and maintenance of energy equipment is crucial in expanding the energy development.

Early experience and information are found to have a big influence on personal behavior and could drive people to engage in similar behavior (Macey and Brown, 1983). Public participation and exposure to information about energy issues are thought to promote renewable energy development (Batley et al., 2000; Ladenburg, 2008; Swofford and Slattery, 2010; Zarnikau, 2003),

and the willingness to pay increases as people are more familiar with renewable energy (Nomura and Akai, 2004). Besides that, households in the same village will imitate each other; thus one or two households with past experience and knowledge would bring along the development of certain energy types. Considering the right-now situation of local people's poor knowledge of renewable energy and the lack of environmental concern, the government should put more effort in enlarging the propaganda of renewable energy to raise people's awareness and knowledge, and provide some training programs to seek out some experts to bring along the development of renewable energy.

Households in rural Qinghai were willing to use clean energy if there was no economic constraint, but energy price was always the obstacle. The same result could be found in a survey done by Zhou and Cui (2007), that 74.3% of households are willing to use renewable energy when economic conditions permit, while 25.3% of households do not know or care about renewable energy in western China. The rich renewable energy resources and investments will assure the great development potential of renewable energy in Qinghai Province. Furthermore, sparse population in pastoral regions makes small photovoltaic power stations and hydropower plants more cost-effective than the expansion of electricity grids to satisfy the lighting needs of herdsmen. However, the relatively high cost might hinder the wide spread of renewable energy systems in the energy market. Thus, finding new ways to decrease the cost and enlarging the support of government will promote the utilization of renewable energy in rural Qinghai.

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References

Abegaz, A., van Keulen, H., Haile, M., Oosting, S.J., 2007. Nutrient dynamics on smallholder farms in Teghane, Northern Highlands of Ethiopia. Advances in Integrated Soil Fertility Management in Sub-Saharan Africa: Challenges and Opportunities 1091, 365–378.

AIR, I., 2002. Indoor air pollution in developing countries: recommendations for research. Indoor Air 12, 198–207.

Barnes, D.F., 1988. Electric power for rural growth: How electricity affects rural life in developing countries. Boulder, CO Westview Press.

Batley, S.L., Fleming, P.D., Urwin, P., 2000. Willingness to pay for renewable energy: implications for UK Green Tariff Offerings. Indoor and Built Environment 9, 157–170.

Bhattacharya, S.C., Abdul Salam, P., 2002. Low greenhouse gas biomass options for cooking in the developing countries. Biomass and Bioenergy 22, 305–317.

Cai, G., Zhang, L., 2006. Research on Xizang rural energy consumption and its environmental impact. Resource Development and Market 22, 238–242.

Dutta, S., 2003. Mainstreaming gender in energy planning and policies. UNESCAP Project on Capacity Building on Integration of Energy and Rural Development Planning. Background paper for expert group meeting, June–July.

Ek, K., 2005. Public and private attitudes towards "green" electricity: the case of Swedish wind power. Energy Policy 33, 1677–1689.

Haberl, H., Sprinz, D., Bonazountas, M., Cocco, P., Desaubies, Y., Henze, M., Hertel, O., Johnson, R.K., Kastrup, U., Laconte, P., Lange, E., Novak, P., Paavola, J., Reenberg, A., van den Hove, S., Vermeire, T., Wadhams, P., Searchinger., T., 2012. Correcting a fundamental error in greenhouse gas accounting related to bioenergy. Energy Policy 45, 18–23.

Hansla, A., Gamble, A., Juliusson, A., Garling, T., 2008. Psychological determinants of attitude towards and willingness to pay for green electricity. Energy Policy 36, 768–774.

Heltberg, R., 2003. Household Fuel and Energy Use in Developing Countries—a Multicountry Study. A World Bank Publication.

IEA, International Energy Agency, 2010. World Energy Outlook. Paris.

Joon, V., Chandra, A., Bhattacharya, M., 2009. Household energy consumption pattern and socio–cultural dimensions associated with it: a case study of rural Haryana, India. Biomass and Bioenergy 33, 1509–1512.

Kostakis, I., Sardianou, E., 2012. Which factors affect the willingness of tourists to pay for renewable energy? Renewable Energy 38, 169–172.

Kowsari, R., Zerriffi, H., 2011. Three dimensional energy profile: a conceptual framework for assessing household energy use. Energy Policy 39, 7505–7517.

Ladenburg, J., 2008. Attitudes towards on-land and offshore wind power development in Denmark; choice of development strategy. Renewable Energy 33, 111–118.

Liu, G., Lucas, M., Shen, L., 2008. Rural household energy consumption and its impacts on eco–environment in Tibet: taking Taktse county as an example. Renewable and Sustainable Energy Reviews 12, 1890–1908.

Macey, S.M., Brown, M.A., 1983. Residential energy conservation: the role of past experience in repetitive household behavior. Environment and Behavior 15, 123–141.

Natural Geography Chronicles Compiling Committee of Qinghai Province (Ed.), Qinghai People's Publishing House, Xining.

Nomura, N., Akai, M., 2004. Willingness to pay for green electricity in Japan as estimated through contingent valuation method. Applied Energy 78, 453–463.

Owens, S., Driffill, L., 2008. How to change attitudes and behaviours in the context of energy. Energy Policy 36, 4412–4418.

Ping, X., Jiang, Z., Li, C., 2011. Status and future perspectives of energy consumption and its ecological impacts in the Qinghai–Tibet region. Renewable and Sustainable Energy Reviews 15, 514–523.

Qie, X.S., Toumi, R., Zhou, Y.J., 2003. Lightning activity on the central Tibetan Plateau and its response to convective available potential energy. Chinese Science Bulletin 48, 296–299.

Qinghai Bureau of Statistics, 2012. Qinghai Statistical Yearbook. China Statistics Press, Beijing.

Rath, Amitav, 2005. Energy, women and rural poverty: a review focusing on Latin America. Policy Research International, Ottawa, 31 May 2005.

Roe, B., Teisl, M.F., Levy, A., Russell, M., 2001. US consumers' willingness to pay for green electricity. Energy Policy 29, 917–925.

Stern, P.C., 1992. What psychology knows about energy conservation. American Psychologist 47, 1224–1232.

Swofford, J., Slattery, M., 2010. Public attitudes of wind energy in Texas: local communities in close proximity to wind farms and their effect on decision-making. Energy Policy 38, 2508–2519.

Viklund, M., 2004. Energy policy options—from the perspective of public attitudes and risk perceptions. Energy Policy 32, 1159–1171.

Wang, Q., 2009. Prevention of Tibetan eco–environmental degradation caused by traditional use of biomass. Renewable and Sustainable Energy Reviews 13, 2562–2570.

Wang, Q., Qiu, H., 2009. Situation and outlook of solar energy utilization in Tibet, China. Renewable and Sustainable Energy Reviews 13, 2181–2186.

Wei, X., Yang, P., Wang, Y., Xie, Z., 2004. Use of rural energy resources and eco–environmental degradation in Tibet. Journal of Environmental Sciences: China 16, 1046–1050.

Xiang, S.A., Guo, R.Q., Wu, N., Sun, S.C., 2009. Current status and future prospects of Zoige Marsh in Eastern Qinghai–Tibet Plateau. Ecological Engineering 35, 553–562.

Zarnikau, J., 2003. Consumer demand for 'green power' and energy efficiency. Energy Policy 31, 1661–1672.

Zhou, S., Cui, Q., 2007. The research on rural energy consumption in traditional western pastoral areas. Energy Technology and Management 5, 108–112.