

CORNELL UNIVERSITY

Understanding Urban Residential Electricity Usage

Behavior under Time-of-Use Pricing:

A Case Study in Jiangsu Province, China

A Thesis

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in Partial Fulfillment of the Requirements for the Degree of

Masters of Science

by

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ABSTRACT

China surpassed the United States in 2010 to become the world's largest energy consumer, and accounted for 71% of global energy consumption growth in 2011. China's energy mix is carbon intensive, using coal to supply 71% of the 85 quadrillion BTU (90 EJ) it consumed in 2008. One approach to reduce electricity consumption by building residents is through the Time of Use (TOU) pricing, a demand response mechanism that the electricity price is high during peak load demand period (during the day, and early evening) and low during off-peak load demand period (late at night) to increase grid utilization and reduce additional peak load generation.

Since 2003, Jiangsu Province in China has implemented TOU pricing scheme for residential customers. Throughout the years, over 95% of urban residents have voluntarily enrolled in the TOU program, the program has shifted peak load over 1000MW maximum, achieving on average 90.19% of grid utilization in 2007. Despite the effort, in summer 2014, peak demand in Jiangsu surged and reached historical high and risked grid reliability. The study surveyed over 1000 urban residential families in three representative cities in Jiangsu Province, namely Nanjing, Yangzhou, and Xuzhou, to develop a deep understanding of how residential customers have been responding to the price signal and electricity company's communication effort on the pricing scheme. Yangzhou's survey results are coupled with actual electricity consumption data to examine effects of behavior on energy consumption results, as a basis for identifying effective strategies to reduce residential consumption. The result has indicated that the prevalence of room air conditioning has played a pivotal role in residential consumers' electricity usage pattern. Room air-conditioners require consumers to actively turn it on and off to operate, which significantly reduces unnecessary cooling. Utility companies' active communication also plays

an important role for residential customers to engage in peak shifting or energy conservation behaviors.

As a result of this study, based on strong empirical and measured data, the design and implementation strategies of pricing program, as well as supporting approaches including communication, are proposed to further shift peak load, enhance grid reliability, and facilitate carbon emissions mitigation.

BIOGRAPHICAL SKETCH

Jing is pursuing a M.S. in Human-Environment relations, majoring in Sustainable Design. Jing did her undergrad in Engineering Science, energy systems option at the University of Toronto. After spending the past 5 years looking into technical solutions to make our world more sustainable, Jing has decided to take a shift and look at sustainability from a human dimensions' perspective. Jing is interested in human-factor related studies on building energy efficiency, energy conservation and energy management. Her previous work includes demand side of energy management, energy policy, electricity systems planning, and building energy efficiency technology research.

Originally from China, Jing is hoping her study can help to mitigate China's environmental and energy problems.

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The completion of this master thesis also concludes my two years of academic study at Cornell University. This thesis for me is not only a research project, but also a journey, a journey of self-discovery for knowledge, friendship, love and myself.

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The financial support from Lehman Fund has allowed me to extend my thesis research into a larger scale and be able to attend conferences like ACEEE Intelligent Building Conference and Behavior, Energy and Climate Change Conference.

I would also like to thank Prof. James Sweeney and Carrie Armel from Stanford University for providing me the most up to date research ideas and topics in the areas of energy and behavior.

Towards the end of the end, this research is just the beginning. It really triggered my interests in demand side management and encouraged me to do a start up in this area in the future. This research had been super fun. I sincerely do thank all the support and help I got for completing this research and hopefully this research will provide useful findings for future demand response program implementation in utility companies. I love you all.

In Memory of My Father

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GLOSSARY

Time-of-use pricing (TOU): Instead of a single flat rate for energy use, time-of-use rate plans are higher when electric demand is higher. This means when you use energy is just as important as how much you use (PG&E, 2014). Typically applies to usage over broad blocks of hours (e.g., on-peak=6 hours for summer weekday afternoon; off-peak= all other hours in the summer months) where the price for each period is predetermined and constant (SmartGrid Initiative, n.d.).

Critical peak pricing (CPP): when utilities observe or anticipate high wholesale market prices or power system emergency conditions, they may call critical events during a specified time period (e.g., 3 p.m.—6 p.m. on a hot summer weekday), the price for electricity during these time periods is substantially raised. Two variants of this type of rate design exist: one where the time and duration of the price increase are predetermined when events are called and another where the time and duration of the price increase may vary based on the electric grid's need to have loads reduced; (SmartGrid Initiative, n.d.).

Critical Peak Rebates (CPR): when utilities observe or anticipate high wholesale market prices or power system emergency conditions, they may call critical events during pre-specified time periods (e.g., 3 p.m.—6 p.m. summer weekday afternoons), the price for electricity during these time periods remains the same but the customer is refunded at a single, predetermined value for any reduction in consumption relative to what the utility deemed the customer was expected to consume. (SmartGrid Initiative, n.d.).

Advanced metering infrastructure (AMI): an integrated system of smart meters, communications networks, and data management systems that enables two-way communication between utilities

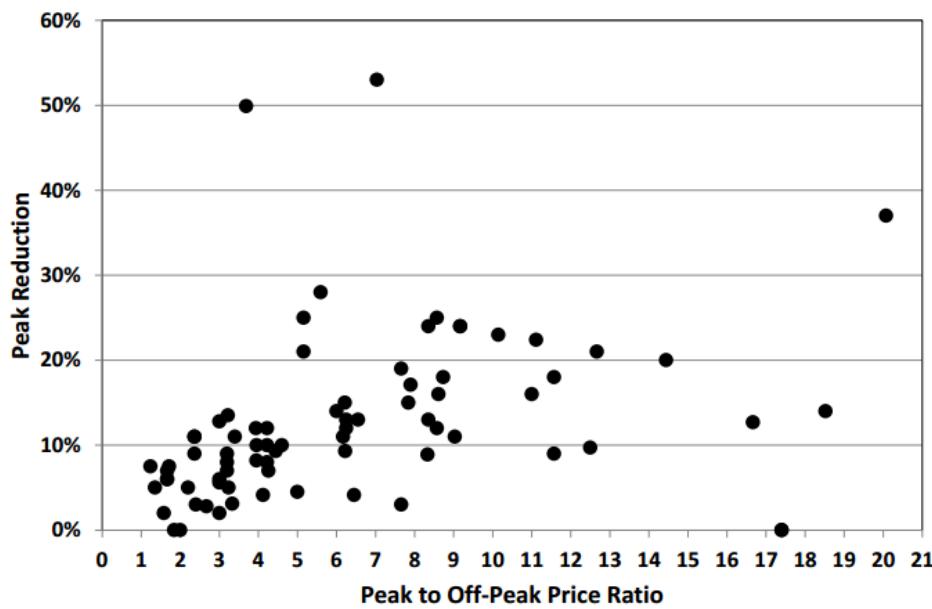
and customers. Customer systems include in-home displays, home area networks, energy management systems, and other customer-side-of-the-meter equipment that enable smart grid functions in homes, offices, and factories. (SmartGrid Initiative, n.d.).

1. INTRODUCTION

Time of Use (TOU) pricing is an adaptive mechanism where the electricity price is high during the peak load demand period (during the day, and early evening) and low the during off-peak load demand period (late at night). During peak hours, cost for electricity generation is higher, the implementation of TOU pricing will be able to reflect electricity wholesale price to customers. Under this scheme, consumers have economic incentives to shift their electricity use to off-peak load demand periods. By shifting load to off-peak hours, TOU improves electricity grid stability, improves grid utilization rate by reducing peak electricity generation and thus reduce CO₂ emissions.

TOU programs have been adopted in countries and regions such as United States, Canada, and European Union. The pricing system was demonstrated to be effective in shifting electricity use in existing programs (Faruqui, Sanem, & Shultz, Consistency of Results in Dynamic Pricing Experiments - Toward a Meta Analysis, 2013; Department of Energy, n.d.; Valeria, Sean, & Anne, 2012).

Depending on the specific TOU program design, the effectiveness of TOU varies. In some programs, enabling technologies are also used in combination with TOU pricing. For example, customers will be able to view their on-peak and off-peak electricity usage under with in home smart meter display. In a meta-study done by Brattle Group of 79 price-only treatment including Time of Use, Critical Peak Rebate, and Critical Peak pricing, peak reduction can range from 0 to over 50% (Faruqui, Sanem, & Shultz, Consistency of Results in Dynamic Pricing Experiments - Toward a Meta Analysis, 2013).



Note: Data points from Japan and PSE&G are omitted because of extremely high price ratios

Figure 1 Time varying pricing impact meta-study (Faruqui, Sanem, & Shultz, Consistency of Results in Dynamic Pricing Experiments - Toward a Meta Analysis, 2013)

TRADITIONAL TOU DESIGN

Typical TOU design divides the day into time periods that during certain periods of time, the electricity rate is higher than other time periods. The design of the TOU program means to encourage users to use electricity during off-peak period to increase utilization of the electricity grid and avoid long term electricity generation infrastructure investment.

The design criteria of the TOU pricing are the follows:

1. Short peak period – the on-peak period shall be kept as short as possible to provide flexibility for customers for shift load. 4 hours peak period is considered to be reasonable. Voluntary TOU program with long peak period often have low enrollment rate.

2. Strong price signal- Price signal should be strong enough to gain people's attention for customers to shift their electricity usage from on-peak to off-peak (Faruqui, Hledik, & Palmer, Time-varying and dynamic rate design). Industry norm is peak price to be around 1.5 times of off-peak pricing (Cappers, 2015).

The design of TOU pricing should reflect system costs of electricity generation. Therefore, TOU pricing in many places are implemented as seasonal and is only implemented on weekdays (Faruqui, Hledik, & Palmer, Time-varying and dynamic rate design).

TIME OF USE IMPLEMENTATION STATUS IN CHINA

In the announcement by the Chinese National Development and Reform Commission in December, 2013, all regions in China must develop and implement a TOU pricing mechanism for residential consumers by the end of 2015. According to the mandate, electricity companies shall develop mechanisms to encourage residential consumers to voluntarily enroll in the TOU programs (Li T. , 2013).

Pilot TOU projects have been carried out in Chinese cities, with varying degree of success. In a pilot TOU in Zhejiang province, about 20% of the electricity is shifted from on-peak to off-peak (Li B. , 2012). Yet other pilot programs, such as the ones in Shijiazhuang, Hebei Province, were not well received by the consumers. Even though TOU pricing has demonstrated effectiveness in shifting its electricity use, after half year of the pilot implementation in 2013, only 10% of the customers in Shijiazhuang were willing to continue with the program, a considerably low rate to achieve the benefits of TOU programs (Hebei Youth Daily, 2014).

The varying results of the TOU pilot projects have puzzled Chinese decision makers, and there haven't been studies on the dilemma on the effectiveness in shifting electricity pattern and

consumers' unwillingness of participating in the program. The current approach is simply based on economic analysis and there lacks of studies on why consumers responded to the pricing schemes the way they are. US Department of Energy has recently started to fund consumer studies under Smart Grid Initiative to investigate consumers' behavior under time of use pricing (Department of Energy).

In China however, this area of study is in a complete void. From the pilot TOU projects reports from China Southern Power Grid Company, the voluntary measure of the TOU pricing is the major concern for the electricity company. Difficult to anticipate consumers' responses have put on great financial risks for electricity companies' investment in the infrastructure for TOU pricing. Only rely on availability of pricing incentives and metering infrastructure to predict consumer behavior has demonstrated to be ineffective. Therefore it is essential to consider consumers' perspective and feedbacks in TOU programs' implementations, and therefore encouraging more residential consumers to enroll in the program (Li B. , 2012).

BACKGROUND OF JIANGSU PROVINCE'S RESIDENTIAL TOU PROGRAM

Jiangsu Province is the pioneer of China for residential TOU implementation. Since 2003, Jiangsu Province has reached around 95% voluntary enrollment of urban residential customer (Yan, 2014). The rate design for TOU pricing is:

	Peak Period 8am-9pm	Off-Peak Period 9pm – 8am
Rate	0.5583 RMB/kWh	0.3583 RMB/kWh

By 2007, the program has shifted peak load over 1000MV maximum, achieving 90.19% of grid utilization. By 2008, Jiangsu's electric grid has successfully shifted over 1TW, which can be interpreted as a save on investment of 1TW power station. If we were to calculate the average investment for new power plant as 4500 RMB/kW, the save on investment is over 4.5 billion RMB. TOU pricing has greatly improved grid utilization rate. (Jiangsu Electric Company, 2008).

UNIQUENESS OF JIANGSU'S TOU DESIGN

The design of Jiangsu's TOU pricing can be traditionally considered as a "bad" example of TOU design. The TOU pricing is the same all year round without any seasonal variability or weekday/weekend difference. The extensive peak period from 8am to 9pm leaves very little flexibility for customers to shift their electricity price. This voluntary program however has received 95% voluntary enrollment rate for urban residential customers. The incentives that customers get from enrolling in TOU are in the form of bill savings. When rolling out TOU pricing in 2003, the TOU pricing was designed to save each family 15% of electricity bill under their previous usage patterns, with even greater savings if they engage in behavior change. As the evolving of appliances composition throughout the years, by 2007, on average, electricity bill has decreased by 6 cents per kWh, around 11.5% (Jiangsu Electric Company, 2008).

The reason for Jiangsu Electric to design such as long peak period is mainly because of the characteristic of the load curve. Customers who enroll in TOU pricing as the result of bill saving incentives then engage in behavioral change to shift their electricity usage pattern to save further on electricity. The reason for Jiangsu Electric to start the TOU program was to ensure grid stability as around 2003; the government forbids additional investment on generation stations. To meet growing demand on the grid side, TOU program becomes the "go to" option for the electricity company to not overload electricity grid (Yan, 2014).

As Jiangsu electric only has bulk data on the peak electricity shifted, there had no study done to investigate what certain behaviors the customer have actually engaged in to shift their electricity usage. This study is to investigate residents' actual electricity usage behavior helps Jiangsu Electric to understand what actually contributed to residential customers' electricity usage pattern, how they shifted their electricity usage and what other factors influence their electricity usage and behavior. With that information, Jiangsu electric will be able to utilize the results to design better TOU pricing and provide complementary services and enabling measures. The lessons learned from TOU pricing in Jiangsu province also provides valuable insights to other utility companies especially because Jiangsu Province has received actual active participation of TOU programs despite of a pricing structure that is traditionally perceived as "very bad for behavioral change". From the typical Jiangsu Province residential load curve, the implementation of TOU pricing has indeed changed residents' behavior. There is a significant increase in electricity usage right before 8am, and after 9pm for TOU pricing users. We can clearly see the original electricity peak from 8pm is successfully shifted to after 9pm.

Jiangsu Province Typical Load Profile

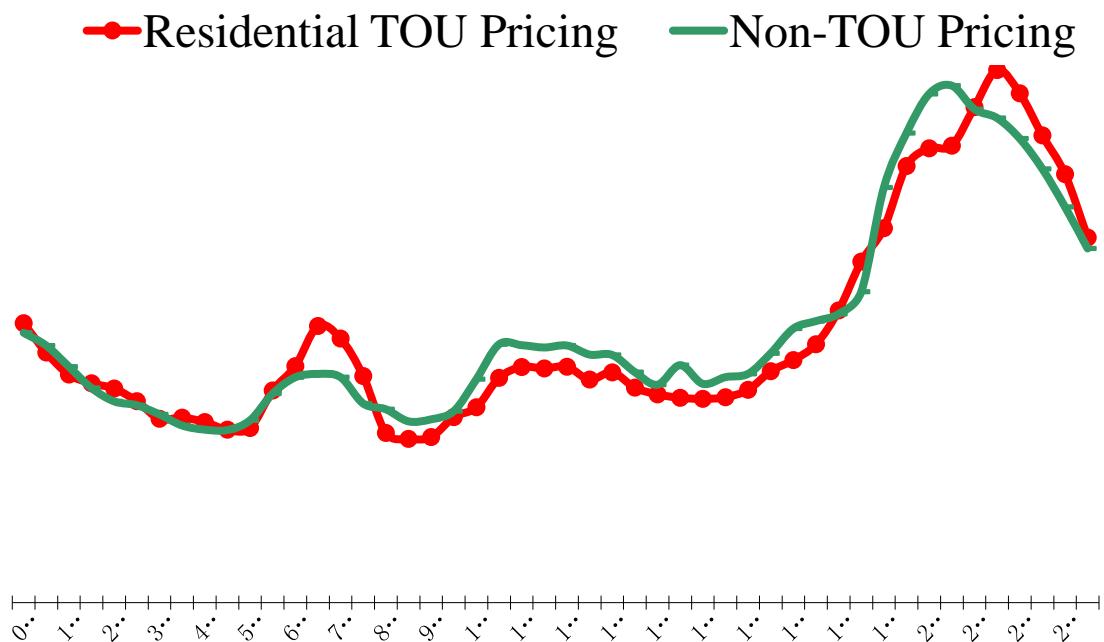


Figure 2 Jiangsu Province typical residential load profile TOU vs. Non-TOU customers (Jiangsu Electric, 2014)

2. LITERATURE REVIEW

2.1 PAST STUDIES

The U.S. Department of Energy (DOE) collaborating with Smart Grid Investment Grant (SGIG) to award utility companies to conduct consumer behaviors studies to examine acceptance, retention and response of consumers under time based rate programs, including time of use, critical peak, and critical peak rebate. In addition to pricing signals, other factors such as the existence of advanced metering infrastructure and customer systems such as in-home displays are also investigated to understand the effectiveness of those devices in changing customers' behaviors. The studies include both experimental control group studies and also survey studies.

Utility	Rate Design	Experiment Design	Areas investigated	Results
Green Mountain Power 250,000 customers, under eVermont Project (Blumsack & Hines, 2013)	All year round, critical peak events (called between 1-6pm weekday): CPP- Flat: 14.184 cents/kWh CPP: 60.000 cents/kWh	Experimental design – treatment compared to non-treatment with surveys: CPR, CPR+IHD, CPP, CPP+IHD, Flat	<ul style="list-style-type: none">Customer acceptance and response to different TOU programsCommunication strategies, In home display (IHD) (Information feedback)	Most common behavior changes: turn off lights, delay laundry Next common behavior changes: adjust air conditioning, delay cooking Least common behavior: adjust thermostat setting or appliance timers
	CPR: Flat: 14.557 cents/kWh CPP: 60.000			

		cents/kWh		
Detroit Edison Company, 2.1 million customers (DTE Energy, 2014)	Off-Peak: 4.0 cents/kWh, Shoulder: 7 cents/kWh Peak: 12 cents/kWh Critical Event: 100 cents/kWh	Experimental Design and survey	<ul style="list-style-type: none"> Communication strategies, In home display (IHD) (Information feedback) Customer behavioral change 	Behavior changes since joining SmartCurrents: <ul style="list-style-type: none"> Most people imposed minor changes over multiple months
Cleveland Electric Illuminating Company 750,000 customers (Neenan, 2013)	Critical rebate: Level 1: 40 cents/kWh Level 2: 80 cents/kWh	With customers with central air-conditioning. Separate into control and experimental groups	<ul style="list-style-type: none"> The timing and magnitude of changes in customers' peak demand and energy usage patterns due to exposure to several different designs of CPR and enabling technology 	Sample sources: <ul style="list-style-type: none"> The most majority of people participating in the survey has home ranges from 2000-2999 sq.ft. Fewer people live in smaller home sizes.
Marblehead Municipal Light Department 10,000	Critical event: 105 cents/kWh	Experimental and control group design and survey studies	<ul style="list-style-type: none"> Behavior under CPP and enabling communication technology, billing with display technology, other enabling technology (i.e. 	Significant majority of survey participants are live in single family homes. 49% of respondents to the survey believed that their electric bill dropped from 2011 to 2012. Low utilization of and high criticism for

**customers(GDS
Associates, 2013)**

**Minnesota
Power, 145,000
customers**

**(Energy Center
of Wisconsin,
2014)**

Off-peak: -2.99
cents/kWh

Peak: 1.415
cents/kWh

Critical events: 77
cents/kWh

Experimental Design and
survey

- wifi enabled thermostat
and hot water switch)
- Reaction to energy tips

online portal, there still existed a large
amount of enthusiasm for the option.
People generally found enabling
technology useful

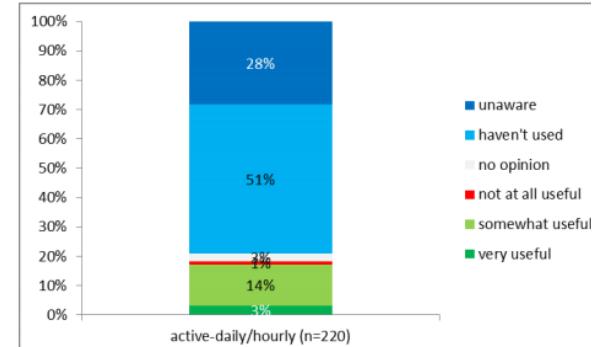
Around 50% of participants find energy
saving recommendations somewhat useful.

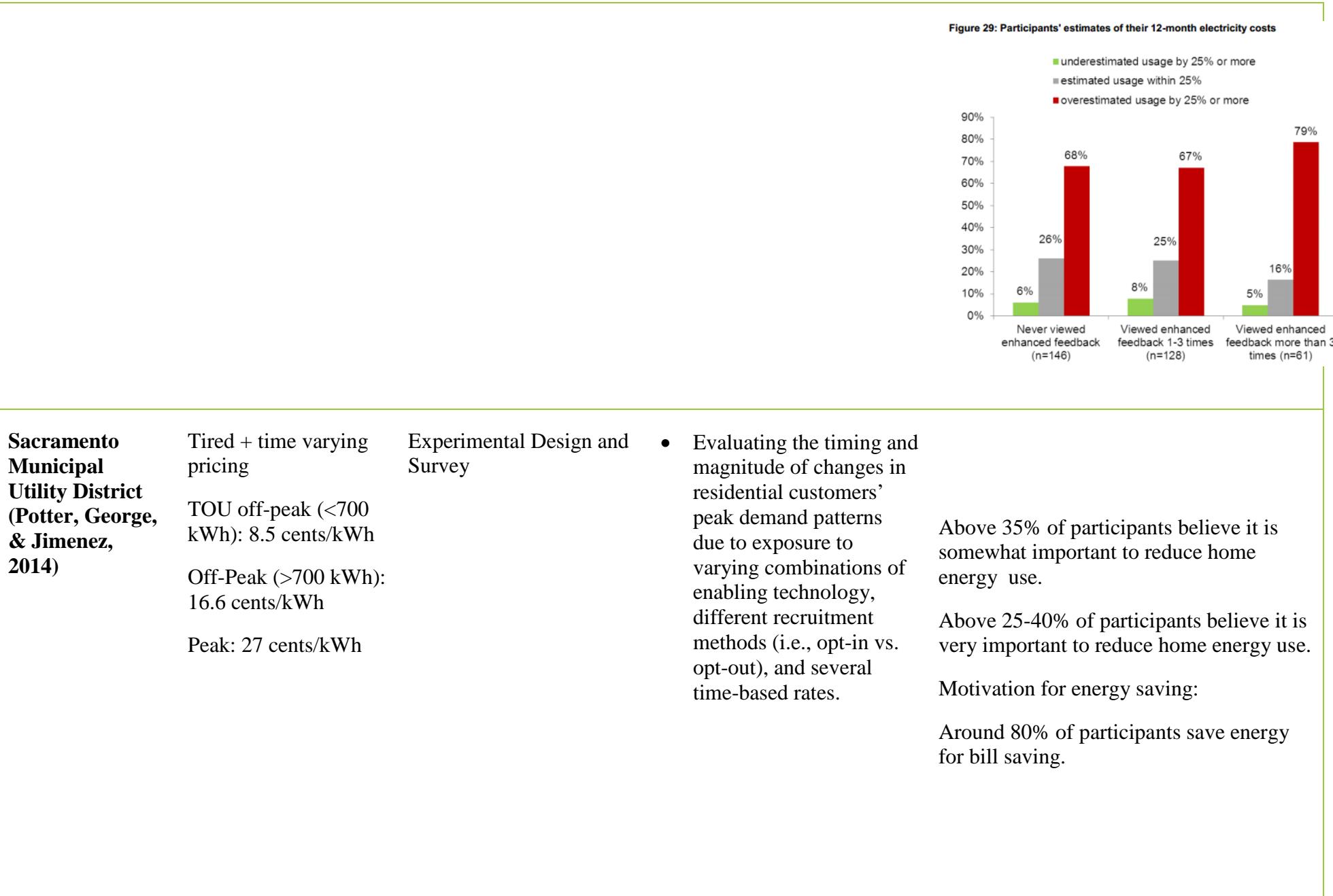
Around 40% of participants haven't used
“My action plan” at all.

Around half of the participants haven't
used notification method for energy use.

About 70% of the participants OVER-
estimated their electricity usage by 25%.

Figure 24: Awareness and perception of features among active users: notification:

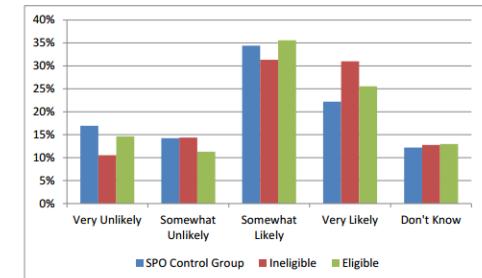




30-35% of participants indicated they are somewhat likely to take advantage of SMUD-Sponsored Energy Efficiency Programs, and 20-30% of participants indicated they are very likely to take advantage of SMUD-Sponsored Energy Efficiency Programs.

Figure

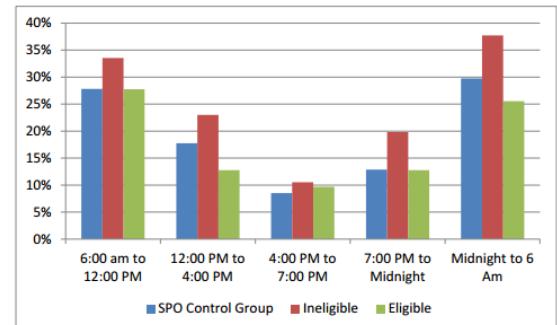
D-6: Likelihood of Customers to Take Advantage of SMUD-Sponsored Energy Efficiency Programs (Such as Rebates or Home Energy Audit Services) (n=1,142)



Around 60% of the participants only operate the air-conditioning systems on hot days and then shut it off after the house cools down in the evening, compared to 30-40% of the participants leave it on daily and pre-set thermostat setting for temperature control.

The percent of thermostats set to off at a given time of day – 4pm-7pm has indicated to be the least possible time to set thermostat off (only 10% or less of the participants set thermostats off during this period of time).

Figure D-4: Percent of Thermostats Set to Off at a Given Time of Day (n=1,115)



**Vermont
Electric
Cooperative
(Vermont
Electric
Cooperative,
2013)**

Off-Peak: 12.844 cents/kWh
Shoulder: 15.730 cents/kWh
Peak: 19.168 cents/kWh

Experimental design and survey

- Evaluating the timing and magnitude of changes in customers' peak demand and energy usage patterns due to exposure to a three-period TOU rate with variable peak prices, enhanced customer service-based information feedback and various types of enabling control and information technologies.

Kitchen (43.2%) and living room (37.8%) are the most common locations for In Home Display plugged in. Most people (63.8%) find it easy to understand. However, people still don't check it frequently, because it wasn't helpful (41.7%) and people just forgot about it (41.7%). A significant portion of people (43.8%) could not tell if they have actual energy saving or not because of the In Home Display.

6. Where is your In Home Display plugged in?		
	Response Percent	Response Count
Kitchen	43.2%	1
Bedroom	2.7%	1
Livingroom	37.8%	1
Family Room	8.1%	1
We move it around	2.7%	1
We unplugged it	5.4%	1
Other (please specify)		1
answered question		2
skipped question		1

7. The information on the In Home Display is (check all that apply):

	Response Percent	Respon- Count
Accurate	31.9%	
Easy to understand	63.8%	
Informative	55.3%	
I haven't used it enough to have an opinion	8.5%	
Inaccurate	10.6%	
Difficult to understand	8.5%	
Didn't find the information useful	10.6%	

Please explain why:

answered question

skipped question

9. Please share why you don't you check your In Home Display more frequently (check all that apply):

	Response Percent	Respon- Count
I learned all I needed to know from it after the first couple of months	16.7%	
It's too difficult to understand	16.7%	
It was in the way where we had it plugged in	0.0%	
The data wasn't accurate	16.7%	
It wasn't helpful	41.7%	
Just forgot about it	41.7%	

Other (please explain)

answered question

skipped question

In many of those DOE sponsored studies, a survey is followed up after experimental studies to understand customers' perspectives of the pricing and communication methods.

Several common themes had come out from those studies sponsored by DOE and Smart Grid Initiatives:

1. What particular energy usage behaviors customers had been involved in order to respond to the pricing? What methods could encourage certain behavior retention?
2. What particular communication methods are effective in communicating to customers regarding to energy usage and encourage them to change behaviors?
For example: display technology, providing energy tips etc.
3. How do residents perceive their energy usage and behaviors?
4. How do residents' attitudes influence their behavior?
5. How would payment methods influence residents' energy usage behavior and their attitudes?

In addition to survey questions, demographic information is collected to understand social economic status, housing size, family composition, education level, rent or own etc.

Those survey studies often involve one qualitative study by recruiting participants for focus group, and one quantitative study to gain more details of customers' responses. Generally Internet survey is used and each participant is rewarded with cash for survey participation.

In the past, studies had done regarding to different behavior techniques to encourage energy conservation behavior change.

2.2 SUMMARIZED LITERATURE FINDINGS

COMMUNICATION

Communicating energy usage information to customers had been seen as one approach to raise customers' energy usage in order to encourage them to reduce energy use. In a large meta-study of 156 published field trials and 525,479 study subjects from 1975 to 2012, with quantified energy savings from information based strategies, on average individuals in the experiments reduced their electricity consumption by 7.4%. In this meta-study, information strategies include saving tips, energy audits, different forms of energy use feedback and pecuniary strategies.

Independent variables	Weighted Average treatment effect
Individual usage feedback	-8.5%
Energy Saving tips	-9.6%
Real time feedback	-11%
Audits and consulting	-13.5%
Monetary Savings Info	-7.7%
Monetary incentives	-5.7%
Social comparison	-11.5%

Data show that in terms of conservation behavior, individualized audits and consulting are more effective than historical, peer comparison energy feedback and pecuniary feedback strategies (Carroll, Hatton, & Brown, 2009).

CHANGE IN ACTUAL BEHAVIOR UNDER TIME OF USE PRICING

From Green Mountain Power's study, major behaviors people have engaged in include:

Largest – Turn off lights, delay laundry

Second largest vote – Delay cooling, adjustment air conditioning

Received least vote- Appliance times, thermostat settings

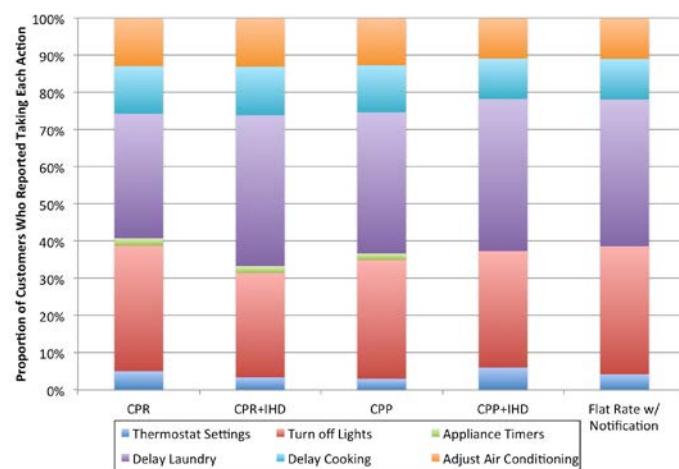


Figure 3 consumer appliances usage behavior change under Time of Use Pricing (Blumsack & Hines, 2013)

From another research by Franklin Energy which summarized US utility programs, the study at Energy Trust of Oregon in a home energy monitor pilot program, indoor lighting has received the largest vote on their conservation effort (71% vote with home energy monitor group) , followed by electric clothes drying (40% with home energy monitor group) . Then it is followed by computer use (31-33% with home energy monitor group), lastly, electric space heating, water heating (only 26%, and 19% comparatively with home energy monitor group) (Carroll, Hatton, & Brown, 2009).

As noted in the previous studies, it indicated certain behaviors people engage in order to shift their electricity usage or lower their electricity bill. The most common practice is turning off lights with thermostat setting to be the lowest priority for people to change behavior. There is always a discrepancy of what energy usage behavior they change to their actual effectiveness. Take the Green Mountain Power's study as an example, its service area Vermont is in the cold area where space heating is the major energy cost (Vermont and New York State have very similar climate). However, there had been little been done to actually change thermostat setting to shift electricity usage or lower electricity bill in general.

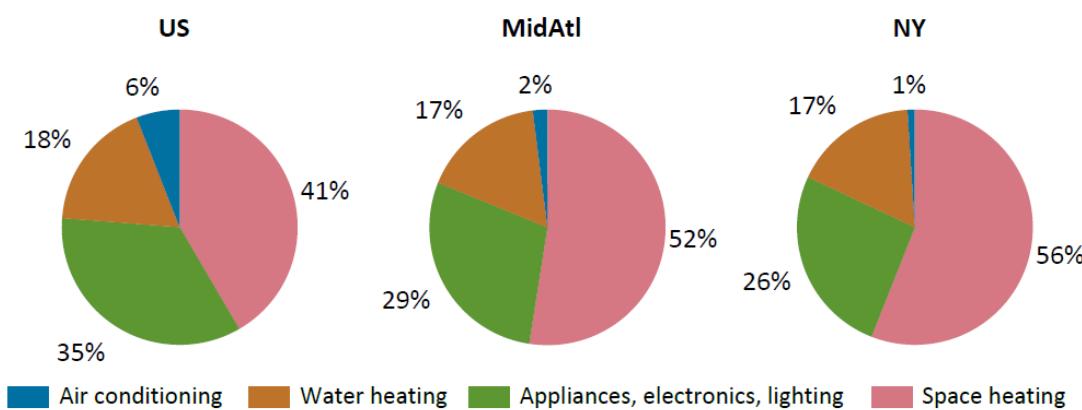


Figure 4 Household energy use in New York 2009 survey (EIA, 2009)

Again, water heating is the second largest energy use in homes, there had been little attention to change their electricity usage regarding to water heating.

The most obvious energy usage for customers are lighting and appliances and customers had been paying most attention in reducing energy usage in lighting and appliances

usage, but in reality they counted only a small portion of home energy usage but had received most attention.

It will be very interesting to study in the context of Chinese customers, and if their actions taken to shift load are actually the most effective measures they can actually do.

ENVIRONMENTAL ATTITUDES

In a study by Kollus and Agymen (2002), they have analyzed the well accepted gap between the possession of environmental knowledge and environmental awareness, and pro-environmental behavior (Kollmuss & Agyeman, 2002). Barriers lie in the middle include individuality, responsibility, and practicality, which can be illustrated by the graph below.

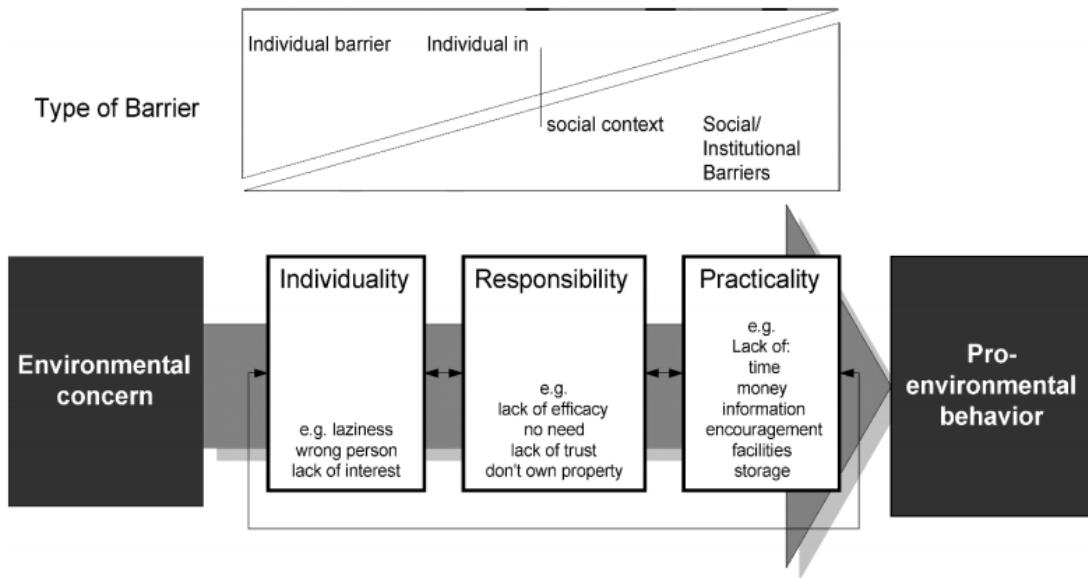


Figure 5 environmental attitude and behavior gap (Blake, 1999)

SOCIOECONOMIC STATUS AND ENERGY USAGE:

Past studies have demonstrated that socioeconomic status generally a large predictor for energy use. In the study by Steemers and Yun analyzing Residential Energy Consumption Survey (RECS) data, increased wealth might link to choices of larger homes, more air-conditioned or heated homes (Steemers & Yun, 2009).

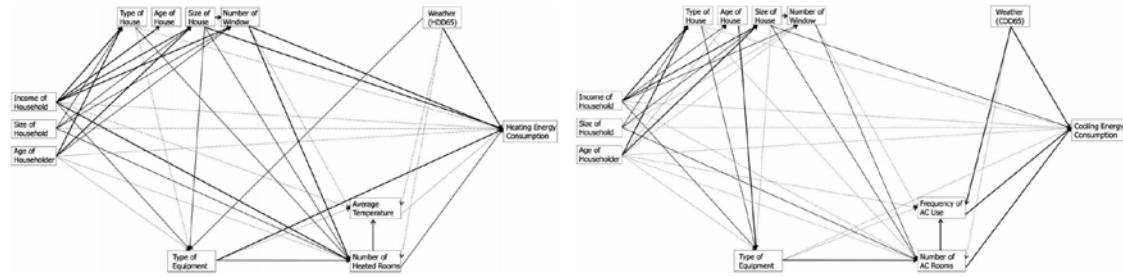


Figure 6 Model for predictors for cooling and heating energy consumptions

(Steemers & Yun, 2009)

In other studies, for example by Chang (2015), energy consumption increases with income in emerging market and developing countries, while in developed country, energy consumption increases with income only to certain threshold. It again demonstrated there should be a positive relationship between income and energy consumption (Change, 2015) .

2.3 THEORY

Changing customers' behavior is an area that falls into psychological persuasion models where each component or factor interacts to change customers' behavior.

The persuasion model has been evolved throughout the years and different streams of psychologies had been elaborating the model in slight different perspectives and components.

Carrie Armel is an established psychologist on energy and consumer usage behavior. In the persuasion model used in Carrie Armel's presentation from Stanford Precourt Energy Efficiency Center, change in behavior includes attend to the concept, understanding, believing, remembering, and willing to act on it (Armel).

The (Armel) is used as the basis, with a slight modification from Richard Petty and John Cacioppo's model (Petty & Cacioppo, 1986).

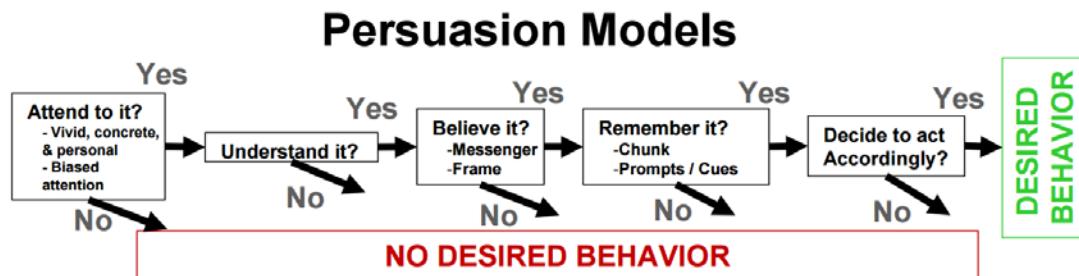


Figure 7 persuasion model used in Carrie Armel's presentation from Stanford Precourt Energy Efficiency Center (Armel)

Richard Petty and John Cacioppo brought up one of the earliest persuasion model. Different from Carmel's model, in Petty and Cacioppo's model, an important factor that could prohibit behavior is the motivation behind the behavior.

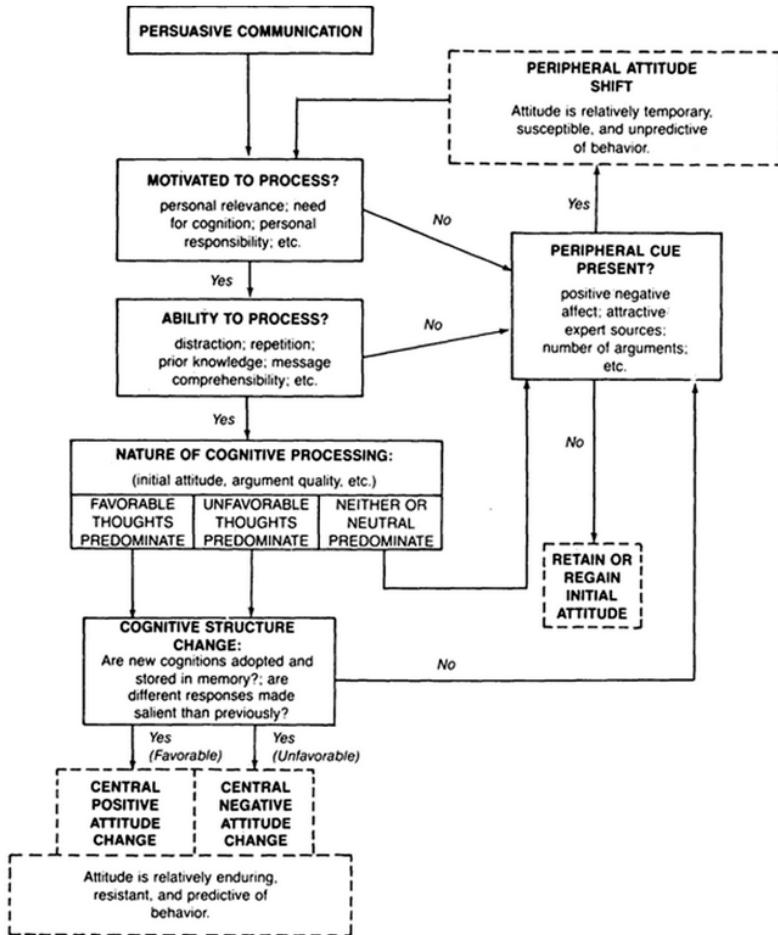


Figure 8 Petty and John's Cacioppo's persuasive communication model

Despite the difference between the two models, persuasive communication model provides a framework of understanding the process of getting people to shift their electricity usage from peak periods to off-peak.

3. MAJOR RESEARCH QUESTIONS AND HYPOTHESES

3.1 MAJOR RESEARCH QUESTION

Past studies investigating different aspects of persuasion techniques or social/environmental factors that could influence consumers' behaviors have yield various results as discussed above.

This study will map out how each component in the persuasion model is actually carried out in the Jiangsu Electric's residential Time of Use program and draw a road map on Jiangsu Electric's residential Time of Use programs to identify further improvements and study investigations.

The two models discussed above come from a pure psychological perspective. For the study of Time of Use pricing, an important component that I see missing from this traditional persuasion model is the actual ability of conducting such behavior. After buying in all the persuasive communication, if without the ability to actually perform such behavior, this particular behavior would not happen.

In order investigate how Time of Use pricing would change customers' behavior, a combined persuasive framework is proposed.

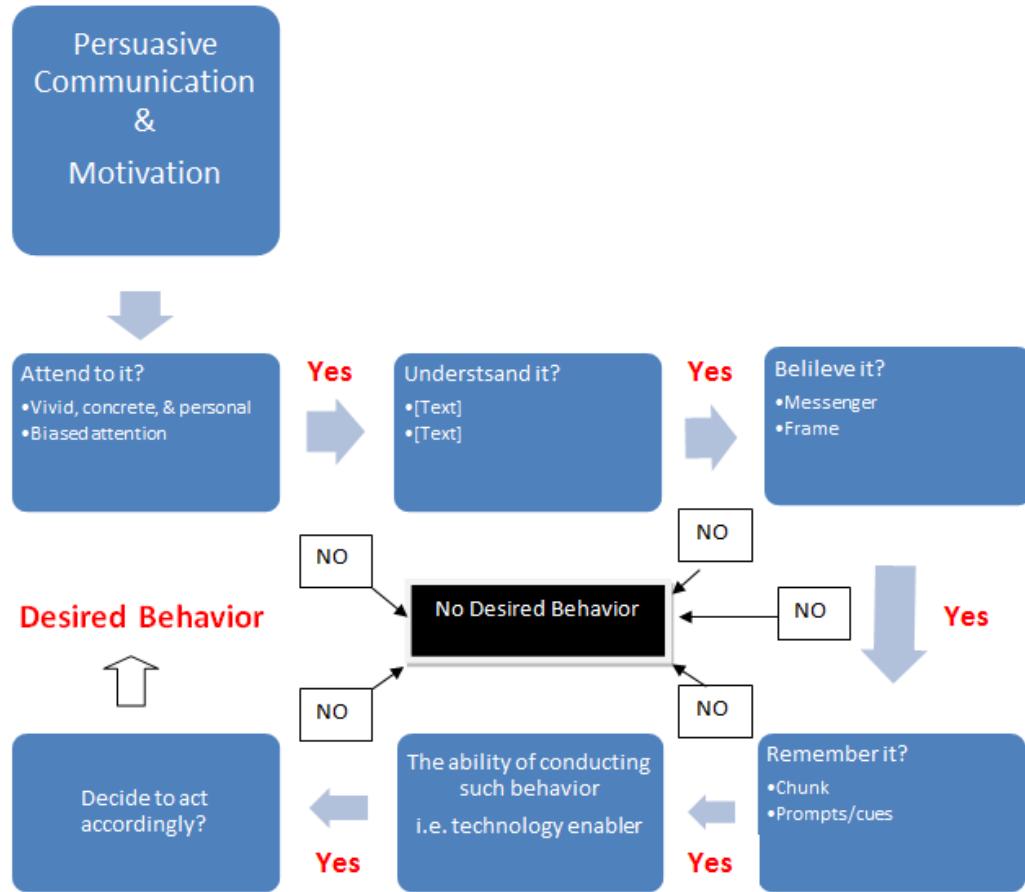


Figure 9 Combined framework to study customer behavior under Time of Use. This model is a combination of Armel and Petty&Cacioppo's model with author's modification of adding "ability of conducting such behavior".

As shown above, to get other people to reach desired behavior is difficult with uncertainties, which is making predicting behavior even more challenging. However, there are always certain patterns to follow where improving any of those steps in the persuasion model would increase the probability of targeted audience to reach desired behavior.

The goal for the residential demand response program (in this case, Time of Use program), the desired behavior is for customers to shift their electricity usage to off-peak hours. Motivation provided to the customers will be the lowered electricity price during

off-peak hours. In this persuasion model, it includes factors including how well do people actually care about this motivation and they actually buy-in with the motivation.

In order to study how utility company actually persuades customers to shift their electricity usage to off-peak hours, I categorize each sub-process into this persuasion model and determine potential areas of study.

Column 1: “processes in the persuasion model” corresponds to each component in the persuasion model above.

Column 2: “Areas to investigate in residential TOU programs” corresponds to how I believe each sub-process of TOU programs fall into.

Column 3: “Areas that falls into the categories of study” corresponds how I might categorize each sub-process during the study.

Processes in the persuasion model	Areas to investigate in residential TOU programs	Areas that falls into the categories of study
Motivation	Price incentives	Communication
Attend to it?	The benefit of joining TOU programs and shift their electricity usage	Communication
Understand it?	Understand why they should shift their electricity usage	Communication
Believe it?	Believe they can actually save on bill/help the electricity grid/or other motivation when they shift their electricity usage.	Communication
Remember it?	Continued communication with customers for them behavior retention.	Communication

The ability of conducting such behavior? (Added to the original persuasion model)	Are there enablers for them to actually shift their behavior? For example, technology enablers, their flexibility in schedule etc.	Appliance usage
Decide to act accordingly?	If people actually would bother to shift their electricity usage. How would factors like social economic status influence their behavior? Their attitude? Awareness?	Lifestyle Attitude Awareness
Desired behavior	Even for people who shifted their electricity usage, what are the actual behaviors they have been engaged?	Appliance usage Behavior change

Motivation had been addressed earlier in the introduction stage where bill saving has served as a strong motivation for residential consumers to join Time of Use pricing. Customers have all be aware of benefits of joining Time of Use pricing. Our major research question is about what customers have actually done after they joined Time of Use pricing.

Therefore, the major research question will be:

What types of residential behaviors are engaged to shift peak energy use under time of use pricing or to save energy? What social economic, communications, as well as attitude factors influence behavioral change?

The persuasive model is used as a framework to investigate hypotheses as follows.

Results will be organized into the categories of “understand”, “believe”, “remember”,

“the ability of conducting such behavior”, “decide to act accordingly”, and “desired behavior”.

3.2 HYPOTHESES

COMMUNICATION

Consumers who receive energy usage feedbacks will use less electricity compared to those who don't receive feedbacks.

CHANGE IN ACTUAL BEHAVIOR UNDER TIME OF USE PRICING

Jiangsu Electric's residential customers' electricity usage behavior changes under Time of Use pricing do not align with the most effective strategies to shift energy use.

ATTITUDE

Environmental attitude does not necessarily lead to less energy use compare to peers for Jiangsu Electric's customers.

SOCIOECONOMIC STATUS AND ENERGY USAGE

Increased socioeconomic status is positively correlated with residential energy usage.

4. METHODOLOGY

4.1 DESIGN OF INSTRUMENT

In the case of Jiangsu Electric, since residential Time of Use study had been rolled out for more than 10 years with extremely high enrollment rate, it would be very difficult to find control group who did not enroll in the pricing. Therefore, a control experiment study is less likely to be effective. At the same time, one survey study is proposed:

Survey distribution method: paper survey is proposed to avoid self-selection issues that often happen during Internet survey (Hudson, Seah, Hite, & Haab, 2004). In addition, Internet usages as well as emails are not as prevalent among Chinese residents while phone remains the most common of communication methods. From interviews with the utility company employees, elderly customers seem to be the ones pay more attention to electricity bills. Internet survey would miss out on elderly customers who are more concerned with electricity usage.

SURVEY DESIGN PROCEDURES

1. Referencing past utility studies sponsored by Smart Grid Initiative and DOE to come up survey questions that cover the following areas:
 - Appliance usage behavior
 - Energy usage behavior
 - Peak shifting behavior
 - Communication methods
 - Demographics
 - Attitudes

2. Literature review of Jiangsu's load curve, Jiangsu electric's past studies and interview with Jiangsu Electric's employees to understand better electricity usage in Jiangsu's context and revise survey questions. Detailed interview questions and answers are included in Appendix A.

One particular theme come out of this process is the dramatic influence of residents' air conditioning usage to load during summer. Air-conditioning usage is especially important for both residents and local utility companies:

On one hand, residents' electricity usage and bill might double or even triple during summer due to air-conditioning usage, on another hand, electricity grid faces greatest overloading challenge when air-conditioning is on and residential customers' contribution to electricity grid grows from very low – around 10% to 30-40% during hot summer month (Jiangsu Electric, 2014).

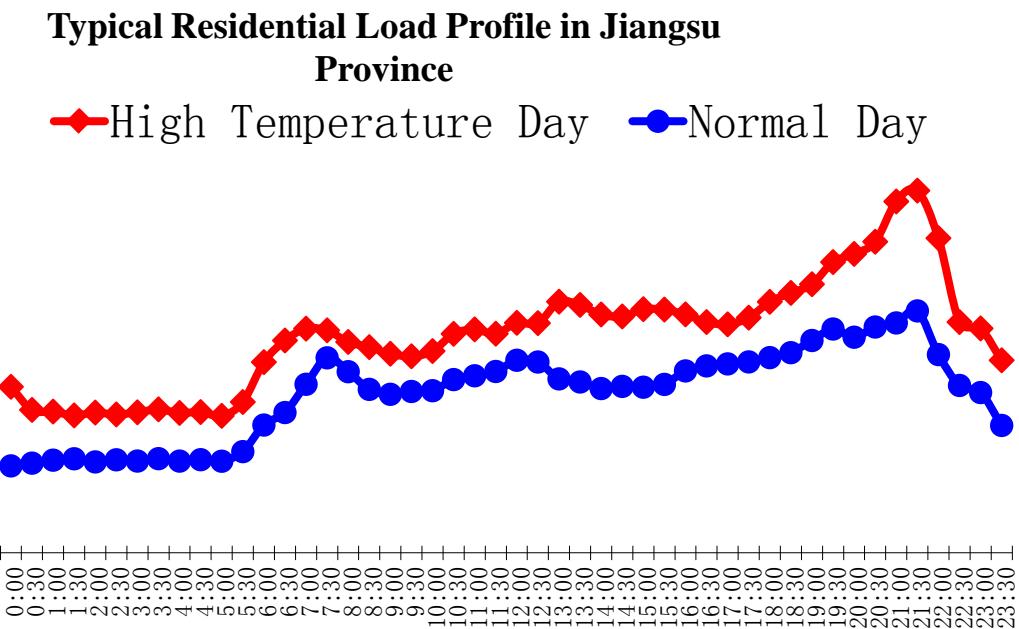


Figure 10 Typical Jiangsu residential load profile for typical high temperature day (Aug.18.2010) and a typical normal temperature day (May.14,2010)

Another interesting note is that during winter, most cities in Jiangsu do not provide centralized heating systems. Residents need to provide their own means of heating. As winter in Jiangsu is not very cold, residential electricity load due to heating do increase significantly, but it is not necessarily large enough to challenge grid stability.

The fact that the TOU pricing is the same all year around is interesting – it could result in two different consequences – people actually build up behaviors to shift load, or people just totally ignore TOU and use electricity their normal way. We would like to find out what actual behaviors that actually occurred during the survey.

Additional survey questions are added to emphasize on the use of air-conditioning. Small amount of questions focused on heating methods are also added into the survey.

3. Invite local residents to join a focus group study to further revise the survey.
Please see Appendix B for Focus group interview.
4. Final pre-testing of surveys. 20 random participants are asked to fill out the survey with the researcher together. Participants ask the researcher questions during the process of filling out surveys if they need to clarify certain questions. During this process, some questions that are not applicable are deleted. Some wording of the questions had been revised to make the questions more clear. Certain potential flaws have also been observed during this process:
 1. Participants might not read the questions carefully which result in contradictory answers.

2. Participants might fill out survey randomly.
3. For questions participants do not necessarily understand, they might not ask surveyors for clarification but just go ahead and circle one answer.

The survey was developed on the basis of consumer surveys of TOU programs in United States. However, because the surveys in United States are internet surveys compared to this survey is paper based, those flaws are difficult to completely eliminate, but the survey was revised the best to avoid those potential flaws.

4.2 SURVEY STUDY PROCEDURE

An extensive survey is designed to evaluate potential factors influence people's electricity usage behavior from the aspects of:

1. Socio-economic status
2. Demographic characteristics
3. Home appliances usage
4. Environmental attitudes
5. Communication methods:
 - a. between utility company and customers
 - b. Consumers' awareness of electricity usage
6. Educational efforts

The survey consists of 89 multiple choice as well as short answer questions. Please see Appendix D for the full survey.

4.2.1 SITE SELECTION

Three cities in Jiangsu Province, Nanjing, Yangzhou and Xuzhou have participated in the study.



The three cities are different in terms of life style and climate.

Nanjing is the capital city of Jiangsu province with developed economy. It is a relatively busy city lifestyle mixed with all kinds of industries. Nanjing is in the hot summer, cold winter zone where no central heating system is provided during winter.

Yangzhou is a relatively small and relaxed city. Yangzhou is also a tourism city and people tend to come home early from work. Yangzhou is in the hot summer, cold winter zone where no central heating system is provided during winter.



Figure 11 Lan Yuan, a neighborhood in Yangzhou where part of the survey was taken place

Xuzhou is an industrial city with 90% of the electrical load comes from industrial activities. Xuzhou is also a transportation center. Xuzhou is the only city among the three with central heating system.

4.2.2 DATA COLLECTION METHOD

Jiangsu Electric was in charge of distributing and collecting the survey. Local utility companies affiliated with Jiangsu Electric are responsible for collecting survey results within the city. The surveys are printed out and the employees of the local utility companies visit residents for them to fill out the survey. The data are collected from different income neighborhood within the city. In bulk part, one high income, one medium income and a low income neighborhood was identified within each city for the utility companies to visit.

The employees of the utility companies used methodologies such as setting up booth for people who passes by to fill out the surveys, interview residents in their homes or simply asking people who stops by to fill out the survey.

Partial of the surveys are filled out by residents by hand, and some of the surveys are filled out by the utility company employees while interviewing the customers.

Participants' addresses are recorded to match up with their real electricity usage.

Each participant receives 20 RMB worth coupon or gifts from the utility company with equivalent monetary value.

4.2.3 DATA CLEANING PROCEDURES

Data was cleaned using the following criteria:

- Data that can be determined as not valid are taken out from the data set if they have nearly identified answers.
- Certain short answer questions are taken out of the survey when it can be assumed to be filled out by the utility company employees instead of the residents.
- In the conclusions you talk about data validity. I think you need to mention here.

Valid surveys with corresponding real electricity usage in Nanjing: 110, in Xuzhou: 148, in Yangzhou: 429. Please see full data cleaning process in Appendix C.

4.2.4 REAL ELECTRICITY DATA

Real electricity data for survey participants are included from Jan.1, 2012 to Aug.31, 2014. Number of families collected in the real electricity data:

Yangzhou: 500, Nanjing: 500, Xuzhou: 375

The data includes daily peak and off peak periods' electricity usage.

Real electricity usage data are summarized into nine categories to match up with survey results. April and May are used as a periods where neither air-conditioning nor heating influence residents' electricity usage.

Summer: June.1 to Aug.31 (2012, 2013, 2014) (Average, Peak, Off-Peak)

April-May: April.1 to May.31 (2012, 2013, 2014) (Average, Peak, Off-Peak)

Winter: Dec.1 to Feb.28 (2012 Dec-2013 Feb, 2013 Dec-2014 Feb) (Average, Peak, Off-Peak)

“Average” category takes entire days’ electricity usage and average out throughout the time periods.

“Peak” category takes only the peak periods’ electricity usage and average out throughout the time periods.

“Off-Peak” category takes only the off-peak periods’ electricity usage and average out throughout the time periods.

Rarely, data with “errors” are taken out. Around less than 10 data points have errors that reported daily electricity usage for over 100000 kWh. Those data points are deleted.

Daily electricity usages that are reported to be “0” are all taken out because we would like to investigate electricity usage behavior when the house is occupied.

4.2.5 DATA ANALYSIS PROCEDURES

For real electricity usage data, all cleaned up data points (Yangzhou: 500, Nanjing: 500, Xuzhou: 375) are used to plot load curves patterns for all three cities. Hourly weather data file with temperature and humidity (Jan.1, 2012-Aug.2014) is also obtained for Nanjing and Xuzhou.

Families who filled out survey are matched up with real electricity usage. We would like to see if there are relationship between the survey questions they answered with their actual electricity usage.

For categorical questions: ANOVA test with Tukey correction – responses of each individual question are matched up with their real electricity usage data with the nine categories mentioned above (when applicable). For example, questions regarding to summer air-conditioning only matches up with summer electricity usage data.

For continuous questions: regression analysis is conducted to investigate if the answers result in any statistical significance regarding to real electricity usage.

5. RESULTS

5.1 ELECTRICITY LOAD DATA OVERVIEW

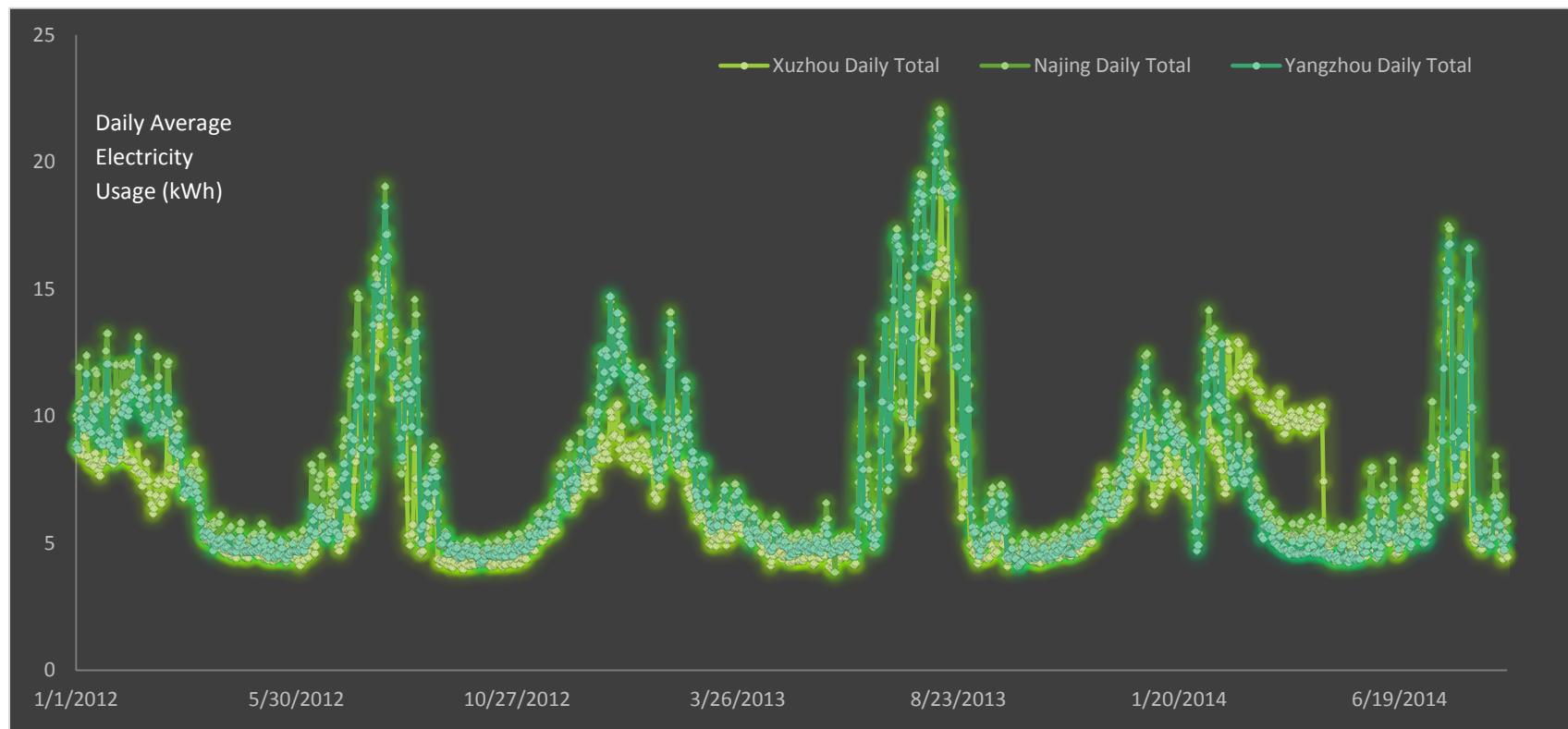


Figure 12 Electricity usage data generated load curve

The load curve is computed from averaging out the daily electricity usage over all collected families of that one particular city. From the load curve, it is clear that during the summer months the electricity usage triples or even more. Similar patterns also happen during the winter months, even though the increase in electricity usage is not as dramatic as the summer month (200% increase during winter, 400% increase during summer).

Yangzhou and Nanjing are geographically adjacent to each other, therefore similar climate is implied. This is also reflected in the graph that the electricity usage load for both Nanjing and Yangzhou are very similar. Xuzhou's load curve is similar but different from Yangzhou and Nanjing's curve. Xuzhou is north of Nanjing and Yangzhou, which during winter it is colder and centralized heating system is supplied to many neighborhoods. As seen here on the graph, Xuzhou's electricity usage during winter is quite different from Yangzhou and Nanjing's electricity usage.

As indicated from the graph, climate plays a major role in residential electricity usage which implies air-conditioning is the highest electricity load driver. Next highest electricity consumption source comes from space heating. Just to confirm the electricity usage is actually correlated with climate, a graph is plotted below for Nanjing. The when temperature is high, electricity consumption surges. Similar trend also applies to winter months. As shown in the graph, air temperature during summer is quite high – goes to 35 °C or even higher. Winter, comparatively, is not as cold; it just slightly goes below freezing.

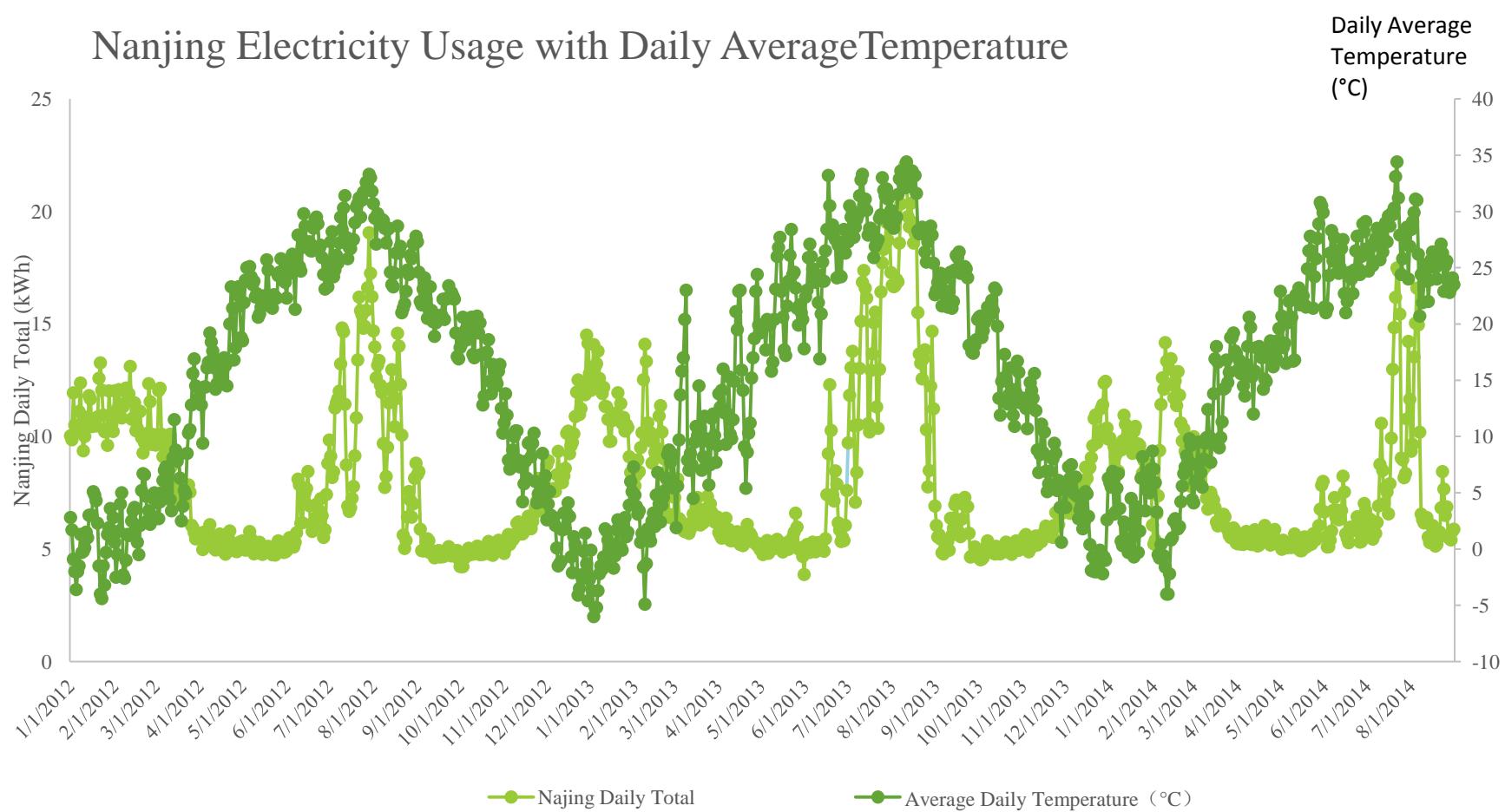


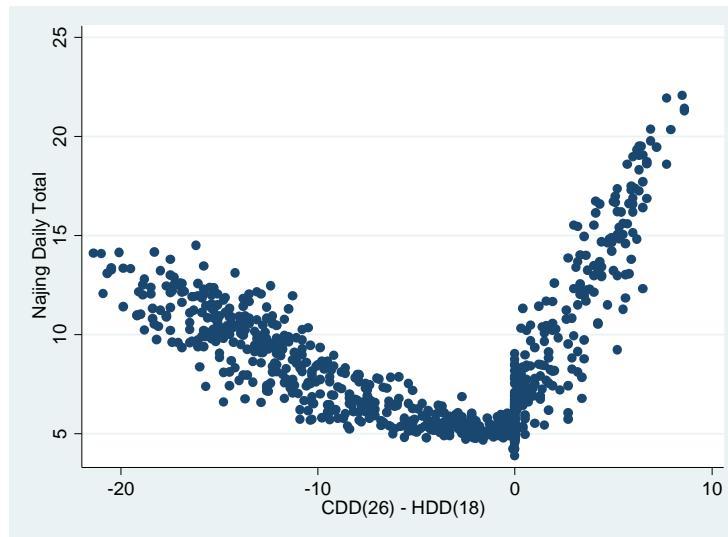
Figure 13 Nanjing electricity usage with temperature overlay

A quick linear relationship analysis had been done in order to verify the relationship between electricity usage and temperature. Temperature studied using heating degree days (HDD) and cooling degree days (CDD). Heating degree days are categorized as temperature below 18 degree C, and cooling degree days are categorized for temperature above 26 degree C.

HDD and CDD are used to investigate a potential linear relationship between temperature and electricity usage in Nanjing.

```
. twoway (scatter NajingDailyTotal CDD26HDD18, sort)
. regress NajingDailyTotal CDD26HDD18
```

Source	SS	df	MS	Number of obs = 974 F(1, 972) = 13.32 Prob > F = 0.0003 R-squared = 0.0135 Adj R-squared = 0.0125 Root MSE = 3.4121					
Model	155.080027	1	155.080027						
Residual	11316.7424	972	11.6427391						
Total	11471.8224	973	11.7901567						
<hr/>									
NajingDail~1	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]				
CDD26HDD18	-.0577605	.0158264	-3.65	0.000	-.0888183	-.0267028			
_cons	7.740937	.1279527	60.50	0.000	7.489842	7.992032			



It can be clearly seen from the graph as well as from the analysis that there is very strong relationship between temperature and electricity usage. During summer, electricity usage goes up with temperature. During winter, electricity usage goes up when temperature gets colder.

Another area of investigation is on how peak or off-peak periods electricity consumption change over time.

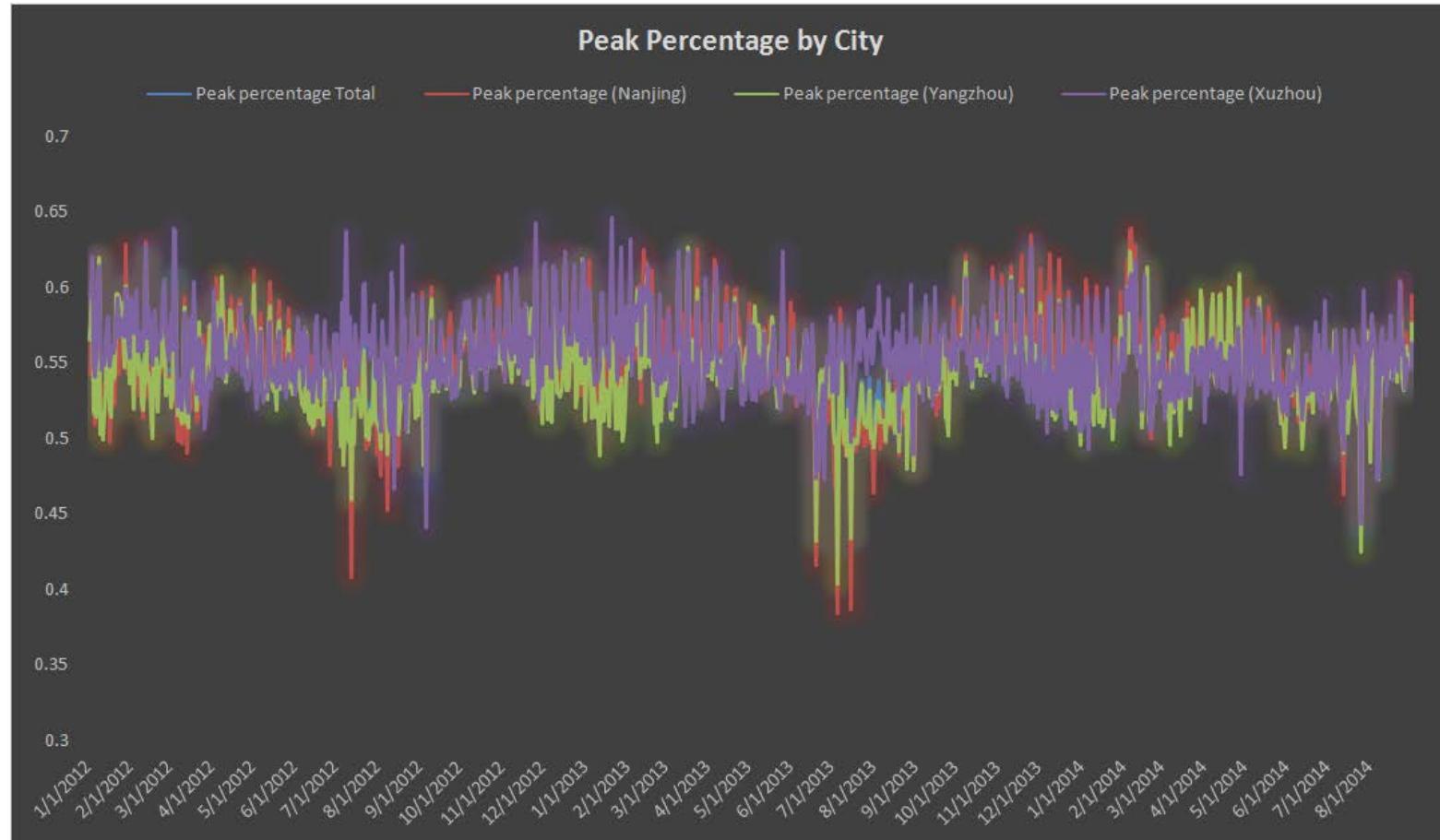


Figure 14 Peak to off-peak electricity usage percentage of Nanjing, Yangzhou and Xuzhou

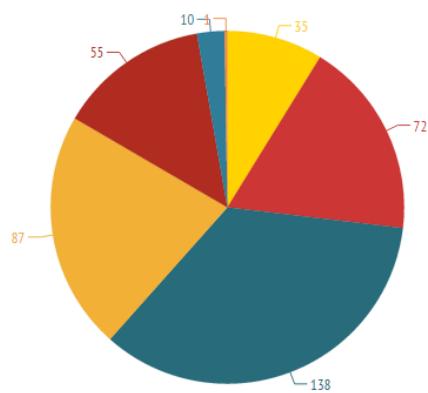
As indicated in the graph, off-peak electricity usage can even exceed electricity usage during off-peak periods during certain periods, such as some days in July. Electricity usage during the summer months surges, but it is not when it is the hottest that off-peak electricity usage reaches the maximum percentage in daily electricity usage. According to the graph, July seems to be the period of time that off-peak electricity percentage reaches a maximum or even exceed peak electricity usage. It is subject to investigation why certain pattern happens.

5.2 DESCRIPTIVE AND STATISTICAL RESULT OF YANGZHOU

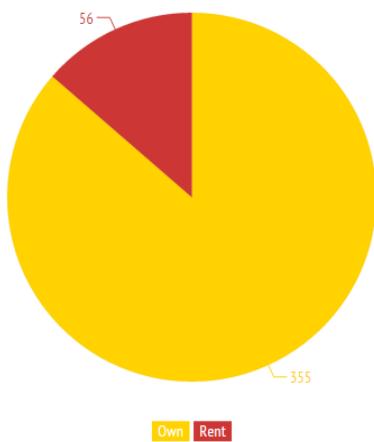
PARTICIPANTS' FAMILY AND SOCIOECONOMIC STATUS SKETCH UP

From the descriptive results, it shows that Yangzhou's survey respondents mostly live in their own house and has lived there for at least two years. In general respondents have a healthy family. Family sizes range from 3-5 composes of most of the families. Family members with highest education level to be bachelor degree composed of majority. Annual family income mostly ranges from 30,000 to 200,000 RMB.

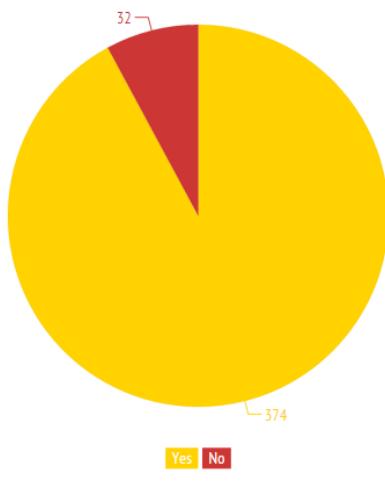
82. How many family members live in your home on a regular basis?



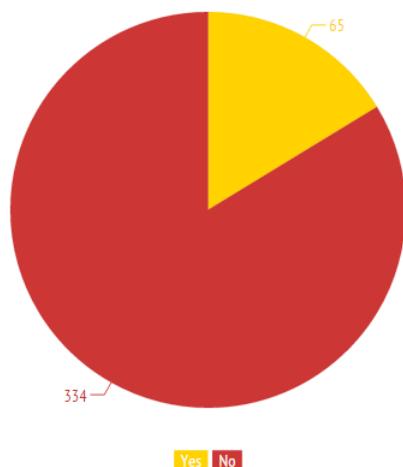
84. Do you own or rent the house?



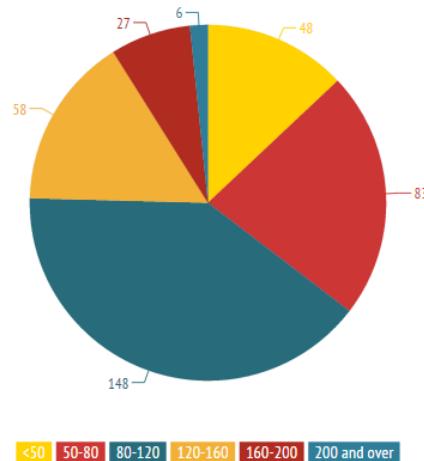
85. Have your family stayed in this house for more than two years?



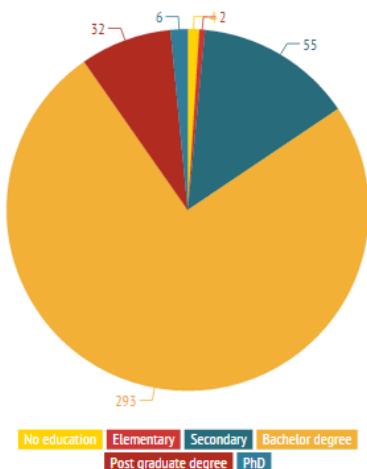
86. Is any of your family member has chronic illness or disability?



87. Your home size (square meters)



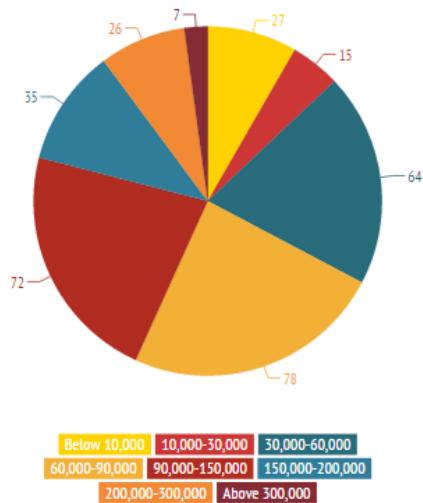
88. What is the highest education your family members have obtained who permanently live in your home?



(Note this question had been modified incorrectly by the utility company. The second choice was 50 with 10 selections. It was combined into the 50-80 range)

Note this question had been modified by utility company, master degree and PhD are supposed to be together in one option: post-graduation degree

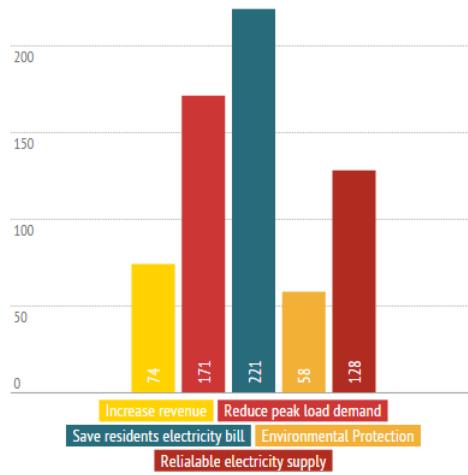
89. What is your family's annual income (after tax and can be spent)?



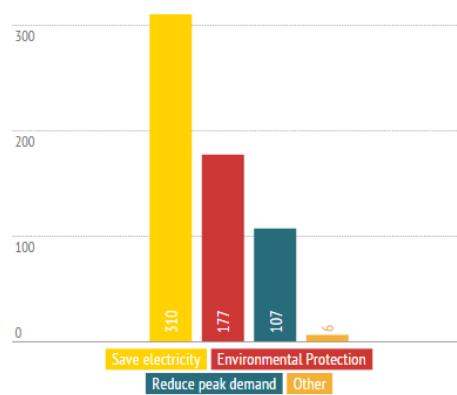
UNDERSTAND- IF PEOPLE UNDERSTAND WHY THEY ENROLLED IN TOU

From the survey results, respondents believed power companies promoted time of use pricing mostly to help people to save on electricity bills, reduce peak load pricing as well as provide more reliable electricity supply. Residents joined Time of Use pricing mostly to save on bills.

39. Why do you think the power companies promoted time of use pricing? (Check all that apply)



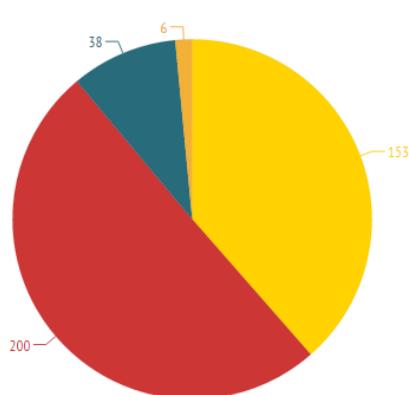
40. Why did your family enroll in Time of Use Pricing? (Check all that apply)



An understanding of the relationship between environmental issues and energy use could help residents be more aware of their electricity usage.

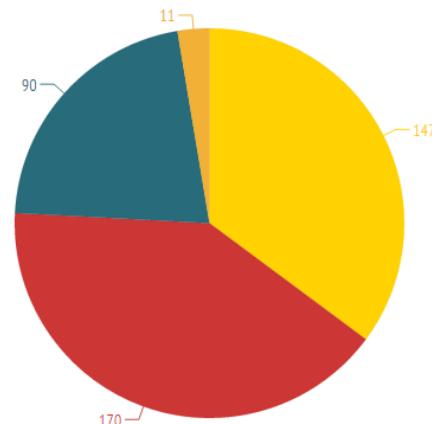
From the survey results, respondents care about air-pollution and climate change in some extent. People especially care about air-pollution. Most people believe in climate change and half of the respondents believed there could be relationship between fossil fuel usage and electricity usage during peak time.

70. Do you care about air-pollution?



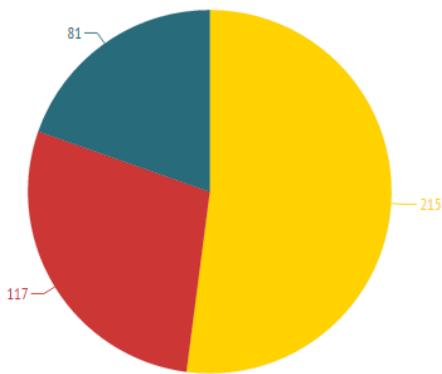
Very much | Somewhat | Rarely | Not at all

72. Do you care about global climate change?



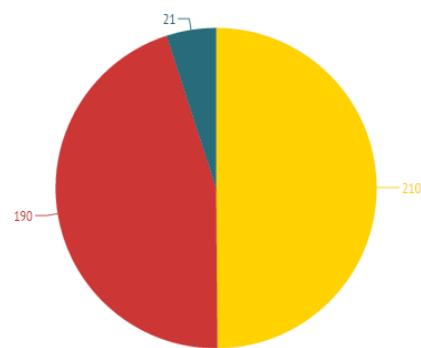
Very much | Somewhat | Rarely | Not at all

73. Do you believe in climate change?



Yes | No | Neutral

75. Do you think using electricity at peak time or off-peak time has anything to do with fossil fuel electricity generation?



Yes | No | Maybe

For customers who believe chemical industry as the main driver, their family's summer off-peak electricity usage is higher compared to those families who don't believe that.

71. What aspects do you think are the major contributors to air pollution?

Believed chemical industry is one main driver – do not believe chemical industry as a main driver

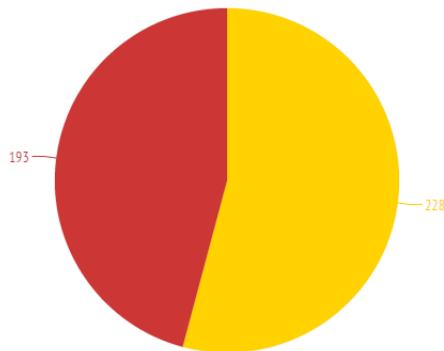
Summer Off-Peak (0.18, 1.33)

BELIEVE- IF PEOPLE BELIEVE IN THE REASON OF JOINING TOU

Energy saving information, energy usage feedback or energy tips could potentially help customers to manage their electricity usage, conserve energy, and shift their electricity usage to off-peak. Most of the respondents have indicated they have received energy saving information before from the electricity company, and most of them think the information was somewhat useful. Most customers refer to past month's electricity usage to adjust their electricity usage for coming month. Most of the families believe their home used relatively little electricity.

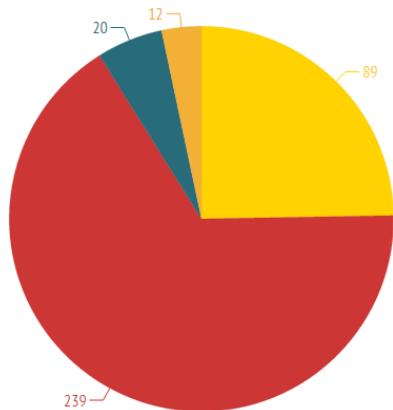
Residents are well aware that air-conditioners and fridge use most of the electricity at home.

52. Have you ever received energy saving information from the electricity company?



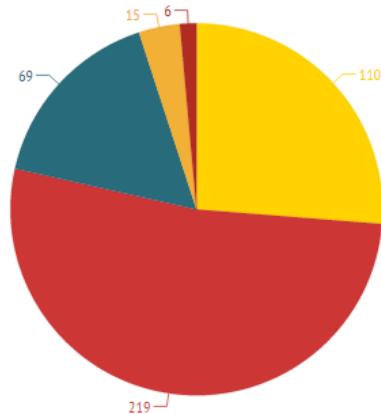
Yes | No

57. Do you think the information provided by the power company useful?



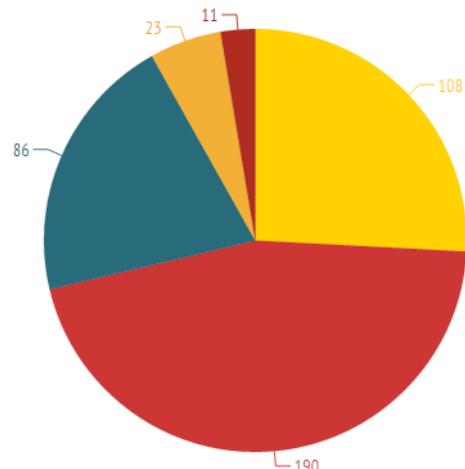
Very useful | Somewhat Useful | Not useful
I don't remember those informat...

66. Do you think information on the receipt to provide you with information on how to save on energy next month will be useful?



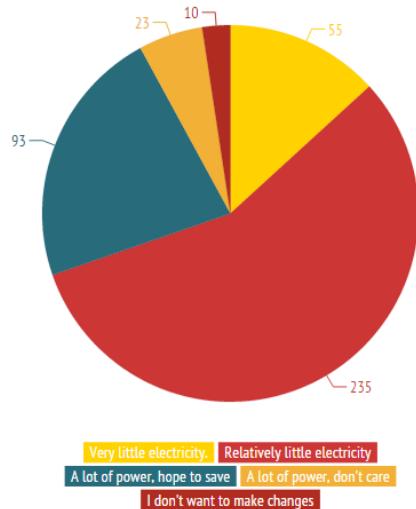
Very useful | Somewhat useful | I don't think I can remember
Would not be useful | I don't care about bill saving ...

67. If electricity company send you energy saving tips on your phone, will you read them?

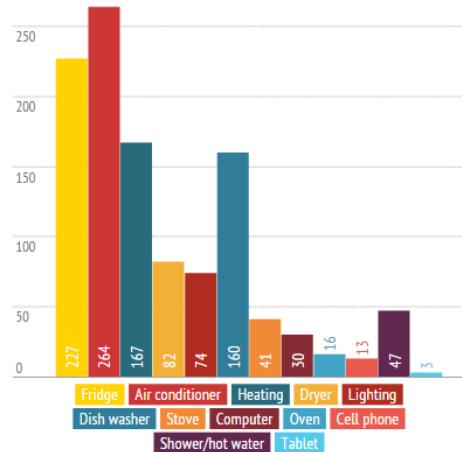


I will read them frequently | I will read them sometimes
I will read them occasionally | Never
I don't want to receive them

58. Which statement reflected your home electricity usage?

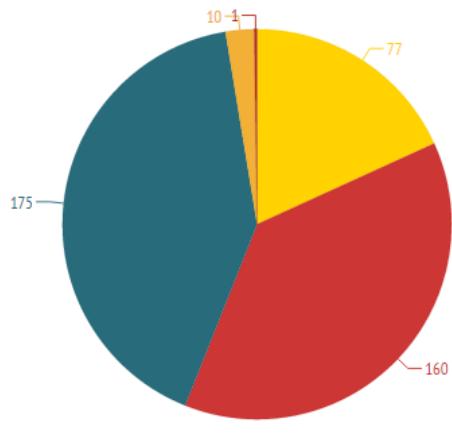


61. What do you think are the top three electricity consumption appliances in your family?



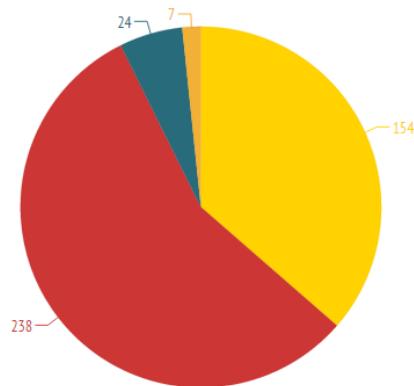
Most of the residents actually think their electricity bill is neither high or low, or just a bit high. Respondents have also reported knowing power consumption of each appliance could potentially help them to save on electricity.

46. How do you view your electricity bill?



Very high | A bit high | Neither high nor low | Relatively low
Very low

47. Do you think if you know the power consumption of each appliance, that information can help you save on electricity?



Certainly Yes | Should help some | Should not help | Do not care

64. How do you check your electricity usage?

Do not check electricity usage – check electricity usage

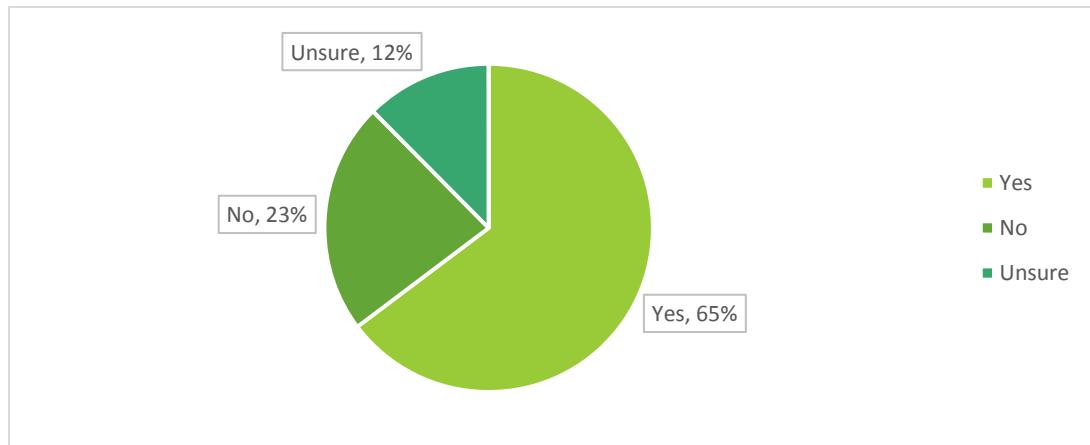
Summer Average (0.40,3.45)

Summer Peak (0.095,1.76)

Summer Off-Peak (0.23,1.77)

REMEMBER – IF PEOPLE ACTUALLY REMEMBER TOU AFTER THEY ENROLLED

Even though the most majority of urban residential customers have enrolled in Time of Use pricing according to the electricity company, from the survey there are still people who responded they are not enrolled in Time of Use. From the chart below, there are 23% of people who filled out “No” and “12%” of the population who filled out unsure (please see below). Because the electricity company had reported the overall enrollment of 95% of population in Time of Use pricing, there is a clear discrepancy between the two. There could be potentially two possibly – they are really not enrolled in Time of Use pricing or they are not aware their families are enrolled in time of use pricing. The statistical results show that if people reported they are not enrolled in Time of Use pricing, their average electricity usage for summer average, summer off-peak, winter off-peak, April-May Average, or April-May off peak are higher compared to people who reported they are enrolled in Time of Use pricing.



No-Yes

Summer Average (0.05,3.58)

Summer-Off Peak (0.09,1.88)

Winter Off-Peak (0.04,2.81)

April-May Average (0.03,1.73)

April-May Off Peak (0.17,1.00)

Because there is also a possibility that for people who filled out their homes are not enrolled in TOU or not sure if they are in TOU are the ones who do not pay bills at home. A cross tabulation had done to validate this belief. The statistical output is organized in following way: Is your home enrolled in TOU (row) Option 1: Yes, Option 2: No VS are you responsible for paying the bill (column) Option 1: Yes, Option 2: No

32. Is your home enrolled in time of use pricing?	68. Are you responsible for paying electricity bills at home?			Total
	1.00	2.00		
1.00	141 1.1 55.95 70.85	111 1.2 44.05 58.42		252 2.3 100.00 64.78
2.00	41 0.5 46.07 20.60	48 0.5 53.93 25.26		89 0.9 100.00 22.88
3.00	17 2.3 35.42 8.54	31 2.4 64.58 16.32		48 4.8 100.00 12.34
Total	199 3.9 51.16 100.00	190 4.1 48.84 100.00		389 8.0 100.00 100.00

Pearson chi2(2) = 8.0014 Pr = 0.018

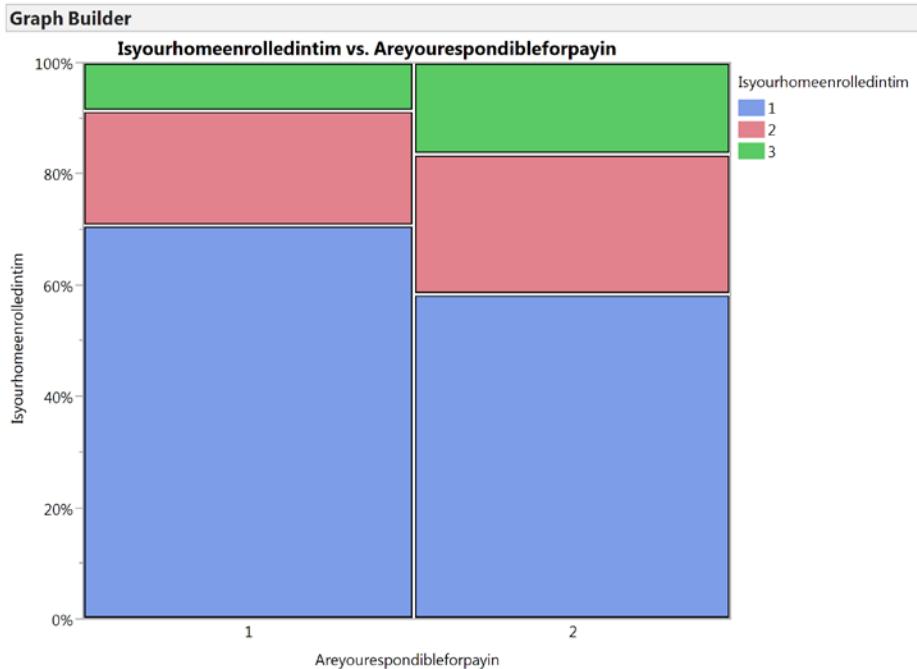


Figure 15 Is your home enrolled in TOU (row) Option 1: Yes, Option 2: No VS are you responsible for paying the bill (column) Option 1: Yes, Option 2: No – JMP output

From the statistical result, there is a clear relationship between if people believe they are enrolled in TOU pricing and if they are the one paying bills. Chi-Square = 0.018 indicated a relationship between the two variables. There are much more people who believed they are not in TOU or unsure if they are in TOU are not responsible for paying bills at home.

THE ABILITY OF CONDUCTING PEAK SHIFTING BEHAVIOR

APPLIANCES

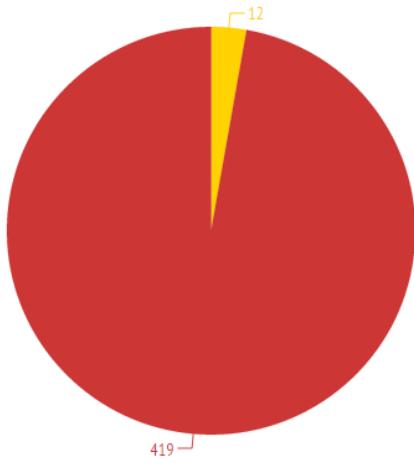
As shown in the result, a great majority of residents use room air-conditioning at home. Room air-conditioners give residents' ability to turn them on and off more easily as each individual room requires a separate hand hold control. Residents have the ability to set

temperature control points. It has shown that residents only open air-conditioners in the rooms they occupy and shut the windows and doors when air-conditioners operate.

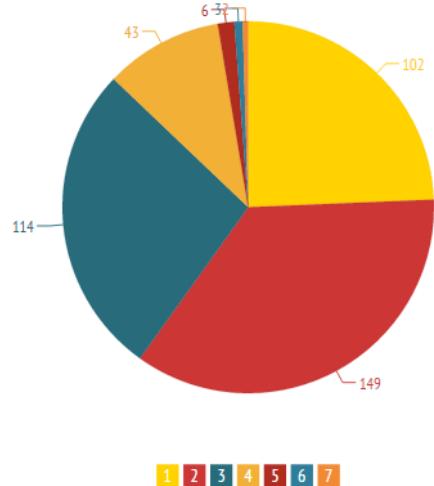
Shower time is another behaviors change that people are engaged in. It has indicated that families with electric water heater use less electricity in April-May for all average, peak or off-peak periods.

People's ability of shifting their electricity usage has largely accounted to when people get up or go to sleep. Especially because peak periods are really long, that makes leaving enough rooms very important. The longer off-peak periods people have after 9pm, (before they go to sleep) is directly correlated with their April-May Off-Peak periods.

6. What is the type of air-conditioning at home?



7. What is the number of room air-conditioner at your home?



9. What is the normal temperature setting of your air-conditioner during summer? ____ °C

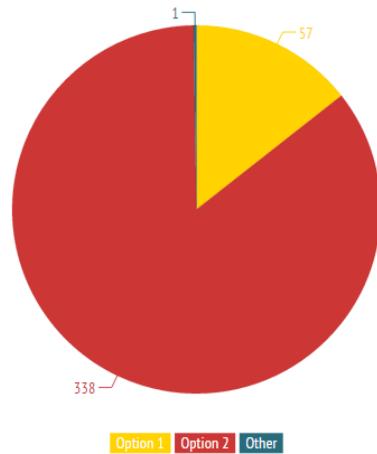
★ 26.4°C

Average Summer indoor temperature set point

● 1.44°C

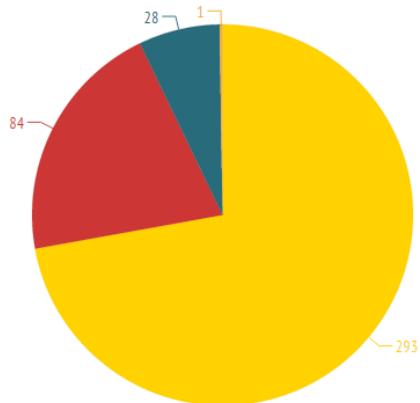
Standard Dev

10. How do your family normally uses air-conditioner?



Option 1: Keep all air-conditioner on at home
Option 2: Turn on air-conditioners in rooms that are occupied

12.What is your family's ventilation habit when using air conditioning?



Always shut doors and windows
Sometimes shut doors and windows...
Occasionally shut doors and wind...
Never shut doors and windows

27. Type of water heater – electronic

Yes-No

April-May Average (0.35,1.44)

April-May Peak (0.09,0.72)

April-May Off Peak (0.24,0.77)

How many off-peak times do each family have before going to sleep?

30. When do your family members get up in the morning and go to bed in the evening?

(How many hours after 9pm)

For April-May Off-peak: Statistical significance: $p = 0.021$, R Square = 0.0128

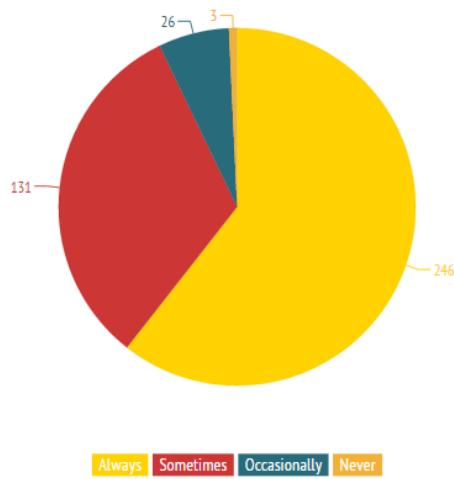
DECIDE TO ACT ACCORDINGLY – IF PEOPLE ACT TO THE OPTIMAL ENERGY SAVING/BILL SAVING STRATEGIES

AIR-CONDITIONING

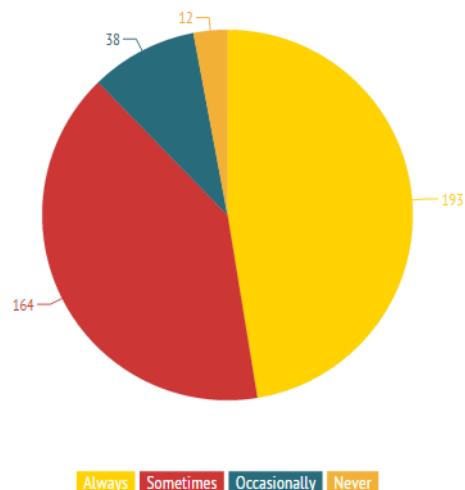
From the survey results, it shows that people actually turn air-conditioners off when going out. Most people set a timer always or sometimes before going to sleep for both energy saving reasons and health reasons.

People reported their energy saving effort to be very hard or made some efforts. People believe the motivation for other people to save on electricity is mostly for bill saving. For residents who turn off air-conditioners in the evening for health reasons, their electricity usage is lower during summer peak periods. Top behavior changes relating to electricity usage are changing in air conditioning usage and bath time.

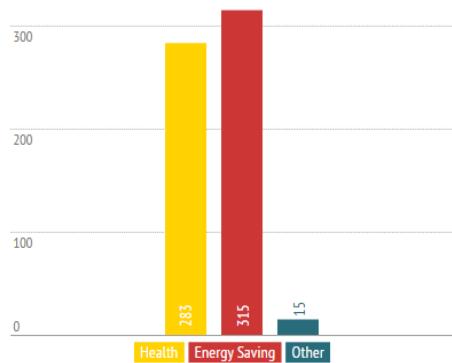
11. Do you turn off air-conditioner when going out?



13. Will you turn off AC or set a timer for AC before going to sleep?



14. What is the reason you turn air-conditioner off or set a timer when going to sleep (Check all that apply)



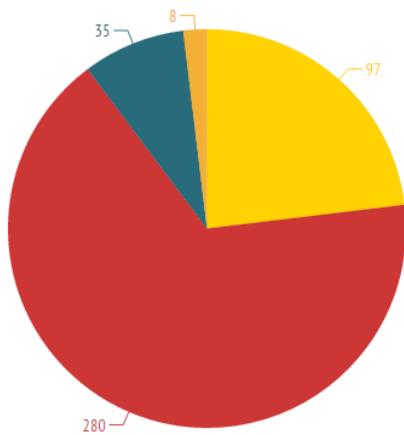
14. Health as the reason you turn air-conditioner off or set a timer when going to sleep

Yes – No

Summer Peak

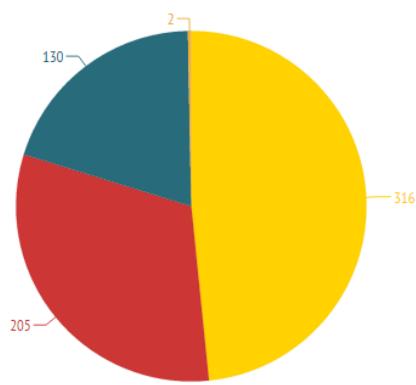
(-1.50,-0.4)

48. How to describe the effort your family made regarding to energy saving?



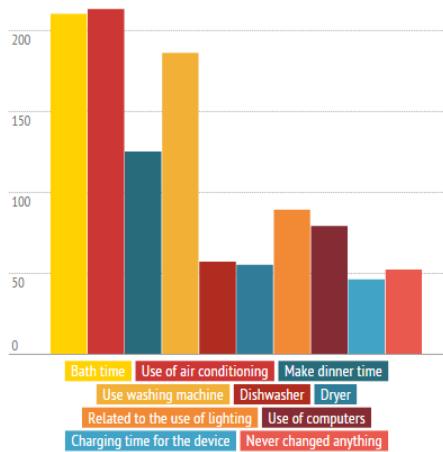
Tried very hard | Made some efforts | Rarely done anything
Never

49. What do you think the main reason is people around made efforts to save on electricity?



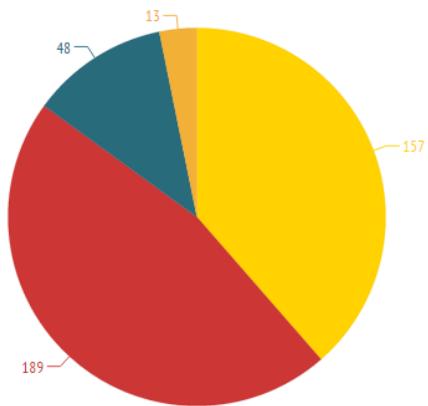
Save electricity | Protection of the environment
Help to reduce peak load | Other

55. What effort did your family make to change living habits or electricity usage habits for Time of Use Pricing? (Check all that apply)



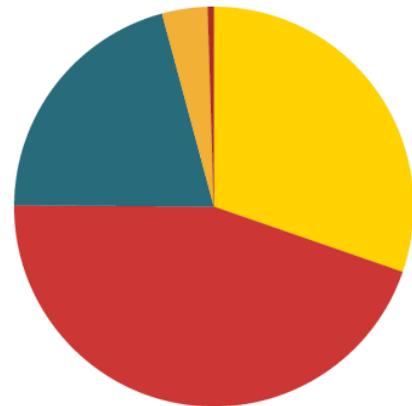
DESIRED BEHAVIOR

15. Have you ever use less air conditioning to save on electricity?



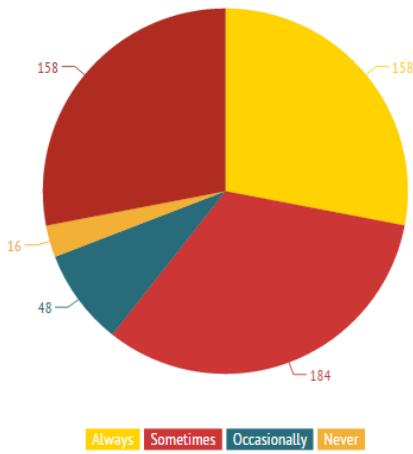
Always | Sometimes | Occasionally | Never

16. Did you ever raise air-conditioner set temperature to save on electricity?



Always | Sometimes | Occasionally | Never | Other

17. Did you ever reduce air-conditioner use during peak period (high electricity price period)?



Statistical significance has been detected for the number of air-conditioning at home. “More than 4” means more than 4 air conditioners at home. 1 means 1 air-condition, 2, means 2 air-conditioners, 3 means 3 air-conditioners.

Question: How many room air-conditioners at home?

“More than 4” - 1 “More than 4”- 2

Summer Average	(2.28,7.66)	(0.96,6.03)	(0.76, 5.13)
Summer Peak	(1.15,4.09)	(0.44,3.21)	(0.43,2.82)
Summer Off-Peak	(0.93,3.68)	(0.39,2.98)	(0.13,2.37)
Winter Average	(2.71,10.11)	(1.38,9.35)	(1.21,7.19)
Winter Peak	(1.11,4.91)	(0.44,4.01)	(0.50,3.57)

Winter Off-Peak	(1.25,5.40)	(0.64,4.55)	(0.44,3.80)
April-May Average	(0.27,1.77)	(0.05,1.47)	
April-May Peak	(0.71,3.31)	(0.40,2.84)	
April-May Off-Peak	(0.33,1.60)	(0.24,1.45)	

It can be clearly shown in the result that families with more room air conditioners use more electricity compared to families with less air-conditioners at home.

55. What effort did your family make to change living habits or electricity usage habits to shift peak electricity usage?

	Use of Air-conditioner (Yes-No)	Use washing machine (Yes-no)	Dryer (Yes-no)	Never Changed Anything (Yes-no)
Summer Average	(0.41,3.01)	(0.10,2.66)	(0.22,3.77)	
Summer Peak	(0.10,1.53)		(0.27,2.21)	
Summer Off-Peak	(0.21,1.52)	(0.04,1.33)		
Winter Average	(0.64,4.12)			
Winter Peak	(0.11,1.91)			
Winter Off-Peak	(0.47,2.38)			(-2.68,-0.01)
April-May Average	(0.01,1.25)			

April-May Off-Peak	(0.05,0.65)	(0.02,0.61)
--------------------	-------------	-------------

It can be clearly shown that for families who made behavior changes, their electricity usage is significantly different. Given air-conditioning as the highest portion of electricity usage, for customers who claimed they changed their living habit for air-conditioning usage, their electricity usage is significantly higher in almost all seasons, including summer, winter as well as April-May. For customers who changed their washing machine usage, statistical significance has been detected for summer average, summer off-peak and April-May Off Peak where their electricity usage is higher if they made living habit change with the usage of washing machine. Dryer's adoption rate is rather low comparatively so we won't consider this result regarding to dryer useful. For customer who claimed they never changed anything, their electricity usage is actually lower compared to people who claim they made changes.

6. DISCUSSION

The preliminary survey results have shown that air-conditioning related behaviors have the greatest impact on residential family electricity usage. Appliances usage behavior other than air-conditioning also plays a role in non-summer seasons. Communication and awareness play a significant role in people's energy usage and their energy shifting behavior. Attitude in general plays a smaller role. It was also noticed that is discrepancy between people's beliefs and their actual electricity usage. Socioeconomic statuses have been reported to have no direct effect on residential family use.

6.1 PERSUASIVE MODEL

To revisit the persuasion model, it composes of components of "motivation", "attend to it", "understand it", "believe it", "remember it", "the ability of conducting such behavior", "decide to act accordingly" and "desired behavior".

From the studies shown above, customers have actually made significant efforts to save on electricity, especially for air-conditioning usage. However, unlike other Time of Use pricing scheme in other jurisdictions, Jiangsu has used bill saving as a motivation to successfully attract the most majority of the customers to engage in Time of Use pricing. After people are enrolled in the pricing, people come to an understanding of different pricing at different times of the day, which encourages people to shift their electricity to off-peak or use less electricity during on-peak periods. Because of the prevalence of room-air conditioners, it gives residential customers more ability and control to actually adjust their electricity usage behavior to save on electricity usage during certain periods

of the day. Survey results shows people actually decide to act according to the most optimal way to use air-conditioners.

This two-step persuasive communication is really different from other TOU programs.

Step 1: Use monetary incentives to attract customers to join the program	Step 2: Through communication, and feedback, and the existence of room air-conditioning actually helps customers to reach desired electricity usage behavior.
Motivation	Remember it?
Attend to it?	The ability of conducting such behavior
Understand it?	Decide to act accordingly?
Believe it?	Desired behavior

TOU programs in many jurisdictions have encountered difficulty in implementation.

Potential reasons are the current “one step” approach to persuade people to shift their electricity usage from on-peak to off-peak. It requires strong motivation and incentives in every stage of the persuasive model in order for customers to shift their electricity usage to off-peak.

6.2 SOCIOECONOMIC STATUS

From the socio-economic status perspective, the survey have showed no direct relationship between people’s income, the size of houses, level of education, size of

families on how home's actual energy consumption for average population. Potential factors that contribute to interesting phenomena is that the survey is done in the city where people all live in apartment buildings, therefore, their family sizes, home sizes are all limited by the apartment building. Because of the extreme high density of Chinese population and easy access to public transit, urban populations all live in apartment buildings; it is extremely rare to non-existence for people to live in single family house or even townhouse in China. People live in apartment buildings regardless of their socioeconomic status. Due to the limitation of the space, affluent families do not necessarily have more electric appliances or source of electricity usage in their homes. It does not, however means that high economic status people are actually have similar electricity usage footprint with other people, additional information would be needed. In terms of peak shifting and energy conservation for individual homes, socioeconomic status is not a determining factor.

6.3 APPLIANCE USAGE

Residential electricity usage is significantly influenced by residents' appliance usage pattern.

AIR-CONDITIONING

Air-conditioning plays a key role in summer electricity usage. One special outcome that has been observed is the special role room conditioning had been playing in Chinese residential energy usage. In Western residential families, it is most common to have central air-conditioning and thermostat that controls electricity usage for the entire family

while each individual room might or might not have individualized on and off and also temperature control.

From the survey, it had been noted that the prevalence of room air-conditioning (97% of family surveyed use room air-conditioning) have directly contributed to energy saving efforts to homes.

INDIVIDUAL CONTROL HAS TO BE USED TO TURN ON AND OFF ROOM AIR-CONDITIONING

Room air-conditioning comes with a controller that users have to press buttons on the controller and point to the air-conditioner in order to control individual air conditioner: turning it on and off, control temperature, control wind speed and direction, schedule air-conditioning on and off etc. A typical room air-conditioning controller is shown below.



Figure 16 A typical room air conditioning controllers in China

From the survey, a majority people are actually using the most energy efficiency approach when using room air-conditioning. 85% of survey respondent reported turning on air-conditioning only in rooms that are occupied and only 15% of survey respondent keep all air-conditioning on at home. In terms of turning off-air conditioning, the

majority of the respondents turn air-conditioning off when the rooms are no longer occupied: 61% of respondent always turn off air-conditioning when going out with 32% respondents sometimes turning off air-conditioning when going out. In addition, residents in general have very good ventilation habits – people keep windows and doors shut when turning on air-conditioning: 72% of respondent always shut doors and windows when air-conditionings are on, with 21% of respondent sometimes shut windows and doors when air-conditionings are on. It could also attribute to people want rooms to quickly cool down. This habit is effective in reducing energy wasted to cool rooms. Shutting doors and windows directly contribute to the coolness of the room. While in homes with central air-conditioning, it would be more difficult for people to monitor if windows are all well shut in all rooms.

Number of room air conditioners installed at home has shown a statistical significance effect on home electricity consumption. Families with more than 3 air-conditioning units at home use significantly more electricity all year around. The reason that it might vary all year around instead of only summer is that because the city survey had been consulted do not have centralized heating system. The “air-conditioning” units are actually also electric space heaters during winter so it is used to control temperature at homes all year around (70% of the survey participant choose to heating method as air-conditioning/heat pump).

TURNING AIR-CONDITIONING OFF DURING EVENING

From the survey, people turn the air-conditioning off or set a timer to turn off air-conditioning during evening (48% reported always turning it off while 40% reported sometimes turn it off) due to both health and energy saving reasons. It is also believed it

is easy for people to get cold when blowing air-conditioning when sleeping so it is common to turn off air-conditioners after people fall asleep.

It is interesting note that despite people turn air-conditioning off during evenings, from the load curve in the electricity consumption section of the result, sometimes off-peak energy use is comparable or even higher than on-peak energy use for particular days, this could account to the fact that evenings of hot summer days are unbearable that people keep their air-conditioning on until they go to sleep. If people have a long day outside home, it is possible they actually use air-conditioning during off-peak hours more.

EFFORT FOR USING AIR CONDITIONER TO SAVE ON ELECTRICITY

In the survey, people actually understand air-conditioner is the largest contributor for people's home electricity usage. In question 61 where it asks residents to rate top three electricity consumption appliances, air-conditioner received most votes (264 out of 420 votes). Therefore, if they have the willingness of saving electricity, air-conditioner would be the most important one to consider. As the result, a significant portion of population has attempted to change their air conditioning usage behavior to either off peak or on peak. Question 15, have you ever use less air conditioning to save electricity (39% always, 46% sometimes), question 16, have you ever raise air conditioner set temperature to save on electricity. (30% always, 45% sometimes). Question 17, did you ever reduce air-conditioner use during peak period? (39% always, 45% sometimes).

For people who choose if they made efforts of changing living habits or electricity usage habits to shift peak electricity usage in question 55, it is noted for people who choose they made efforts to shift electricity usage for air-conditioning usage, their electricity

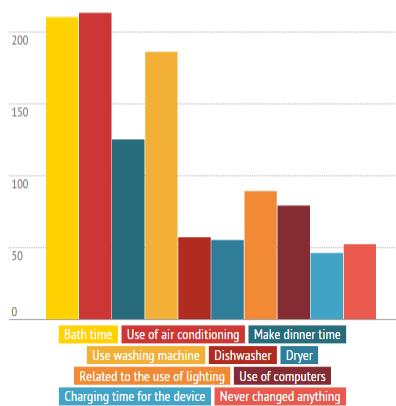
usage for all seasons for both on peak and off-peak periods are statistically higher average compared to people families who do not make efforts to shift their electricity usage. This contradicts our beliefs that for families who made efforts to use less electricity during on peak hours should use more electricity during off peak hours. The consistent higher electricity usage for both peak and off-peak for people who claim they made efforts in electricity usage could due to potential fact that those people who make more efforts to shift their electricity usage knows air conditioners play a key role in their family's electricity usage so their air-conditioner usage are high to begin with.

TEMPERATURE SETTING

Average temperature setting is around 26.4°C during summer which is already at the suggested home temperature set point by US DOE.

OTHER APPLIANCES AND ELECTRICITY USAGE BEHAVIOR

55. What effort did your family make to change living habits or electricity usage habits for Time of Use Pricing? (Check all that apply)



This result shows air-conditioning, fridge and heating are significant electricity consumption sources in homes. There is however, one item that stands out – dish washer that does not align with what we understand about the city before. Because of extreme low adoption of dish washers in the city of Yangzhou, it is almost impossible to get so many votes for the choice of dish washer. This discrepancy shows there are potential issues regarding to data collection where this choice is randomly selected and do not reflect their real usage.

From the 2000 electricity consumption survey in Yixing, Jiangsu, a city that is similar in lifestyle compared with Yangzhou also in the same province, air conditioner is indeed the highest energy consumption sources at home (440.6kWh/year per household), followed by refrigerator (308.3 kWh/year per household). Data for space heating is lacking. Lights also take a significant portion of electricity usage (192.9 kWh/year per household).

Surprisingly, rice cooker also plays a big role in electricity usage (average 244.5 kWh/year per household), but people really do not realize how much electricity cost is it in cooking. Water heating for shower accounts for relatively little electricity usage in annual residential consumption (average 27.5 kWh/year per household) (Brockett, Fridley, Lin, & Lin). Even though this particular survey was conducted over 10 years ago but it helps to indicate important sources of electricity consumption in residential homes.

Therefore, from the surveys we have seen, it is clear that people have been able to identify air-conditioning as the most energy consuming appliances at home, at the same time, people also understand the significance of fridge in electricity consumption. From this survey, people seem to have the correct understanding of their highest electricity consumption sources.

WATER HEATER

Even though water heater is not a significant amount of energy consumption, partially because instant water heaters have been prevalent so it avoided wasted energy consumption. But from our survey, adjusting people's time to take shower seems to be a quite common approach to avoid on peak electricity usage. There are actually families who take showers during off peak time just to save on electricity. People who use electric water heaters compared to people who do not use electric water heaters have shown a statistical significance compared to people who do not use electric water heater in all categories in April-May. It makes sense because in other months, electric water heating accounts for a small role compared to air conditioning, so the difference cannot be really detected.

WASHING MACHINE

Changing washing machine times is also identified as a potential approach to shift electricity usage from on peak to off-peak. Because it is not a frequent activity, it can easily be used during off-peak hours and is one of the activities people mostly engage in. From the statistical analysis, it is noticed that customers who claim to move their washing machine usage to off-peak indeed have higher electricity usage during off-peak periods for the summer months and April-May compared to people who do not move washing machine usage to off-peak hours.

LIGHTING

Lighting plays a relatively smaller role in home's electricity consumption but still people employ energy efficiency behavior towards lighting – people start to purchase more

energy efficiency lighting fixtures and turn lights off when leaving home (76% participants reported they always turn lights off when leaving the room and they go for energy saving bulbs when purchasing new ones).

6.4 FLEXIBILITY OF ADJUSTING BEHAVIOR

From our survey results, families wake up on average at 6:30 am and go to bed at 10:30pm. This means families have 1.5 hours before peak period starts and 1.5 hours after peak periods end to change shift certain electricity usage during the day. It had been reported from our survey, also the focus group that families get up earlier in the morning to take shower and do clothes washing during off peak hours. From the survey, 56% of participants have reported it is relatively easy to adjust their electricity usage behavior from on peak to off-peak.

Other appliances other than air conditioning, lighting, cloth washer and shower time are actually much more difficult to engage compared to air-conditioning and water heater. Fridge for example even though it uses significant amount of electricity in residential homes, it is very challenging to change electricity usage behavior of fridges. Due to the long hours of peak time usage, there are few behaviors people can actually engage in to shift peak electricity usage to off-peak with other appliances. The long peak hour also provides significant obstacles for shifting cooking time. People can only shift cooking to later during the day rather than earlier.

Some small appliances like rice cooker indicated actually use a lot of electricity but had been neglected by residents. However, residents do not actually know their electricity usage had been escalating also because those small appliances. If people actually know

those small appliances use so much electricity, it might help residents to reduce the usage of certain appliances during peak hours or overall.

One interesting finding we had noticed in the study is that for people who claimed they made behavior changes in certain appliances; their electricity usage is actually higher compared to people who did not make behavior changes. For example, for people who claimed they adjusted their behavior for air-conditioning usage, their electricity usage is actually higher compared to people who don't. It could be due to adverse selection effect – for people who made behavior changes regarding to air-conditioning, their usage could potentially higher to begin with, and that is why they need to make changes to lower their electricity usage.

6.5 COMMUNICATION

Communication between utility companies or even between general media and the public is very important. Time of Use pricing has been implemented for over 10 years and the most initial communication between utility companies and residential customers are difficult to retrieve. However, from our focus group and survey, the reason people joined Time of Use pricing at the first place was simply to save on their electricity bill. Bill saving, especially without changing behavior, is very effective in attracting customers. According to our statistical analysis, those customers who never check their electricity usage indeed have significant higher electricity usage for the summer months, regardless of peak or off-peak periods.

BILLING INFO

Because electricity cost is relatively low comparatively for their income, there are some residential customers who simply ask banks to automatically deduct their electricity bill, or pay bills through Alipay (Chinese version of Paypal). These customers do not receive a receipt from the utility company regarding their electricity usage and therefore do not receive feedback about their electricity usage. As a result, these customers cannot adjust their behavior accordingly.

AWARENESS

Even though Time of Use pricing has been implemented for 10 years, there are still residents who don't know their families have been enrolled in Time of Use pricing. According to the electricity company, almost all urban residential customers had been enrolled in Time of Use pricing. For survey participants who put down they "did not enroll in Time of Use Pricing" (where they actually did enroll in reality) actually uses significantly more electricity during both on peak and off-peak periods during summer.

6.6 ATTITUDE

Attitudes related questions do not directly address the issues related to sustainability. No statistical significance has been detected to directly link people's attitudes to their electricity usage. This is potentially due to lack of communications to actually change their attitudes. In the survey, people have little knowledge about how their electricity usage could actually influence the environment. Even though the population has expressed certain concern of environmental issues, such as air pollution (39% selected very much, 30% selected somewhat) and global warming (35% selected very much, 41%

selected somewhat), they could not necessarily link their home electricity usage to environmental problems.

Even more, the utility company has indicated that they have told customers to replace natural gas supplied stove into electric stove because it is more environmentally friendly. This information is misleading because in many cases natural gas supplied stove has less carbon foot print compared to electric stove. The utility company claims this is the kind of “environmental education” they had been engaged in, therefore it explains why there had shown no relationship between people’s environmental attitudes to electricity usage.

6.7 HYPOTHESES

The study suggested Yangzhou’s residential customers have actually engaged in desired electricity usage behavior. Hypotheses to explore potential reasons for people’s behaviors are tested.

1. Hypothesis on people’s appliances behavior is rejected that people actually conduct behaviors in the way that actually helps with peak load shifting and electricity saving in general.

From the study, it has been proved that residential customers actually understand what are the top electricity usage appliances or behaviors. People are aware that air-conditioning, fridge and space heating account for the top three electricity usage sources. For air-conditioning, people also engage in energy saving behaviors to save on air-conditioning electricity usage.

Unlike US residential customers who engage in behavior changes under TOU that do not align with highest electricity consumption sources, urban residents in Yangzhou has the

awareness and effective electricity usage that actually align with the highest electricity consumption sources under TOU pricing.

2. Hypothesis on attitudes do not necessarily lead to less energy usage compare to peers cannot be rejected. No sufficient evidences are available to support this claim.

From the study, it had been noted high environmental attitudes have no relationship with a family's electricity usage.

3. Hypothesis on social economic status is positively correlated with residential energy usage can be rejected because no statistical significance have been observed with increase in social economic status with electricity usage in this particular group we are studying.

Because of the small apartment size among urban residents and their electricity usage is correlated with the number of room air conditioning at home, people engaged in the energy saving behaviors especially for air-conditioning. Therefore, social economic status does not make a difference in household electricity usage among the survey participants.

4. Hypothesis on communication that people will use less electricity if they are given information feedback is not rejected.

For people who never check their electricity usage, their family's electricity usage is higher than families who do check their electricity usage. Communication between

Electricity Company and general population provide active feedback for customers to adjust their electricity usage behaviors to save on bills.

6.8 PEAK SHIFTING AND ENERGY CONSERVATION IMPLICATIONS

As the goal is for residential electricity consumers to use less electricity during peak periods in order to reduce the pressure on the grid, either customers “shift” their electricity usage to off-peak or they simply use electricity during on-peak periods do not result a difference for the electricity company for the purpose of TOU pricing.

The implementation of Time of Use pricing has resulted in two kinds of consumer behaviors:

1. Peak electricity usage reduction/energy conservation
2. Peak electricity usage shifting

PEAK ELECTRICITY USAGE REDUCTION/ENERGY CONSERVATION

Air-conditioning again plays a significant role for those two kinds of behaviors. Since Yangzhou gets very hot during summer (Specific Yangzhou’s historical weather data could not be found. Please reference Nanjing’s temperature curve since those two cities are very close geographically), especially during the day, it is difficult for people to not use air-conditioner. Also they could not potentially “shift” their air-conditioning usage because they have to turn it on when it is hot. However, people can definitely choose to use less air-conditioning during the day by turning up the temperature set points, use air-conditioning for shorter periods of time or engage in energy efficient way of using air-conditioner, such as keeping windows and doors shut.

Therefore, air-conditioning mostly plays the role for peak electricity usage reduction/energy conservation.

Lighting usage is another behavior that shares similar behavior compared to air conditioning. People have to use lighting to light up their home in the evenings, but again people can choose to use lighting in an energy conservation manner, such as turning lights off when the rooms are not occupied, use less lighting, or dim the lights if possible.

Compared to lighting, air-conditioning plays a much significant role in peak electricity usage therefore would require most attention from the electricity company.

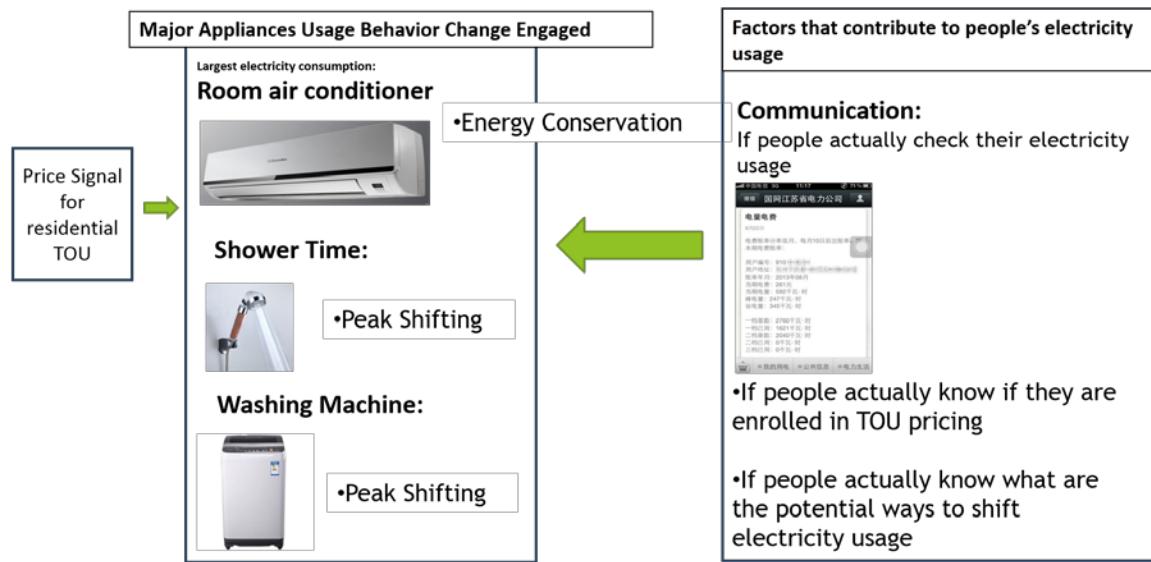
PEAK ELECTRICITY USAGE SHIFTING

For appliances or electricity usage behavior that does not require usage when needed, or have some flexibility in usage, people have the ability shift their usage to off-peak periods.

From the results and discussion above, changing shower time, washing machine time would be the most common electricity usage shifting behavior. Even though people could potentially shift their dinner time to off-peak (after 9pm), it is not common for people to delay their dinner time so late to save on electricity bill.

6.9 ROAD MAP

The simple roadmap below illustrates how urban residential consumers in Jiangsu province actually use their electricity and the potential factors that can reduce their electricity usage and shift peak.



As there are significant differences in lifestyle for urban electricity consumers in China and US, a comparison table had been made to discuss the differences in electricity usage behavior, as well as how they could respond to TOU pricing.

Appliance or electricity consumption behavior that has the ability to shift usage	China	US
Dish washer	No. Low ownership of dishwasher	Yes – can postpone dishwashing into evening
Washing machine	Yes – adjust the time of using washing machine, but it is not necessarily daily	Yes – adjust the time of using washing machine, but it is not necessarily daily
Dryer	No – low ownership of dryer	Yes – adjust the time of using dryer, but it is not necessarily daily
Hot water heater	Yes – common practice, take shower in off-peak time	Potentially heat up water in the evening if with appropriate control
Air-Conditioning	Yes – adjust temperature setting, change the time of day air-conditioning is used. Use less air-conditioning. Room air-conditioning and individual room control provides capability of using air-conditioning only in the room that are occupied	More difficult because central air-conditioning
Make Dinner time	Yes – rice cooker commonly used. Pre-use rice cooker	Yes – potentially
Lighting	Yes – individual control but people turn lights off anyway when leaving the room	Yes – it is voted to be the top behavior people engage under Time of Use pricing.

As noted above, even though in US space heating accounts for the largest energy consumption in homes, people are in general do not engage in those behaviors potentially because of central air-conditioning. Central air-conditioning provides less sense of control to force customers to use them. Most common TOU behavior changes in US

including lighting, delay laundry and dish washer while in China most common behavior change under TOU are air-conditioning related behaviors, delay laundry and change shower time. Save on lighting energy behavior happens regardless of the existence of TOU pricing.

From this study, it had been noted that urban residential customers have been in general employing good electricity usage behavior, which contributes to energy conservation and peak shifting. This behavior mostly comes from the prevalent of room air conditioning and individual monitor control provides residents the ability of using air conditioning units only when rooms are occupied and are needed to be cooled. Washing machine and shower time has been another approach to shift electricity usage.

Further studies should include experimental studies to understand what kinds of information communication with residential customers are more effective in terms of helping them to reduce their electricity bill further. Also because air conditioning is absolutely the largest electricity usage consumption at home, potential technical direct control of air-conditioning would be very effective. However, direct control of air-conditioning could result in dissatisfaction and discomfort of customers. Future studies should investigate solutions to address this dilemma.

Communication is important in helping people to reduce their electricity consumption. The utility company could consider providing electricity consumption individuals who never check their electricity usage or motivate this group of customers to engage in peak shifting in other ways that can be studied. Other communication methods can be used to

encourage people to shift their electricity usage, like peer comparison. Pilot studies would be helpful to investigate those new methods and areas of studies.

6.10 KEY TAKE AWAY POINTS: SENSE OF CONTROL

Similarities can be drawn from people's behavior of using room air conditioning, and use of lighting. Customers have to engage in actions that require them to turn on, and off lights or air conditioning by themselves. It could be explained that because of central air-conditioning do not engage users as much – too much automation, residents then do not necessarily engage with central air conditioning or even thought of doing so. This small "inconvenience" in people's life becomes their reminder of their energy use and so they are more conscious about their electricity usage behavior and act out in the best of their interests. The use of room air conditioning is not only prevalent in Jiangsu Province but very common throughout China.

6.11 DATA COLLECTION CHALLENGES

A paper survey was used instead of an internet or phone survey. The main reason was the consideration of potential self-selection issues with internet survey and low internet adoption rates for middle age and the elderly. A phone survey was also eliminated because Chinese citizens are very cautious about phone calls from unknown sources due to consistent fraudulent phone calls.

The paper survey imposed challenges to data collectors as it is very time consuming. Even though the paper survey eliminated more self-selection issue as internet survey does, it possesses potential challenges during actual implementation as discussed below.

Because this data collection process is led by the utility company, it had been clear from the data shown that two cities, Nanjing and Xuzhou had significant portion of the surveys not filled out by participants but the Nanjing and Xuzhou utility company employees who simply want to quickly get the work done. After deleting surveys that are believed to be faked from Nanjing and Xuzhou, only merely more than 100 copies had left for each city (two third of responses had been eliminated). Even in Yangzhou, there are certain hand wrote questions that are believed to be filled out by the utility employees and those questions had been taken out. This was out of expectation because researchers have visited the walked through data collection process with those utility company employees who will survey the customers. Higher management have accounted this for their lack of education of lower level employees as many of them only had a middle school level of education and they simply do not care about supporting research. Because the data collection process is very time consuming, it is somewhat understandable data collectors have lost patience in the process and decided to make up data.

The results shown from those data are not consistent with Yangzhou's statistical analysis result and the small sample has lower statistical power so that we would not trust data and results from those two cities. Therefore, Nanjing and Xuzhou's results are not reported but only included in Appendix G. Because of lack of credibility of data from Nanjing and Xuzhou, we have potential reason to question the credibility of Yangzhou data as well. However, only a very small portion of potential suspicious data was identified (Less than 10%).

Potential approaches to avoid issue are to actually employ credible researchers and research assistants to participate in the process. That could potentially take longer but ensures the credibility of the data.

6.12 FUTURE STUDIES

CHALLENGES: THE TRANSITION OF CHINESE RESIDENTIAL HOMES

Even though room air conditioning encourages users to engage in energy efficient behaviors, China is in transition into modernized homes where many of the newer residential buildings equip them with central air-conditioning as a selling point. This could potentially lead to increase in air conditioning electricity usage as well as heating demand. Additional studies should be engaged in understanding potential approaches for people to keep on engaging in energy conservation behaviors with central air conditioning.

STUDY PEOPLE'S BEHAVIOR HORIZONTALLY

Horizontal studies of participants' behaviors are not included in the study. This is an area worth of investigation. Potentially factor analysis and cross tabulation should be utilized to conduct such a study to find more about underlying common links between people's behavior.

6.13 POTENTIAL IMPROVEMENT OF TOU PROGRAMS IN JIANGSU PROVINCE

From the studies, it had been revealed that despite the unfavorable Time of Use rate design, people in general have used electricity in an energy efficient way at the same time satisfying their daily needs. However, potential improvements of the TOU programs can be tried to further increase electricity company's utility rates.

AIR-CONDITIONING RELATED STRATEGIES

Even though people had already been using air-conditioning in an energy efficient manner, because of the high energy consumption of air-conditioning, it is possible to reduce energy usage even more during peak.

Potential direct control or monetary incentives can be engaged to encourage residents to turn off air-conditioning more frequently. For example, Electricity Company can encourage people to turn off/raise set point temperature of air-conditioning after every 15 minutes of cooling for another 15 minutes. It is possible that people do not feel a difference in changing in temperature during such a short periods of time. The electricity company can alternate families who use air-conditioning in a scheduled time. For example, half of the city turns off air-conditioners from 8pm-8:15pm, and the other half of the city turns off air-conditioners from 8:15pm to 8:30pm.

Additionally, Electricity Company can provide residents with additional information regarding to energy saving on air-conditioner. For example, Electricity Company can provide service to change residents' air-conditioners filter since it is difficult for people to understand how to do it by themselves.

COMMUNICATION

Even after so many years of implementation of Time of Use pricing, there are still residents who do not recall they are enrolled in Time of Use pricing. Even more, some people have chosen to pay bill automatically from their bank. Therefore they do not even get to see their bills, nor making actions to save on electricity usage.

Therefore, the key is really to gain people's attention for this pricing and engage in users so they have the actual understanding of their electricity usage. Provide information to reach electricity consumers is important, but in the case that they do not even read their bills, the electricity company might want to promote programs in a way that get people's attention. For example, the electricity company could run ads to encourage people to pay attention to their bills and for people who do that can potentially win a prize or enter a lottery.

Furthermore, for those customers who never read their bills, it could be useful to provide paper bills to those customers' homes to increase their chance of reading bills. Additionally, because residents' smart meters are all locked up by the electricity company in hallways, people could not actually read their meter readings. It could also be helpful to provide in-home displays for their electricity bill.

Additionally, the electricity company should actively communicate with customers on potential ways to reduce electricity usage and actually provide guidance, enable technology, and service to achieve such behaviors.

7. CONCLUSION

The study has investigated how Jiangsu residential consumers respond to the Time of Use pricing for the past 10 years since its implementation. As no studies have ever been conducted to understand real behaviors behind that load shifting, this study provides an angle to understand those behaviors and provide insights for future TOU program design, not only for Jiangsu Electric but also for utilities across the world.

It had been noted that Jiangsu's urban residential customers have been in general employing good electricity usage behavior which contributes to energy conservation and peak shifting. Room air conditioning has played a key role in the behavior. Customers are well aware air conditioning is the largest contributor to their electricity usage and their behaviors regarding to the usage of air conditioning contribute to minimized usage of air conditioning already. Room air conditioners are only used when rooms are occupied, when it is needed with doors and windows well shut. As a result, socioeconomic status plays little role in actual electricity usage. This is a clear contrast with families in the United States equipped with central air conditioning where minimum residents' behaviors are engaged, which contributes to great wastes of air conditioning. Also because residential customers in Jiangsu employee very different appliances in China, for example, dish washer and clothes dryer have very low adoption rates, certain behaviors to shift peak in the United States, such as postponing dish washing time or dryer time, would not be applicable in China. Compared to United States residents who mostly only adjust lighting to save on electricity or shift peak, Chinese customers understand air conditioning consumes most energy so that people are actually engaging in behaviors that could reduce or shift air conditioning use.

Jiangsu province's persuasive communication model for Time of Use can be illustrated as follows. The graph shows currently how each component fits into the model of persuasion those actually lead customers to perform desired behavior.



Even though residential consumers in general have good air conditioning usage habit, communication efforts could be further investigated to better communicate electricity consumption usage with customers to help them be aware of their bills.

Because of the long hours of peak periods, there leave little rooms for behavior change but residents seem to have tried to shift their electricity usage in those small windows anyway. Because it is nearly impossible for utility companies to change their pricing structure because of political complications, it is best to attempt communication measures that could potentially help customers to shift their electricity usage, for example, peer comparison has been identified as a new method to encourage savings in the US. Similar pilot projects could be conducted in China to compare results.

Also because Chinese residents in generally live in apartment buildings with much less footprint, electricity consumption level per family are much lower to begin with. Compared to United States families who live in single family homes, Chinese family's carbon footprint would be much less comparatively. In study done by National Bureau of Economic Research in 2009, even in the dirtiest Chinese city (Daqing), a standardized household produces only one-fifth of that in America's greenest city (San Diego) (Zheng, Wang, Glaseser, & Kahn, 2009). Potentially Chinese residential customers' more "sustainable" lifestyle would be able to provide more guidance to United States utilities and urban planners in general.

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APPENDIX A: INTERVIEW WITH JIANGSU ELECTRIC

Interview with Jiangsu Electric marking and sales department:

1. Is TOU pricing the same all year around?

Answer: Yes. We want to make sure people get into the habit of energy saving or peak shifting.

2. What is the electricity generation composition for both on peak and off-peak?

Answer: around 80% (do not have specific data but a norm)

3. When promoting TOU pricing, did general public understand the societal value of TOU pricing and why the electricity company actually promoted TOU? (i.e. grid utilization rate, grid stability) If so, did the residents actually understand societal values? Or you only told residents about bill saving?

Answer: General public does not understand those societal values. Therefore, we only tell them that joining TOU can save on electricity bills.

4. In the “Jiangsu Province TOU pricing promoting roadmaps”, what did you actually communicate to the residents? What are those specific examples in the road map?

Answer: simulated electricity usage behavior and use this information to tell residents' what difference that make if you enroll in TOU or not. Tell residents what behaviors they can use to save even more under TOU.

5. Do you foresee any recent changes of TOU pricing? (like change the time period or change the rate) When tired pricing is also implemented with TOU, are you going to have any further promotion regarding to energy saving behavior?

Answer: No change regarding to residential TOU pricing. That could be TOU rate change for large industrial customers.

Not sure about energy conservation aspects. Shanghai and Sichuan also has TOU. Encourage distributed generation. Encourage electric vehicle. Encourage electric billing.

6. Have you considered promoting smart homes to customers? Like remote controlling customers' air conditioning to shift load?

Answer: Yes. Considered and did trial before. Did not very good response from customers.

7. Why do you think electricity is more environmentally friendly compared to burning natural gas? Is it a part of the public environmental education?

Answer: from small area, then yes. (NOTE, I DISAGREE WITH THEIR RESPONSE FOR USING ELECTRICITY IS MORE ENVIRONMENTALLY FRIENDLY)

APPENDIX B: FOCUS GROUP INTERVIEW

Electricity Company invited five residents to the office to participate in focus group interview in Nanjing. Residents are compensated by a gift prepared by the electricity company. Note taken by Jingkun Liu from Tsinghua University. Those residents who participated in focus group interview are active participants of community activities.

1. What is your family composition?

Number of family members: 3,3,3,4,3

Four families composed of a couple and a child. The family with 4 people have a relative often comes over to stay.

2. What is your daily routine? When do you get up and when do you go to sleep?

Family 1: Get up 6am, go to bed at 10pm. Normally go to sleep after coming back from work.

Family 2: Get up at 6am, go to bed at 10pm. Use more electricity in the evenings of summer and winter.

Family 3: Get up at 7am, go to bed at 10pm. Use more electricity after 9pm to save on bill for TOU.

Family 4: Get up at 5am and go to bed at 9pm. Another possibility is to get up at 8am and go to bed at 2am.

Family 5: Get up at 7am, go to bed at 12am. Could go to bed anytime between going to work and 12am.

3. Do you care about your family's electricity usage?

Family 1: Yes. 300 RMB for two month

Family 2: Yes. 200 RMB (maybe per month?)

Family 3: Do not care. During summer about 500-600 RMB (per month?), non-summer period about 200-300 RMB (per month?)

Family 4: Not really because Alipay automatically deduct money so we do not know about electricity usage. If we pay using wechat or pay at the electricity company's operating location, then we will know how much electricity we actually used.

Family 5: Do not really care. Do not use too much electricity. We mainly use computer and we do not have large appliances. We live in a new neighborhood.

APPENDIX C: SURVEY DATA CLEANING

Questions encountering the issues of conflicting results include:

Question 1: Do your family use washing machine for laundry?

If answered no, then should skip question 2 regarding to the frequency of using washing machine.

Question 5. Do your family use air-conditioning?

If answered do not have air-conditioning should skip all questions regarding to air-conditioning usage.

Question 13: Will you turn off AC or set a timer for AC before going to sleep?

If answered no, then should skip following questions regarding to the reasons for doing so.

Question 32: Is your home enrolled in time of use pricing?

If answered no, then should skip following questions regarding time of use pricing and peak shifting behaviors.

Question 38: Did your family ever adjust electricity usage behavior for time of use pricing?

If answered no, then should skip question 55 on particular behaviors change for time of use pricing.

Question 56: Whether Electricity Company informed you about how save on electricity bill for time of use pricing?

If answered no, then should skip following questions regarding to the effectiveness of the communication method.

Question 65: Would you read electricity usage information on your receipt on peak/off peak info? (If it is on the receipt)

If answered no, then should skip following questions regarding to different communication method regarding to receipts.

Question 73: Do you believe in Climate Change?

If answered no, then should skip following questions regarding to potential reasons contributing to climate change.

Question 82: How many family members live in your home on a regular basis?

The number reported here should match with question 83's family member composition regarding to their age/occupation. If family member numbers in 83 do not add up to question 82, and then skip answers in question 83.

APPENDIX D: SURVEY INSTRUMENT AND QUESTION CATEGORY

	Appliance	AC	Energy Saving	Communication	Peak Shifting	Heating	Time of Use	Attitude	Demo-graphic	Social Economic Status	Awareness
1. Do your family use washing machine for laundry?		1									
Yes											
No											
2. Which of the following best represent your family's frequency for washing clothes?		1									
Biweekly											
Once a week and a half											
Once a week											
Twice a week											
At least twice a week											
Other											
Everyday - 7											
Twice a day - 8											
Everyday during summer - 9											
3. How many hours do your family watch TV per week? (Please account the cumulative TV hour. For example, if		1									

**the family has two TVs,
each opens five hours
per week, then in total
the family TV watching
hour is 10 hours.)**

1-2 hours

2-5 hours

5-10 hours

10-20 hours

20-30 hours

30-40 hours

40-60 hours

60 hours

Do not watch TV

**4. How many hours do
your family use
computer per week?
(Please account the
cumulative computer
hour. For example, if the
family has two
computers, each is used
for 5 hours per week,
then in total the family
computer usage hour is
10 hours)**

1

1-2 hours

2-5 hours

5-10 hours

10-20 hours

20-30 hours

30-40 hours

40-60 hours

60 hours

Do not use computer

5. Do your family use air-conditioning?

1 1

Yes

No

6. What is the type of air-conditioning at home?

1 1

Central

Room

7. Number of room air-conditioning

1 1

1

2

3

4

5

6

7

8. Does each room in your home have a separate thermostat?

1 1

Yes

No

I do not know what thermostat is

9. What is the normal temperature setting of your air-conditioner

1 1

during summer? ____ ° C

20

21

22

23

24

25

26

27

28

29

30

10. How do your family
normally uses air-
conditioner?

1 1

Keep all air-conditioner
on at home

Turn on air-conditioners
in rooms that are
occupied

Other

11. Do you turn off air-
conditioner when going
out?

1 1

Always

Sometimes

Occasionally

Never

12. When using air
conditioning, your

1 1

family: (Ventilation)			
Always shut doors and windows			
Sometimes shut doors and windows			
Occasionally shut doors and windows			
Never shut doors and windows			
13.Will you turn off AC or set a timer for AC before going to sleep	1	1	
14. What is the reason you turn air-conditioner off or set a timer when going to sleep (Check all that apply)	1	1	
Health			
Energy Saving			
Other			
15. Have you ever use less air conditioning to save on electricity?	1	1	1
Always			
Sometimes			
Occasionally			
Never			

16. Did you ever raise air-conditioner set temperature to save on electricity?	1	1	1
Always			
Sometimes			
Occasionally			
Never			
I do not know raising air-conditioner set temperature can reduce electricity use	1	1	1
17. Did you ever reduce air-conditioner use during peak period (high electricity price period)?			
Always			
Sometimes			
Occasionally			
Never			
18. How often do you change air-conditioner filter?	1	1	
Every half a year			
Every month			
Every half a month			
I never changed air conditioner filter			
19. Did the electricity company ever communicated with you regarding to air-conditioning and	1	1	1

electricity saving?		
Always		
Sometimes there		
Occasionally there		
Never		
20. What is the heating system in your home?		1
Electric Heating		
Central Heating		
Gas or water at home		
Air-Conditioning/Heat Pump		
Other		
No Heating		
22. Do you have the habit of turning lights off when leaving the room?	1	1
Always		
Sometimes there		
Occasionally there		
Never		
23. When purchasing new light bulbs you will choose?	1	1
Incandescent		
Energy saving bulbs		
Does not matter		
24. Do your family use rice cooker?	1	

Always	
Sometimes	
Occasionally	
Never	
I do not have rice cooker	
25. Do your family use oven?	1
Always	
Sometimes	
Occasionally	
Never	
My family does have an oven	
26. Do your family have an electric stove?	1
Yes	
No	
27. What is your family's water heater type:	
Solar water heaters	
Electric water heater	
Gas water heater	
Heat Pump Water Heater	
Other	
Do not know	
28. Do your family use electric fans?	1
Always	
Sometimes with	

Occasionally use		
Never use		
29. Generally do your family prefer to use air conditioner or fan?	1	1
Electric fan		
Air conditioning		
Does not matter		
30. When do your family members get up in the morning and go to bed in the evening?		1
How many hours before 8am?		
How many hours after 9pm?		
31.What are your family's natural ventilation habits? (Check all that apply)	1	1
Open window all year around		
Do not open window when air conditioner is turned on		
Do not open window when heating is on		
My family has a central HVAC system, therefore do not open window to ventilate		
Other		
32. Is your home enrolled in time of use		1

pricing?		
Yes		
No		
Not sure		
34. Do you think it is easy to remember when is on peak and when is off peak	1	1
1		
2		
3		
4		
5		
36. Do you think the electricity price should be the same all year around?		1
Yes, so it helps customers to remember		
No, then what do you suggest?		
37. Do you think it is easy to change electricity usage pattern for time of use pricing?	1	1
Very easy		
Relatively easy		
Relatively difficult		
Very difficult		
I never thought about changing my electricity usage behavior for time		

of use pricing

38. Did your family ever adjust electricity usage behavior for time of use pricing?

1 1

0???

Always

Sometimes

Occasionally

Never

39. Why do you think the power companies promoted time of use pricing? (Check all that apply)

1 1 1

Increase revenue

Reduce peak load demand

Ensure residential electricity use

Save residents electricity bill

Environmental Protection

Other. Please Specify:

40. Why did your family enroll in Time of Use Pricing? (Check all that apply)

1 1

Save electricity

Environmental Protection		
Respond to the electricity company's call to reduce the peak		
Other		
41. Did your family member ever discussed about electricity saving with other people? (neighbours, colleagues, other family members etc)	1	1
Yes		
No		
42. Use your household tiered pricing?		1
Yes		
No		
I do not know what is tiered pricing		
43. Your family is:		1
Monthly meter reading		
Bi-monthly meter reading		
Do not know		
46. How do you view your electricity bill:		1
Very high		
A bit high		
Neither high nor low		

Relatively low		
Very low		
47. Do you think if you know the power consumption of each appliance, that information can help you save on electricity?	1	1
Certainly Yes		
Should help some		
Should not help		
Do not care		
48. How to describe the effort your family made regarding to energy saving?	1	1
Tried very hard		
Made some efforts		
Rarely done anything		
Never		
49. What do you think the main reason is people around made efforts to save on electricity?	1	1
Save electricity		
Protection of the environment		
In response to the call of the power companies to reduce grid load		
Other		

50. Did Electricity Company ever communicate the electricity saving potential of the following appliances or life-style? (Check all that apply)	1	1	1
Refrigerator			
Air conditioning			
Illumination			
Cook / electric cookers			
Oven			
Bath / heater			
Heating devices			
Dryer			
Dishwasher			
Do not know / the electricity company had never communicated anything			
51. Did Electricity Company ever communicate the peak power saving potential of the following appliances or life-style? (Check all that apply)	1	1	1
Refrigerator			
Air conditioning			
Illumination			
Cook / electric cookers			

Oven		
Bath / heater		
Heating devices		
Dryer		
Dishwasher		
Do not know / the electricity company had never communicated anything		
52. Have you ever received energy saving information from the electricity company?	1	1
Yes		
No		
53. When you purchase new appliances, do you consider energy efficiency labeling (right)?	1	1
Always		
Sometimes		
Occasionally		
Never		
55. What effort did your family make to change living habits or electricity usage habits for TOU? (Check all that apply)	1	1
Bath time		
Use of air conditioning		

Make dinner time			
Use washing machine			
Dishwasher			
Dryer			
Related to the use of lighting			
Use of computers			
Charging time for the device			
Never changed anything			
56. Whether electricity company informed you about how save on electricity bill for time of use pricing?	1	1	1
Yes			
No			
Told but cannot recall			
Do not remember			
57. Do you think the information provided by the power company useful?	1		
Very useful			
Somewhat Useful			
Not useful			
I don't remember those information			
58. Which statement reflected your home electricity usage?		1	
I think my household			

uses very little electricity.

I think my household uses relatively little electricity, but there is space for more energy saving

I think my household uses a lot of my power, I will appreciate any method to reduce my electricity bill

I think my household uses a lot of my power, but I won't do anything

I do not know the electricity usage level is high or low, but I don't want to make any changes

59. When you go to sleep or go out, do you unplug or turn off the power supply to saving electricity?

1

Always

Sometimes

Occasionally

Never

60. From which sources you had received energy saving information?

1 1

Newspaper

TV

Internet		
Community broadcasting		
Electricity company communication		
61. What do you think are the top three electricity consumption appliances in your family?	1	1
Fridge		
Air conditioner		
Heating		
Dryer		
Lighting		
Dish washer		
Stove		
Computer		
Oven		
Cell phone		
Shower/hot water		
Tablet		
62. Do you care about information on electricity bill saving?	1	1
Very much		
Somewhat		
Not really		
Not at all		
63. How do you pay electricity bills? (Check	1	

all that apply)	
Electricity company operation location	
Food markets	
Alipay (it is like Payall Chinese version)	
Wechat	
Power Service Hotline	
Power Service website	
Bank auto charge	
Other. Please Specify: _____	
64. How do you check your electricity usage? (Check all that apply)	1
Electricity company operation location	
Food markets	
Alipay (it is like Payall Chinese version)	
Wechat	
Power Service Hotline	
Power Service website	
I don't check our electricity usage	
Other. Please Specify: _____	
65.Would you read electricity usage information on your	1 1 1

receipt on peak/off peak
info? (if it is on the
receipt)

All the time

Sometimes

Rarely

Never

I don't care

66. Do you think
information on the
receipt to provide you
with information on how
to save on energy next
month will be useful?
(for example,
information at the
beginning of the summer
to help you with energy
saving on air-
conditioning)

1

Very useful

Somewhat useful

I don't think I can
remember

Would not be useful

I don't care about bill
saving on energy

67. If electricity
company sends you
energy saving tips on
your phone, will you
read them?

1 1

I will read them
frequently

I will read them sometimes	
I will read them occasionally	
Never	
I don't want to receive such messages	
68. Are you responsible for paying electricity bills at home?	1
Yes	
No	
70. Do you care about air-pollution?	1
Very much	
Somewhat	
Rarely	
Not at all	
71. What aspects do you think are the major contributors to air pollution? (Check all that apply)	1
Transportation	
Residential electricity use	
Industrial and commercial electricity use	
Chemical industry	
Other	
72. Do you care about global climate change?	1

Very much		
Somewhat		
Rarely		
Not at all (Please skip to question 73 to continue the questionnaire)		
73. Do you believe in climate change?		
Yes		
No (Please skip to question 73 to continue the questionnaire)		
Neutral (Please skip to question 73 to continue the questionnaire)		
74. What do you think of the cause of climate change?	1	
Geographical movements		
Human cause		
Other		
75. Do you think using electricity at peak time or off-peak time has anything to do with fossil fuel electricity generation?	1	1
Yes		
No		
Maybe		

76. How much fossil fuel (coal/natural gas) do you think account for our electricity generation mix?	1
0-30%	
30-70%	
70-100%	
77. Are you familiar with concepts related to smart grid or smart meter?	1
Very knowledge	1
Moderately knowledgeable	
Have never heard of	
78. Do you think it is citizen's responsibility to protect the environment?	1
Very much agree	
Somewhat agree	
Neither agree or disagree	
Somewhat disagree	
Very much disagree	
79. Gender	1
Male	
Female	
80. Age	1
81. Occupation	1
Student	

Full Time	
Retired	
No occupation	
82. How many family members live in your home on a regular basis?	1
1	
2	
3	
4	
5	
6	
7	
83. What is your family composition for family members who permanently live in your house:	1
Children before school	
Elementary or secondary school	
College student	
Full time employee working outside	
Working from home	
Retired	
84. Do you own or rent the house:	1
Own	
Rent	

85. Have your family stayed in this house for more than two years?	1
Yes	
No	
86. Is any of your family member has chronic illness or disability?	1
Yes	
No	
87. Your home size (square meters)	1 1
<50	
50-80	
80-120	
120-160	
160-200	
200 and over	
88. What is the highest education your family members have obtained who permanently live in your home?	1 1
No education	
Elementary	
Secondary	
Bachelor degree	
Post graduate degree	
PhD (Only in	

Yangzhou's)

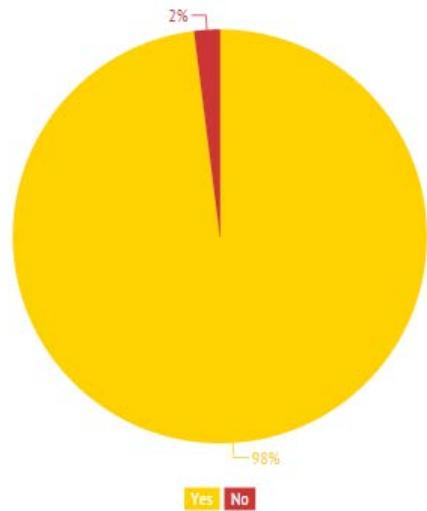
89. What is your family's annual income (after tax and can be spent)?	1	1
Below 10,000		
10,000-30,000		
30,000-60,000		
60,000-90,000		
90,000-150,000		
150,000-200,000		
200,000-300,000		
Above 300,000		

APPENDIX E: COMPARISON BETWEEN YANGZHOU AND US RESIDENTIAL CUSTOMERS' HOME APPLIANCES

Appliances

Yangzhou

Washing
machine



416 samples

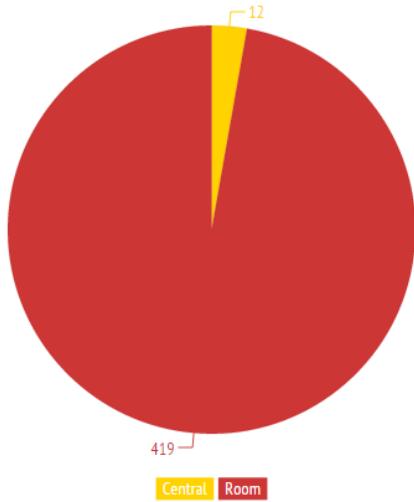
United States

89.1% (2005-2009)

2005-2009 American home survey

(Sarker, 2011)

Type of Air-Conditioning



Central: 88.7%

Room Air-Conditioning: 4.5 %

2005-2009 American home survey

(Sarker, 2011)

431 samples.

On average, per 100 Jiangsu urban residential families, Air conditioning ownership is about 195.96 in 2011
(Hexun.com Macroeconomy Data, 2011).

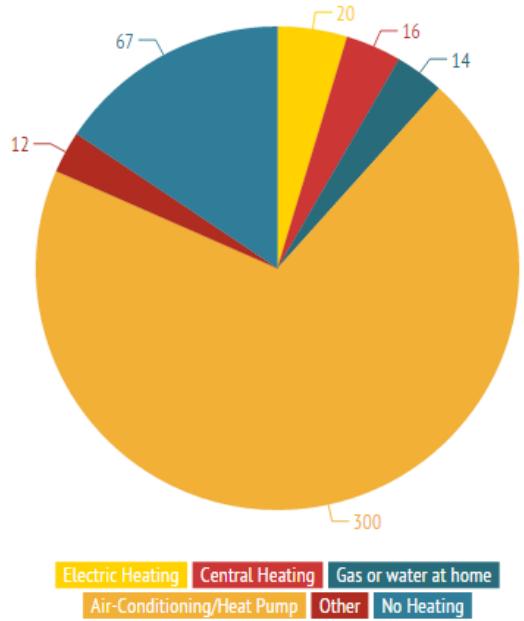
Summer Air-Conditioning set temperature

Average: 26.4°C, Standard Dev: 1.44°C

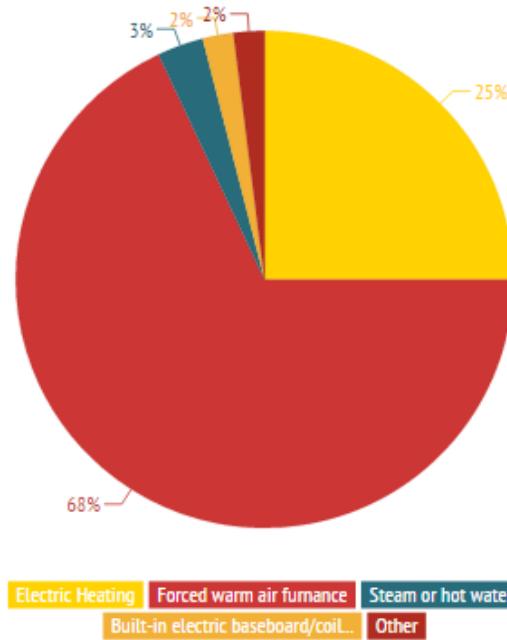
22°C Status quo. The adaptive model in thermal comfort had been recently adopted in the most recent ASHRAE 55 (ASHRAE/ANSI, 2013).

Department of Energy recommended summer temperature setting to be 26°C for energy saving (Department of Energy, 2014).

Heating System



429 Samples in total



2005-2009 American home survey

(Sarker, 2011)

Dish Washer

On average, per 100 Jiangsu urban residential families, dish washer ownership is about 0.77 in 2011 (Hexun.com Macroeconomy Data, 2011).

93% ownership

2005-2009 American Home Survey

(Sarker, 2011)

Clothes Dryer	Very low market share from observation	88.4% ownership 2005-2009 American Home Survey
Refrigerator	On average, per 100 Jiangsu urban residential families, refrigerator ownership is about 100.7 in 2011 (Hexun.com Macroeconomy Data, 2011).	96.4% ownership 2005-2009 American Home Survey (Sarker, 2011)
Cooking Stove	Prevalent in every family	98.5% ownership 2005-2009 American Home Survey (Sarker, 2011)
Bathtub/Shower	Prevalent in every urban family.	99.8% ownership 2005-2009 American Home Survey (Sarker, 2011)
Microwave	On average, per 100 Jiangsu urban residential families, microwave ownership is about 91.58 in 2011 (Hexun.com Macroeconomy Data, 2011).	Very common from observation
Computer	On average, per 100 Jiangsu urban residential families, computer ownership is about 96.94 in 2011 (Hexun.com Macroeconomy Data, 2011).	Very common from observation

TV On average, per 100 Jiangsu urban residential families, computer ownership is about 171.79 in 2011 (Hexun.com Macroeconomy Data, 2011). Very common from observation

APPENDIX F: YANGZHOU DESCRIPTIVE DATA

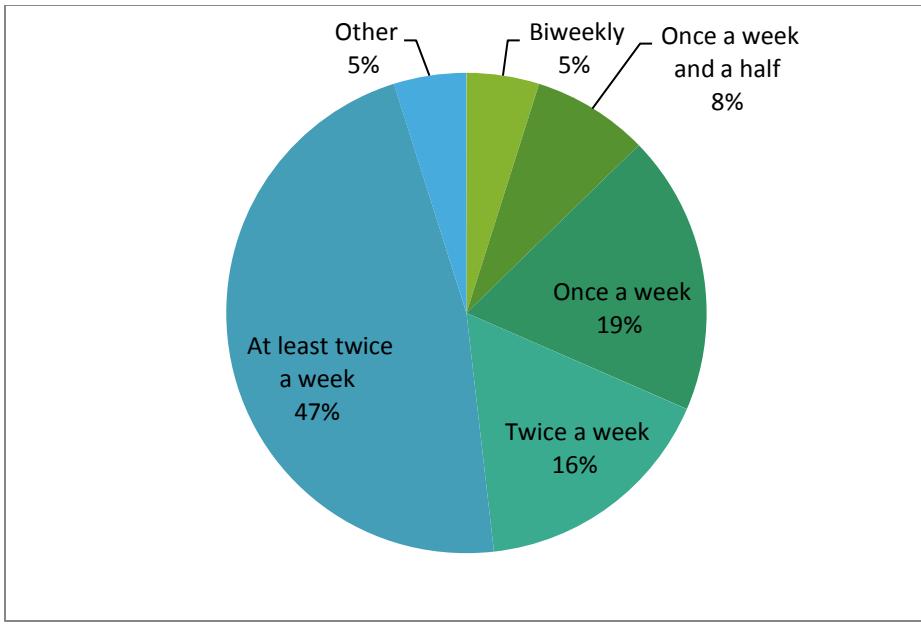
1. Do your family use washing machine for laundry?

Yes	408
No	8



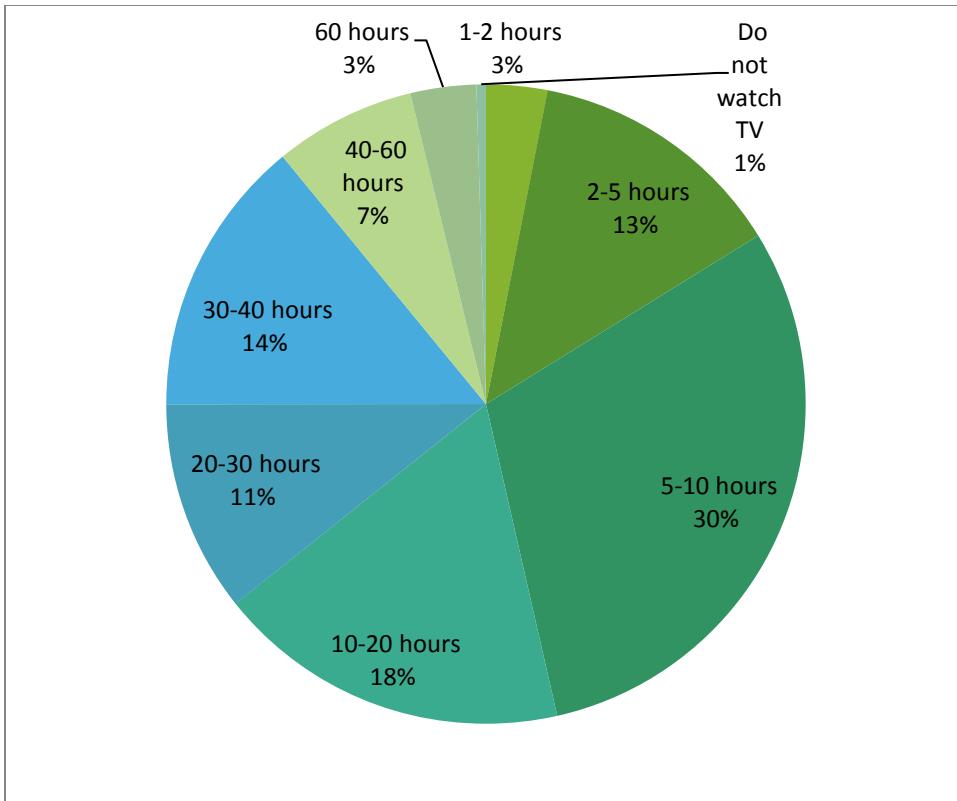
2. Which of the following best represent your family's frequency for washing clothes?

Biweekly	20
Once a week and a half	32
Once a week	77
Twice a week	68
At least twice a week	192
Other (please specify: _____)	20



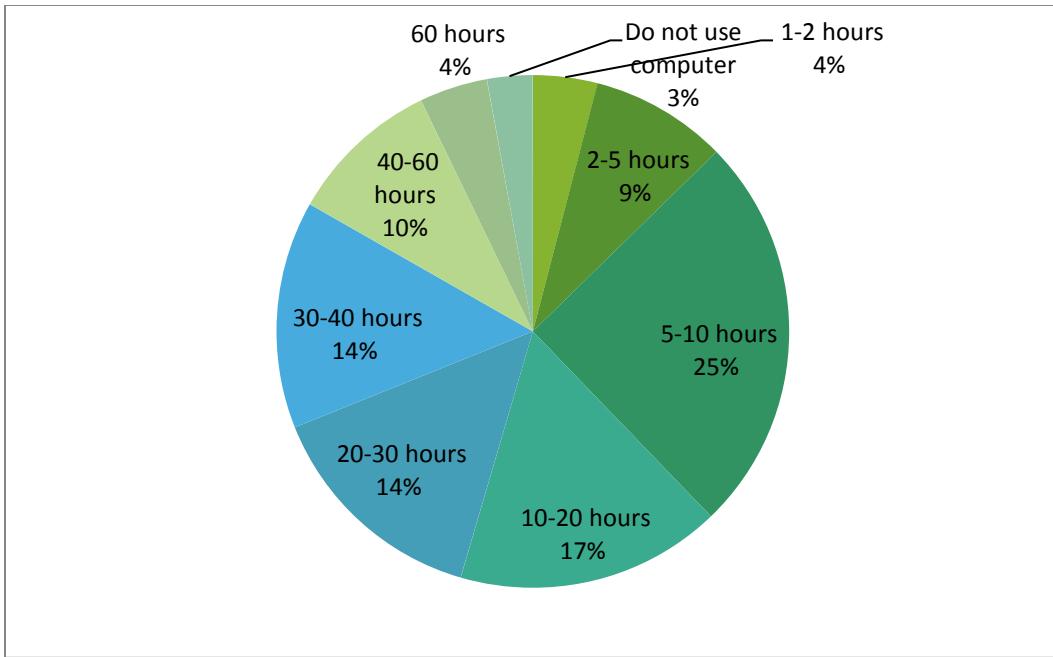
3. How many hours do your family watch TV per week? (Please account the cumulative TV hour. For example, if the family has two TVs, each opens five hours per week, then in total the family TV watching hour is 10 hours.)

1-2 hours	13
2-5 hours	55
5-10 hours	127
10-20 hours	75
20-30 hours	45
30-40 hours	59
40-60 hours	30
60 hours	14
Do not watch TV	2



4. How many hours do your family use computer per week? (Please account the cumulative computer hour. For example, if the family has two computers, each is used for 5 hours per week, then in total the family computer usage hour is 10 hours)

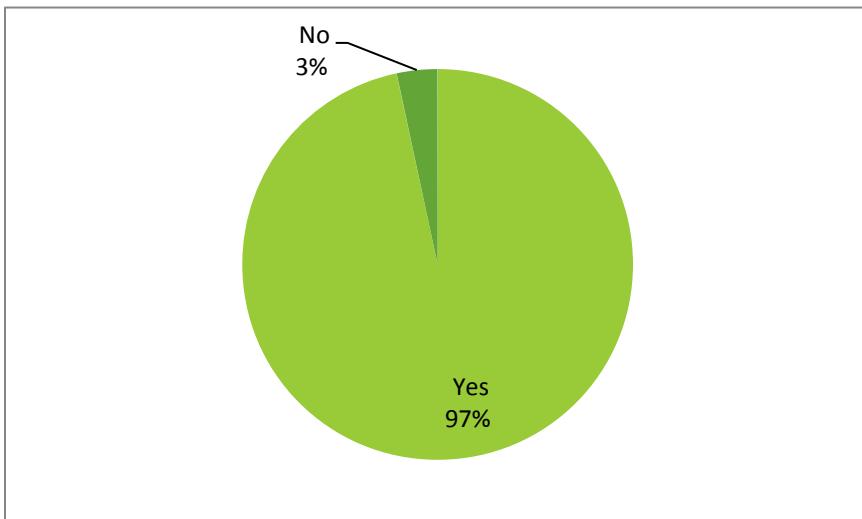
1-2 hours	17
2-5 hours	36
5-10 hours	105
10-20 hours	70
20-30 hours	60
30-40 hours	60
40-60 hours	40
60 hours	18
Do not use computer	12



5. Do your family use air-conditioning?

Yes 401

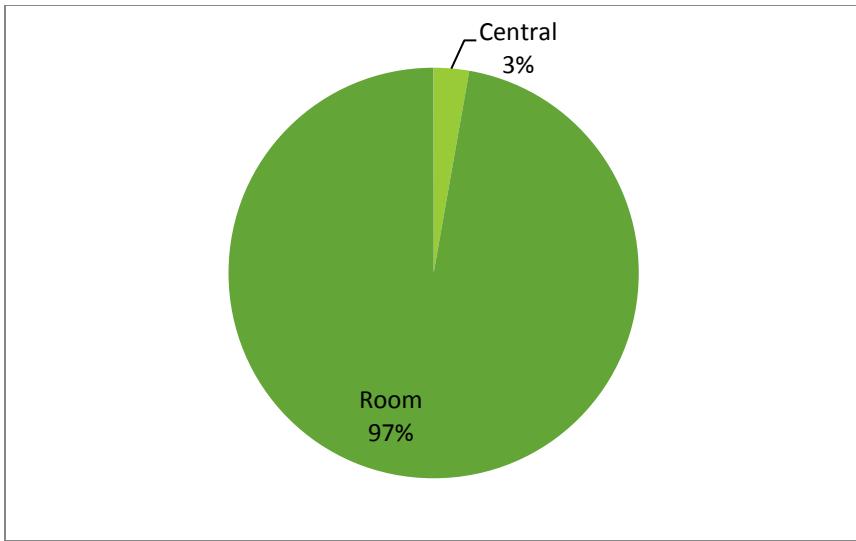
No 14



6. What is the type of air-conditioning at home?

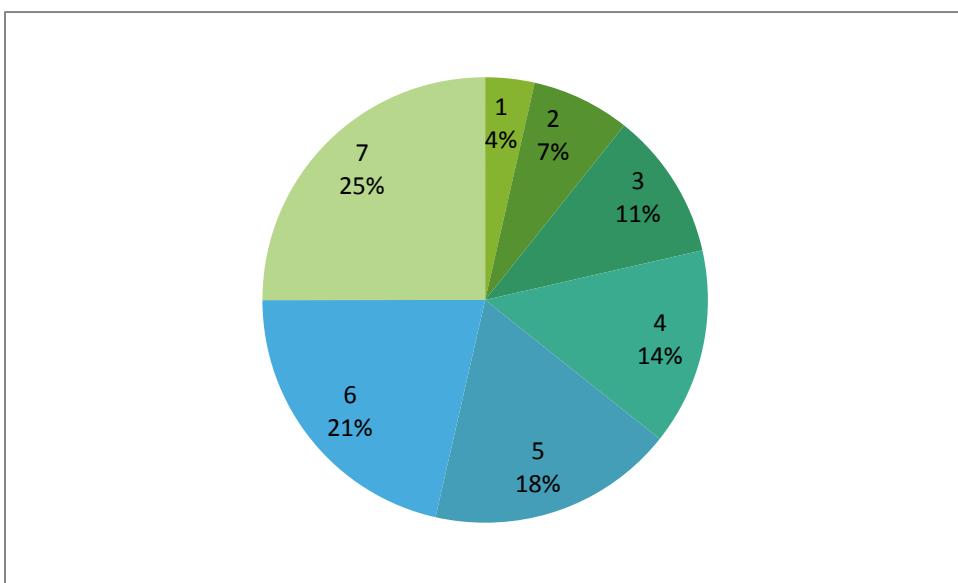
Central 12

Room 419



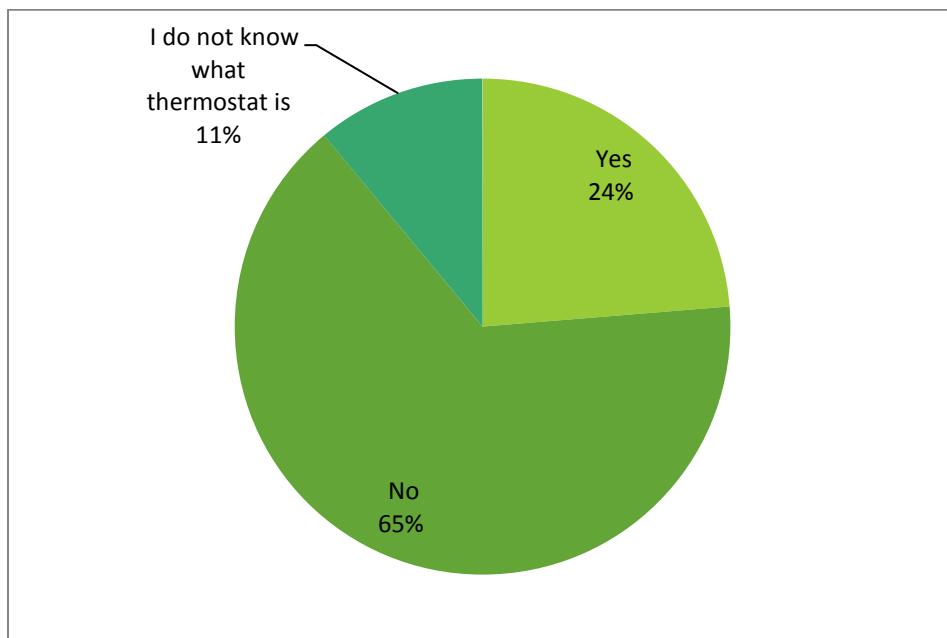
7. Number of room air-conditioning

1	102
2	149
3	114
4	43
5	6
6	3
7	2



8. Does each room in your home have a separate thermostat?

Yes	86
No	237
I do not know what thermostat is	40

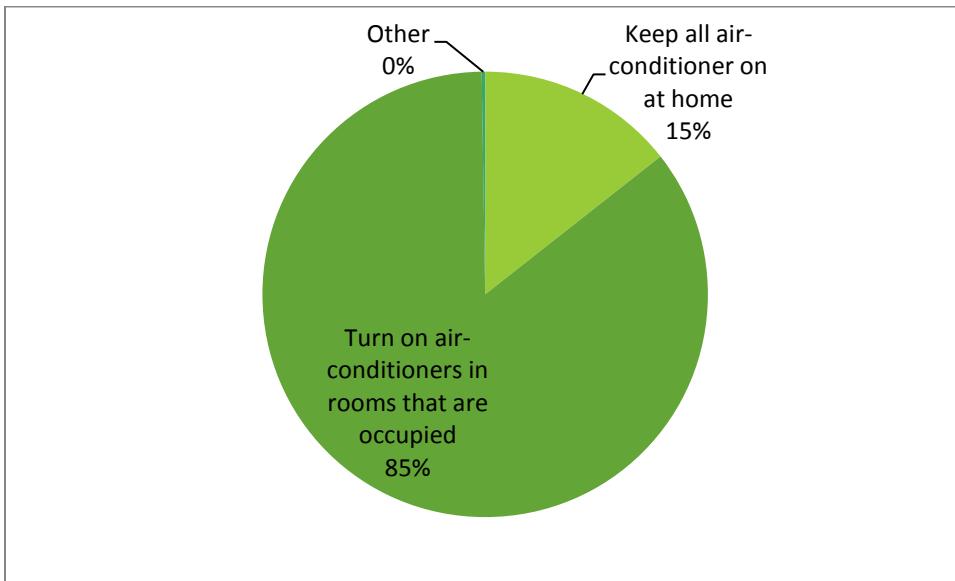


9. What is the normal temperature setting of your air-conditioner during summer? ____ °C

Average: 26.4°C, Standard Dev: 1.44°C

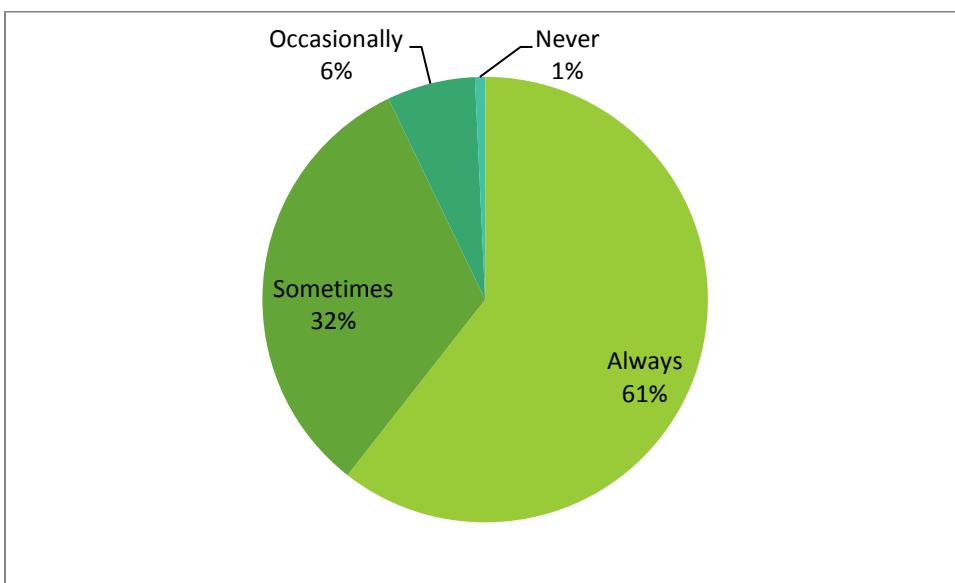
10. How do your family normally uses air-conditioner?

Keep all air-conditioner on at home	57
Turn on air-conditioners in rooms that are occupied	338
Other	1



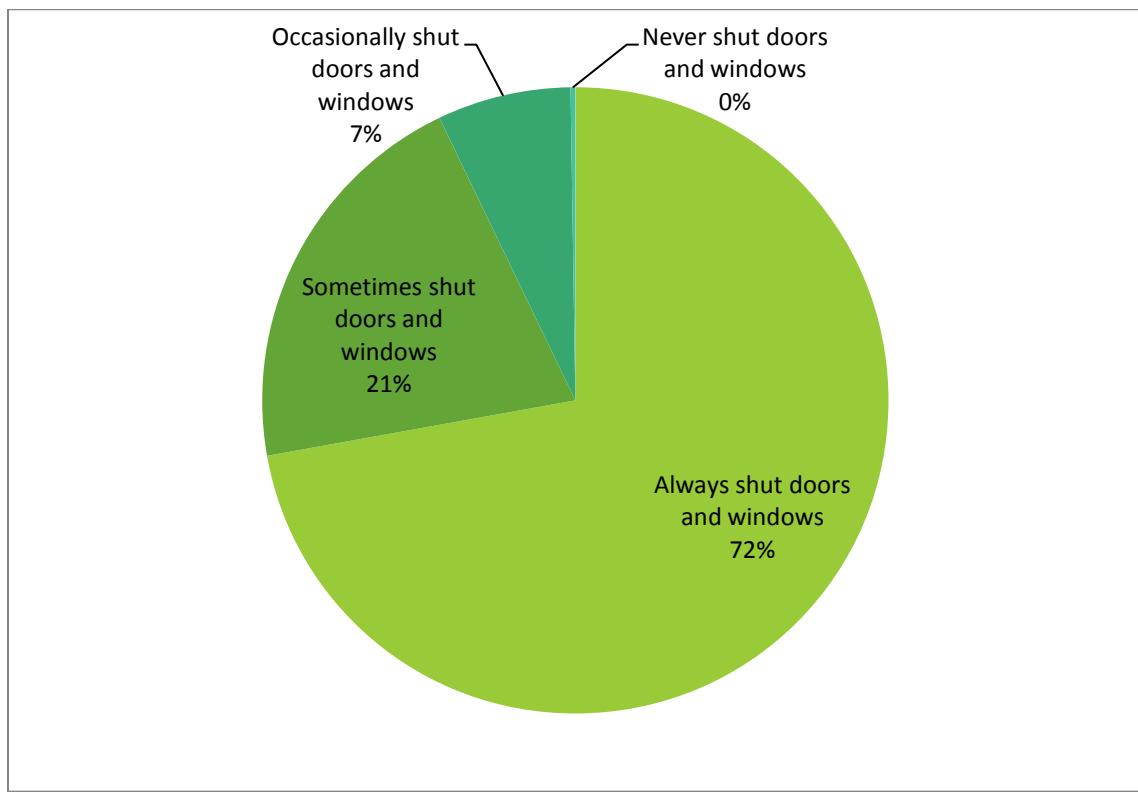
11. Do you turn off air-conditioner when going out?

Always	246
Sometimes	131
Occasionally	26
Never	3



12. When using air conditioning, your family:
(Ventilation)

Always shut doors and windows	293
Sometimes shut doors and windows	84
Occasionally shut doors and windows	28
Never shut doors and windows	1

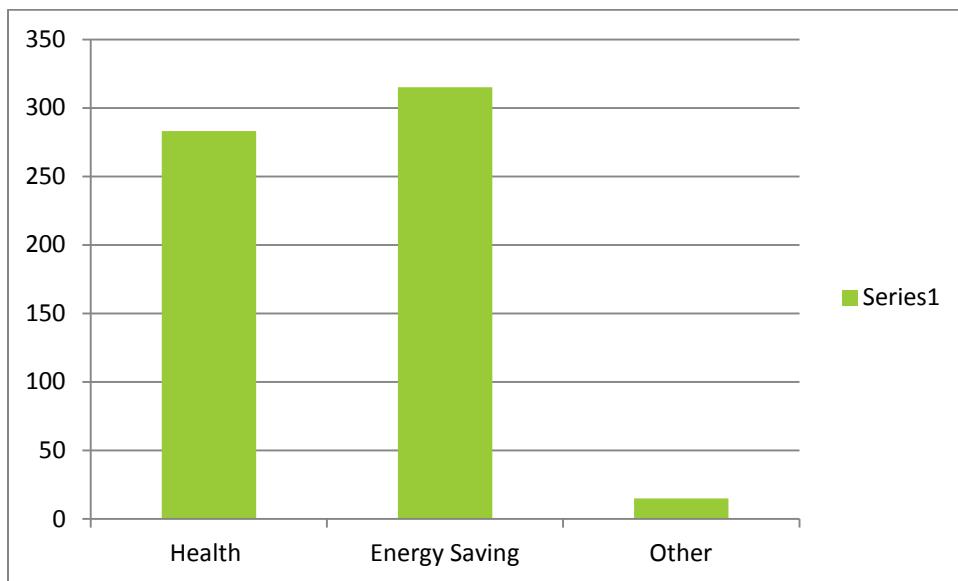


13. Will you turn off AC or set a timer for AC before going to sleep

Always	193
Sometimes	164
Occasionally	38
Never	12

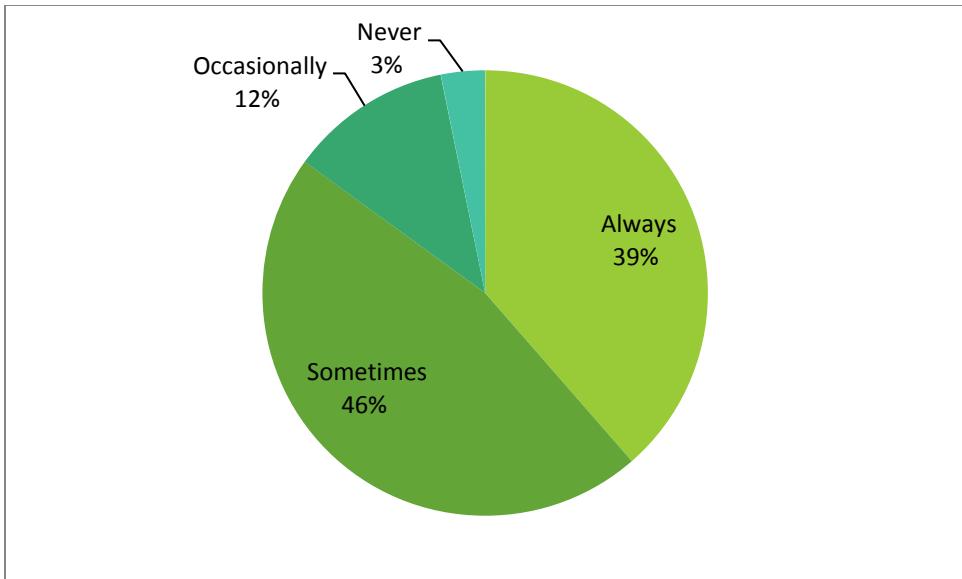
14. What is the reason you turn air-conditioner off or set a timer when going to sleep (Check all that apply)

Health	283
Energy Saving	315
Other	15



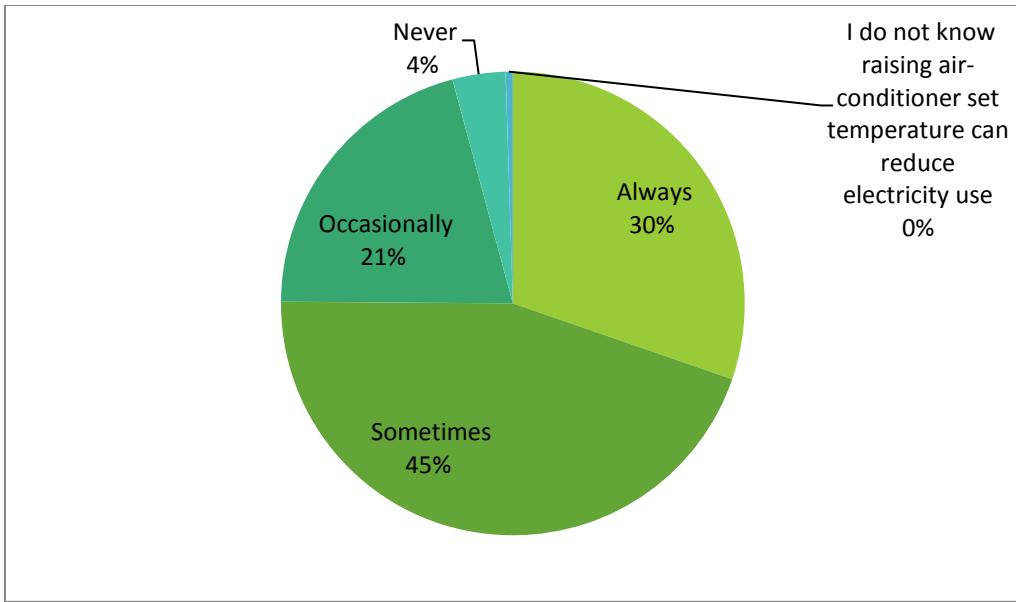
15. Have you ever use less air conditioning to save on electricity?

Always	157
Sometimes	189
Occasionally	48
Never	13



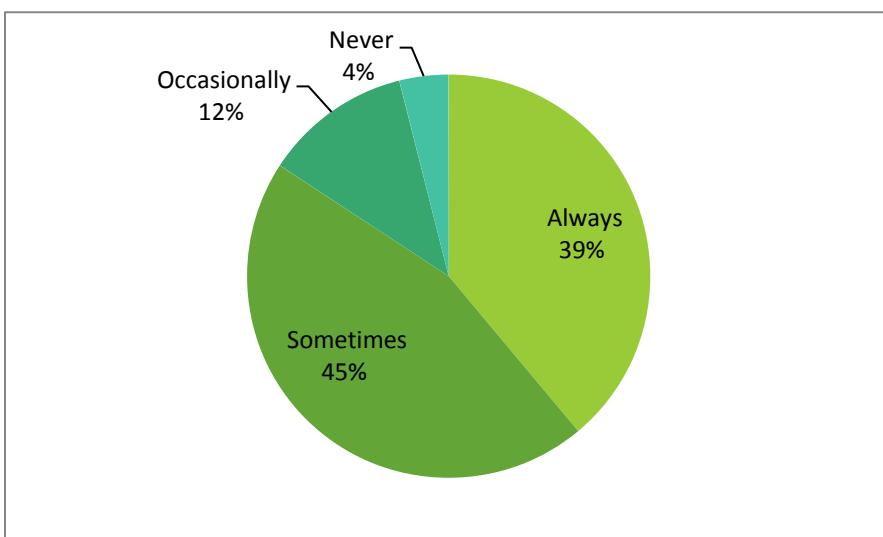
16. Did you ever raise air-conditioner set temperature to save on electricity?

Always	123
Sometimes	182
Occasionally	84
Never	15
I do not know raising air-conditioner set temperature can reduce electricity use	2



17. Did you ever reduce air-conditioner use during peak period (high electricity price period)?

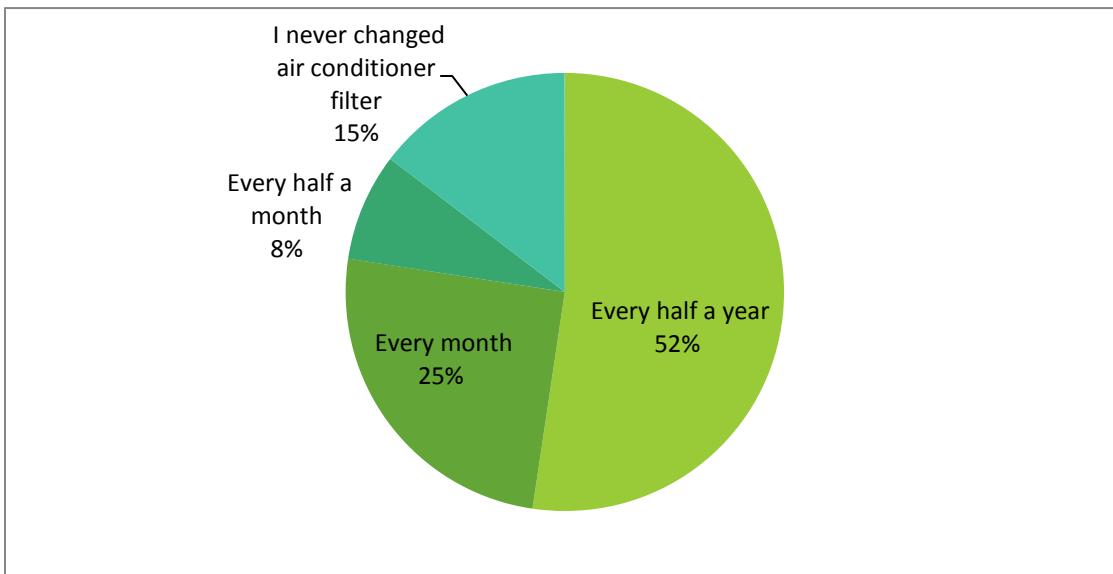
Always	158
Sometimes	184
Occasionally	48
Never	16



18. How often do you change air-conditioner filter?
(Doubt the credibility)

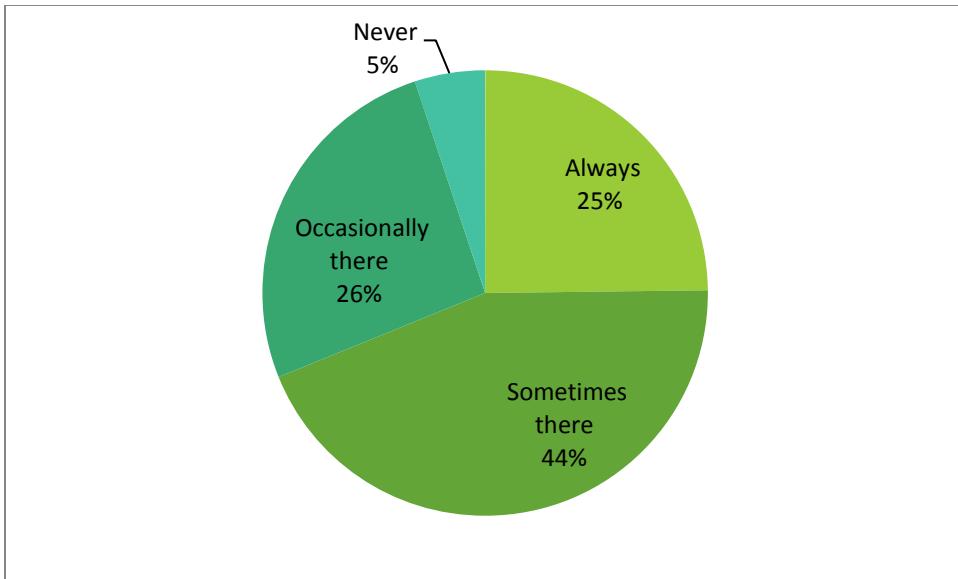
Every half a year	211
-------------------	-----

Every month	101
Every half a month	32
I never changed air conditioner filter	59



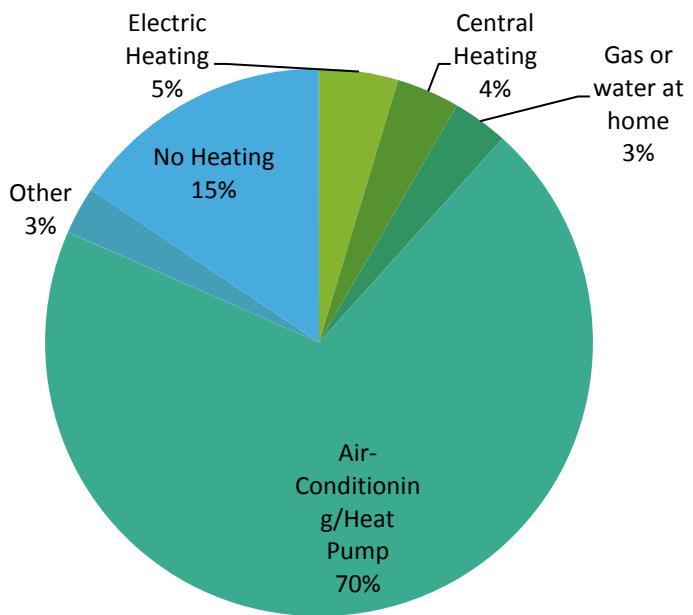
19. Did the electricity company ever communicated with you regarding to air-conditioning and electricity saving?

Always	102
Sometimes there	181
Occasionally there	107
Never	21



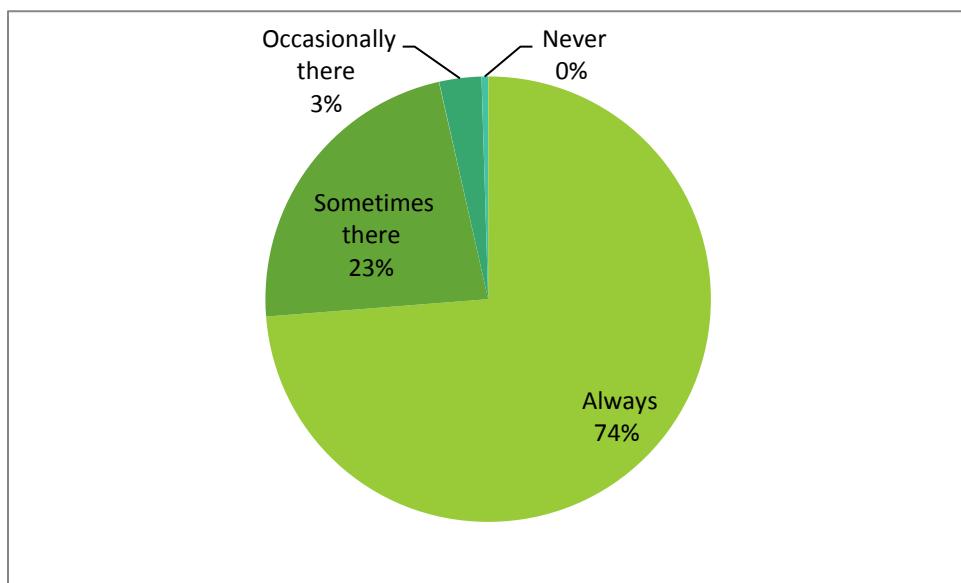
20. What is the heating system in your home?

Electric Heating	20
Central Heating	16
Gas or water at home	14
Air-Conditioning/Heat Pump	300
Other	12
No Heating	67



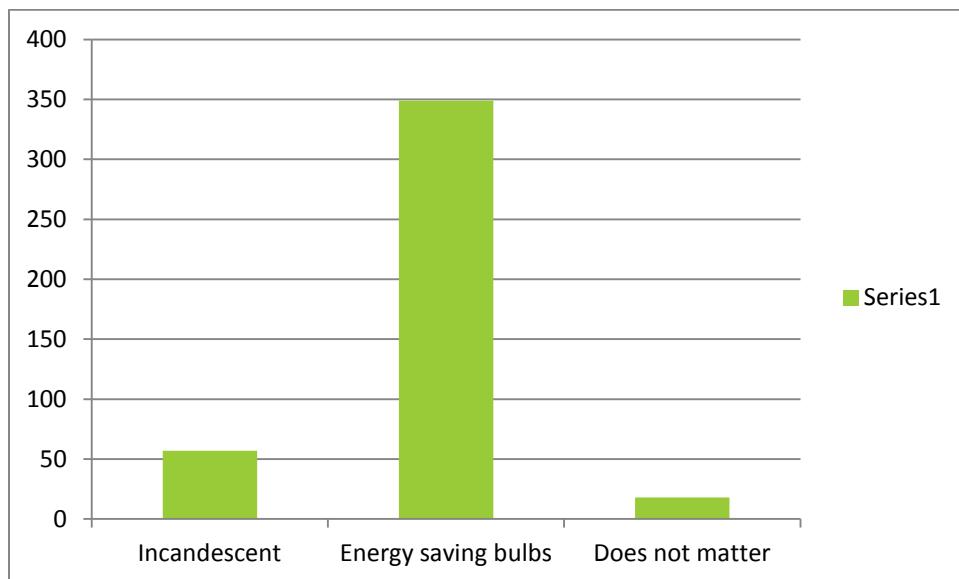
22. Do you have the habit of turning lights off when leaving the room?

Always	312
Sometimes there	96
Occasionally there	13
Never	2



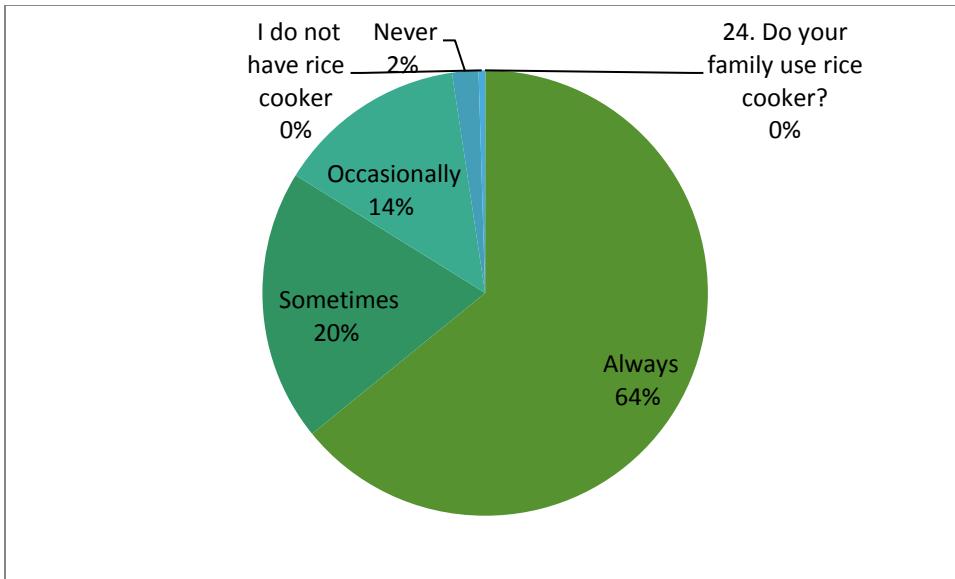
23. When purchasing new light blubs you will choose?

Incandescent	57
Energy saving bulbs	349
Does not matter	18



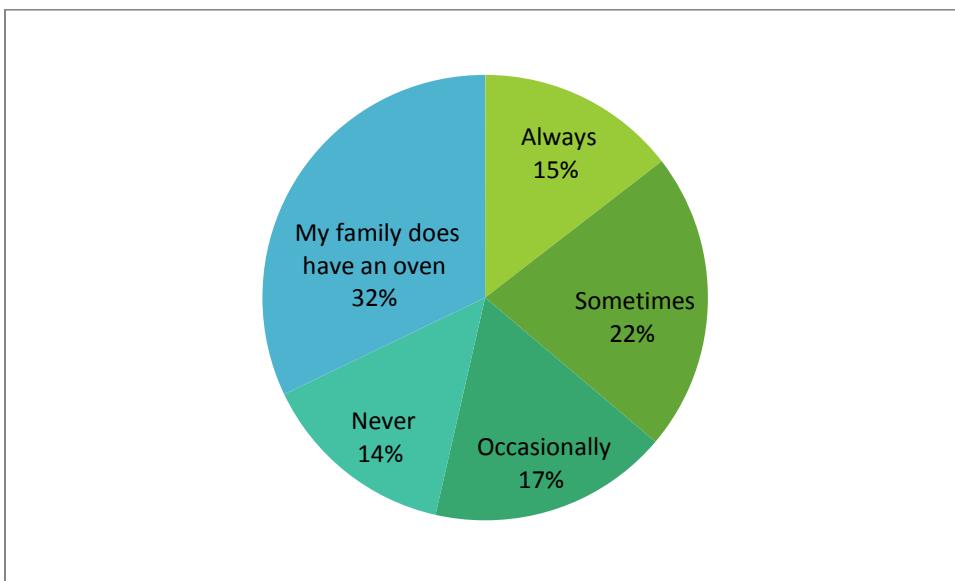
24. Do your family use rice cooker?

Always	270
Sometimes	83
Occasionally	58
Never	8
I do not have rice cooker	2



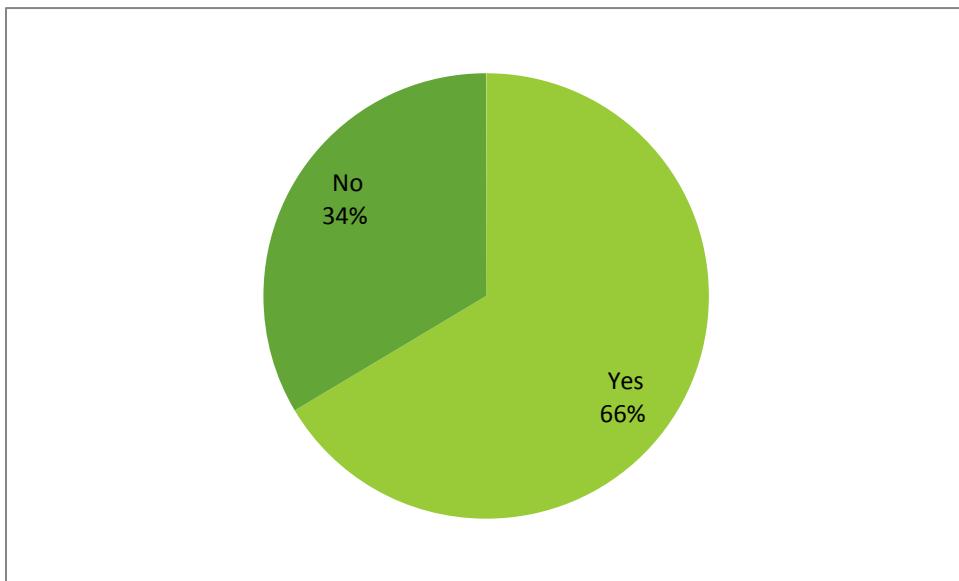
25. Do your family use oven?

Always	61
Sometimes	91
Occasionally	73
Never	60
My family does have an oven	135



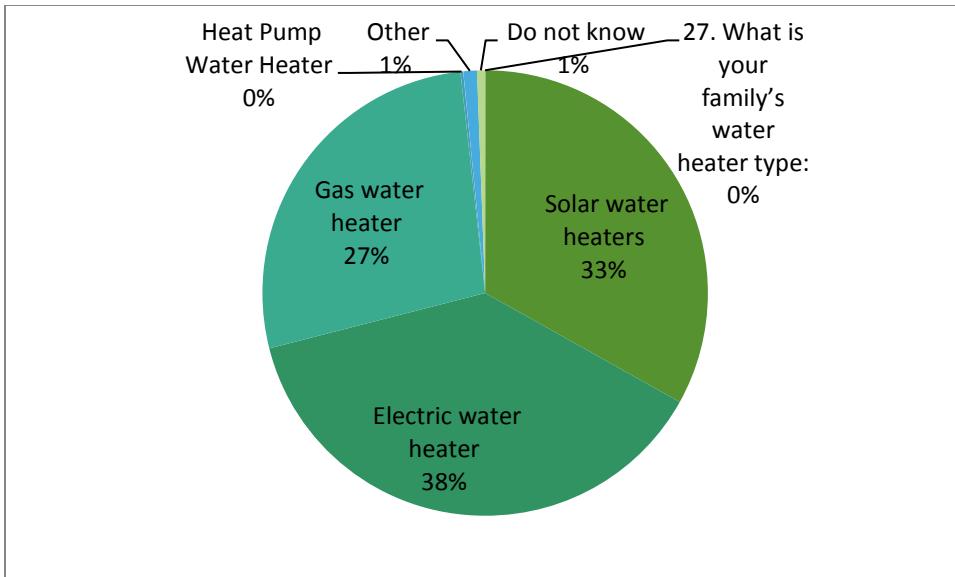
26. Do your family have an electric stove?

Yes	275
No	139



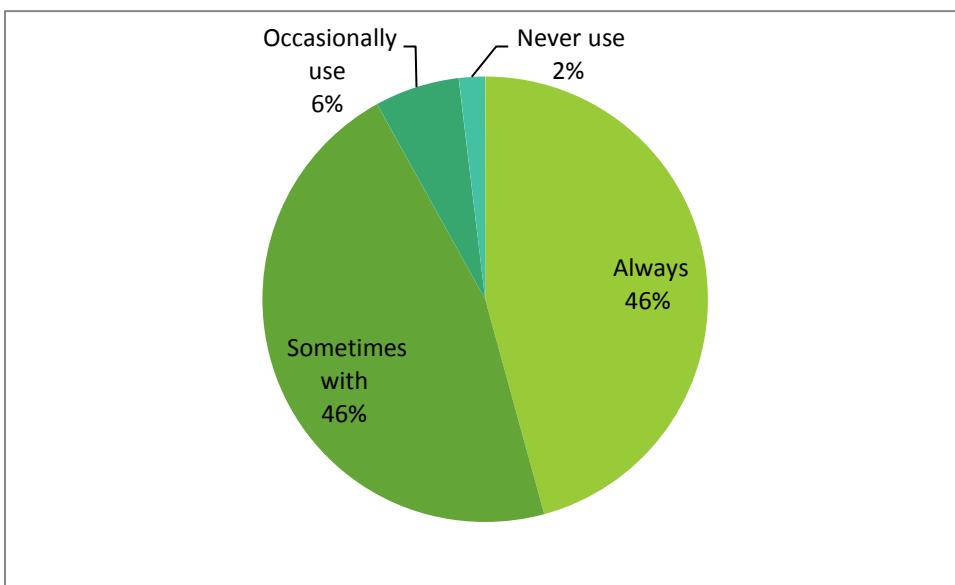
27. What is your family's water heater type:

Solar water heaters	168
Electric water heater	192
Gas water heater	138
Heat Pump Water Heater	1
Other. Please Specify: _____	5
Do not know	3



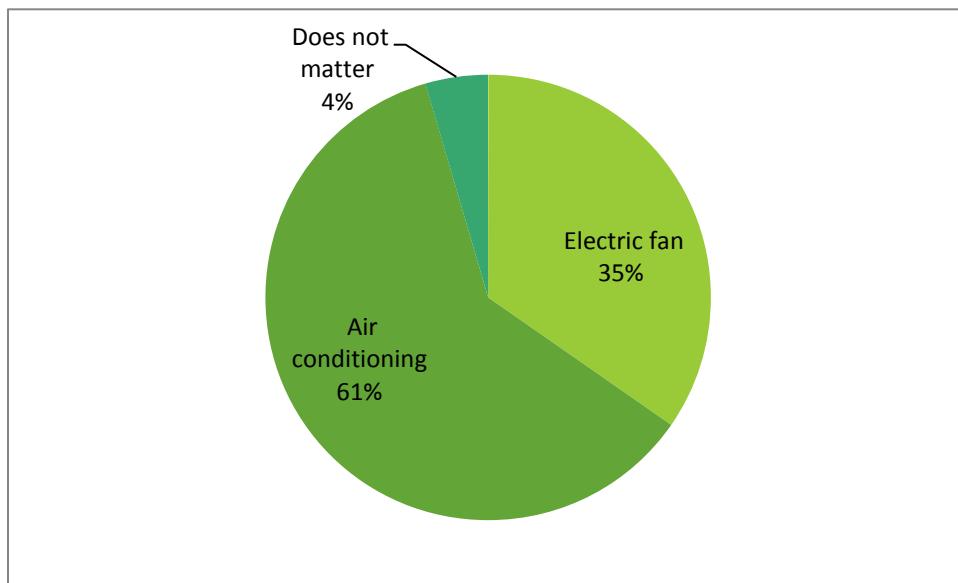
28. Do your family use electric fans?

Always	193
Sometimes with	195
Occasionally use	26
Never use	8



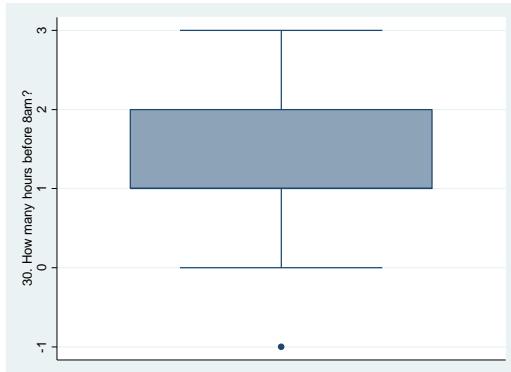
29. Generally do your family prefer to use air conditioner or fan?

Electric fan	145
Air conditioning	254
Does not matter	19



30. When do your family members get up in the morning and go to bed in the evening?

How many hours before 8am?

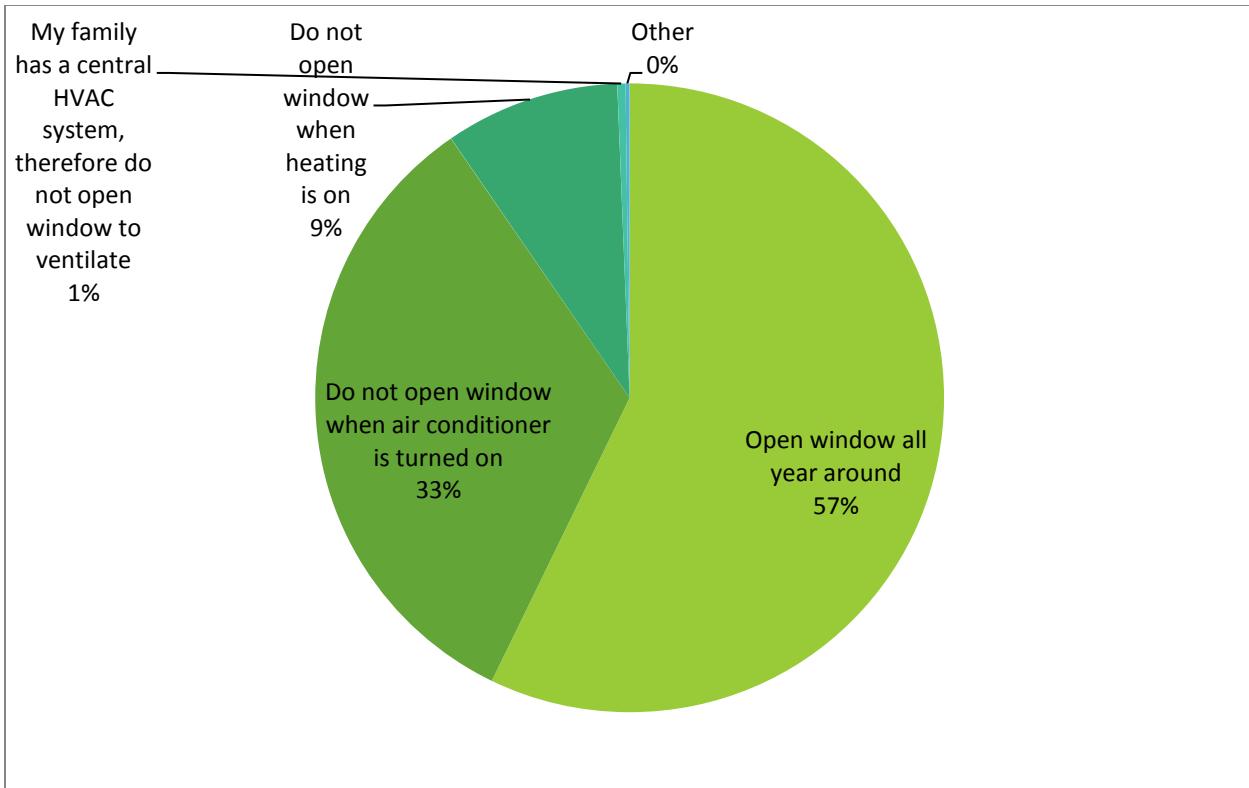


How many hours after 9pm?



31.What are your family's natural ventilation habits?
(Check all that apply)

Open window all year around	274
Do not open window when air conditioner is turned on	159
Do not open window when heating is on	43
My family has a central HVAC system, therefore do not open window to ventilate	2
Other. Please Specify:	1

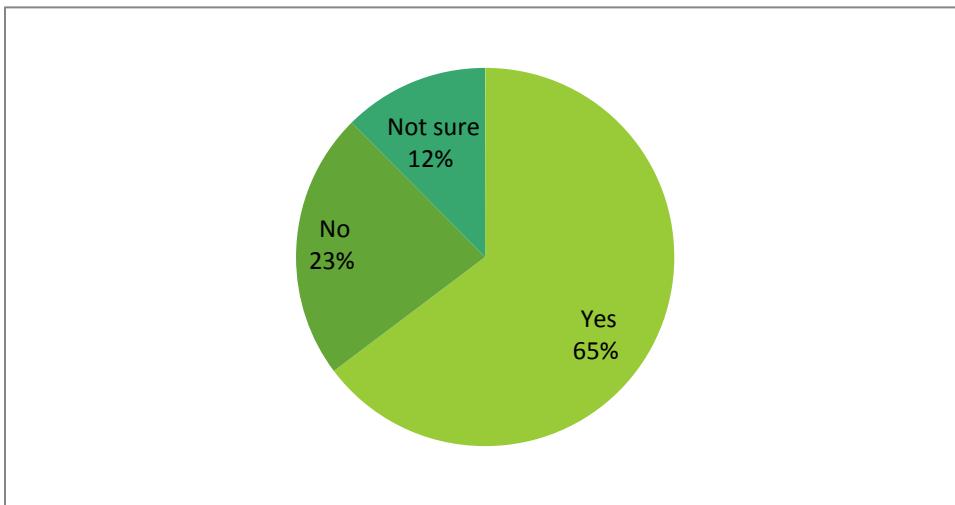


32. Is your home enrolled in time of use pricing?

Yes 255

No (Please skip to question 40 to continue answer the questionnaire) 90

Not sure (Please skip to question 40 to continue answer the questionnaire) 49

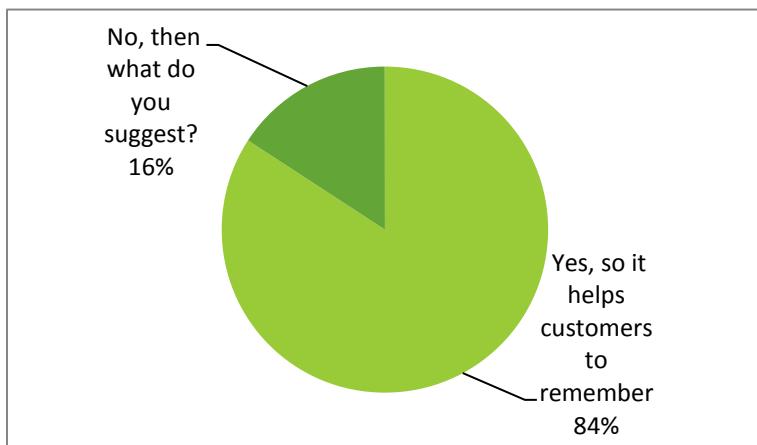


34. Do you think it is easy to remember when is on peak and when is off peak

Very easy to remember	68
Relatively easy to remember	216
Relatively difficult to remember	31
Very difficult to remember	9
I never tried to remember	24

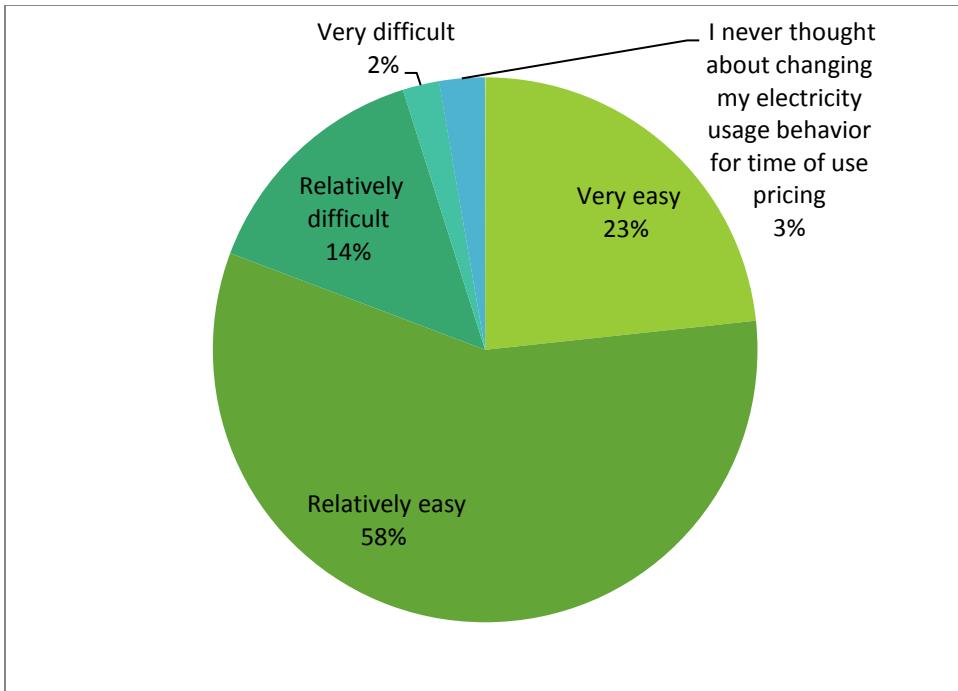
36. Do you think the electricity price should be the same all year around?

Yes, so it helps customers to remember	277
No, then what do you suggest?	52



37. Do you think it is easy to change electricity usage pattern for time of use pricing?

Very easy	86
Relatively easy	212
Relatively difficult	53
Very difficult	8
I never thought about changing my electricity usage behavior for time of use pricing	10

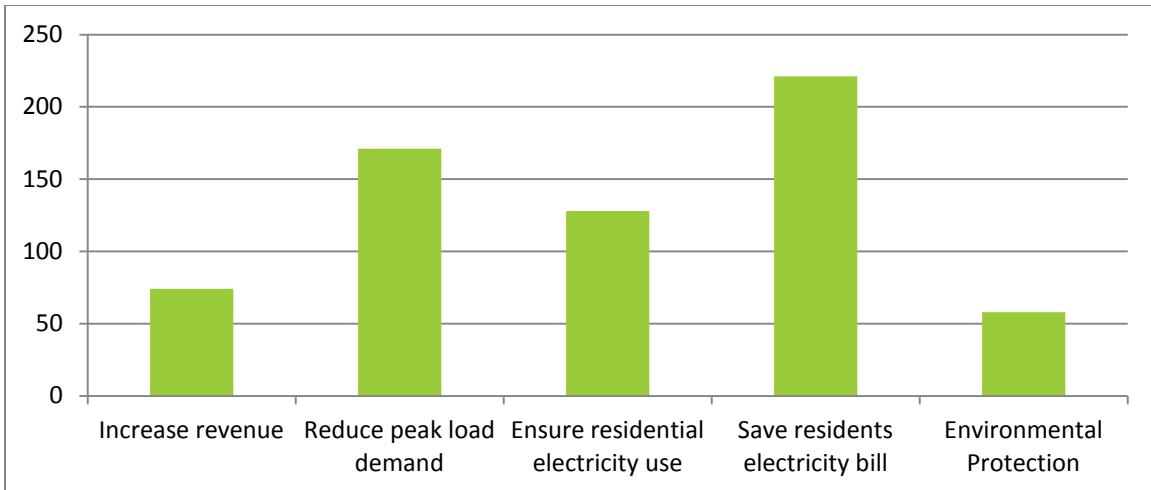


38. Did your family ever adjust electricity usage behavior for time of use pricing?

Always	101
Sometimes	204
Occasionally	55
Never	15

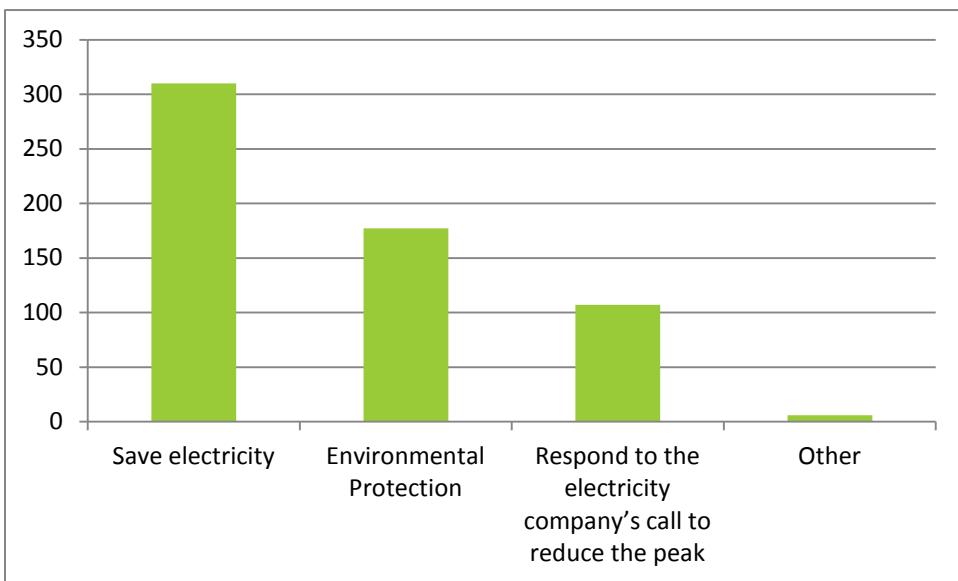
39. Why do you think the power companies promoted time of use pricing? (Check all that apply)

Increase revenue	74
Reduce peak load demand	171
Ensure residential electricity use	128
Save residents electricity bill	221
Environmental Protection	58
Other. Please Specify:	



40. Why did your family enroll in Time of Use Pricing? (Check all that apply)

Save electricity	310
Environmental Protection	177
Respond to the electricity company's call to reduce the peak	107
Other. Please Specify:	6

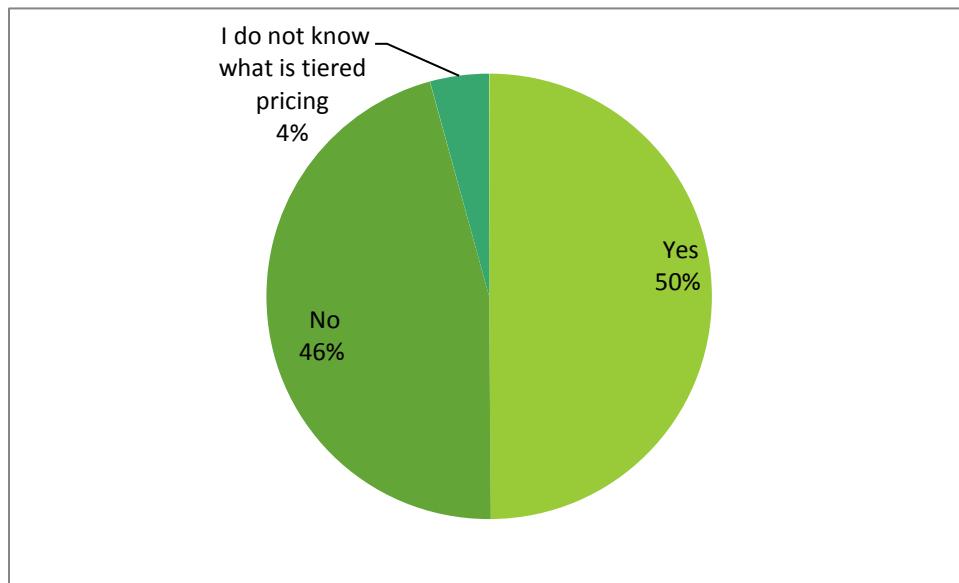


41. Did your family member ever discussed about electricity saving with other people? (neighbors, colleagues, other family members etc)

Yes	221
No	153

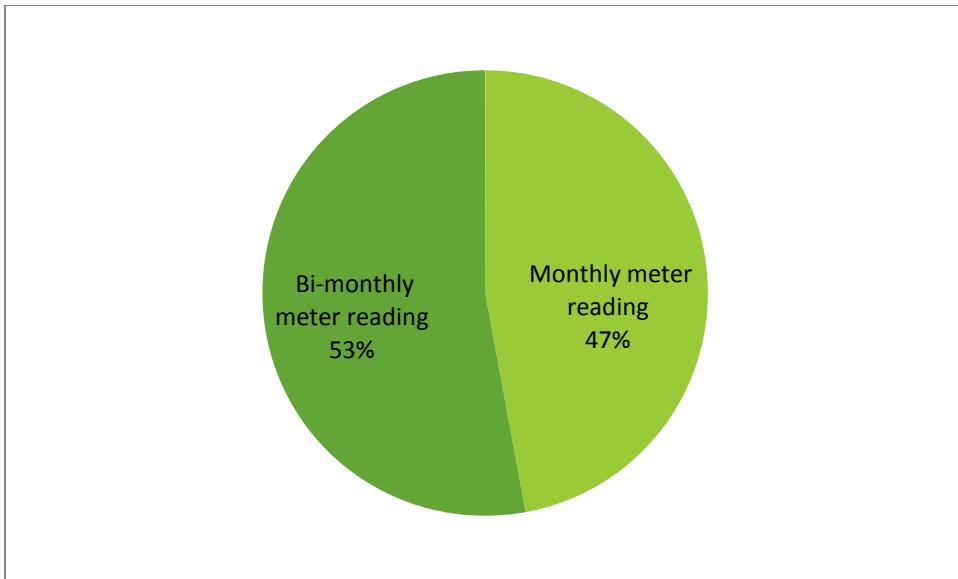
42. Use your household tiered pricing?

Yes	198
No (skip to question 43)	182
I do not know what is tiered pricing (skip to question 43)	17



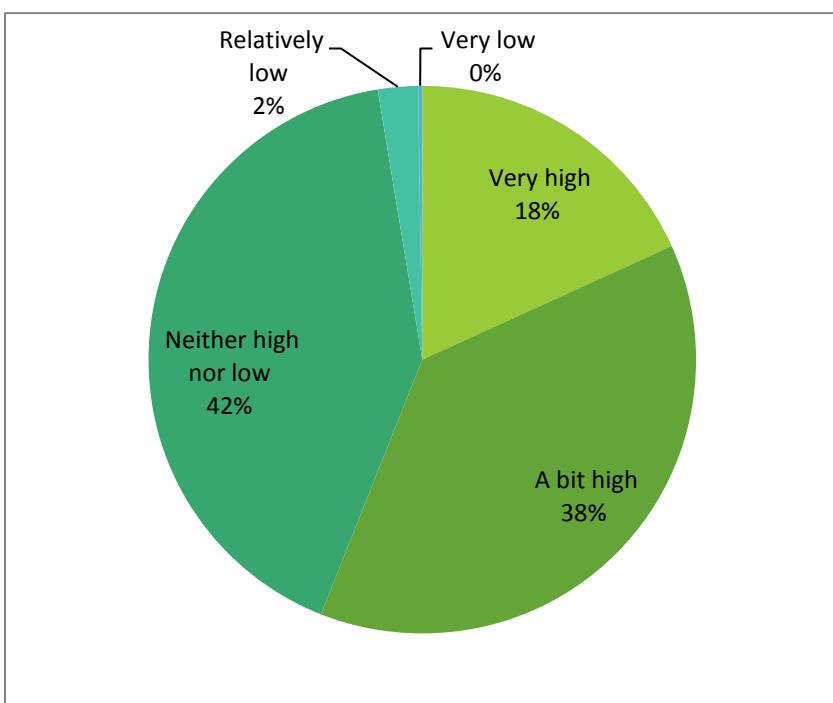
43. Your family is:

Monthly meter reading	154
Bi-monthly meter reading	173
Do not know	



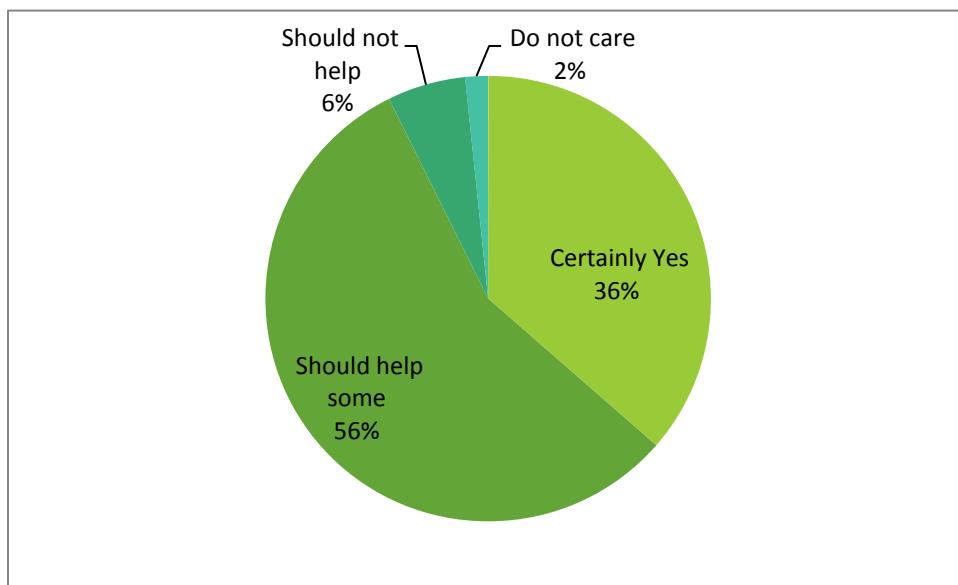
46. How do you view your electricity bill:

Very high	77
A bit high	160
Neither high nor low	175
Relatively low	10
Very low	1



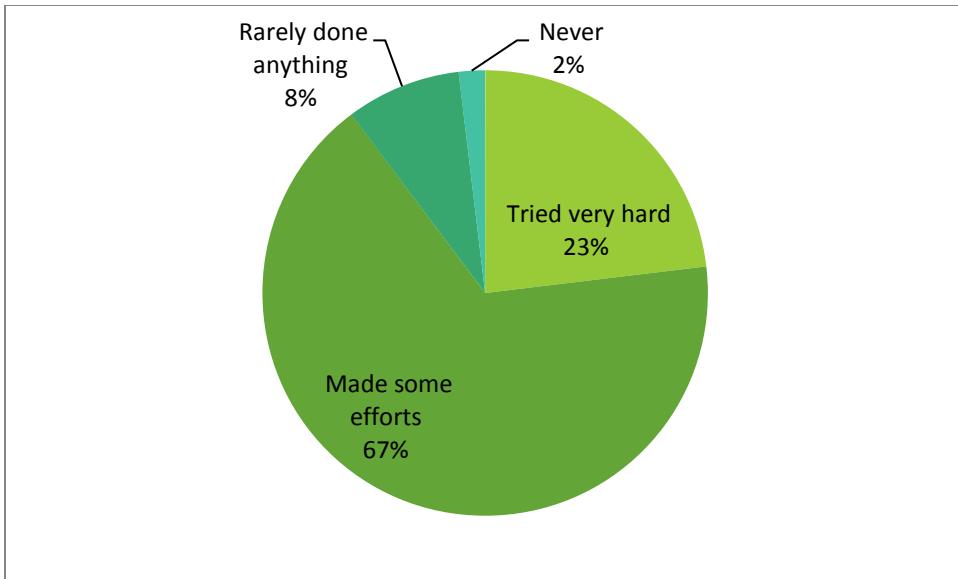
47. Do you think if you know the power consumption of each appliance, that information can help you save on electricity?

Certainly Yes	154
Should help some	238
Should not help	24
Do not care	7



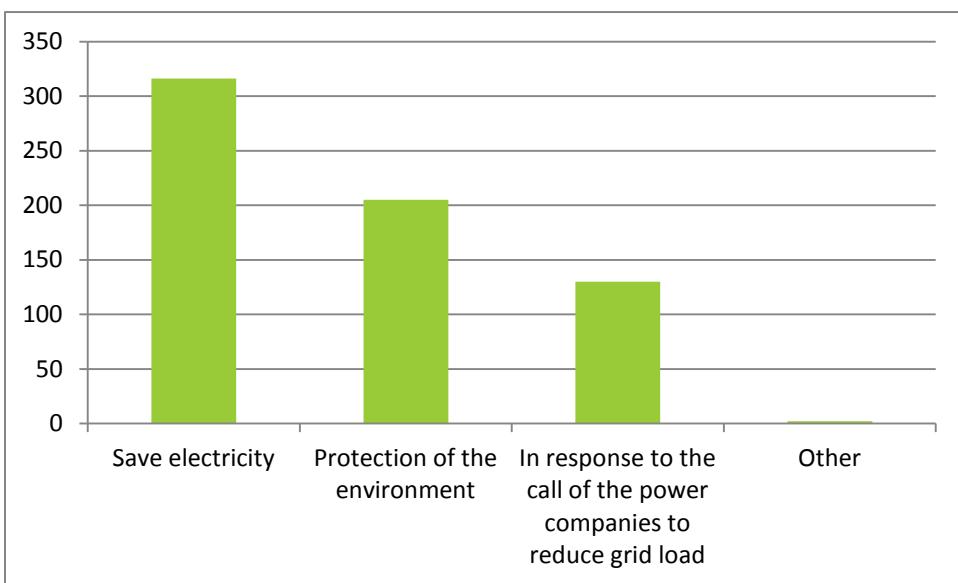
48. How to describe the effort your family made regarding to energy saving?

Tried very hard	97
Made some efforts	280
Rarely done anything	35
Never	8



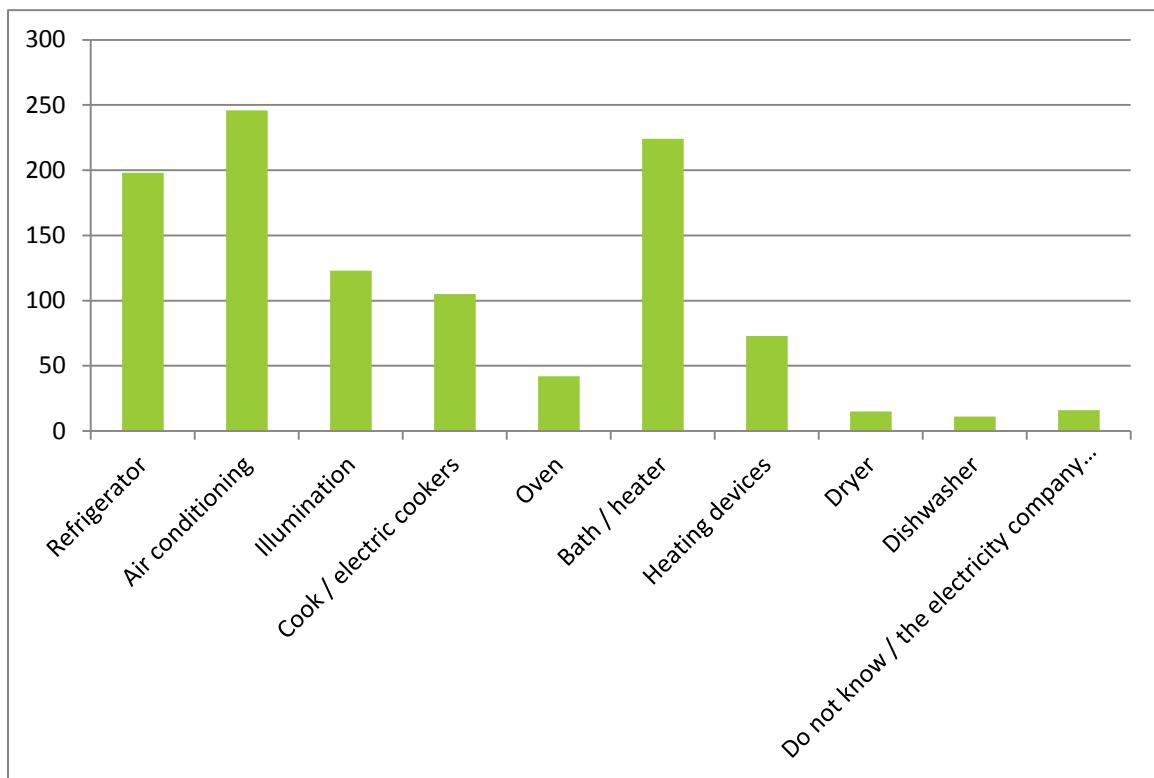
49. What do you think the main reason is people around made efforts to save on electricity?

Save electricity	316
Protection of the environment	205
In response to the call of the power companies to reduce grid load	130
Other. Please Specify:	2



50. Did Electricity Company ever communicate the electricity saving potential of the following appliances or life-style? (Check all that apply)

Refrigerator	198
Air conditioning	246
Illumination	123
Cook / electric cookers	105
Oven	42
Bath / heater	224
Heating devices	73
Dryer	15
Dishwasher	11
Do not know / the electricity company had never communicated anything	16

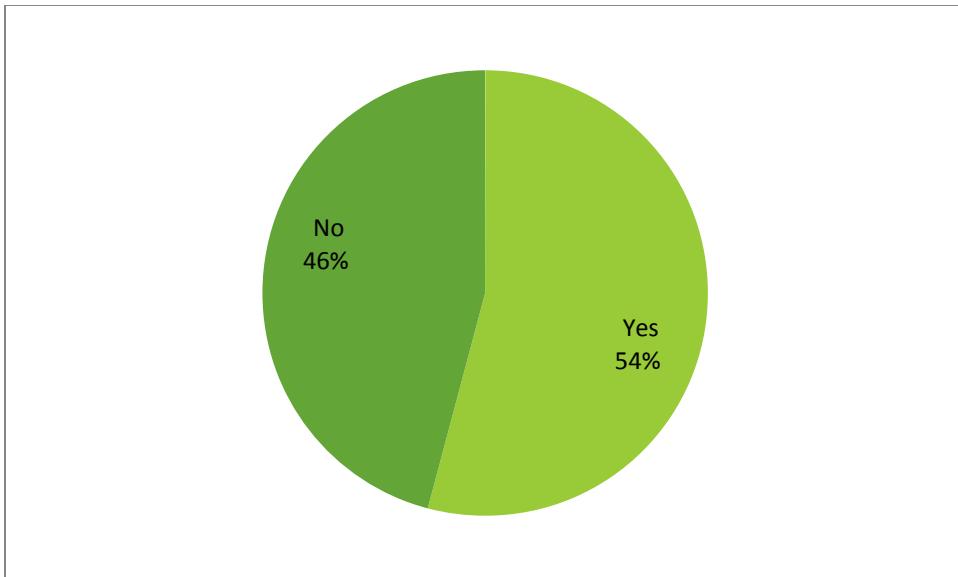


51. Did Electricity Company ever communicate the peak power saving potential of the following appliances or life-style? (Check all that apply)

Refrigerator	204
Air conditioning	222
Illumination	NEED TO FILL IN THE CORRECT ONE!!
Cook / electric cookers	99
Oven	33
Bath / heater	211
Heating devices	79
Dryer	65
Dishwasher	96
Do not know / the electricity company had never communicated anything	26

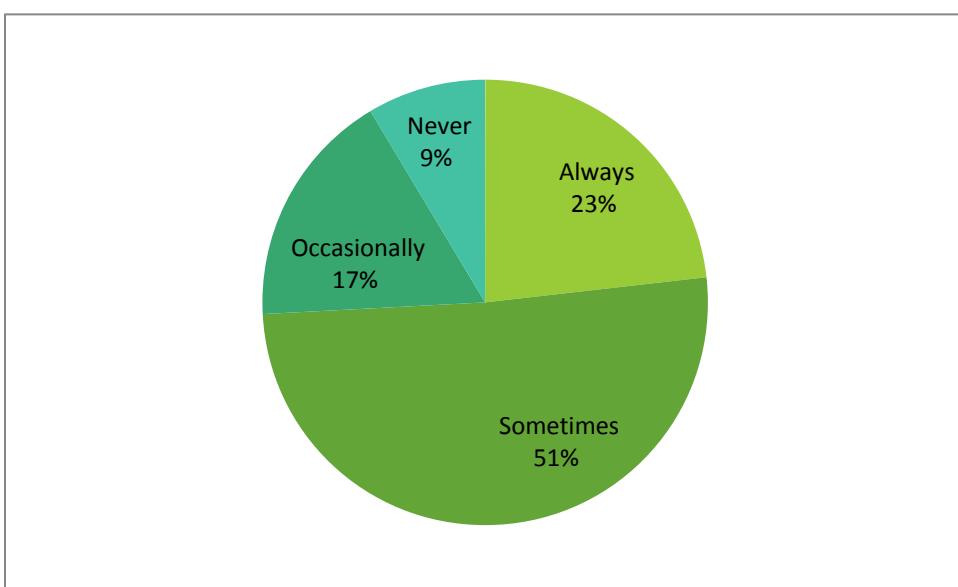
52. Have you ever received energy saving information from the electricity company?

Yes	228
No	193



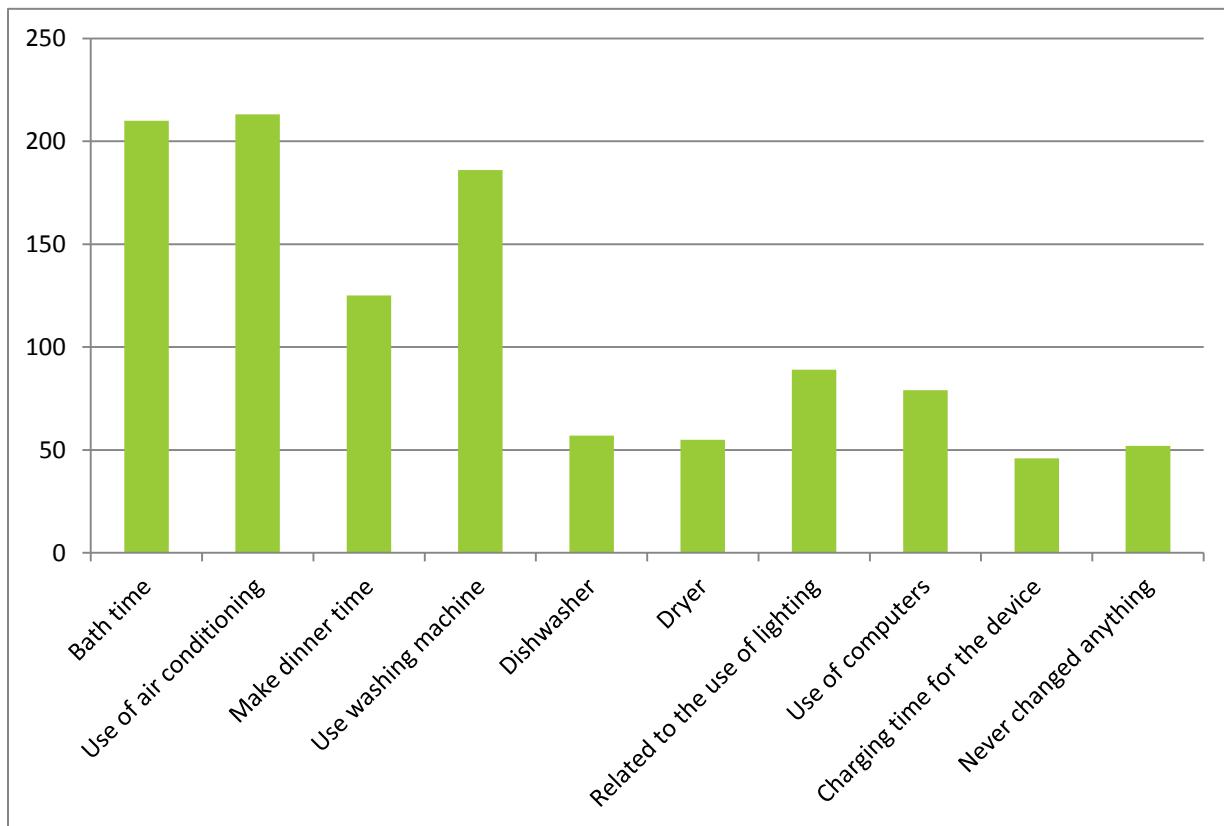
53. When you purchase new appliances, do you consider energy efficiency labeling (right)?

Always	97
Sometimes	213
Occasionally	72
Never	36



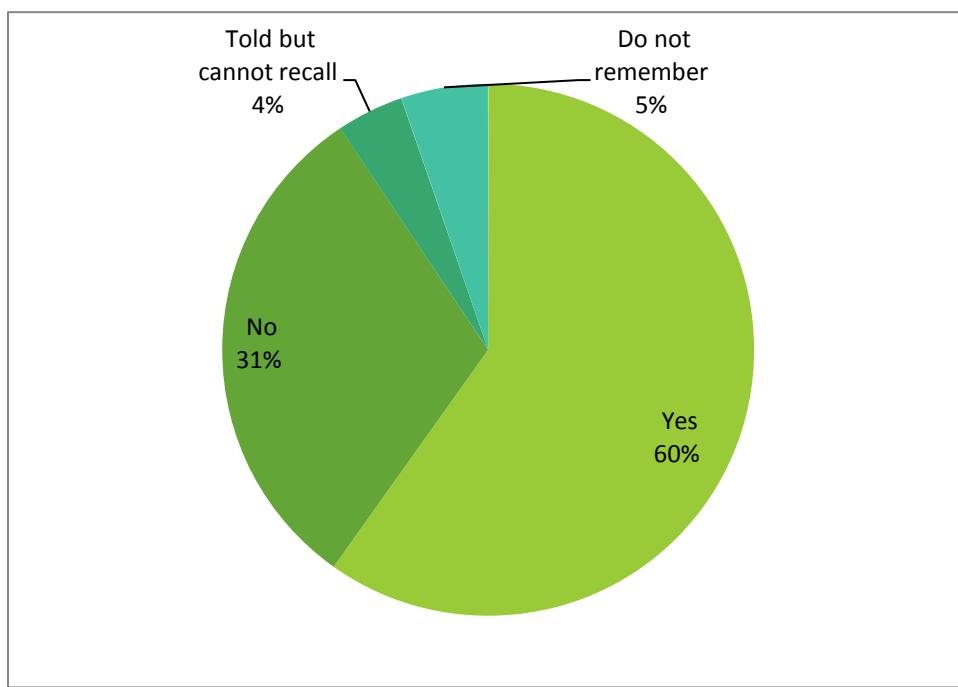
55. What effort did your family make to change living habits or electricity usage habits for TOU? (Check all that apply)

Bath time	210
Use of air conditioning	213
Make dinner time	125
Use washing machine	186
Dishwasher	57
Dryer	55
Related to the use of lighting	89
Use of computers	79
Charging time for the device	46
Never changed anything	52



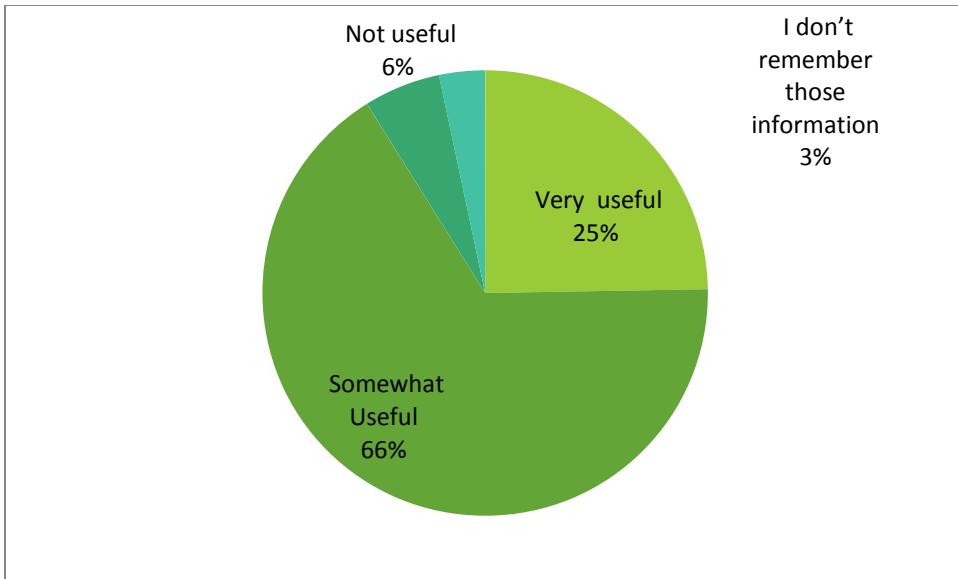
56. Whether electricity company informed you about how save on electricity bill for time of use pricing?

Yes	249
No (please go to question 56 to continue answer the questionnaire)	128
Told but cannot recall (skip 56 questions to continue answer the questionnaire)	17
Do not remember (skip 56 questions to continue answer the questionnaire)	22



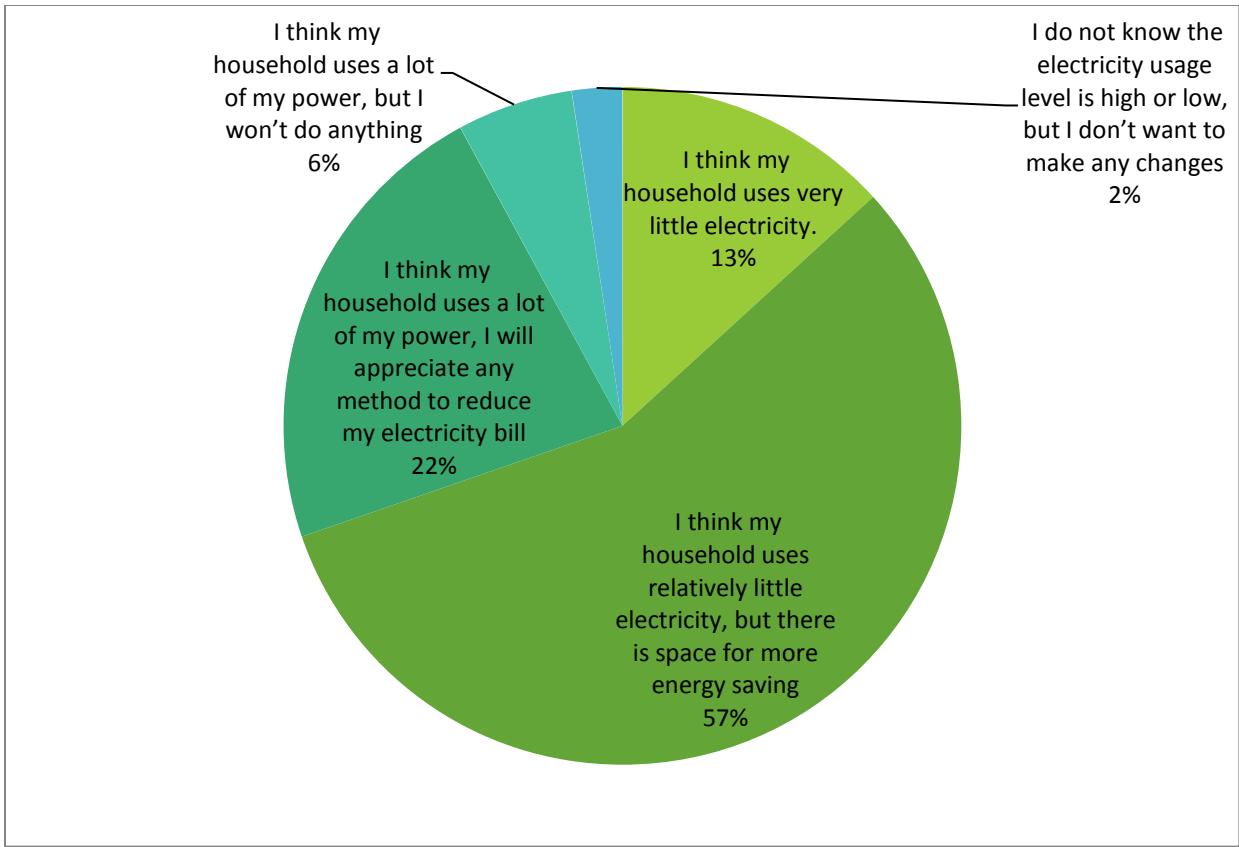
57. Do you think the information provided by the power company useful?

Very useful	89
Somewhat Useful	239
Not useful	20
I don't remember those information	12



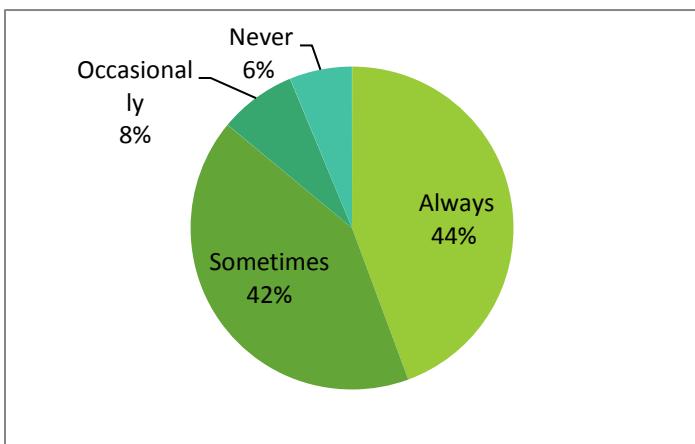
58. Which statement reflected your home electricity usage?

I think my household uses very little electricity.	55
I think my household uses relatively little electricity, but there is space for more energy saving	235
I think my household uses a lot of my power, I will appreciate any method to reduce my electricity bill	93
I think my household uses a lot of my power, but I won't do anything	23
I do not know the electricity usage level is high or low, but I don't want to make any changes	10



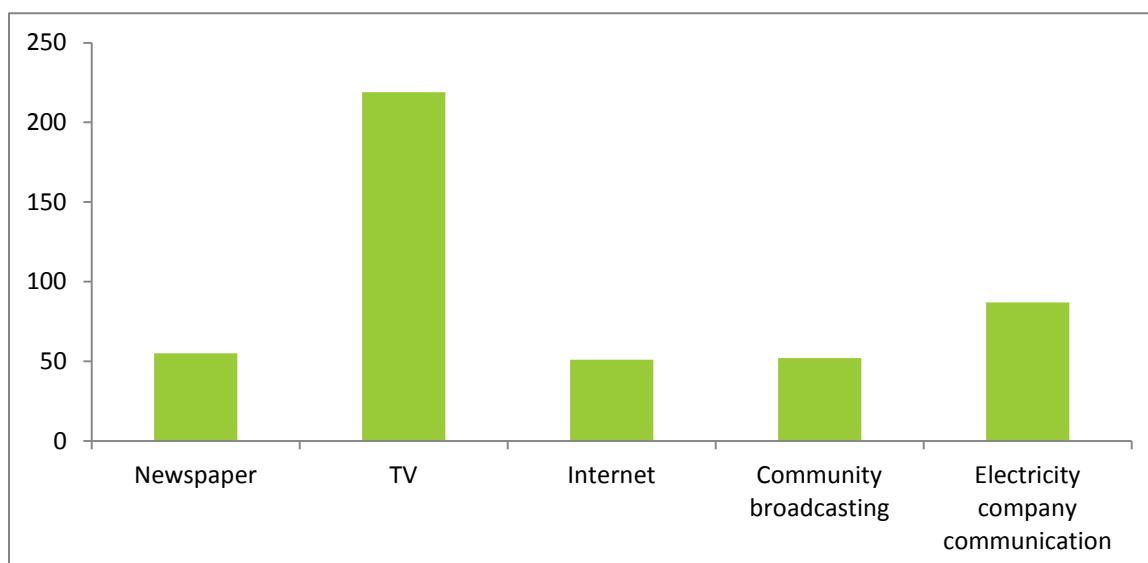
59. When you go to sleep or go out, do you unplug or turn off the power supply to saving electricity?

Always	184
Sometimes	173
Occasionally	32
Never	26



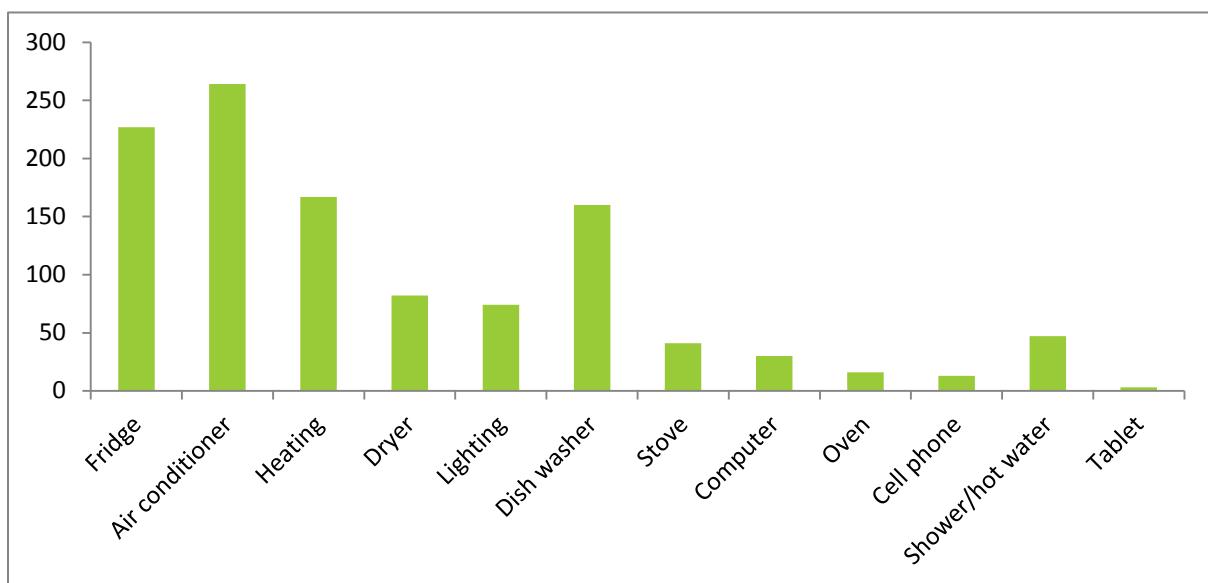
60. From which sources you had received energy saving information?

Newspaper	55
TV	219
Internet	51
Community broadcasting	52
Electricity company communication	87



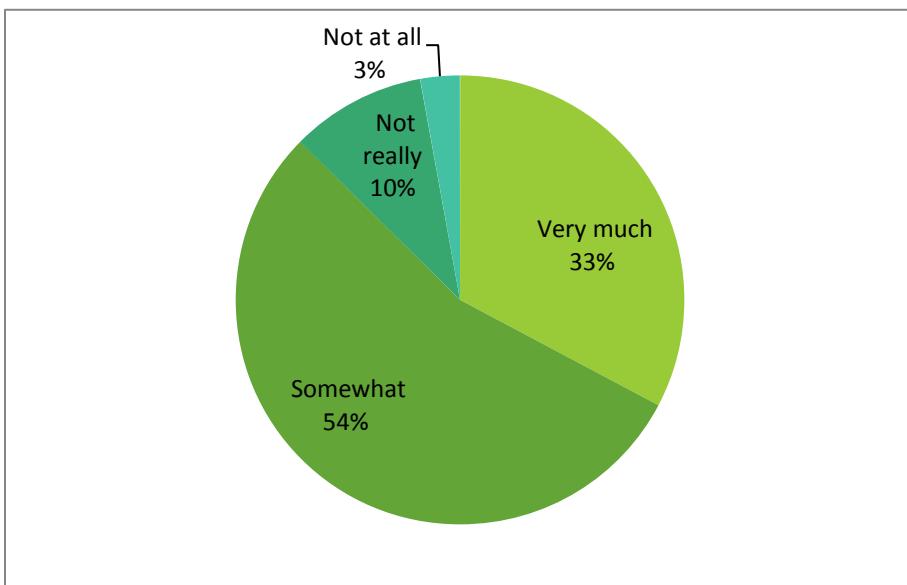
61. What do you think are the top three electricity consumption appliances in your family?

Fridge	227
Air conditioner	264
Heating	167
Dryer	82
Lighting	74
Dish washer	160
Stove	41
Computer	30
Oven	16
Cell phone	13
Shower/hot water	47
Tablet	3



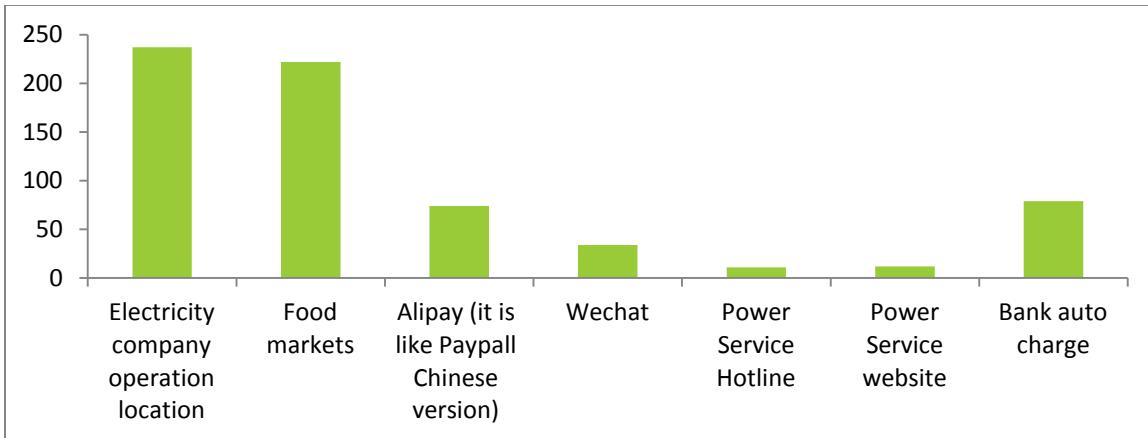
62. Do you care about information on electricity bill saving?

Very much	138
Somewhat	230
Not really	41
Not at all	12



63. How do you pay electricity bills? (Check all that apply)

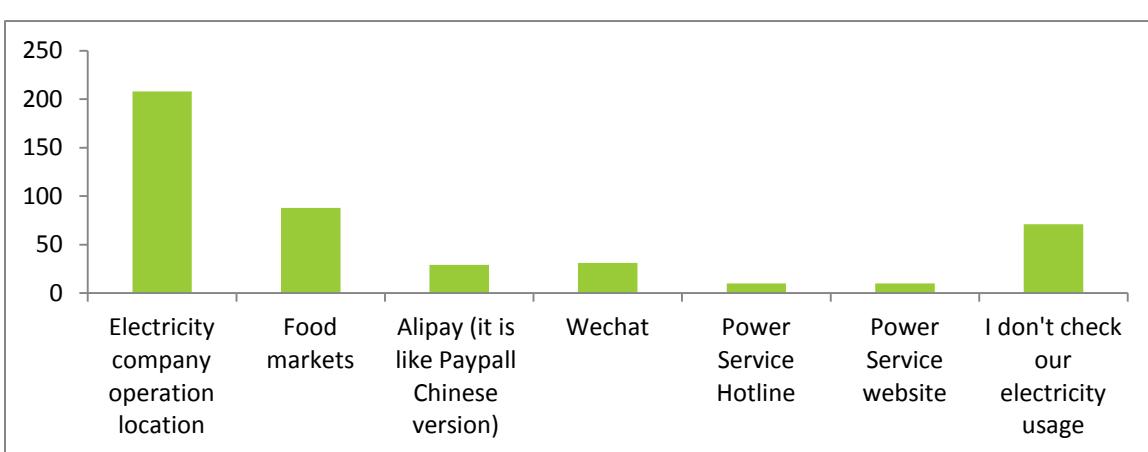
Electricity company operation location	237
Food markets	222
Alipay (it is like Payall Chinese version)	74
Wechat	34
Power Service Hotline	11
Power Service website	12
Bank auto charge	79
Other. Please Specify:	



64. How do you check your electricity usage? (Check all that apply)

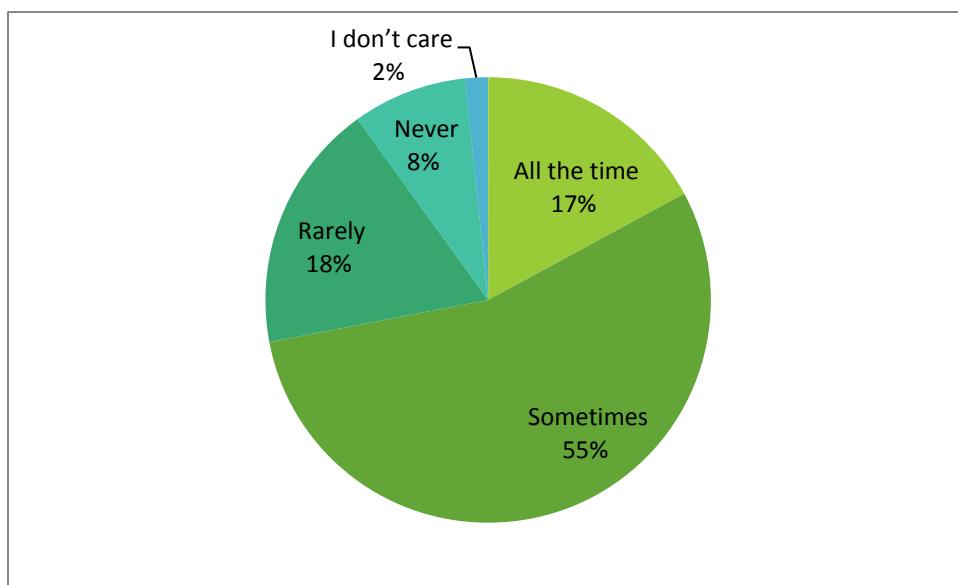
Electricity company operation location	208
Food markets	88
Alipay (it is like Paypall Chinese version)	29
Wechat	31
Power Service Hotline	10
Power Service website	10
I don't check our electricity usage	71

Other. Please Specify:



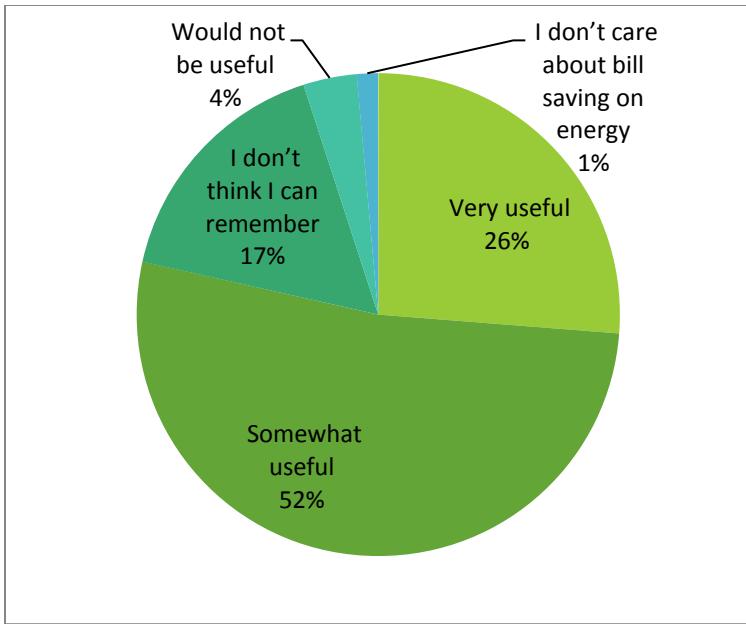
65. Would you read electricity usage information on your receipt on peak/off peak info? (if it is on the receipt)

All the time	72
Sometimes	231
Rarely	76
Never	35
I don't care	7



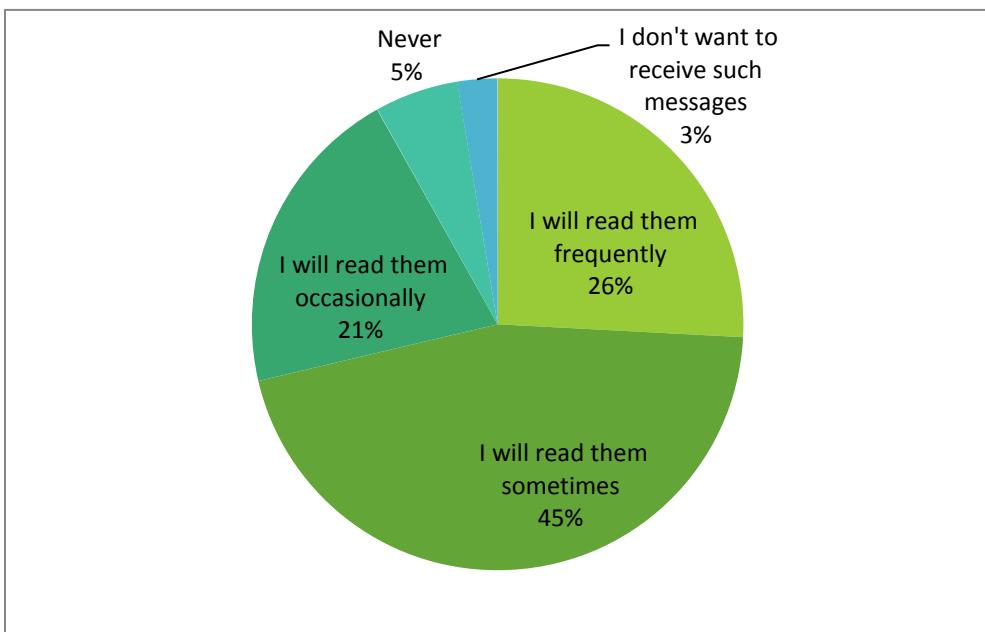
66. Do you think information on the receipt to provide you with information on how to save on energy next month will be useful? (for example, information at the beginning of the summer to help you with energy saving on air-conditioning)

Very useful	110
Somewhat useful	219
I don't think I can remember	69
Would not be useful	15
I don't care about bill saving on energy	6



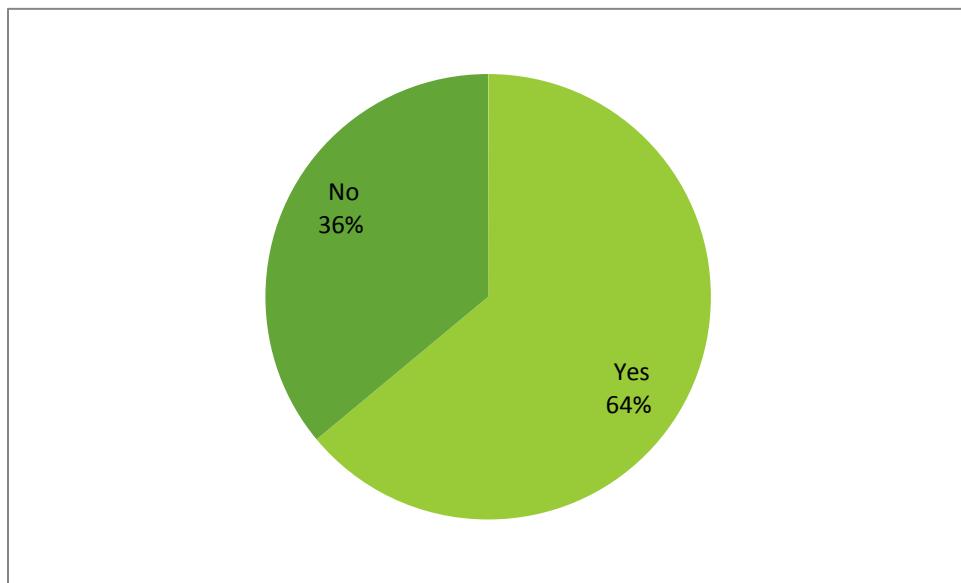
67. If electricity company send you energy saving tips on your phone, will you read them?

I will read them frequently	108
I will read them sometimes	190
I will read them occasionally	86
Never	23
I don't want to receive such messages	11



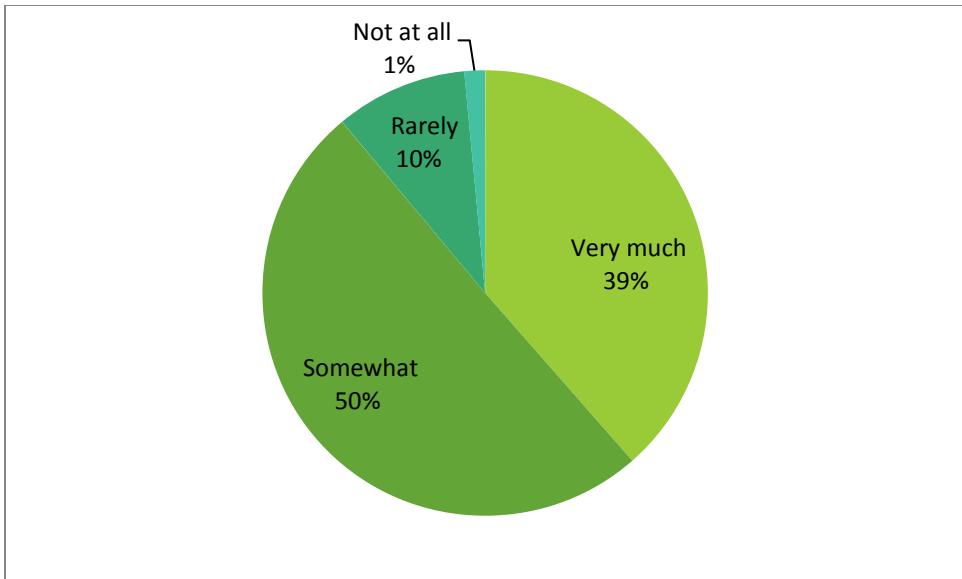
68. Are you responsible for paying electricity bills at home?

Yes	87
No	49



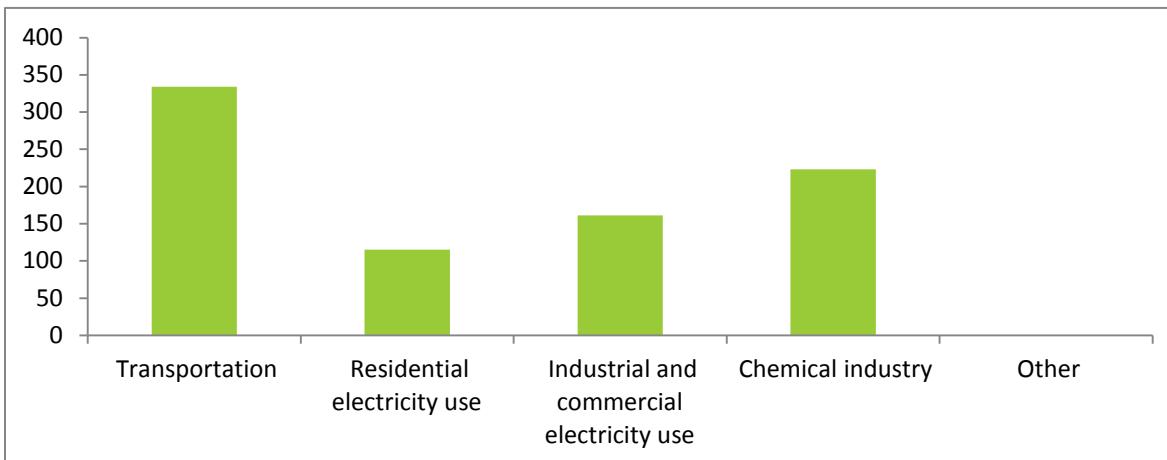
70. Do you care about air-pollution?

Very much	153
Somewhat	200
Rarely	38
Not at all	6



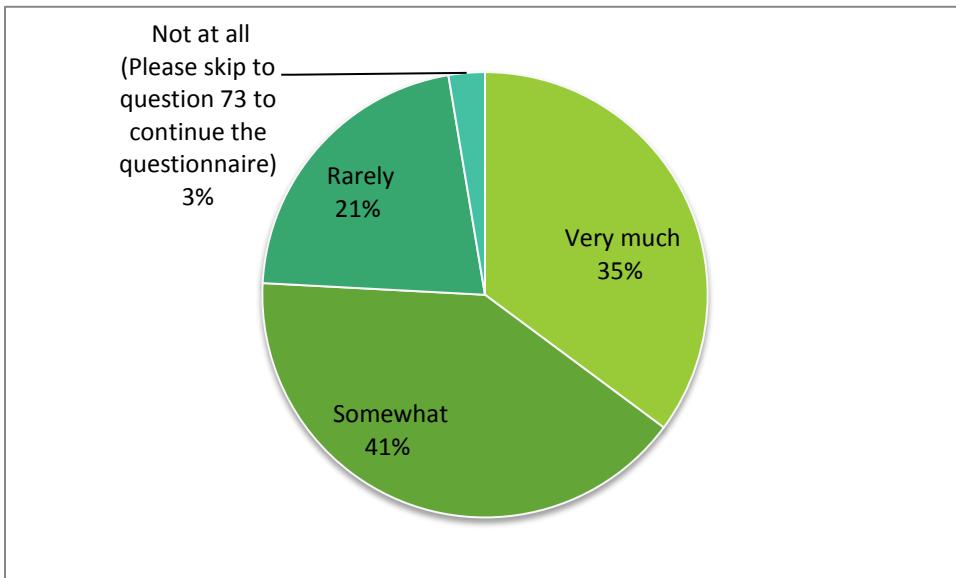
71. What aspects do you think are the major contributors to air pollution? (Check all that apply)

Transportation	334
Residential electricity use	115
Industrial and commercial electricity use	161
Chemical industry	223
Other	



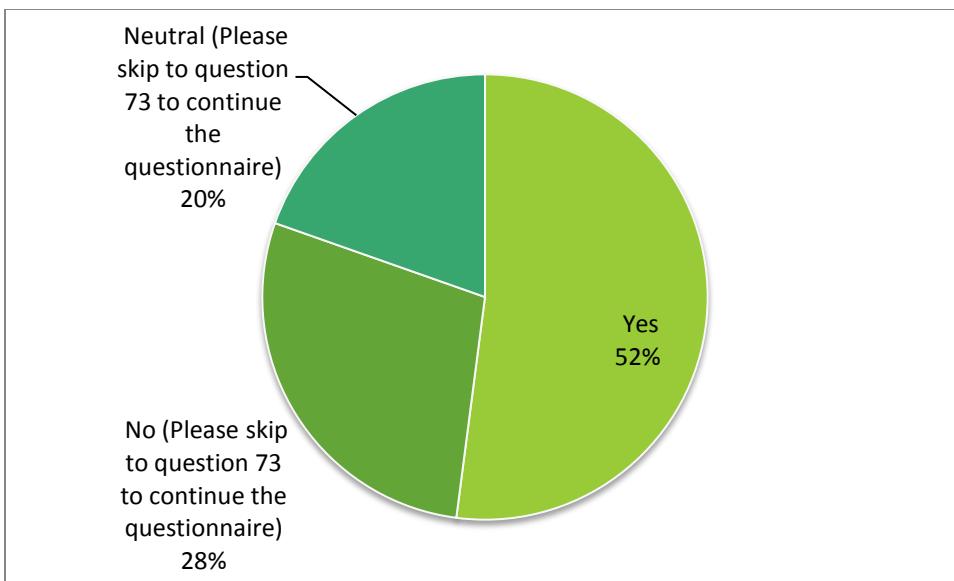
72. Do you care about global climate change?

Very much	147
Somewhat	170
Rarely	90
Not at all (Please skip to question 73 to continue the questionnaire)	11



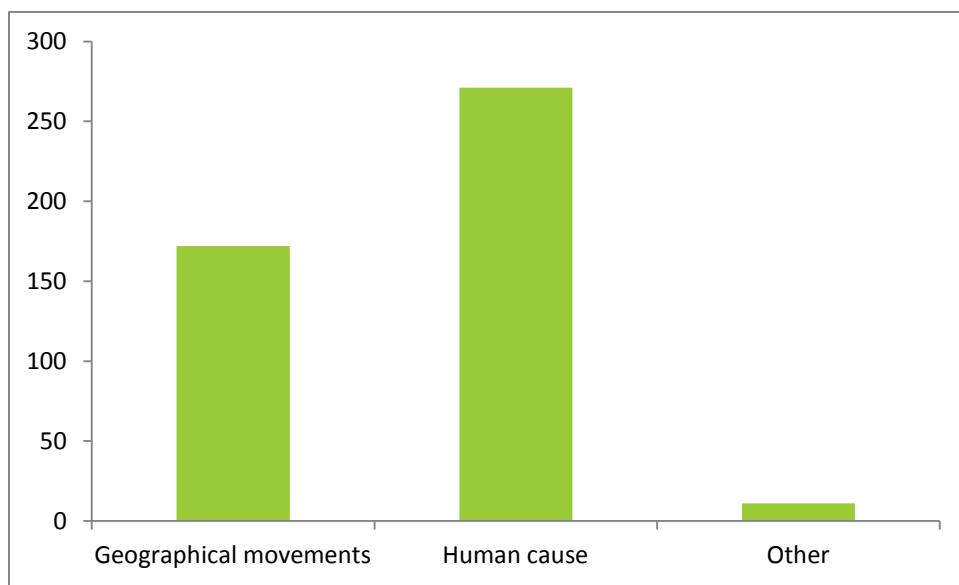
73. Do you believe in climate change?

Yes	215
No (Please skip to question 73 to continue the questionnaire)	117
Neutral (Please skip to question 73 to continue the questionnaire)	81



74. What do you think of the cause of climate change?

Geographical movements	172
Human cause	271
Other	11



75. Do you think using electricity at peak time or off-peak time has anything to do with fossil fuel electricity generation?

Yes	210
Maybe	189
No	21

76. How much fossil fuel (coal/natural gas) do you think account for our electricity generation mix?

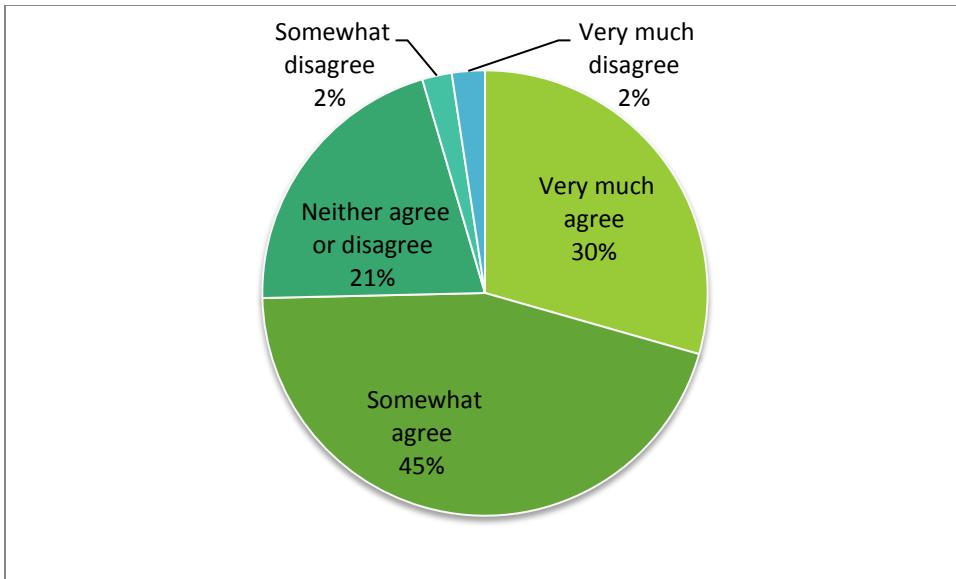
0-30%	135
30-70%	185
70-100%	96

77. Are you familiar with concepts related to smart grid or smart meter?

Very knowledge	96
Moderately knowledgeable	280
Have never heard of	46

78. Do you think it is citizen's responsibility to protect the environment?

Very much agree	123
Somewhat agree	189
Neither agree or disagree	87
Somewhat disagree	9
Very much disagree	10



79. Gender

Male	4
------	---

Female	7
--------	---

80. Age	No age reported
---------	-----------------

81. Occupation	too little report
----------------	-------------------

Student	2
---------	---

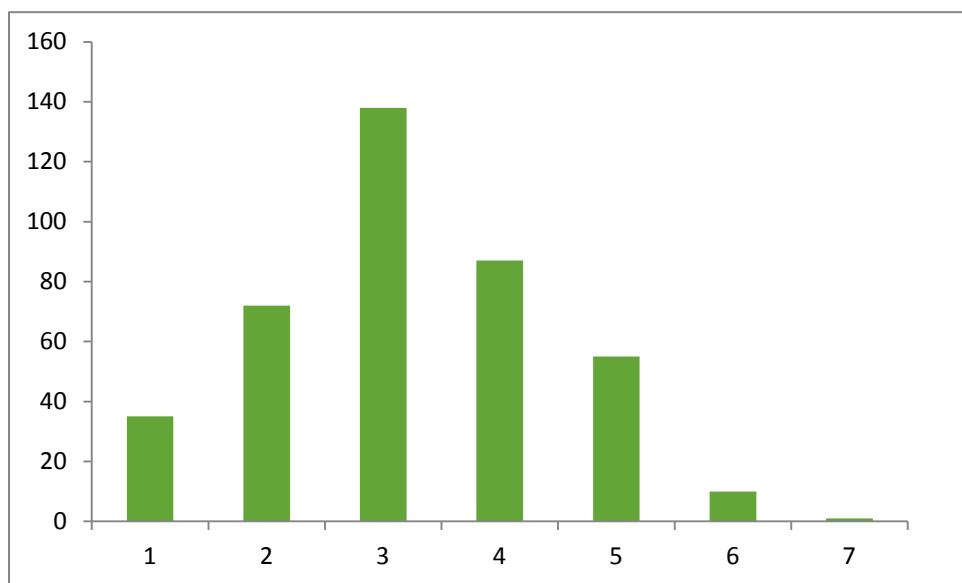
Full Time	1
-----------	---

Retired	4
---------	---

No occupation	
---------------	--

82. How many family members live in your home on a regular basis?

1	35
2	72
3	138
4	87
5	55
6	10
7	1



83. What is your family composition for family members who permanently live in your house:

Too
little
reported

Children before school

Elementary or secondary school

College student

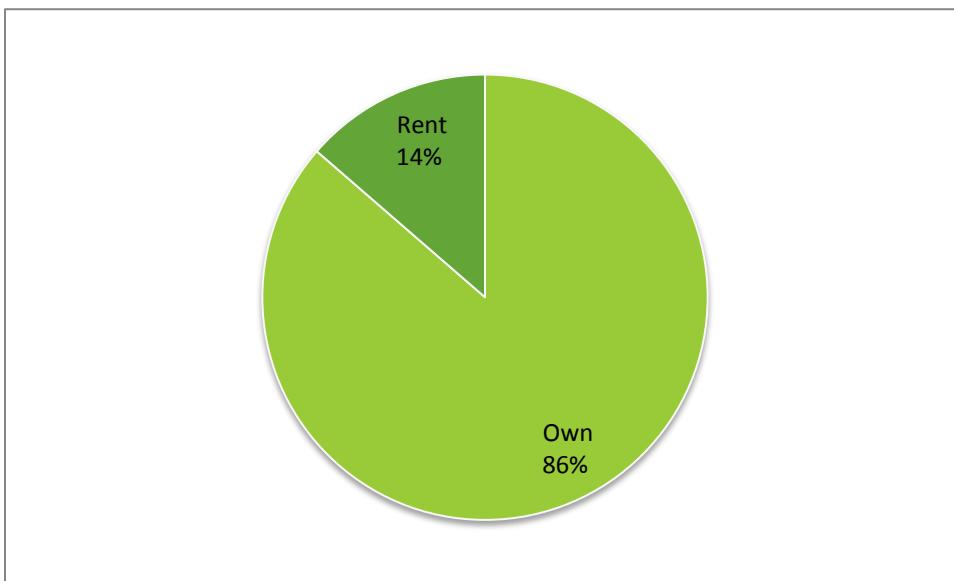
Full time employee working outside

Working from home

Retired

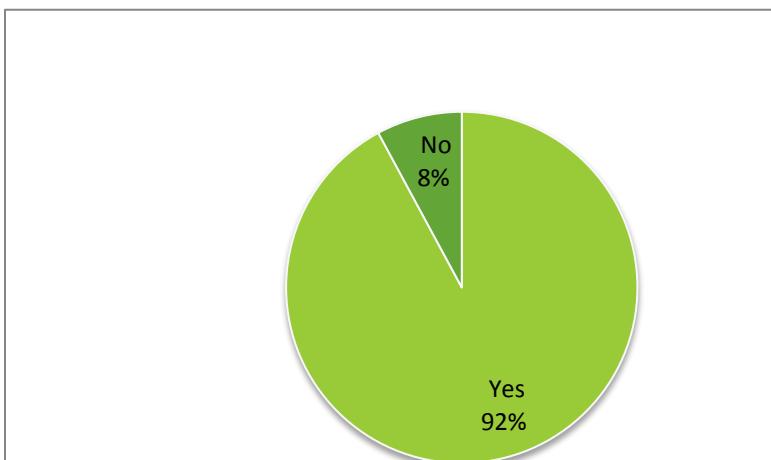
84. Do you own or rent the house:

Own	355
Rent	56



85. Have your family stayed in this house for more than two years?

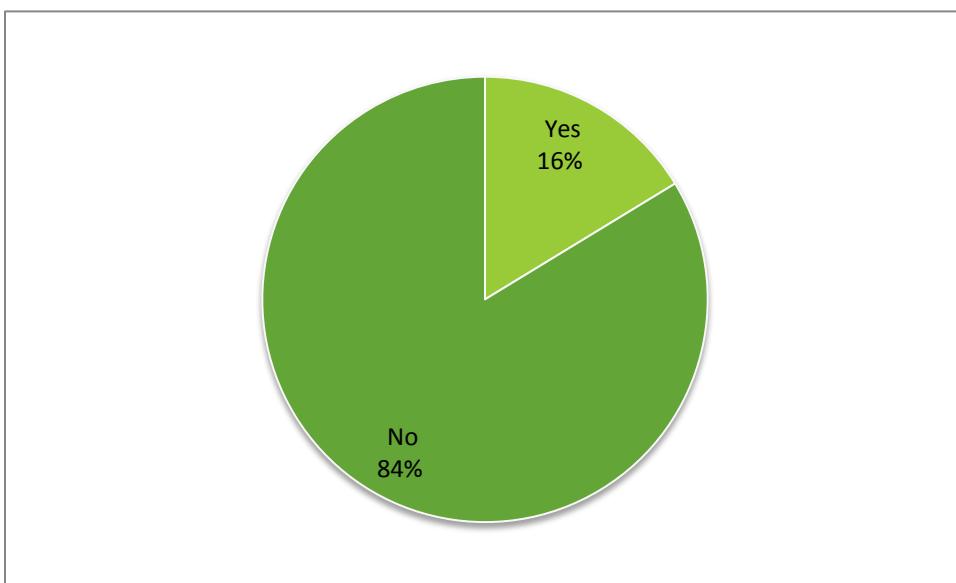
Yes	374
No	32



86. Is any of your family member has chronic

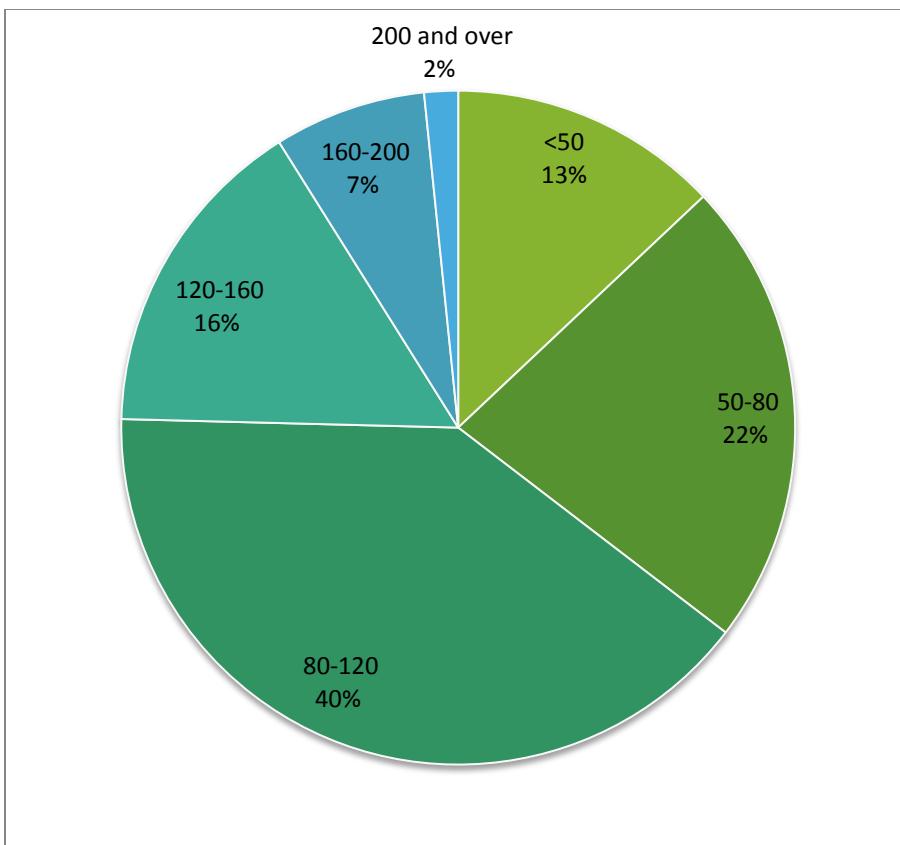
illness or disability?

Yes	65
No	334



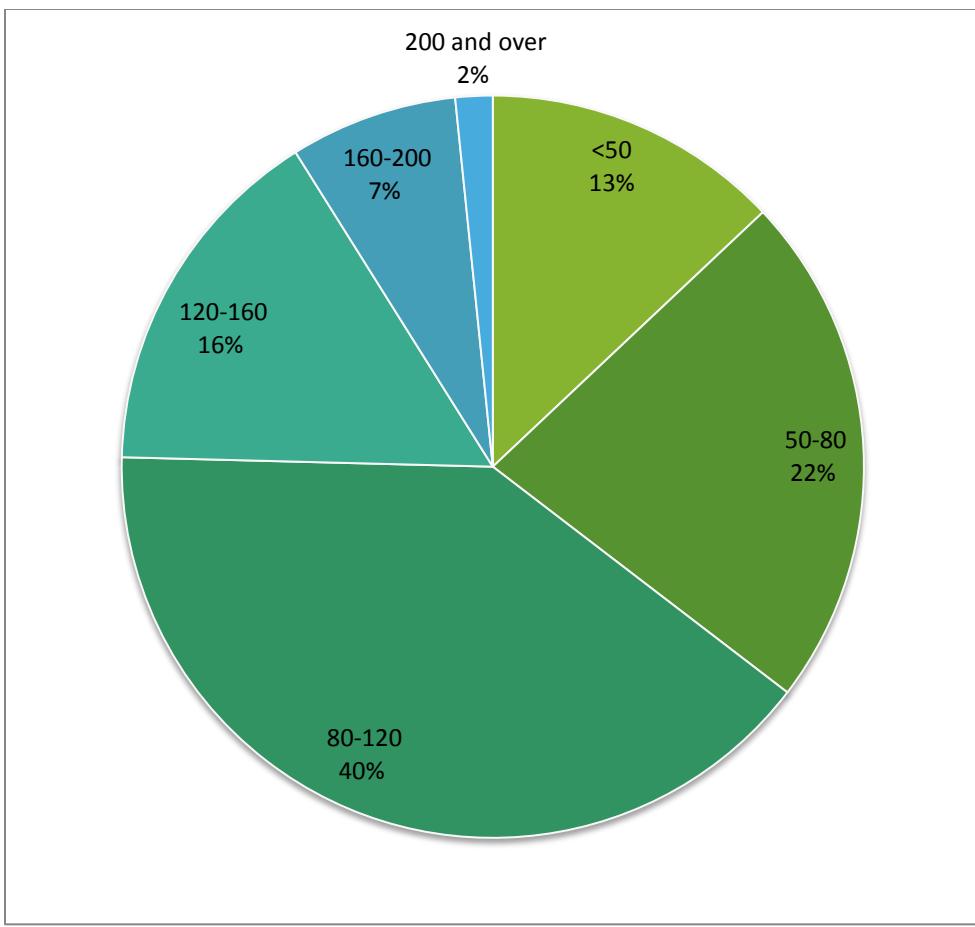
87. Your home size (square meters) (Note this question had been modified incorrectly by the utility company. The second choice was 50 with 10 selections. It was combined into the 50-80 range)

<50	48
50-80	83
80-120	148
120-160	58
160-200	27
200 and over	6



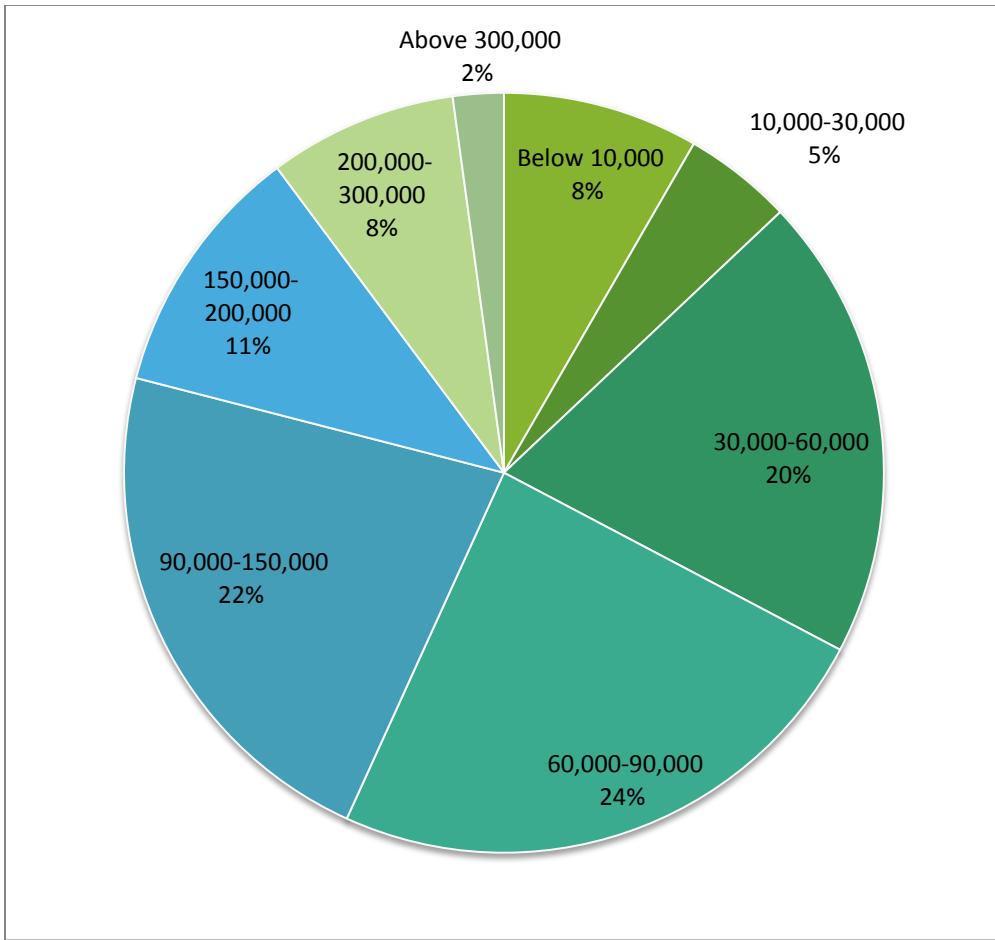
88. What is the highest education your family members have obtained who permanently live in your home? (Note this question had been modified by utility company, master degree and PhD are supposed to be together in one option: post-graduation degree)

No education	4
Elementary	2
Secondary	55
Bachelor degree	293
Master Degree	32
PhD	6



89. What is your family's annual income (after tax and can be spent)?

Below 10,000	27
10,000-30,000	15
30,000-60,000	64
60,000-90,000	78
90,000-150,000	72
150,000-200,000	35
200,000-300,000	26
Above 300,000	7



APPENDIX G: XUZHOU AND NANJING SURVEY RESULTS

	Xuzhou	Nanjing
1. Do your family use washing machine for laundry?		
Yes	126	99
No	16	7
2. Which of the following best represent your family's frequency for washing clothes?		
Biweekly	8	7
Once a week and a half	5	12
Once a week	30	19
Twice a week	29	28
At least twice a week	33	29
Other	1	1

Everyday - 7	3	2
Twice a day - 8	2	2
Everyday during summer - 9		1
3. How many hours do your family watch TV per week? (Please account the cumulative TV hour. For example, if the family has two TVs, each opens five hours per week, then in total the family TV watching hour is 10 hours.)		
1-2 hours	23	7
2-5 hours	23	34
5-10 hours	15	12
10-20 hours	17	16
20-30 hours	22	7
30-40 hours	17	17
40-60 hours	10	9

60 hours	4	3
Do not watch TV	14	2
4. How many hours do your family use computer per week? (Please account the cumulative computer hour. For example, if the family has two computers, each is used for 5 hours per week, then in total the family computer usage hour is 10 hours)		
1-2 hours	23	9
2-5 hours	19	21
5-10 hours	30	14
10-20 hours	26	20
20-30 hours	14	13
30-40 hours	7	17
40-60 hours	4	5
60 hours	5	6

Do not use computer	17	1
5. Do your family use air-conditioning?		
Yes	127	96
No	18	4
6. What is the type of your air-conditioning at home?		
Fixed frequency	36	24
Frequency alterable air-conditioner	69	45
Do not know	25	24
7. What is the type of air-conditioning at home?		
Central	12	31
Room	108	66
7. Number of room air-conditioning		

	1	11	6
	2	37	17
	3	24	12
	4	5	3
	5	1	
	6		
	7		
8. Does each room in your home have a separate thermostat?			
Yes			44
No			47
I do not know what thermostat is			3
9. What is the normal temperature setting of your air-conditioner during summer? ____ ° C	Mean: 25.55 degree C, Std.dev:2.15 degree C	Mean: 25.25 degree C, Std.dev: 1.923 degree C	

10. How do your family normally uses air-conditioner?		
Keep all air-conditioner on at home	8	5
Turn on air-conditioners in rooms that are occupied	109	86
Other	8	
11. Do you turn off air-conditioner when going out?		
Always	108	69
Sometimes	11	19
Occasionally	3	7
Never	3	7
12 When using air conditioning, your family: (Ventilation)		
Always shut doors and windows	111	73
Sometimes shut doors and windows	13	16

Occasionally shut doors and windows	3	5
Never shut doors and windows	2	6
13. Will you turn off AC or set a timer for AC before going to sleep		
Always	50	61
Sometimes	37	51
Occasionally	19	22
Never	19	23
14. What is the reason you turn air-conditioner off or set a timer when going to sleep (Check all that apply)		
Health	79	55
Energy Saving	38	44
Other		
15. Have you ever use less air conditioning to save on electricity?		

Always	35	43
Sometimes	51	42
Occasionally	30	12
Never	10	7
16. Did you ever raise air-conditioner set temperature to save on electricity?		
Always	70	41
Sometimes	36	35
Occasionally	16	12
Never	4	8
I do not know raising air-conditioner set temperature can reduce electricity use		7
17. Did you ever reduce air-conditioner use during peak period (high electricity price period)?		
Always	42	32

Sometimes	43	35
Occasionally	19	18
Never	25	21
18. How often do you change air-conditioner filter?		
Every half a year	54	44
Every month	29	21
Every half a month	7	15
I never changed air conditioner filter	38	24
19. Did the electricity company ever communicated with you regarding to air-conditioning and electricity saving?		
Always	48	26
Sometimes there	43	25
Occasionally there	36	30

Never	18	25
20. What is the heating system in your home?		
Electric Heating	15	20
Central Heating	49	17
Gas or water at home	57	9
Air-Conditioning/Heat Pump	15	47
Other	6	
No Heating		11
22. Do you have the habit of turning lights off when leaving the room?		
Always	117	69
Sometimes there	17	20
Occasionally there	7	9

Never	5	7
23. When purchasing new light blubs you will choose?		
Incandescent	12	24
Energy saving bulbs	129	77
Does not matter	3	8
24. Do your family use rice cooker?		
Always	89	70
Sometimes	39	15
Occasionally	4	7
Never	3	8
I do not have rice cooker	7	4
25. Do your family use oven?		

Always	6	10
Sometimes	32	15
Occasionally	17	11
Never	15	11
My family does not have an oven	75	55
26. Do your family have an electric stove?		
Yes	103	62
No	41	35
27. What is your family's water heater type:		
Solar water heaters	50	20
Electric water heater	51	52
Gas water heater	55	30

Heat Pump Water Heater	36	4
Other	3	1
Do not know	1	1
28. Do your family use electric fans?		
Always	63	63
Sometimes with	45	31
Occasionally use	19	14
Never use	17	
29. Generally do your family prefer to use air conditioner or fan?		
Electric fan	37	53
Air conditioning	78	35
Does not matter	26	16

30. When do your family members get up in the morning and go to bed in the evening?		
How many hours before 8am?		Mean: 1.5, Std Dev:0.81
How many hours after 9pm?		Mean:1.5, Std Dev:0.86
31.What are your family's natural ventilation habits? (Check all that apply)		
Open window all year around	113	61
Do not open window when air conditioner is turned on	54	34
Do not open window when heating is on	31	24
My family has a central HVAC system, therefore do not open window to ventilate	2	1
Other	1	
32. Is your home enrolled in time of use pricing?		
Yes	99	76
No	13	10

Not sure	31	20
36. Do you think the electricity price should be the same all year around?		
Yes, so it helps customers to remember	84	64
No, then what do you suggest?	14	13
37. Do you think it is easy to change electricity usage pattern for time of use pricing?		
Very easy	38	33
Relatively easy	41	22
Relatively difficult	20	9
Very difficult	7	15
I never thought about changing my electricity usage behavior for time of use pricing	5	8
38. Did your family ever adjust electricity usage behavior for time of use pricing?		
Always	30	26

Sometimes	51	28
Occasionally	14	15
Never	16	19
39. Why do you think the power companies promoted time of use pricing? (Check all that apply)		
Increase revenue	17	3
Reduce peak load demand	73	63
Ensure residential electricity use	43	22
Save residents electricity bill	49	25
Environmental Protection	33	12
Other. Please Specify: _____		
40. Why did your family enroll in Time of Use Pricing? (Check all that apply)		
Save electricity	91	64

Environmental Protection	33	25
Respond to the electricity company's call to reduce the peak	36	21
Other		
41. Did your family member ever discussed about electricity saving with other people? (neighbours, colleagues, other family members etc)		
Yes	66	48
No	42	41
42. Use your household tiered pricing?		
Yes	94	82
No	22	12
I do not know what is tiered pricing	25	8
43. Your family is:		

Monthly meter reading	37	33
Bi-monthly meter reading	63	40
Do not know	6	21
46. How do you view your electricity bill:		
Very high	22	8
A bit high	59	52
Neither high nor low	55	40
Relatively low	2	2
Very low	2	3
47. Do you think if you know the power consumption of each appliance, that information can help you save on electricity?		
Certainly Yes		45
Should help some		43

Should not help			11
Do not care			7
48. How to describe the effort your family made regarding to energy saving?			
Tried very hard	19		20
Made some efforts	95		60
Rarely done anything	20		16
Never	8		7
49. What do you think the main reason is people around made efforts to save on electricity?			
Save electricity	111		76
Protection of the environment	60		38
In response to the call of the power companies to reduce grid load	35		29

Other		
50. Did Electricity Company ever communicate the electricity saving potential of the following appliances or life-style? (Check all that apply)		
Refrigerator	73	33
Air conditioning	103	57
Illumination	64	26
Cook / electric cookers	32	11
Oven	24	5
Bath / heater	28	8
Heating devices	60	26
Dryer	15	8
Dishwasher	11	6
Do not know / the electricity company had never communicated anything	16	15

51. Did Electricity Company ever communicate the peak power saving potential of the following appliances or lifestyle? (Check all that apply)		
Refrigerator	50	28
Air conditioning	98	54
Illumination	47	22
Cook / electric cookers	21	13
Oven	23	3
Bath / heater	21	2
Heating devices	59	29
Dryer	35	3
Dishwasher	16	6
Do not know / the electricity company had never communicated anything	26	19
52. Have you ever received energy saving information from the electricity company?		

Yes	88	37
No	55	59
53. When you purchase new appliances, do you consider energy efficiency labeling (right)?		
Always	54	34
Sometimes	36	47
Occasionally	24	10
Never	30	10
55. What effort did your family make to change living habits or electricity usage habits for TOU? (Check all that apply)		
Bath time	66	29
Use of air conditioning	79	48
Make dinner time	3	10
Use washing machine	47	18

Dishwasher	8	2
Dryer	6	2
Related to the use of lighting	9	4
Use of computers	11	6
Charging time for the device	21	11
Never changed anything	26	7
56. Whether electricity company informed you about how save on electricity bill for time of use pricing?		
Yes	75	50
No	25	29
Told but cannot recall	14	8
Do not remember	19	10
57. Do you think the information provided by the power company useful?		

Very useful	51	25
Somewhat Useful	37	36
Not useful	5	9
I don't remember those information	6	6
58. Which statement reflected your home electricity usage?		
I think my household uses very little electricity.	18	17
I think my household uses relatively little electricity, but there is space for more energy saving	63	45
I think my household uses a lot of my power, I will appreciate any method to reduce my electricity bill	41	17
I think my household uses a lot of my power, but I won't do anything	4	9
I do not know the electricity usage level is high or low, but I don't want to make any changes	15	9
59. When you go to sleep or go out, do you unplug or turn off the power supply to saving electricity?		
Always	57	44

Sometimes	50	37
Occasionally	22	17
Never	16	7
60. From which sources you had received energy saving information?		
Newspaper	35	38
TV	48	32
Internet	31	25
Community broadcasting	28	19
Electricity company communication	73	20
61. What do you think are the top three electricity consumption appliances in your family?		
Fridge	65	42
Air conditioner	42	71

Heating	100	8
Dryer	12	4
Lighting	10	10
Dish washer	3	3
Stove	19	9
Computer	23	19
Oven	14	17
Cell phone	3	2
Shower/hot water	50	47
Tablet	7	1
62. Do you care about information on electricity bill saving?		
Very much	33	33

Somewhat	81	46
Not really	19	20
Not at all	9	7
63. How do you pay electricity bills? (Check all that apply)		
Electricity company operation location	79	33
Food markets	34	30
Alipay (it is like Paypal Chinese version)	20	18
Wechat	5	4
Power Service Hotline	3	4
Power Service website	7	7
Bank auto charge	28	28
Other. Please Specify: _____	1	1
—		

64. How do you check your electricity usage? (Check all that apply)		
Electricity company operation location	29	29
Food markets	12	12
Alipay (it is like Payall Chinese version)	7	11
Wechat	4	4
Power Service Hotline	19	19
Power Service website	3	8
I don't check our electricity usage	35	22
Other. Please Specify: _____	2	
—		
65. Would you read electricity usage information on your receipt on peak/off peak info? (if it is on the receipt)		
All the time	34	23
Sometimes	62	53

Rarely	27	20
Never	15	8
I don't care	3	2
66. Do you think information on the receipt to provide you with information on how to save on energy next month will be useful? (for example, information at the beginning of the summer to help you with energy saving on air-conditioning)		
Very useful	42	20
Somewhat useful	58	44
I don't think I can remember	20	26
Would not be useful	11	7
I don't care about bill saving on energy	8	3
67. If electricity company send you energy saving tips on your phone, will you read them?		
I will read them frequently	47	36

I will read them sometimes	52	31
I will read them occasionally	30	22
Never	5	6
I don't want to receive such messages	6	5
68. Are you responsible for paying electricity bills at home?		
Yes	87	59
No	49	25
70. Do you care about air-pollution?		
Very much	67	29
Somewhat	62	51
Rarely	10	19
Not at all	3	3

71. What aspects do you think are the major contributors to air pollution? (Check all that apply)		
Transportation	112	60
Residential electricity use	13	8
Industrial and commercial electricity use	77	30
Chemical industry	101	53
Other		
72. Do you care about global climate change?		
Very much	48	25
Somewhat	56	50
Rarely	33	20
Not at all (Please skip to question 73 to continue the questionnaire)	4	2
73. Do you believe in climate change?		

Yes	82	46
No (Please skip to question 73 to continue the questionnaire)	10	11
Neutral (Please skip to question 73 to continue the questionnaire)	42	34
74. What do you think of the cause of climate change?		
Geographical movements	35	25
Human cause	90	55
Other	3	2
75. Do you think using electricity at peak time or off-peak time has anything to do with fossil fuel electricity generation?		
Yes	56	32
No	70	53
Maybe	15	10

76. How much fossil fuel (coal/natural gas) do you think account for our electricity generation mix?		
0-30%	15	18
30-70%	98	58
70-100%	23	13
77. Are you familiar with concepts related to smart grid or smart meter?		
Very knowledge	13	11
Moderately knowledgeable	86	68
Have never heard of	46	18
78. Do you think it is citizen's responsibility to protect the environment?		
Very much agree	80	40
Somewhat agree	44	28
Neither agree or disagree	10	25

Somewhat disagree	8	2
Very much disagree	1	2
79. Gender		
Male	69	35
Female	72	23
80. Age		Mean: 43.8, Std. Dev: 11.5
81. Occupation		
Student	1	2
Full Time	109	28
Retired	13	5
No occupation	16	3
82. How many family members live in your home on a regular basis?		

	1	9	2
	2	22	6
	3	80	38
	4	14	16
	5	14	
	6		
	7		
83. What is your family composition for family members who permanently live in your house:			
Children before school	34-1 child	10-1 child	
Elementary or secondary school	39-1 child. 2-2 children	28-1 child	
College student	15-1 college student	13-1 college student, 1-2 college students, 1-3 college students	
Full time employee working outside	28-1 full time, 69-2 full time, 12-3 full time	13-1 full time, 30 - 2 full time, 6-3 full time, 5-1 full time	

Working from home	14-1 working from home, 8-2 working from home, 1-4 working from home	11-1 working from home, 4-2 working from home
Retired	24-1 retired, 20-2 retied	16-1 retired, 8-2 retired
84. Do you own or rent the house:		
Own	130	79
Rent	12	12
85. Have your family stayed in this house for more than two years?		
Yes	116	77
No	25	11
86. Is any of your family member has chronic illness or disability?		
Yes	3	11
No	137	77
87. Your home size (square meters)		

<50	8	
50-80	43	
80-120	50	
120-160	29	
160-200	5	
200 and over	5	
88. What is the highest education your family members have obtained who permanently live in your home?		
No education	2	1
Elementary		2
Secondary	15	29
Bachelor degree	144	54

Master Degree	7	3
PhD	3	
89. What is your family's annual income (after tax and can be spent)?		
Below 10,000	17	6
10,000-30,000	23	28
30,000-60,000	33	23
60,000-90,000	26	13
90,000-150,000	20	8
150,000-200,000	9	7
200,000-300,000	4	4
Above 300,000	3	