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Big Data Insights into the Distributional Effects of Thai Energy Policy 2006-2013

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Abstract

This paper looks at the distributional effects of recent Thai energy policies for consumers, evaluating their effectiveness and discussing the major beneficiaries.

Energy policies are found to have diverse and unexpected effects on different groups. These groups can be classified by income, by geographical locations, by education level or other variables. Data science and large data sets allow better analysis and better targeting of policies.

The paper utilizes and introduces tools useful for consumer energy policy. Multivariate regressions are used to forecast changes in energy demand. Engel curves are used to build a working frame for determining the level of subsidy for each type of energy. Big data and time series are used to track the real distributional effects of energy policies. Estimates of the share of different subsidies that reach the poor in Thailand are made, and suggestions to improve policies to improve targeting are proposed.

Free electricity does an excellent job of targeting the poor. Subsidies of LPG for cooking help large middle income families. Subsidies on transportation fuels barely reach the poor. Distribution across regions and age groups show strong patterns suggesting opportunities for political parties to benefit by selecting subsidies that benefit certain regions or demographics.

Keywords: Public Economics, Energy Policy, Income Distribution, Subsidies

1. Introduction

The years 2006-2013 saw increasing energy prices for almost all energy classes. During this era of high energy prices, the government of Thailand initiated a variety of programs to alleviate the adverse effects of these prices on the quality of life of those with low incomes. Energy policies controlling price were enacted across all sources of energy including electricity, benzene, Liquefied Petroleum Gas (LPG), and diesel. Electricity for households using less than 90 Kwh was given for free. The price of benzene was fixed for some period as the world price continued to rise. Diesel was fixed at a maximum retail price of 30 baht per liter, Gasohol (Benzene with 10% ethanol) was sold at fixed or reduced prices. LPG (propane) gas was sold at a fixed discounted price for all of this decade.

Alleviating poverty was only one facet of Thai energy policy during this very active period. Another primary objective was ensuring sufficient future energy supplies through subsidizing alternative energy, including high subsidies for electricity produced using solar energy, lower subsidies for energy from other alternative energy sources such as biomass, wind, biogas, etc., and an ultimately unsuccessful campaign to institute the use of nuclear power and increase the use of coal.

Additional energy policies were addressed at investing in energy sources in other countries, energy security, climate change, and to a lesser degree energy conservation. Finally some policies were designed to support industry, either directly related to energy, or with significant implications for energy use such as automobiles.

Although the focus of this paper is primarily on those policies designed to alleviate poverty, it could be instructive to look at the distributional effects of other energy policies as well. Supporting alternative energy has put significant upward pressure on electricity prices in Thailand, with distributional effects. Furthermore, the support that the government has given to the automobile industry also has had a strong effect on distribution of benefits and energy use. The effects of the controversial first-car policy in which taxes were not required on the first car a family bought will be discussed briefly below.

Large companies have excellent information about their customers but governments often know very little about their clients. Although government policies are designed for particular purposes, such as to help the poor, or to help a region or group, it is often difficult to determine the effects of such policies. Little information is available about individual poor families. Recent big data approaches allow for a better estimation of the effects of policies, and suggest improvements in policy designs in the future. The paper uses a mix of regression types, Engel curves, time series, maps and aggregate statistics to address these issues.

2. Literature Review

In recent years, there has been much discussion of the expense and misalignment of subsidy programs around the world. As the price of energy rose to a peak in 2008, and remained high thereafter, programs that subsidized energy became very expensive. The International Energy Agency (IEA) estimated the total cost of energy subsidies to national governments at about 500 Billion dollars a year, or approaching 1% of global GDP at the peak of this period (IEA et. al., 2010). In some countries, such as Indonesia, Bangladesh, and Pakistan, the subsidy bill was much higher in the range of 15% to 43% of government expenditure. (Clements, et al., 2013, p.68). This money, it was argued, could be better spent on other government programs. The program reason given for the expense of government subsidies was poor targeting. (World Bank, 2010) If the subsidies reached only the poorest persons, the cost of the programs would be low. Therefore the problem could be thought of as an inability to target, rather than subsidy programs themselves.

According to del Granado et al. (2012), fuel subsidies are a costly approach to protecting the poor due to substantial benefit leakage to higher income groups. The top income quintile receives six times more in subsidies than the bottom quintile. Furthermore, according to Dartanto (2013), fuel subsidies in Indonesia leads to a severe budget deficit and worsened income distribution. Almost 72% of fuel subsidies are enjoyed by the 30% of the richest income groups.

Rao (2010) suggests that subsidies targeted only to kerosene-dependent urban areas would have a higher efficacy than broad-based subsidies. In urban areas, subsidies are progressive, and provide benefits of up to 5 to 10% of household expenditure among poorer households which lack affordable access to LPG and biomass. On the other hand, kerosene subsidies are regressive and of minimal financial value to poor rural households because household quotas are based on cooking needs, but kerosene is used predominantly for lighting.

Several studies in Thailand found that universal price subsidies benefited the rich. (Lewis, 2013) Anand et al. (2013) also propose that developing a system to better target subsidies will be a major factor in reducing subsidies over the medium run. Therefore, in the energy sector reform process, instead of blanket energy subsidies, targeted subsidies were proposed. For example life-line tariffs for electricity, which allow consumers to receive a subsidized tariff rate or free electricity for consumption below a certain level. In the Philippines, the Electric Power Industry Reform act introduced a life-line tariff schedule at a subsidized rate for poor households in 2006. (Department for International Development, 2002) Indonesia has a similar plan. In Malaysia, targeted subsidies were in the form of giving smart cards to owners of fishing boats and public transport vehicles to buy a limited amount of certain fuels at a subsidized prices. (Clements, et al., 2013)

Nikomborirak et al. (2014) recommended targeted subsidies of LPG for the poor in Thailand, with eligibility for subsidies tied to those who receive free electricity. This idea was originally proposed by Prof Praipol Koomsup of Thammasat University. Unfortunately the connection which is conceptually strong, is difficult in practice because of the strong mismatch between those who receive free electricity (north, mountains, poor, small family) and those who use LPG (south, municipal, well off, large family). This is discussed further in section 10 of this paper.

3. Findings to Support Subsidy Programs in Thailand

3.1 A Small Subsidy can Make a Big Difference

Although energy subsidies have received a bad reputation over time, it is mostly because they are so poorly targeted. Many subsidy programs benefit the middle or upper classes with the majority of government funds going to these groups. If energy subsidies are well targeted, the share of a country's income that goes to pay for them can be extremely low. That is because with high income inequality as in Thailand, increasing the income of the poorest citizens by 10% would cost very little. The challenge is to target the energy subsidies sufficiently to those who need them to make subsidy programs economical and efficient enough to be practical. Thus small income transfers can increase the utility or happiness of the country by a very large margin.

3.2 Big Data Provides a Solution for Better Targeting

How therefore can energy subsidies be better targeted? Although governments have been trying to target subsidies for a long time, they have had only poor tools to work with. The advent of big data and increased computer power, allows the government to improve the targeting of subsidies much in the way that big business has been able to move towards individualized marketing. That is one of the primary purposes of this paper – to highlight the role that big data and improved econometrics makes possible.

3.3 Theory vs. Practice - Subsidies versus Cash Transfers

It is a well-established tenet of Economic Theory that it is always at least as good to provide a cash transfer as it is to change the price of a good. A cash transfer would allow individuals to select only goods they themselves preferred, while markets to adjust with welfare effects at least as high as with the subsidy. This is summarized in the Second Fundamental Welfare theorem (Arrow and Debreu, 1954) “under the assumptions that every production set Y_j is convex and every preference relation $\prec_i$ is convex and locally non-satiated any desired Pareto-efficient allocation can be supported as a price quasi-equilibrium with transfers.” (Mas-Colell et. al., 1995). Therefore

it is generally proposed that the poor should be identified and a cash transfer should be made to them in lieu of any subsidies of goods.

Evidence on the other side of this debates comes from three directions. The first is the requirement for perfect information. Strangely enough it is not easy to identify who is poor. Most income and salaries do not go through a formal accounting framework. Only about 20% of the people in Thailand file income tax, and only about 30% have any paper trail of their income at all (Interview, Thai Tax Official).

The second argument is about transactions costs. Although, in theory, it is possible to go to every house in the country every 5 years, and find out if they are poor, the costs to do so would be prohibitive, nor does the government have the capacity to take on such a project. Nor is there a centralized way to transfer funds, although the PromptPay program currently under review in the cabinet may alleviate this problem. Subsidies, if well designed, can be a cheaper and easier solution.

The final issue is that subsidies are not usually an economic decision, but a political one. A one time decision to pay cash to the poor does not work for political campaigns, and so when they have been used before in Iran and Latin America, it just leads to new subsidies being introduced on top of the cash transfers. (Salehi-Isfahani, 2014).

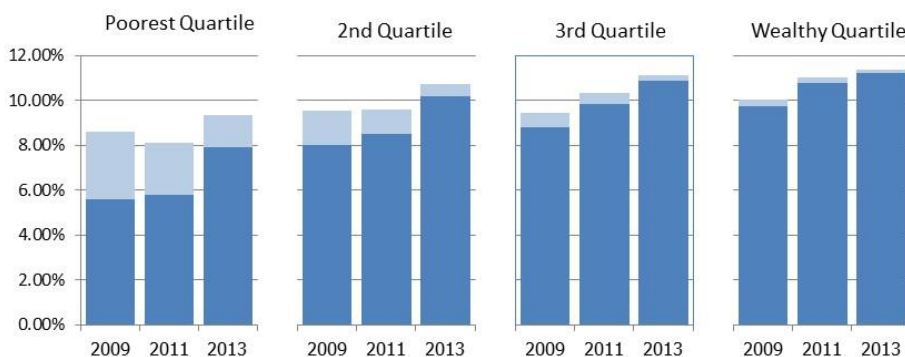
In fact, if Economists want to work with politicians, the author feels they should design short-run and high profile beneficial programs, that can be completed by one government, otherwise there a surfeit of overlapping programs with increased chance for corruption.

3.4 Rising Share of Expenditure Used on Energy

The final reason to support energy subsidies is an increasing burden and expenditure on energy. For all income groups and for all ages, the share of expenditure going to energy has been rising over time. In 2009, share of expenditure on energy ranged from 8-10% while four years later, share of expenditure ranged from 9 to 11.5%. This suggests that energy subsidies should be of increasingly concern to the government.

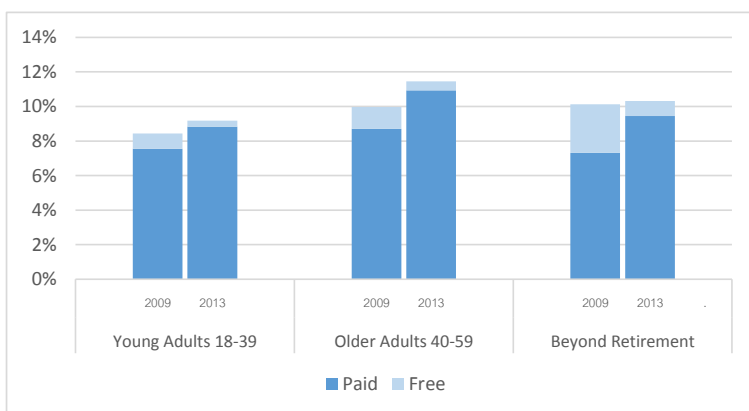
Figure 1 looks at energy use by quartile, with wealthier quartiles using a greater share of income on energy. Dark bars show cash expenditure, grey bars show energy received for free. For all income groups, the share of the budget used for energy has increased between 2009 and 2013. These tables suggest that the country is doing a worse job of aiding the poorest and oldest citizens as shown by the large increase in cash used on energy. For the poorest decile, cash spent on energy increased from 5.9% of expenditure to 8.5%. A large part of this expenditure comes from tighter rules about free electricity. A second cause is a reduction in free firewood.

Figure 1 Total Share of Expenditure Spent on Energy (Expenditure Quartiles)



Note: In the tables, the dark bar shows shares of cash income spent on energy while the grey shows free energy. Free energy consists of subsidies on energy or is energy collected as free firewood or home-produced charcoal. total expenditure has been rising for all groups while free energy has been rapidly falling suggesting stress on poorer households. Source: SES 2009, 2011, 2013

Figure 2 shows the relationship between age of household heads, and energy use. Adults in the age range 40-59 use the highest share of expenditure on energy. If the household head is past retirement, their energy use drops. Again, the country seems to be doing a worse job of caring for its old people as cash spent for energy has increased significantly for the beyond retirement group.

Figure 2 Total Share of Expenditure Spent on Energy (Age Groups)

Source: SES 2009, 2013

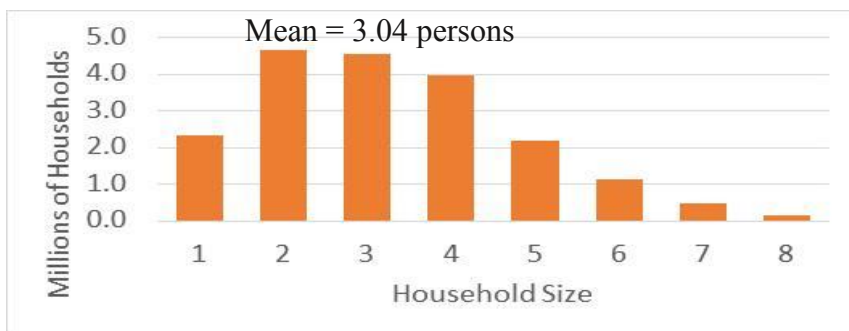
4. Methodology

We use household data, made up of the National Statistics Office Socio-Economic Survey data for 8 years, 2006-2013. In each year about 0.4% of all households are sampled. This a sample of 42,000-44,000 households per year throughout the kingdom. A representative sampling frame was used in data collection, and survey weights are used to adjust for frequency of sampling issues. Total number of observations over the 8 years is approximately 330,000 households. The questions in the survey consist of about 400-600 questions depending on the year.

To consider distributional issues, we use household income as a dependent variable. There were a number of candidate measures. Most important is whether to use household data or per capita data.

Household data was chosen because

- 1) The data is collected at the household level.
- 2) Many energy products make sense at the household level.
- 3) Family size has small standard deviation with 2/3 of families being 2, 3 or 4 persons.

Figure 3 Family Size in Thailand

Source: SES 2013

The Social Economic Survey includes both 1) goods and services that are bought and 2) goods and services that are collected, gathered, given or received for free. This is done to better account for quality of life in Thai households. If money income is a constraint it may be decided to use only purchased goods when doing some types of research. In this paper we use both purchased and “non-purchased items.

Combined cash and non-purchased expenditure were chosen because:

- 1) Free goods can enter regressions as a dummy variable
- 2) For inelastic goods such as energy, demand will be similar even if some of the good is not purchased.
- 3) Non-purchased goods make up only a small proportion of energy related goods, except electricity and firewood.

Altogether about 22% of “expenditure” was not purchased. Most of the non-purchased value is rent for owned housing. For the poorest households, non-purchased goods account for a higher 47% of the total.

The final issue is whether to use the series for Income or the series for Expenditure when determining how well-off a family is. The two series should be similar, Most studies use expenditure, or quoting the World Bank

“Consumption is conventionally viewed as the preferred welfare indicator; for practical reasons of reliability and because consumption is thought to better capture long-run welfare levels than current income.” World Bank (2000)

Income can be much more volatile as “Income in the previous month” depends on the time of year, e.g. for farmers. Others referenced in this regard are Deaton (1997), and Meyer and Sullivan (2003). In short, monthly expenditure was chosen since:

- 1) Expenditure is a more stable series. For instance, a farming family receive most of their income in a particular month.
- 2) Income was not collected for some of the years of the survey.
- 3) It is less likely that people will prevaricate about expenditure.
- 4) Unlike Income, expenditure cannot be negative.

4.1 Education, Region, Age

Income is not the only relevant measure of distribution. From a political point of view, the region in which benefits accumulate is important in that it may sway a political party to select policies which support its political constituents. In this paper geographical distribution is supported through the use of regressions at the regional level and of provincial level mapping for more detailed analysis of geographical distribution.

Educated households may use energy in ways that differ from less educated households, especially when it comes to alternative energy or conservation. This is the thesis of another forthcoming paper (Chankrajang and Lewis, 2016). Policies may benefit one education level more than another.

A household is made up of several individuals with differing educational background. Taking an average of these backgrounds is difficult since anyone under the age of 20 has likely not reached their final educational attainment. The head of the household is likely older and not the most educated person in the household. In this paper we used the highest educational attainment of anyone within the household as a measure of education.

Elderly households have different expenditure patterns from younger households, and may benefit from different subsidies. For anyone working with income distribution in Thailand, it is obvious that the poor in Thailand are often those beyond retirement age. There is very inadequate support for those above the retirement age at this time.

A household is made up of many individuals and an average of ages might give very different results if there is a newborn or an elderly person in the household. This paper uses the age of the household head as a measure of age. Generally the oldest working person will be considered the head of the household. Elderly person who are cared for by the family would not be considered “head of household”.

5. Data

The data used in this study are mostly from the Thai Social Economic Survey, conducted annually. Although the survey has been conducted every year since 2006, income variables are only collected in odd years (2007, 2009, 2011, 2013), and there have been some changes made to variables. In general the analysis below either uses all practically useful data or selects a few years to give a feel for the issue in question.

The following summary statistics for 2013 give an indication of critical values used in the study. Households are divided into quartiles (25%), and median values are supplied for each quartile.

Table 1: Median Expenditure Education and Age by Quartile

	HH Expenditure	All Energy	Share of	Median Highest	Age of
	Baht/Month	Baht/Month	Expenditure	Education	HH Head
Wealthy	33069	3800	11.5%	9.6 (2-yr college)	51
Quartile 3	17687	1700	9.6%	7.3(upper second)	50
Quartile 2	11414	1095	9.6%	5.8 (lower second)	52
Poor	6783	593	8.7%	4.3 (primary)	58

Note: In 2013 the exchange rate was approximately 30 THB: 1 USD

The median household in the wealthy quartile had monthly expenditure of 33,000 baht or about 1,100 USD a month which is 13,000 USD a year. The second quartile spent just over half of that at 17,687 or about 600 USD. The poorest households used a median of 6,783 baht or about 220 USD a month. Since households had an average of 3 persons, per capita numbers were approximately 1/3 of this.

Households spent 8.7-11.5% of their income on energy, with poorer households on the lower end. Education level reflects the person in the household with the highest education level. The wealthiest household had a median educational level of almost 2 years of college or vocational school, while the poorest had completed only primary school. The age of the household head was nearer 50 reflecting the tendency for several generations of Thais to live together. The exception is the poorest quartile where the age of the household head was significantly older at age 58.

Table 2: Median Expenditure and Share of Households Using Electricity and LPG by Quartile

	Electricity			LPG		
	Baht/Month	KwH	Share Using	Baht/Month	Kilograms	Share Using
Wealthy	820	241	99.9	107	5.2	83.7
Quartile 3	450	149	99.7	95	4.6	71.8
Quartile 2	320	108	99.2	64	3.1	58.6
Poor	220	80	97.8	29	1.4	42.8

Electricity: The most interesting takeaway is that usage does not change very much for the bottom $\frac{3}{4}$ of the population. The median usage for most of the population of 80-149 KwH a month is not nearly enough to run an air conditioner, but should be enough for a refrigerator, TV, lights and some small accessories like cooking pots and fans.

LPG: Less than half of poorer households use LPG, and for those who do, the monthly expenditure on LPG is low. Usage refers to those who reported they use LPG as the main source for cooking, but it may be that little cooking occurs in the house besides cooking rice in the universal electric cooker.

For those who use LPG as the primary cooking fuel as indicated in the survey the purchase of a 15 kg LPG tank generally does not occur every month, resulting in a 300 baht cost at 2-3 month intervals. It is unlikely that this average 100 baht per month is a significant expense, especially as poorer families are more likely to cook with collected firewood or their own charcoal. It is not obvious that LPG needs to be subsidized. Furthermore, most of the subsidy will go to wealthier families, as shown in later sections.

Table 3: Median Expenditure and Share of Households Using Gasohol 91 and Diesel by Quartile

	Gasohol 91				Diesel	
	Baht/Month	Liters	Share Using		Liters	Share Using
Wealthy	1000	27	42.2	2000	66.6	49.6
Quartile 3	700	19	42.2	1500	49.3	29.4
Quartile 2	500	14	38.5	1000	33.0	14.7
Poor	400	11	27.6	600	19.7	3.1

Table 4: Median Expenditure and Share of Households Using Benzene 91 and Benzene 95 by Quartile

	Benzene 91				Benzene 95	
	Baht/Month	Liters	Share Using		Liters	Share Using
Wealthy	800	18	21.8	1000	21.2	8.4
Quartile 3	650	14	23.8	600	13.3	6.4
Quartile 2	500	11	25.7	500	11.0	6.6
Poor	400	9	20.4	400	8.5	4.4

As a support for alternative energy, the Thai government has subsidized the use of gasohol (gasoline with 10% ethanol) with a variety of subsidies and promotions including a price reduction for gasohol 91 relative to its substitute, benzene 91. However, in 2013 the government tired of its attempts to persuade citizens to use gasohol through lower prices, and forbid the sale of the alternative, benzene 91. Before 2013, pricing policies resulted in low uptake as there were concerns that gasohol would hurt motorcycle engines. The government resolved the issue in 2013 by stopping the sale of

benzene 91 in Thailand, meaning that most motorcycle drivers were not given a choice and switched by necessity to gasohol 91. As 81% of households outside of Bangkok own a motorcycle (SES 2013) the use of gasohol jumped in the beginning of 2013.

By looking at households who own a motorcycle but no other vehicles, it can be observed that about 6% of motorcycle drivers decided to switch to benzene 95 rather than switching to gasohol 91, presumably due to concerns about their engines. The percent of motorcycle drivers using benzene 95 prior to 2013 was about 2%. That figure jumped to about 8% after the switch to gasohol.

In data for 2013 there are still about 20% of people reporting that they were still using benzene 91, even though it was no longer for sale. Since benzene 91 was not available (except for January surveys which record data from December.) it is assumed that these people were mistaken. Inattentive users probably would not notice the switch between benzene 91 and gasohol 91 as they are essentially the same fuel used in the same way. One explanation is that some motorcycle drivers buy benzene/gasohol from brown beer bottles or other repackaging by the side of the road.

Diesel is used primarily as a fuel for pickup trucks and farm trucks. In rural areas, pickup trucks outnumber cars with a ratio of 2:1. Although diesel was slightly subsidized (the price was capped at 30 baht/liter), many rural users were not even aware of the subsidy program, so it is not clear why the subsidy program was needed. It appears that the subsidy was aimed at the transport sector rather than at farmers. (Chuangwilai, 2014)

6. Regression Results

Tables 5-7 show a series of regression results using expenditure on each of the primary energy types as the dependent variable. The mostly demographic independent variables for each the regressions are as follows:

- *hhexpend* household expenditure in 1000 baht per month
- *familysize* number of persons living in household
- *edumax* highest level of education attainment in household where 2=kindergarten, 4=primary, 5=some lower secondary, 6=lower secondary, 7=some upper secondary, 8=upper secondary, 10=2-year college or vocational, 12=bachelors, 14=masters, with odd numbers showing partial degrees.
- *agehhh* age of household head
- *bangkok* dummy variable = 1 if live in Bangkok
- *dfarmer* dummy variable = 1 if a farmer

$$y = \beta_0 + \beta_1 hhexpend + \beta_2 familysize + \beta_3 edumax + \beta_4 agehhh + \beta_5 bangkok + \beta_6 dfarmer + \epsilon_i$$

Data is for households who spent at least one baht on that energy type, or in the case of LPG, those who indicated that they used LPG for cooking.

Table 5: Regressions Results: Electricity, LPG, and Benzene91 in 2013

	electric b/t	LPG b/t	benzene91 b/t
hhexpend	17.846*** (24.02)	0.585*** (7.10)	12.904*** (7.55)
familysize	30.958*** (11.70)	17.124*** (19.77)	36.771*** (4.84)
edumax	27.254*** (15.42)	-0.386 (-0.88)	41.960*** (8.55)
agehhh	4.420*** (19.08)	0.659*** (7.84)	-0.999 (-1.39)
bangkok	370.039*** (19.94)	-32.702*** (-8.96)	168.989 (1.83)
dfarmer	-77.913*** (-12.67)	14.539*** (4.49)	4.513 (0.26)
_cons	-286.873*** (-17.11)	6.661 (1.14)	198.798*** (3.83)
r2	0.457	0.051	0.168
N	37662.000	28377.000	9047.000

Note: Survey weights were used in all regressions in this paper. All coefficients in this table are in Baht per month for a unit change in a variable. The numbers inside the parentheses are t-statistics. The stars ***, **, and * refer to statistically significant at the 1%, 5% and 10% level respectively.

Electricity: For those who spend money on electricity, expenditure increases by about 178 baht for each 10,000 increase in expenditure. Each additional family member adds 31 baht, which is not very much. Ten years in age increases electricity use by 44 baht, while farmers use less electricity than other professions.

LPG: Increasing household expenditure has almost no effect on the amount of LPG bought, while family size is more important relative to other variables. Bangkok residents seem to use less LPG while farmers use more.

Table 6: Regressions Results: Benzene95, Gasohol, and Diesel in 2013

	benzene95	gasohol	diesel
	b/t	b/t	b/t
hhexpend	22.880*** (4.78)	36.922*** (17.53)	31.343*** (6.32)
familysize	25.231 (1.22)	-11.592 (-1.43)	25.851 (1.80)
edumax	61.636*** (4.02)	73.740*** (14.72)	57.540*** (4.08)
agehhh	4.236 (1.20)	4.387*** (5.71)	-0.528 (-0.35)
bangkok	973.021*** (4.03)	614.601*** (8.38)	275.881* (2.20)
dfarmer	84.151* (2.17)	-4.094 (-0.22)	172.838* (2.54)
_cons	-348.200 (-1.40)	-427.406*** (-8.07)	549.348*** (4.33)
r2	0.294	0.387	0.171
N	2717.000	23725.000	10651.000

Transport Fuel: Transport fuel use of all types seems to be closely linked to education, with higher education linked to increased travel. Subsidizing transport fuels is almost certain to increase benefits to those with education.

Larger families are positively related to benzene 91, but are not statistically related to benzene 95 or gasohol. Larger families own more motorcycles, and subsidizing benzene 91 will likely help those with large families.

Age is not closely linked to fuel use except to gasohol for which there is a positive relationship.

Farmers clearly use more diesel and are more likely to own a pickup truck, though as stated above they are not aware of the program to support diesel pieces.

Table 7: Regressions Results: Paid_Energy, All_Energy in 2013

	paid_energy	all_energy
	b/t	b/t
hhexpend	81.993*** (25.31)	84.462*** (25.62)
familysize	133.688*** (15.28)	135.931*** (15.37)
edumax	132.031*** (17.55)	123.764*** (16.20)
agehhh	8.639*** (12.67)	8.787*** (12.92)
bangkok	-143.671* (-2.50)	-91.517 (-1.56)
dfarmer	210.654*** (7.63)	240.452*** (8.80)
_cons	-1329.549*** (-25.27)	-1283.066*** (-24.56)
r2	0.561	0.567
N	41756.000	41756.000

The final pair of equations looks at expenditure for all types of energy combined. Paid_energy is energy that has been bought with cash, while all_energy refers to all energy used whether paid for, received from the government or others, or collected by the household.

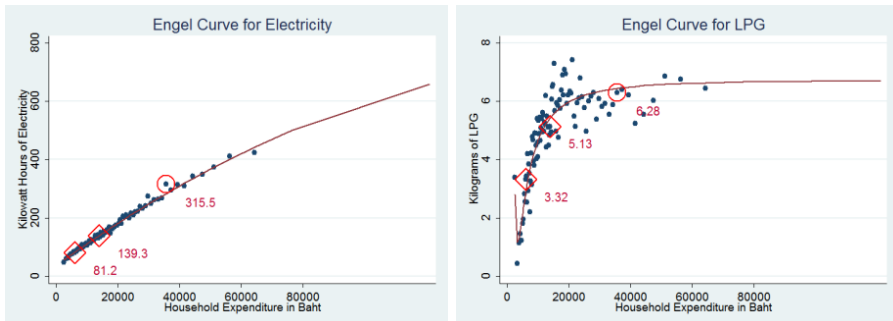
Signs are generally as expected and significant. For each additional 1000 baht of household expenditure, households spend an average 82 baht more on energy. Larger families do use a little more energy (132 baht per family member), but most energy is at the household level (median 1,310 baht/family). Persons who live in Bangkok, use less energy than up country. This is probably a result of less need for transport fuel in the city, as they use more electricity. Farmers use more energy for transport, and less for electricity, resulting in a somewhat higher energy demand overall. The figures for all_energy are not much different from paid_energy, but would likely differ were the regressions repeated for just the poorest quartile.

7. Engel Curves

Energy and Income – Towards Optimal Subsidy Levels

Engel curves are used to study the effect of changes in income on the purchase of goods. In the charts and regressions displayed below, household expenditure continues to be used as a proxy for income. Each dot represents 1% of the population. The horizontal axis is in baht/monthly expenditure. The vertical axis is measured in quantity of energy used by each centile. Expenditure data on energy have been converted to quantities by using data from Energy Policy and Planning Office (2016) and Metropolitan Electricity Authority (2016). Details available on request.

The graphical Engel curves were created by dividing the sample households into income centiles and calculating energy use for each centile. The slope of the Engel curve describes whether the good is a luxury (> 1), necessity ($0 < \text{elasticity} < 1$) or inferior good (< 0). Each dot represents a separate income centile, while the circle at the top represents the 90th centile and the two diamonds represent 10% and 50% expenditure deciles respectively. Data was included only for those households who used that energy source, excluding zero values.

Figure 4 Engel Curves for Electricity and LPG

Note: Open diamonds $\diamond$ demarcate the 10% and 50% income level, while an open circle $\circ$ demarcates the 90% income level. one approach to subsidies is to help those below the 10% income level to use energy at a target level between the open diamonds. for instance, in the electricity engel curve above, we would try to ensure that even the poorest households could use between 81.2 to 139.3 KWh of electricity.

Source: SES 2013

The Engel curve for electricity suggests that electricity is near unit elasticity. Higher income leads to higher electricity usage at approximately a constant rate. Data from the Data Science for Developing Countries website (<http://www.bigdata.econ.chula.ac.th>) suggest an elasticity closer to .8, so that if income (GDP) increases by 5%, residential electricity use would increase by 4%.

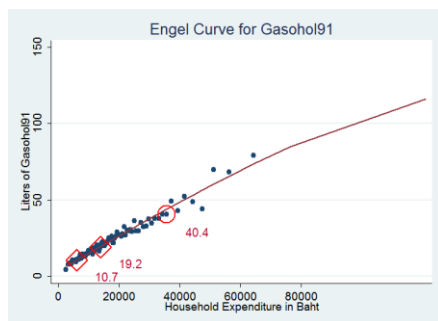
One practical approach to setting subsidies is to set a goal that the poorest 10% of households should ideally be able to consume at similar levels to others in the 10%-50% income level of society. In our Engel curves, we can use the range between the diamonds as the target level and the dots lower than the lower diamond (lower than 10% expenditure level) as the targeted group. The implication for electricity is that we would like everyone in the country to be able to use between 81.2 and 131.1 kilowatts of electricity in each month. In fact current policy is accomplishing that admirably due to the subsidy program in place. The lowest dot on the Engel curve (median

for lowest 1% in terms of expenditure) for electricity is still about 67 Kwh. However, the implication is that 81.2 Kwh would be a good cutoff point for free electricity.

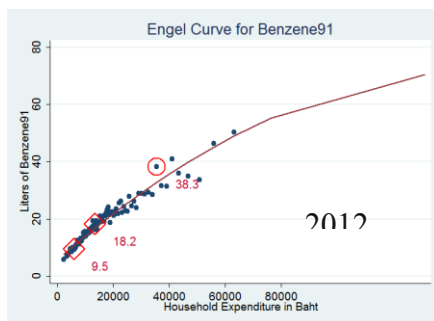
The Engel curve for LPG suggests that poor households use much less LPG. Ideally we would like to allow all households to be able to use between 3.32 and 5.13 kilograms of LPG a month, and the poorest households do not achieve this. Once income reaches about 20,000 baht a month, usage is constant in income. More income does not involve more cooking. A greater number of family members does result in high LPG use.

The policy implication is that there is a need to encourage LPG use to improve quality of life and health. Supplying free stoves may be better than energy subsidies. In Indonesia free stoves and small tanks were given away free to the poor since a switch resulted in a reduction in lung disease from smoke particles. In the Indonesian scheme, subsidized LPG was packaged in 3 KG tanks instead of the usual 12 KG tanks. Therefore, mainly the poor were willing to go through the trouble to replace their tank every ten days or so. This is a kind of self-selecting subsidy. The original stove and tank full of gas were given to the poor directly to promote switching and to avoid rather expensive startup costs. (International Institute for Sustainable Development 2011. p. 10)

Figure 5 Engel Curves for Gasohol 91 and Benzene 91



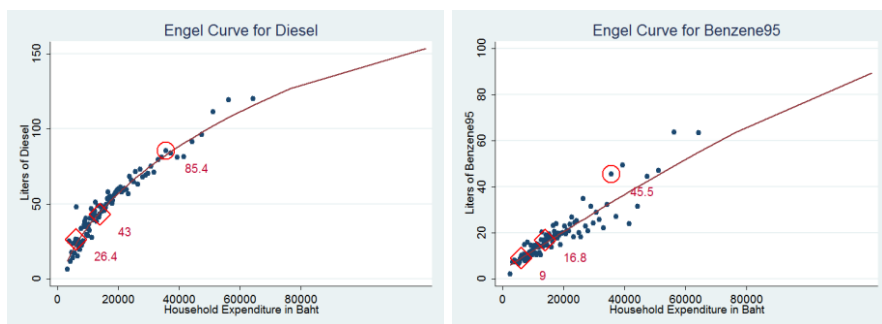
Source: SES 2013



Source: SES 2012

Engel curves are included for both gasohol 91 in 2013 and for benzene 91 a year earlier in 2012. The purpose was to study whether switching to gasohol changed peoples' fuel buying behavior. In 2013, to force a switch to gasohol, the government stopped sales of benzene 91. The two charts are nearly identical. Their similar shape suggest that the transition went smoothly.

Figure 6 Engel Curves for Benzene 95 and Diesel



Source: SES 2013

Diesel and benzene 95 are more specialized fuels used by a small share of households. It should be reemphasized that these Engel curves are only for those households who use the fuel. Households that do not use any are not averaged in. So the Engel curve for diesel looks at only households who buy diesel.

Poorer households buy less diesel. Diesel, however, shows an inelastic income elasticity. As income increases perhaps the household already uses enough diesel. This is probably because often diesel is used for more for work, so when the work is done, no more is bought.

Benzene 95 shows a steady elasticity of income as income increases. Wealthier persons drive more. Benzene 95 is used in nice cars and wealthier people go on vacations and generally travel much more. There does not appear to be an upper limit on this fuel.

What Should we Subsidize

LPG and electricity are important in terms of quality of life – even the poor should be able to eat refrigerated food, watch television, have lights at night, and not destroy their lungs by breathing air that is polluted with smoke particles.

Benzene 91, (now Gasohol 91) may be necessary for production as well as consumption. Workers need to go to their place of work, school children may need a ride to school, markets may be located far from households.

In Thailand, and especially for the poor, this means using a motorcycle. Outside of Bangkok, more than 80% of households have a motorcycle. A motorcycle may be needed for each working person.

Using 10% and 50% expenditure levels as a target, then target levels of subsidies should ensure LPG use between 3 and 5 kilograms per household per month, electricity of more than 80 Kwh a month and the use of between 10 and 20 liters of benzene 91 or gasohol 91 per month.

8. Regional Analysis of Energy Policy

Liquefied Natural Gas (LPG)

Although the subsidies for LPG have recently been abolished, Thailand has had a long history of subsidizing LPG, and it is worth considering if they are needed.

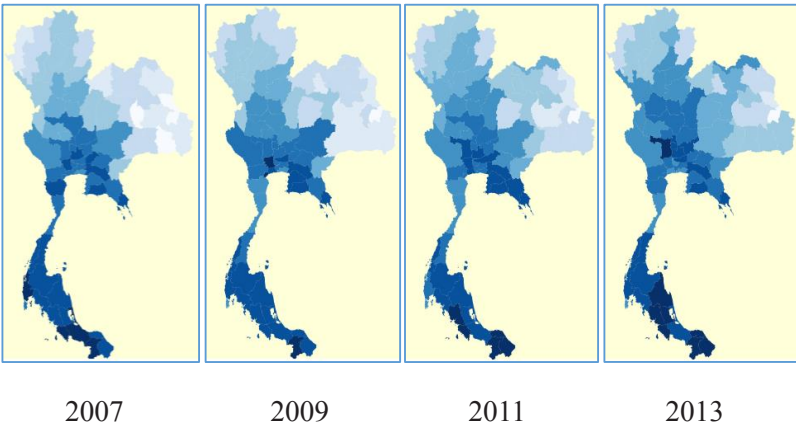
It was Thai policy since the 1990s to keep the price of LPG cheap. Thailand was an exporter of LPG gas, and the idea was that LPG gas was a national resource and belonged to the Thai people and should be used by all Thais, not sold to foreigners at a profit. Unfortunately, because of low prices, it was not long before LPG in Thailand was less than demand, and imports of LPG became a sizeable expense.

Gas is used both for production and for consumption, and often affects the poor. Street merchants use it for cooking and domestic households use it for cooking. Gas also has industrial uses – and from the beginning it was

attempted to keep gas for industry at a higher price. As energy prices rose, gas was also used for transportation. Later governments tried to raise the price for gas for transport be higher than for residential use, with some protection for the somewhat poorer taxi drivers. A succession of governments attempted to close down the subsidy completely, but it was only after the price of LPG declined on its own after the time frame of this paper, that they were able to do so without the wraith of the voters.

Any policy subsidizing LPG will have strong regional biases as natural gas comes from the south, entering either from the gulf of Thailand or from Burma. LPG is not cheaper in the South than other regions but there may be issues of availability as the gas does not need to be transferred far.

Figure 7 Share of Households Using LPG for Cooking by Province by Year



Note: The darkest colors on these maps in the deep south represent more than 90% of households are using gas for cooking while in the north and northeast regions the share might be as low as 20% of households.

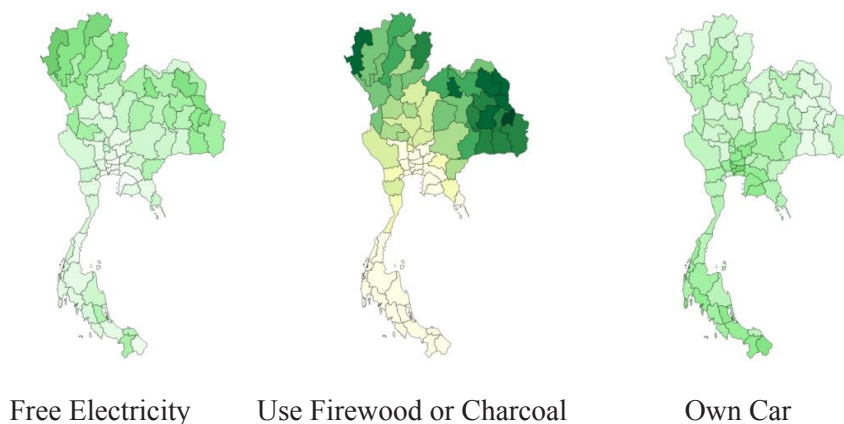
Source: SES various years

Over time, the use of LPG has been spreading from the South northwards towards the North and the Northeast regions as this series of maps shows us.

In both 2011 and 2013, the highest use of LPG was in Naratiwat province at 98% and 97% of sampled households using gas for cooking, while the lowest usage was in Amnart Chareon province for both years with only 15% and 17% of houses using gas for cooking.

The implications for policy are that Parties that wish to win votes in the South and the Central region could promote policies that reduce the price of LPG.

Figure 8 Regional Analysis (continued)



Source: SES: 2013

Several other maps can help us with regional interpretations. In part 6 regressions we found that free electricity most benefits those with smaller households. In addition, there is a strong regional component to free electricity, with those living in cooler mountainous regions receiving free electricity more often. This may not reflect a difference in lifestyle so much as energy needs, since it requires more electricity to keep a refrigerator cool in a hot climate than in a cool climate. Hotter households may also use fans more. The policy implication is that perhaps free electricity cutoffs should vary by province.

Firewood also is available in mountainous forested areas. By far, the northern and northeastern regions rely the most on firewood and charcoal. Almost all of the firewood was collected for free, and 2/3 of the charcoal was free, presumably with the household producing it themselves.

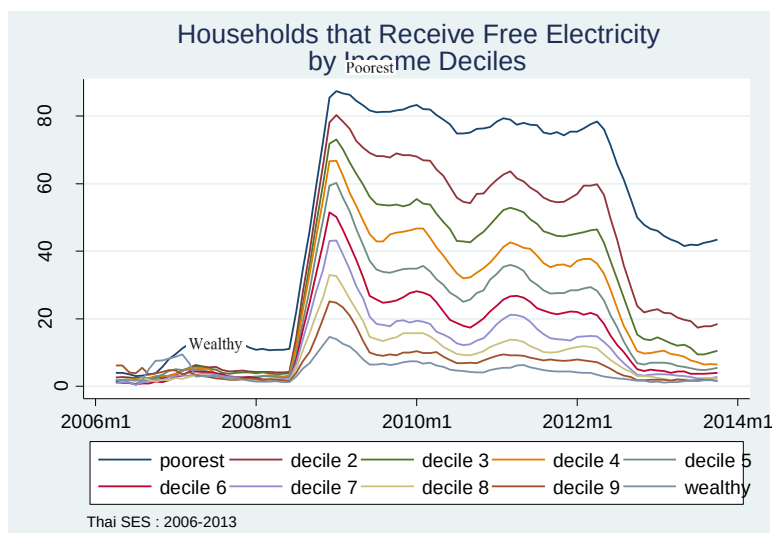
Although less visible in the final map, automobiles are much more common in Bangkok and the surrounding area, while motorcycles and pickup trucks are more common farther away from Bangkok. Policy implications are that programs that benefit car owners, such as support for benzene 95, or the first car policy benefit the Bangkok area and perhaps the south, while programs that promote diesel and benzene 91 benefit those outside of the Bangkok area.

9. Time Series Representations

Thai socio-economic survey data is collected year round with the survey month coded into the data. Therefore a rough time series of results can be generated by taking an average over each of the months of the data. Households can further be divided by the income decile to which they belonged resulting in 10 parallel time series of expenditure data. To give a more consistent time series, averages were smoothed using a 6 month smoothing framework. The final result is a powerful policy analysis tool to analysis the effects of economic policy over time.

9.1 Free 90 Kwh electricity program (2008-present)

The Free electricity program (lifeline levels) was initiated in 2008. The purpose was to help households that used exceptionally low levels of electricity under the assumption that they were the poorest. Compared to other aid programs this one was surprisingly effective. Using 330,000 households from 8 years of the SES expenditure survey, we can see the pattern of benefits from the program.

Figure 9 Timeline of Share of Households Using Free Electricity

Source: SES 2006-2013 Note: In this chart, each income decile has its own line showing the share of that decile that benefits from the program. The horizontal axis is time in months. In 2006, the program didn't exist, so no one benefited. In mid 2008 the policy was introduced, with free electricity for those who used below 90 Kwh. In 2013, the cutoff was reduced to 50 Kwh.

A small trial program was floated in 2007, and the full program began in the middle of 2008. This graph shows what share of each decile received free electricity, with the line on the top being the poorest decile. Eighty percent of the poorest group took advantage of the program. About 60% of the second poorest group took advantage of the program., 50% of the 3rd poorest group, etc. The problem comes when we get down to the 6th poorest group, or households that are slightly wealthier than the average. In this group, about 20% of households took advantage of the program.

Programs that target the poor must strike a careful balance between helping those they wish to help and helping those who do not need help. This could be thought of as a false positive and true positive problem. We want the true positives, but not the false positives. Aid programs always attract free riders who don't need subsidies.

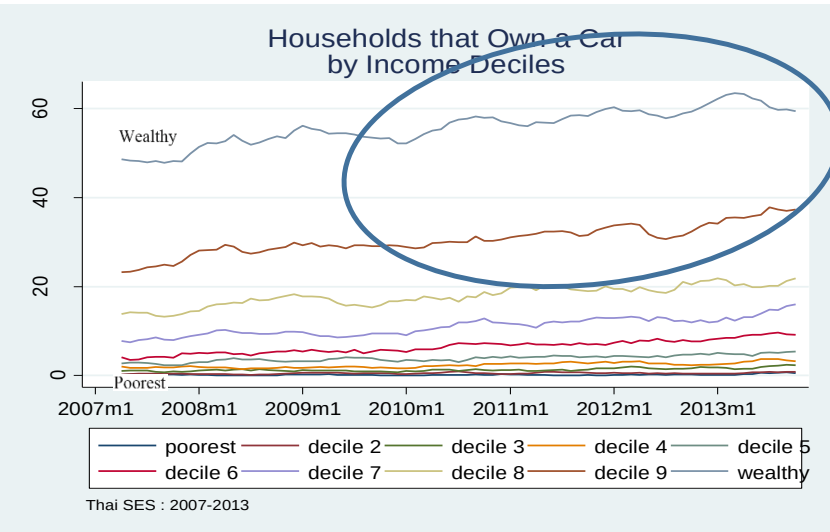
The government was upset about these “false positives” and in 2013, the lifeline program was cut so that only households using less than 50 KWh of electricity received it free. Immediately this eliminated the false positives in decile 6. However, the uptake rate of the poorest group (decile 1) dropped dramatically from 80% to 50%. In other words, to get rid of the false positives we had to get rid of the true positives as well. Was this a good decision? I would argue No – that this program has better targeted poor people than any other energy program, and it should have been left as it was, or possible could use a higher cutoff KWh of about 80 KWh as suggested by the Engel curves in section 7 above.

9.2 First Car Program

In 2011 Bangkok experienced severe flooding and many of foreign automobile factories were damaged due to what they attributed to negligence on the part of the Thai government. The argument was that the government protected Bangkok to the detriment of provinces north of Bangkok where many car producers were located. These foreign car producers threatened to move to Indonesia which has a much bigger population.

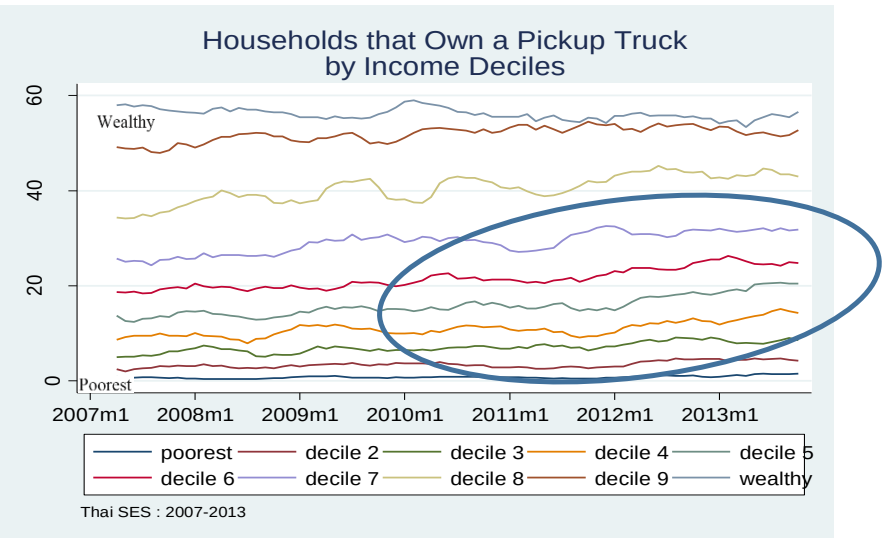
The First Car Policy, which eliminates a 25% tax on new cars, had recently been initiated and was enlisted to help keep these car companies from leaving Thailand. In the popular media the program was portrayed as a way to help struggling new families obtain their first car. However there were always suspicions that benefits went to wealthy families who already had vehicles. Looking at the accompanying time series data helps us investigate the truth of these allegations.

Figure 10 Timeline of Share of Households by Decile that Own a Car



Time series results show that most of the benefit of the First car policy indeed went to the top two deciles in terms of income as the slope of car ownership increased for these deciles after the policy took place.

Figure 11 Timeline of Share of Households by Decile that Own a Pickup Truck



Note: In figures 10 and 11 the wealthiest line is the highest one. The lines show the share of households in each decile that own a car or pickup truck. In 2011 when the first car policy was started, we can see an upward change in the slope of some of these lines, reflecting increased ownership of cars and pickup trucks. Policy implications are that the first car policy was more useful to the kingdom in promoting pickup trucks than it was in promoting passenger cars, as it likely enabled poorer families to own what is usually a productive vehicle.

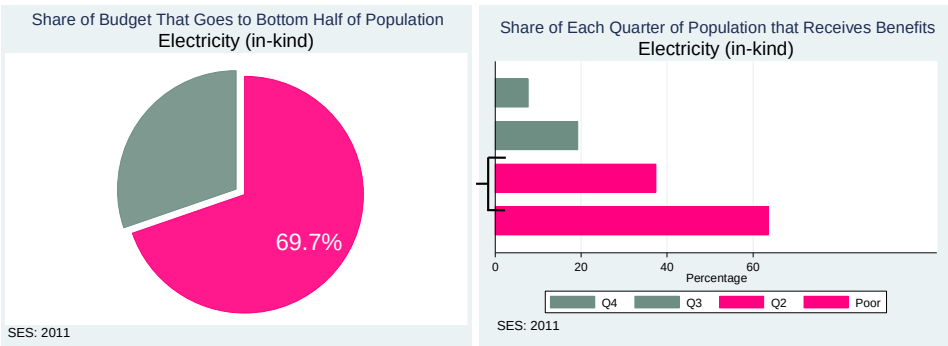
However, when we look at Pickup trucks, the first car policy seemed to be much more beneficial to lower deciles, without really affecting the wealthiest groups. Perhaps we should have had a FIRST PICKUP TRUCK policy?

10. Budget Share of Thai Energy Policies

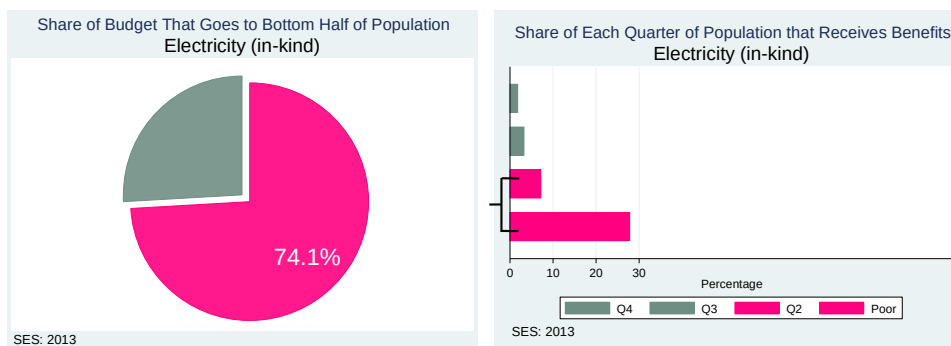
The following pie and bar charts track the beneficiaries of Thai energy policy. The goal is to see what share of the final benefits accrue to each income quartile. The analysis relies on SES survey data and does not include the administrative costs of the program, but rather tracks the benefits to the final recipients.

Figure 12 Electricity (in-kind) Budget Share and Use Share per Quartile, by Year

2011



2013

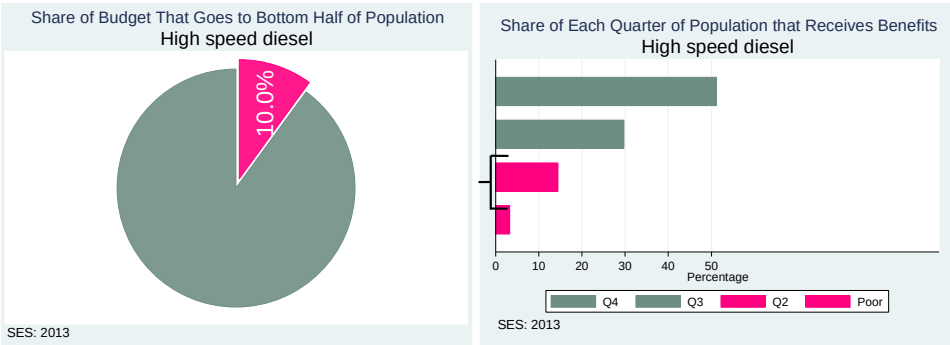


Note: In the pie charts above, Thai households are divided into two halves, the wealthier half and the poorer half. The percentage shows the percent of total program benefits (money spent) going to the poorer half. For instance, in 2011, 69.7% of the benefits of the free electricity program went to the bottom half of households in terms of expenditure. The bar charts show the percentage of each quartile who received any benefit at all from the program with the poorest quartile (25%) on the bottom. The bottom two quartiles make up the lower half of the population in terms of expenditure and are combined together in the budget share pie chart on the left.

As discussed above, starting in 2008, if a household used less than 90 Kwh of electricity, they would not have to pay for it, except a nominal 40 baht usage fee. In 2013, the free electricity program was changed so that only electricity usage under 50 Kwh would be given away free. This change meant that the government budget for the program was better targeted – i.e. 74.1 percent of the budget went to people in the poorest half of the population. But it also meant that it no longer reached many of its intended recipients. From the bar charts, we can see that uptake for the poorest quartile of the population was 65% at 90 Kwh and only 28% at 50 Kwh.

Figure 13 Diesel Budget Share and Use Share per Quartile, by Year

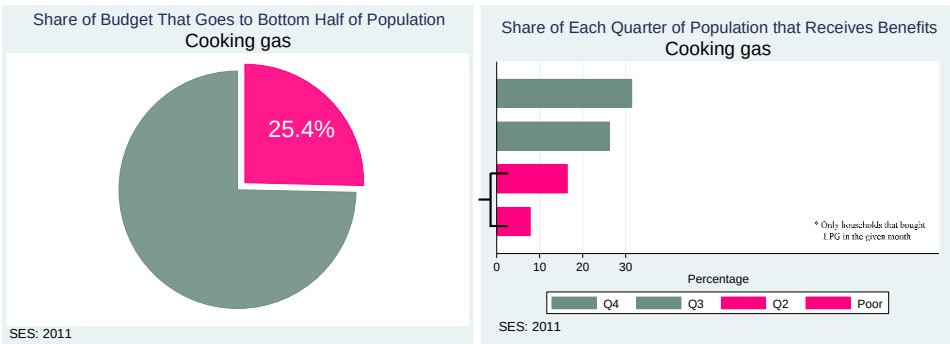
2013



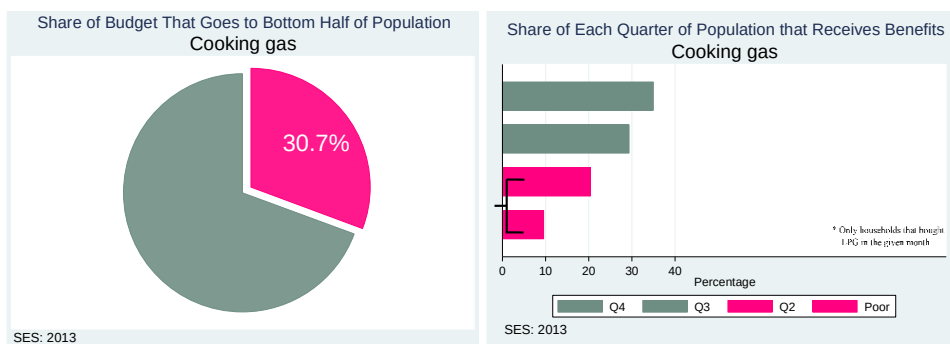
The diesel program was never intended as a program for the poor. Generally it is the wealthier families who own and use pickup trucks or farm equipment. Fifty percent of the wealthiest quartile benefited from this program. Only 10 percent of the subsidy went to the poorest half of the population. There is some pass-on effect as goods that poor people buy may be cheaper if diesel is cheaper, but poor people are much more likely to buy local goods or grow or collect crops themselves, so that cheaper transport costs will mostly go to wealthier groups.

Figure 14 LPG Budget Share and Use Share per Quartile, by Year

2011



2013



The subsidized cooking gas program was designed to reach the poor, but was not very effective at doing so. Depending on the year, a quarter to 30% of the subsidized gas went to the bottom half of the population. This is because many poor households were using charcoal or firewood, especially in the Northeast. There is a strong mismatch between those who use free electricity and those who use LPG Gas.

Table 8: Primary Cooking Fuel of Household Relative to Electricity Use

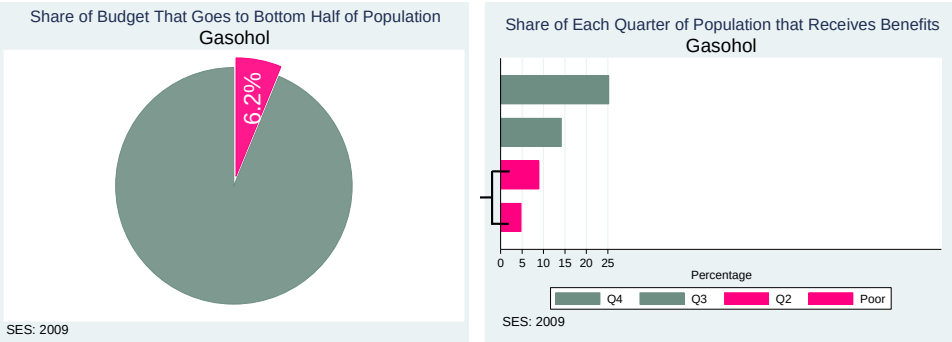
Electricity Use	Gas	Wood or Charcoal	Other
Use less than 50 Kwh electricity	29%	63%	8%
Use less than 90 Kwh electricity	39%	54%	7%
Use more than 90 Kwh electricity	75%	14%	11%

Source: SES 2011

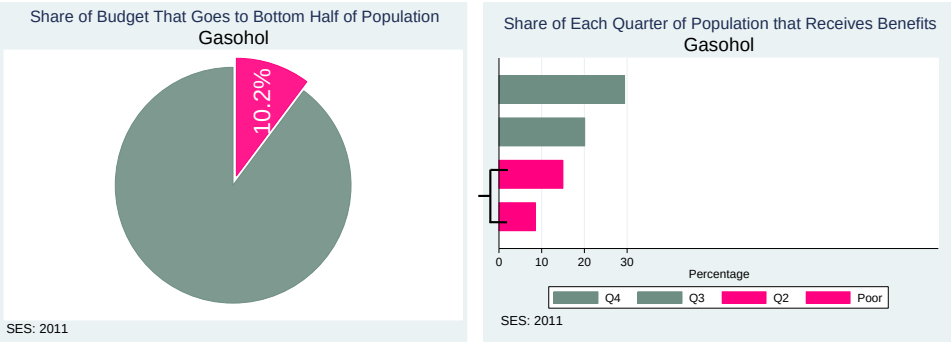
It was thought that electricity use would be a useful way to identify poor people eligible for other subsidies, as subsidies eligibility could be tied to a dwelling with proven low energy use. Unfortunately, for LPG subsidies, the target demographic is very different.

Figure 15 Gasohol Budget Share and Use Share per Quartile, by Year

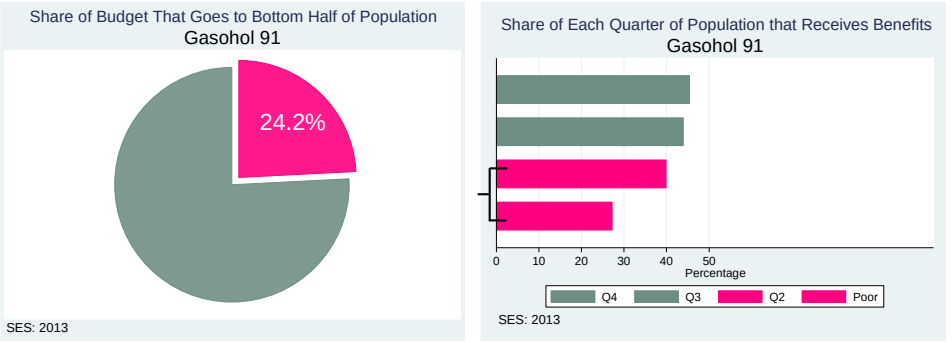
2009



2011



2013



Reducing the price of Gasohol (by reducing the tax) was a policy primarily addressed at encouraging the use of renewable energy. Adoption was very slow in the early years, and almost all of the usage was by the wealthiest quarter of the population, in fact the wealthiest 10% although it is not shown here. There was a widespread perception that gasohol could not be used in motorcycles and might hurt cars as well. The government took a strong arm approach to this problem and removed benzene 91 (unleaded gas) from the market in 2013, leaving people with no option except gasohol. At which point, usage of gasohol jumped. However, poor people drive much less than wealthy people and any policy aimed at cars and trucks will benefit primarily the wealthy. Even after eliminating benzene 91, only about 25% of the budget went to the poorest half of households.

Note: Data used for the pie charts depends on actually or in-kind expenditure from the SES. In-kind consumption is assumed to be the same as the subsidy for electricity. A very few wealthy people do receive large amounts of free electricity presumably from their companies, they are statistically minute in the SES data.

For other energy products, if the product is subsidized and a household buys it, it is assumed they get the benefit from the subsidy. The amount the household spends on the product times the share of the subsidy in the price of the product goes into the pie graph on the left, while whether the household uses any of the product, goes into the bar chart on the right.

11. Conclusions

11.1 Big Picture

The challenges remaining for Energy Policy in Thailand are many. We still need to find a way to reduce our use of energy, as we have one of the worst energy to GDP ratios in Southeast Asia. As an energy importer this is expensive and risky for us. Many well conceived conservation policies were initiated under the thoughtful leadership of former Energy Ministry Piyasvasti Amranand but mostly they were not developed.

We still need to meet our commitments to reducing global warming through NAMAs (Nationally Appropriate Mitigation Action.) Although there was some interest generated when it appeared that Carbon Credits could be profitable, little has been done to reduce Carbon emissions, and help the world we live in (Limmeechokchai, 2016).

Electricity and Fuel supply is still mostly in the hands of large State-Owned Enterprises, with insufficient competition to increase efficiency and reduce price. Electricity is still mostly produced with natural gas which puts us at risk of supply interruptions. (Koomsup & Sirasootorn, 2008)

Alternative energy is far from sufficient to meet future energy needs, so we need to continue to be vigilant and be concerned with promoting alternative fuels and with energy security and energy integration.

11.2 Subsidies

This paper has selected just one issue on the complicated energy agenda by looking at subsidies, but it is an especially important direction for several reasons. Energy subsidies have a strong effect on the lives of ordinary Thai persons, and especially the ones with the hardest lot, and the least reason for hope. Well designed subsidies can make a real difference.

Another reason is that energy subsidies, poorly done, can be very expensive. Thailand is a country with strong Macro policy and weak Micro policy, and there is an opportunity here to do better by using big data techniques.

The paper has looked at current and recent energy subsidy programs and investigated their success at reaching the poor, at reaching the elderly, the educated or uneducated, those who live in different regions. The advent of big data allows us to know much more about those who receive subsidies. In addition to looking at how many of each group receive benefits and how much they receive, some estimate of the share of the budget going to each policy is estimated.

The large data sets used in the paper comes from the National Statistics Office which has taken the lead in Thailand in making government data available both to the public and to researchers. The author is very grateful for their support in making the data obtained available for academic research.

11.3 Summary of Results

In this analysis, free electricity is clearly the winner in terms of reaching its targeted recipients and being used primarily by the poor. In no other subsidy program does more than half of the benefit go to the targeted recipients. Nevertheless there are still unintended consequences to the way free electricity was designed that make it favor those in mountainous areas, those with small families and those with absentee family members. In addition, the cutoff level for free electricity is clearly too low to be optimal.

Subsidizing LPG is largely synonymous with subsidizing the middle class. The characteristics of households who use LPG are closely aligned with a middle class lifestyle. There is only a small overlap between those who receive free electricity and those who use LPG for cooking, which makes any link between the two policies problematic.

Subsidies of vehicles and transportation fuel have the least link to issues of poverty. If subsidizing any transport fuel could help the poor, it would be keeping the price of gasohol 91 cheap, as it is the primary fuel used for motorcycles. Even so, the vast majority of expense will go to wealthier households who drive much more. Perhaps it would be better to subsidize motorcycles instead? Benzene 95 is a luxury fuel, so that its usage rises rapidly as households achieve a high level of income. Diesel is not used at all by the poor, but may benefit the middle class who use it for pickups used in production, or more frequently by the wealthy. However, the 30 Baht per liter price cap set by the government on diesel seems to have been directed only at the commercial transport sector, with little awareness or effect on anyone else.

The first car policy seems to have been directed at supporting the domestic car industry, especially in the aftermath of the flood. Only the top two deciles appear to have been affected by the first car policy for automobiles. However, there does seem to have been an increase in the purchase of pickup trucks for middle decile groups. It might be worthwhile for the government to target this sector directly in the future to decrease production costs.

The ethanol support program, in the form of promoting gasohol is mostly an attempt to prepare the country for a future using alternative fuels. It is not cost effective at current energy prices, and it does not do a very effective job of reaching the poor, so the justification for the policy must be fuel availability in the future.

All alternative energy policies including ethanol and especially solar that are not linked to least cost economic rationality need to be closely monitored for economic reasonability as they have become a strong growth industry for transferring funds from taxpayers and utility users to the wealthy and well-connected in recent years. Although continuous efforts have been made to reduce perverse incentives, more needs to be done in this area.

In summary, if the primary purpose of the government is to subsidize poor people, it is not doing a very good job. Electricity subsidies are very effective at reaching the poor, but have been cut back. LPG subsidies mostly reached those in higher income groups and have very little effect on the household budget. The more useful goal of improving people's health by removing particles for the air is not being met.

11.4 Potential solutions to aid the poor.

In this section, several possible solutions that can help in the design of subsidies are suggested. Engel curves provide a way to estimate the amount of energy that should be provided as lifeline support. Subsidizing capital goods that are used by the poor is a more direct way to reach a target group. Finally, the issue of aid for the elderly and income equality are a more direct way to decrease economic disparity.

1) Use Engel curves to bring the poorest households to a target level set by the 10-50% centile energy use. Suggested levels from section 7 are:

- a. Electricity 80 - 140 Kwh / month
- b. LPG 3-5 Kilograms / month
- c. Gasohol 91 10-20 liters / month.

The manner in which to insure these levels remains to be determined, but it is useful to have a target level. Presumably, the easiest would be the same approach as is used for electricity.

2) Subsidize capital goods used by the poor rather than subsidizing fuel.

- a. Stoves – government could distribute gas stoves or encourage their use.
- b. Motorcycles – why a first car policy, when a significant expense for most of the poor are motorcycles?
- c. Pickup trucks
- d. Farm equipment

3) Other subsidy issues

- a. The subsidy for old people is clearly not sufficient at 600-840 baht a month. For a typical elderly couple who each receive 720 baht a month, this is less than 25% of their monthly costs for the poorest decile.
- b. Energy use should be increased for the poor and decreased for the wealthy. Probably this means higher taxes on cars and benzene⁹⁵ and continued subsidies. It is not true that everyone should reduce energy use.

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