Experiences in household energy consumption survey in Thailand

Wongkot Wongsapai

Vice president:

- Office of National Higher Education Science Research and Innovation Policy Council (NXPO), Thailand
- APEC Center for Technology Foresight wongkot@nxpo.or.th

Associate Professor:

- Faculty of Engineering, Chiang Mai University, Thailand wongkot.w@cmu.ac.th

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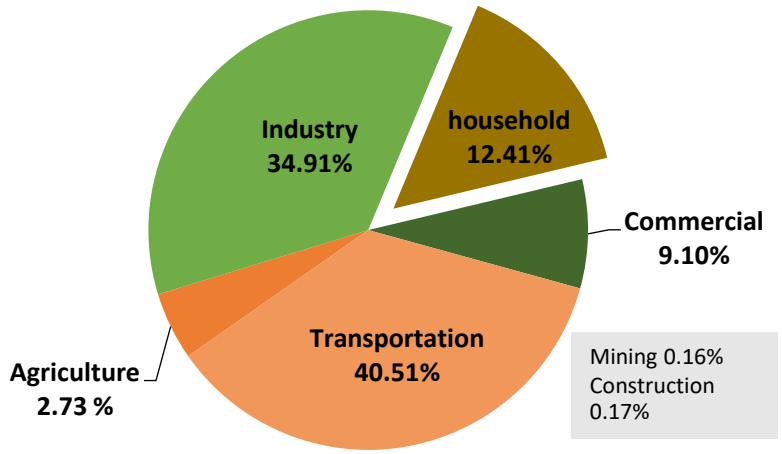
Thailand HH Energy Survey: At-a-Glance

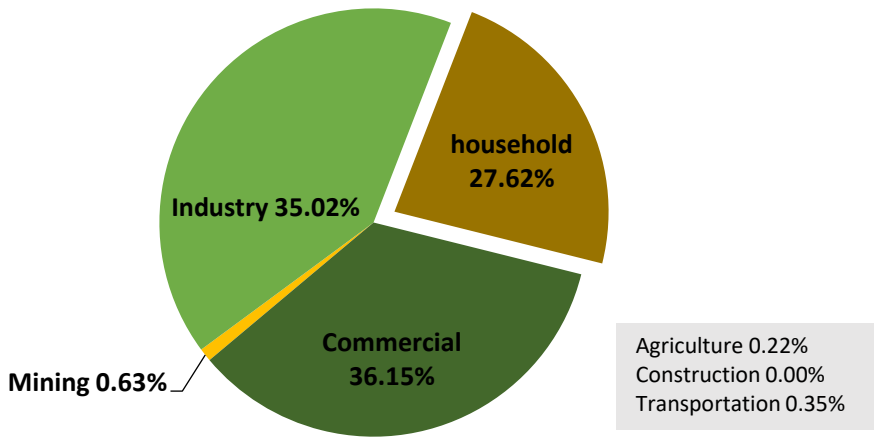
Thailand (2024 data)

- 5 Regions
- Population : 71.67 millions
- Households : 29.12 millions (Source: DOPA) with >99.9% Electrified
- GDP : 526.4 Billion USD 2.5% growth
- Final Energy consumption : 83,020 ktoe (Source:DEDE)
  - Electricity : 19,258 ktoe (23.20%)
  - Coal : 5,633 ktoe (6.79%)
  - Petroleum products : 41,181 ktoe (49.60%)
  - Natural gas : 7,515 ktoe (9.05%)
  - Renewable energy : 6,341 ktoe (7.64%)
  - Traditional renewable energy : 3,092 ktoe (3.72%)

Final energy consumption



Electricity consumption



Timeline of HH energy survey in Thailand

Note

- Electricity
- Renewable Energy
- Petroleum Products
- Energy Price
- Appliances Details
- Household Economy
- Forecast Model

DEDP: HH survey every five year in the past (1980, 85, 91)
→ **Commercial energy growth 16.5%/y**
→ **Traditional RE growth 4.1%/y**

1995

1997 — Department of Alternative Energy Development and Efficiency, MINISTRY OF ENERGY
HH Survey (DEDP) by KMUTT
: All regions (4,000 Q)

2000

2002 — กระทรวงพลังงาน MINISTRY OF ENERGY
Established of Ministry of Energy

2002 — Department of Alternative Energy Development and Efficiency, MINISTRY OF ENERGY
HH Survey (DEDP) by KMUTT
: All regions (4,000 Q)

2010

2014 — สำนักงานสถิติแห่งชาติ
HH Energy Consumption (NSO)
: All provinces (52,000 Q)

2015 — Energy Policy and Planning Office, MINISTRY OF ENERGY
Load Forecast Survey (EPPO)
: Major cities

2016 — HH Energy Consumption (NSO)
: All provinces (52,000 Q)

2016 — HH Energy Survey (EPPO) by CMU
: BMA & Northern provinces (5,000Q)

2018 — HH Energy Survey (EPPO) by 7Us
: All provinces (7,000 Q)

NSO: Energy survey every two years
Census every seven years

2020

Objectives

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We have research questions on these issue…

- **First in-depth household energy survey since 2002, both consumption and production, both commercial energy and renewable energy**
  - Urban area (data from municipality area)
  - Rural area (data from non-municipality area)
- **Structural analysis on the consumption, especially on electricity and petroleum products, including the pattern change → compare to previous survey**
- **Investigation of the energy saving potential in major appliances, from top-down model → including peak cut potential if implementing the higher energy efficiency appliances**

Load forecast or long term energy demand model for Thailand

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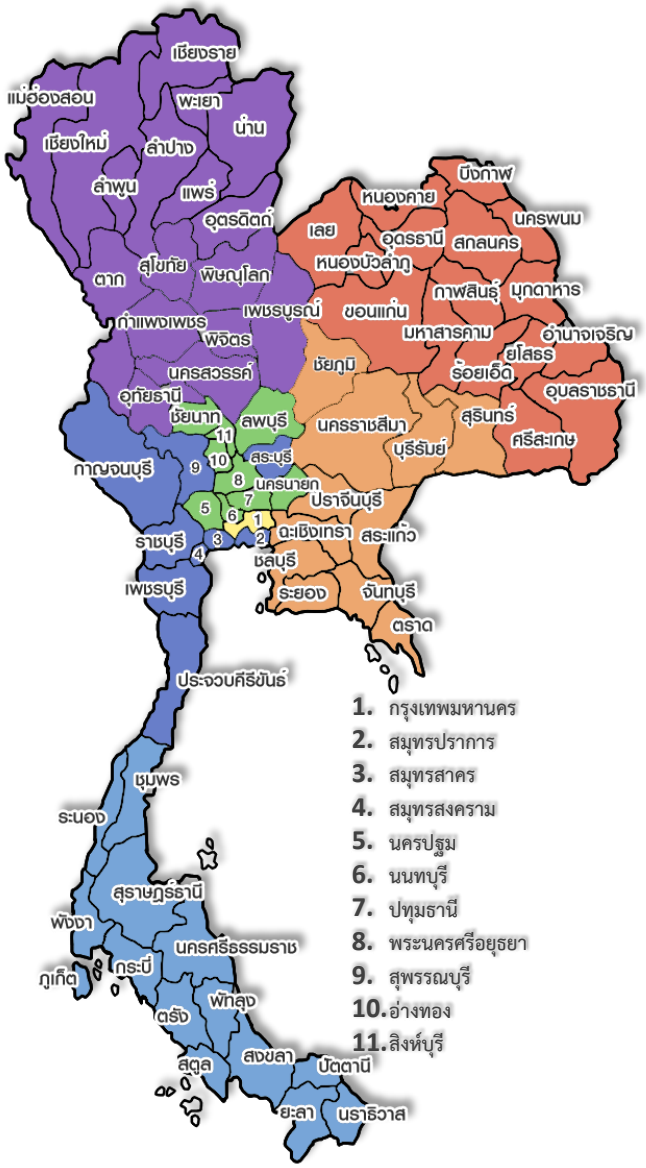
Household Survey in Details

The 2018 Survey Area

Whole Kingdom



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7 Regions (Approx. 1,000 HH/ each region)

Household

2015 Surveyed	2017 Surveying
5,000 Households	> 7,000 Households (1,000 Household/Area)

Areas	Households	%	2017 Surveying
BMA: Chulalongkorn University, CU	2,816,711	11	1,000
Northeastern (upper): Khon Kaen University, KKU	4,615,947	18	1,000
Western: King Mongkut's University of Technology Thonburi, KMUTT	2,614,964	10	1,000
Southern: Prince of Songkla University, PSU	3,444,061	14	1,000
Central: Kasetsart University, KU	2,579,345	10	1,000
Northeastern (lower) & Eastern: Suranaree University of Technology, SUT	4,545,911	18	1,000
Northern: Chiang Mai University, CMU	4,616,138	18	1,000
Total	**25,233,077**	**100**	**7,000**

Survey pattern

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- **Specification of household**
  - Different energy consumption between
    - Rural area
    - Urban area

- **Sampling technique**
  - Stratified Random Sampling with Multiple Stages or Stratified Multistage Sampling
    - 1st stratum: Rural and Urban area
    - 2nd stratum: Province with high and low levels of ratio household in urban
    - 3rd stratum: District with high and low levels of ratio household in urban
    - 4th stratum: local area in rural and urban

$$n = \frac{z^2_{1-\frac{\alpha}{2}} \cdot (\sum_{h=1}^{L} W_h (P_h Q_h))}{e^2}$$

Where

$z_{1-\alpha/2}$ is a standard normalized value which corresponds to selected confidence level

W_h is a weight of stratum h

P_h is a proportion of interested outcome in stratum h and $Q_h = 1 - P_h$

e is a specified level of precision of the estimated true mean value which is normally specified as a percentage of the true mean of a population

Survey activities













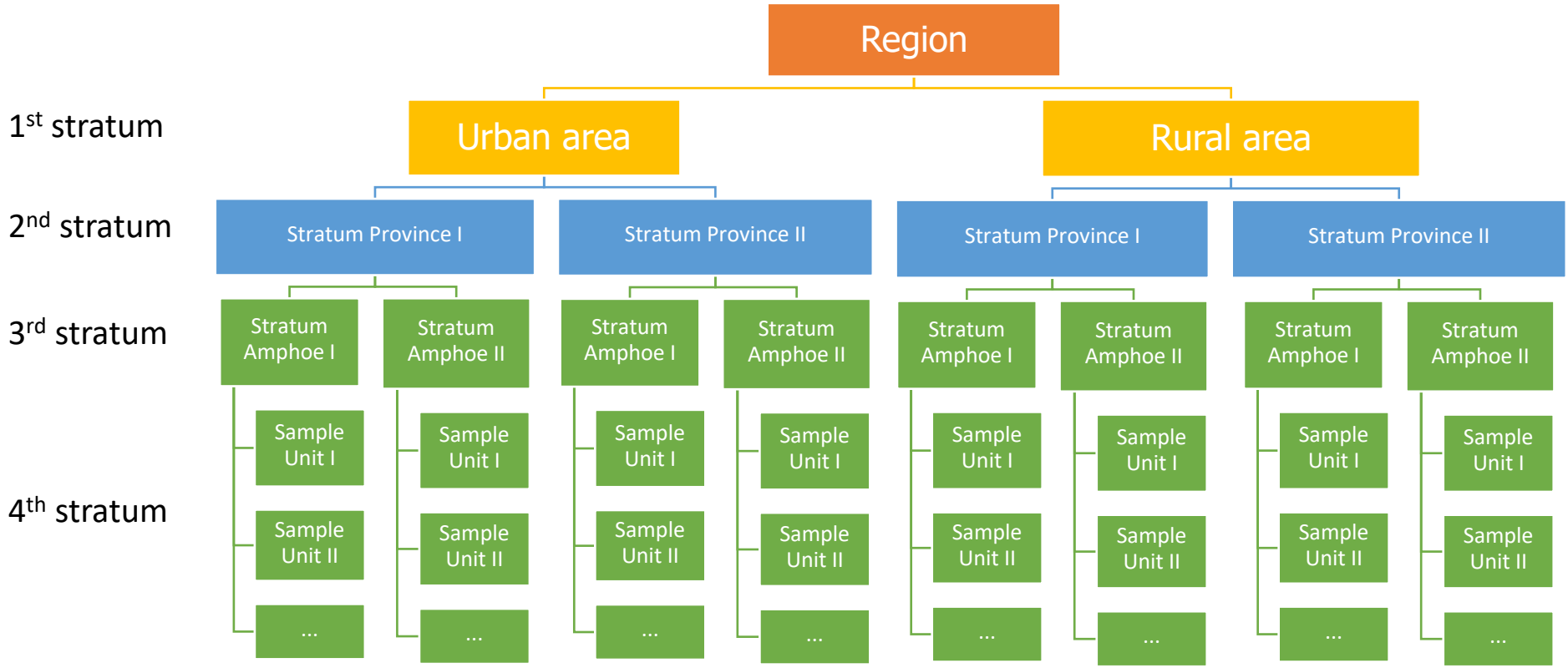






Survey pattern

- Stratified Random Sampling with Multiple Stages or Stratified Multistage Sampling
- Same concept as the DEDP's previous survey for comparability reasons since 2002.



Note: Province = Prefecture (in Japan), Amphoe = City in prefecture, Unit under Amphoe = County/Village

Survey form

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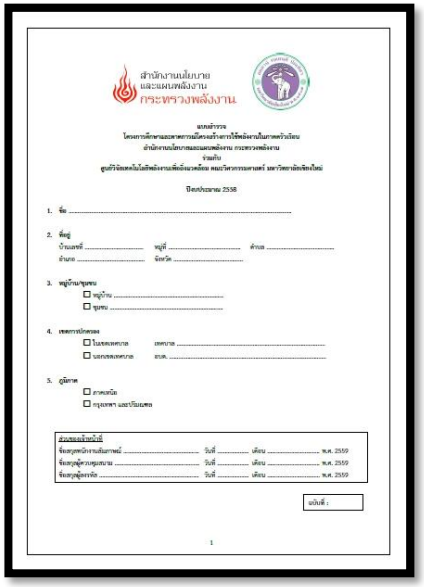
Design Survey Form



Part 1 Economic and Social Information

- Geography
- General Information
- Education Level
- Occupation
- Income & Expense

Part 2 Energy Consumption

- Lighting
- Cooking
- Home Entertainment
- Home Facility
- Heating
- Insect Repellents & Decoys
- Agriculture
- Transportation

Part 3 Energy Sources

- Own harvested
- Purchased Fuel

Part 4 Energy Generation

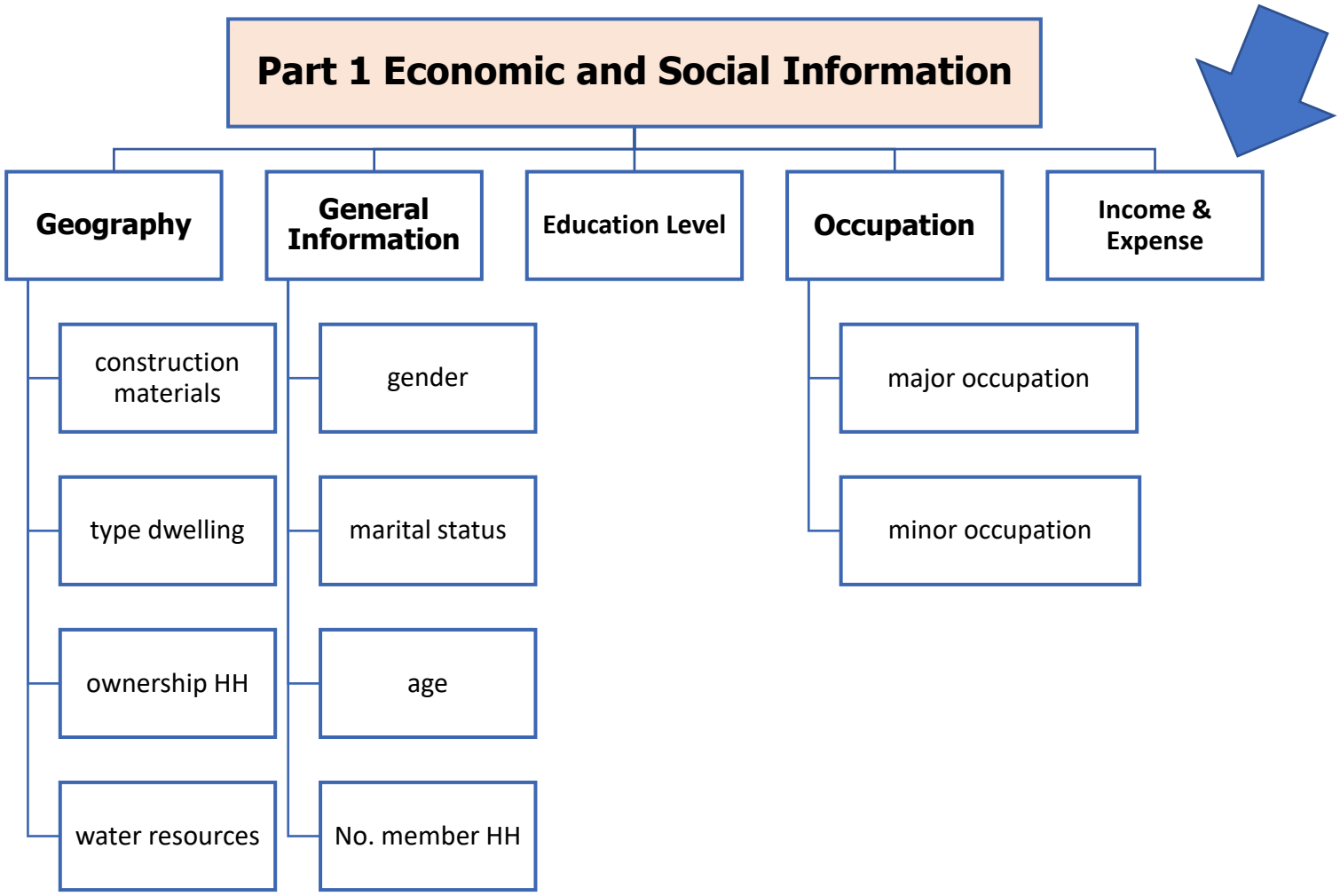
- Charcoal
- Bio gas
- Generator
- Solar cell

Part 5 Future Potential Change

- Cooking : Energy situation
- Transport : Energy situation
- Transport : Shift mode (vehicle)

Survey form

Detail of Survey form



Survey form

Detail of Survey form

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Part 2 Energy Consumption

Lighting

Electricity
- light bulb

Cooking

Electricity
- rice cooker
- stove
- microwave
- oven
- bottle
- kettle
- pan
- toaster
- sandwich
- barbecue

Petroleum (LPG)
- Gas stove

RE
- barbecue
- brazier
- H Eff. stove
- econ stove
- three leg stove

Home Entertainment

Electricity
- TV
- disc player
- mini combo
- home theater
- radio
- computer
- printer
- mobile
- power bank

Home Facility

Electricity
- fan
- ventilator
- air purifier
- water heater
- cleaner
- iron
- refrigerator
- air condition
- washing
- hair dryer
- sewing
- HP cleaner
- pump

Petroleum (LPG)
- water heater

Heating

RE
- permanent oven
- temporary oven

Insect Repellents & Decoys

Electricity
- insect trap
- mosquito

RE
- fire

Agriculture

Petroleum (Oil)
- engine
- lawn mower
- brush cutter
- Lowing
- e-taen
- tractor

Transportation

Petroleum (Oil)
- motorcycle
- car
- truck

Survey form

Detail of Survey form

Part 3 Energy Sources

Own harvested

Renewable energy (RE)

- Type fuel
  - ✓ Fuel wood
  - ✓ Charcoal
  - ✓ Paddy husk
  - ✓ Agricultural waste
- Source
- Transportation
- Quantity (kg/time)
- Frequency (times/year)
- Distance (km)

Purchased Fuel

Petroleum Products

- Type fuel
  - ✓ Gasohol
  - ✓ Diesel
  - ✓ NGV
  - ✓ LPG
- Source
- Transportation
- Quantity (baht/time)
- Frequency (times/month)
- Distance (km)
- Fuel price (baht/unit)

Renewable energy (RE)

- Type fuel
  - ✓ Fuel wood
  - ✓ Charcoal
  - ✓ Paddy husk
  - ✓ Agricultural waste
- Source
- Transportation
- Quantity (kg/time)
- Frequency (times/year)
- Distance (km)
- Fuel price (baht/kg)

Survey form

Detail of Survey form

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Part 4 Energy Generation

- Charcoal
- Biogas
- Generator
- Solar cell

Survey form

Detail of Survey form

Part 5 Future Potential Change

- **Cooking**
  - Energy situation : Fuel
- **Transportation**
  - Energy situation : Fuel
  - Shift mode : Vehicle

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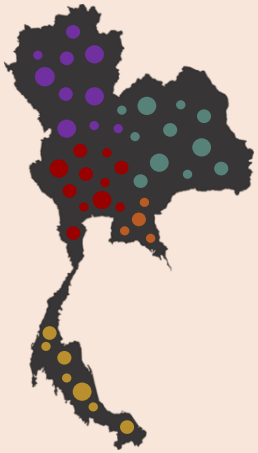
Survey Results and Potential Energy Savings

The 2018 Survey

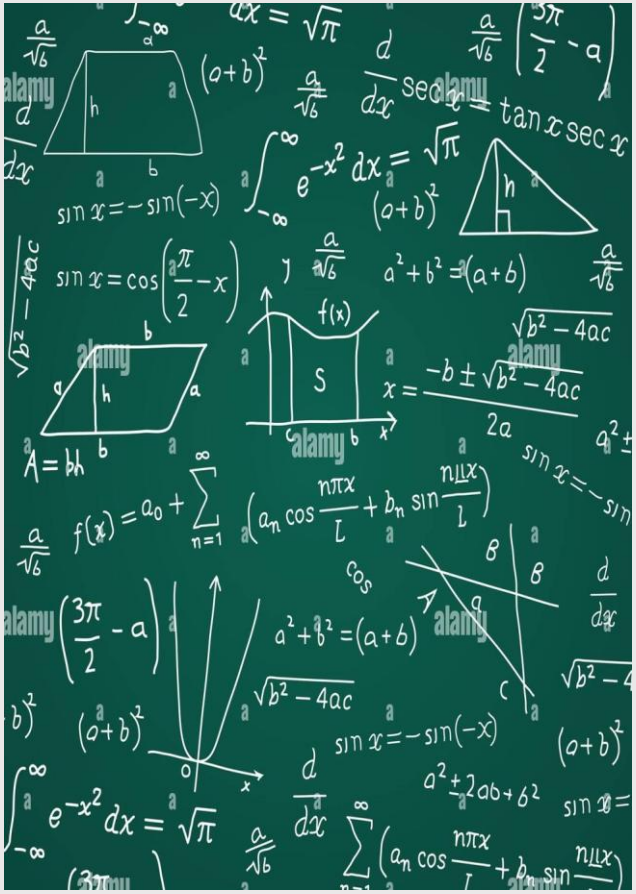
Area Based



7 Regions

- Northern
- Northeastern
- BMA / Central / Western
- Eastern
- Southern

Calculation



Energy conservation potential

Scenario 1: Replace to Energy label 5

Replace the existing appliances into No.5 energy label (with same energy utilization pattern)

Potential Energy Saving from Appliances

Scenario 2: Upgrade to higher technology (in some appliances)

CRT to LED TV & All lighting to LED (with same energy utilization pattern)

Potential Energy Saving from Appliances

Energy Model

Survey: 7,192 Samples from 77 Provinces, then scale up to 25,233,077 HH

Electricity

E=P*N*U*F → E (kWh) = Power rate [kW] * No. appliances * Usage time [hr/year] * **Factor**

Mode	Formula
Lighting	E=P*N*U1*F
Cooking	E=P*N*U3*F
Home Entertainment	E=P*N*U1*F
Home Facility	E=P*N*U1*F
	E=P*N*U4*F
	E=P*N*U2*F
Insect Repellents & Decoys	E=P*N*U1*F
	E=P*N*U2*F

Factor=Load Factor*Seasonal Factor*Utilization Factor

Appliances	Load Factor	Seasonal Factor	Utilization Factor
Air condition	0.75	0.83	0.7
Fan	0.70	1.00	0.7
Refrigerator	0.45	1.00	1.00
Water heater	0.60	0.83	0.70
Washing machine	0.55	1.00	0.70
Automatic Pump	0.45	1.00	1.00

Petroleum Products

E (LPG) =N*U*F → E (kg) = No. device * Usage fuel [kg/year] * Utilization Factor

E (Oil)=N*U*1/C*F → E (liter) = No. vehicle Usage fuel [baht/year] * 1/Cost fuel [baht/litre] * Utilization Factor

Mode	Formula
Cooking	E=N*U5*F
Home Facility	E=N*U5*F
Transportation	E=N*U6*1/C*F

Usage time (h/year)
U1 = h/d * d/w * 52w/y
U2 = h/t * t/w * 52w/y
U3 = m/t * t/d * d/w * h/60m * 52w/y
U4 = m/t * t/w * h/60m * 52w/y

RE

E=U*N*F → E (kg) = No. device * Usage fuel [kg/year] * Utilization Factor

Mode	Formula
Cooking	E=N*U7*F
Heating	E=N*U7*F
Insect Repellents & Decoys	E=N*U7*F

Usage fuel (kg/year)
U5 = kg/tank * tanks/y
U6 = ฿/t * t/m * 12m/y
U7 = kg/t * t/m * 12m/y

Result of Northern

Part 1 Economic & Social Information

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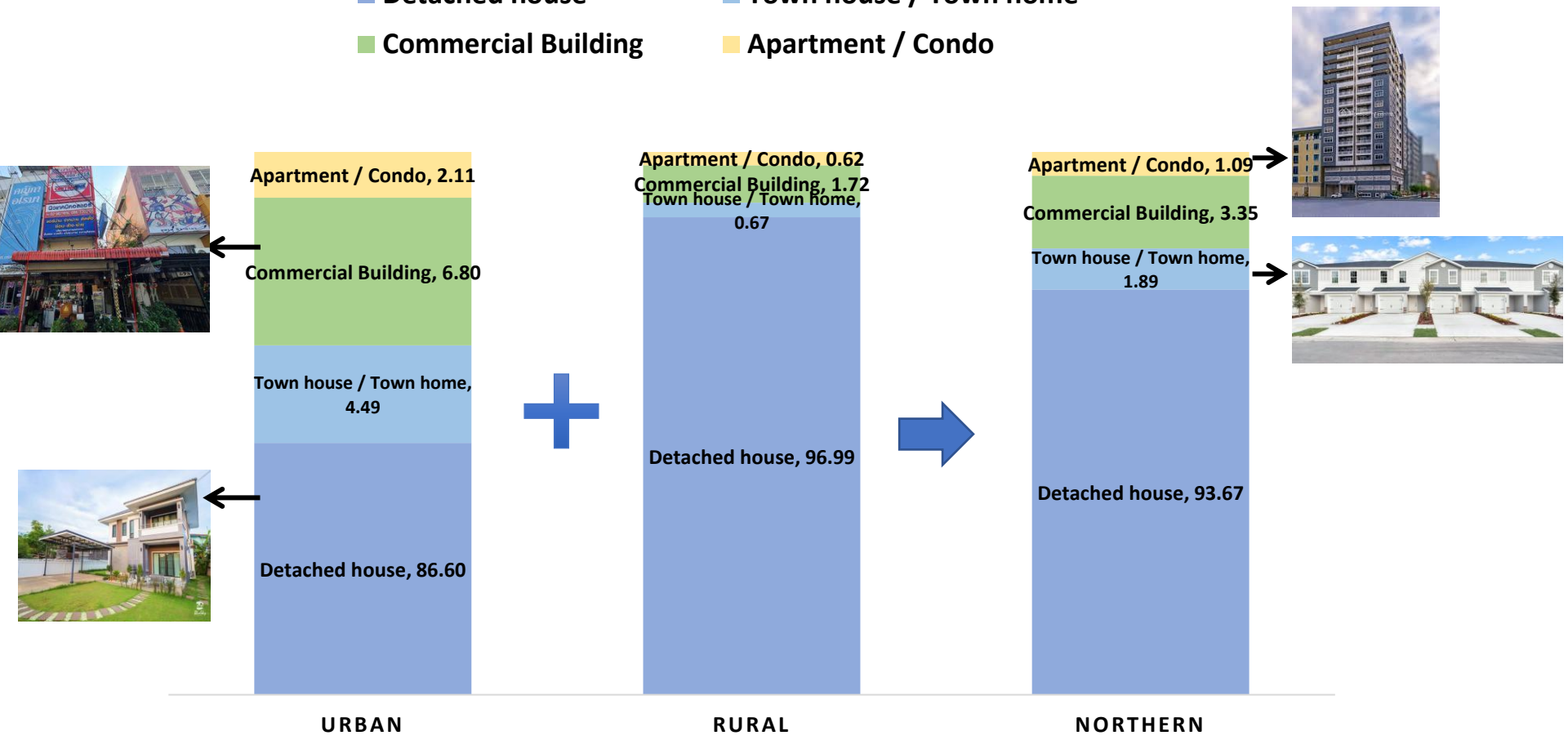
No. Households of Northern
Total : 4,467,077 HH
Urban : 1,413,774 HH
Rural : 3,053,303 HH

PERCENTAGE OF HH ON TYPE DWELLING (%)



Note: Not to scale

Result of BMA

BMA: Bangkok Metropolitan Area

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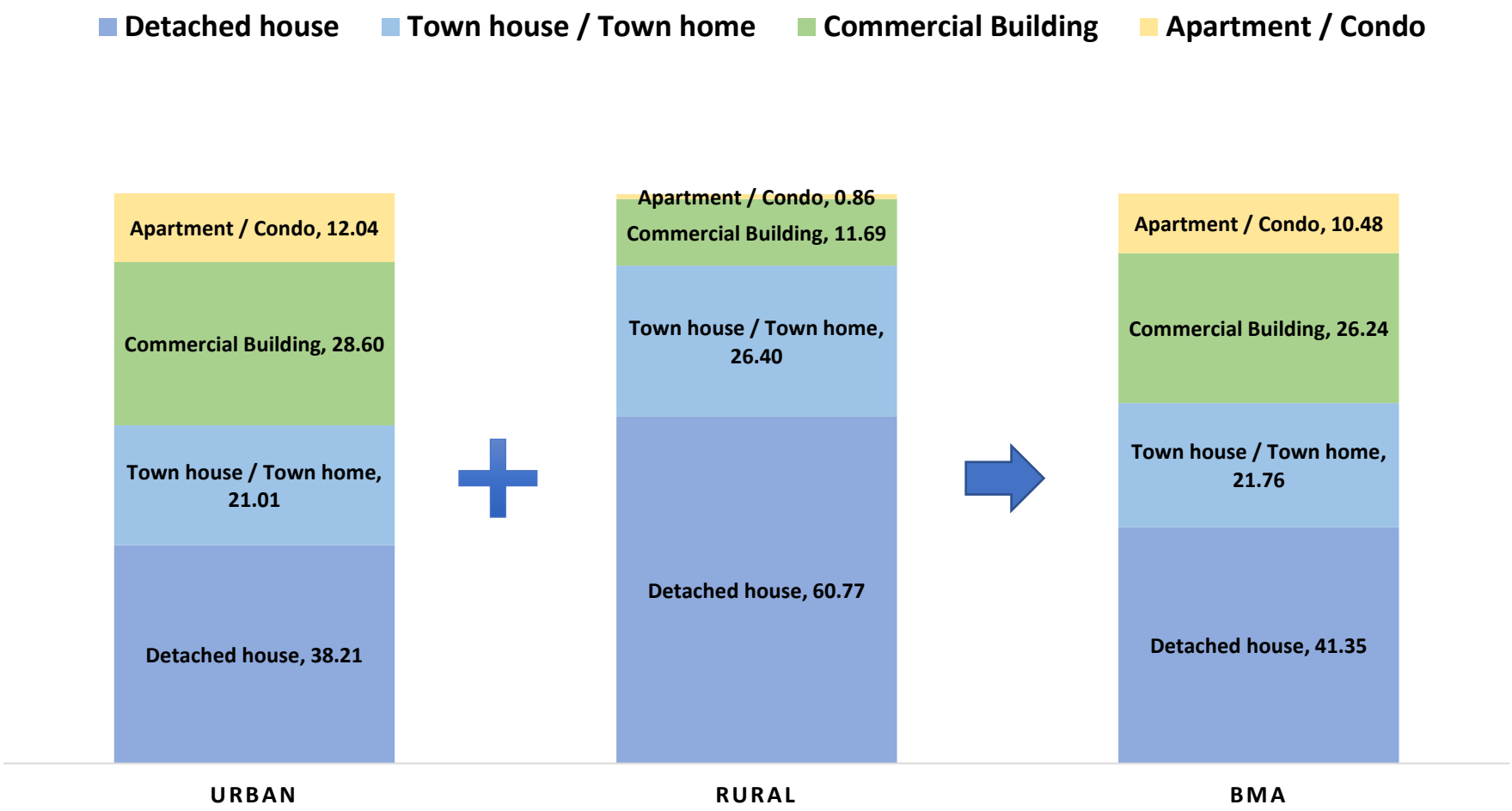
Part 1 Economic & Social Information

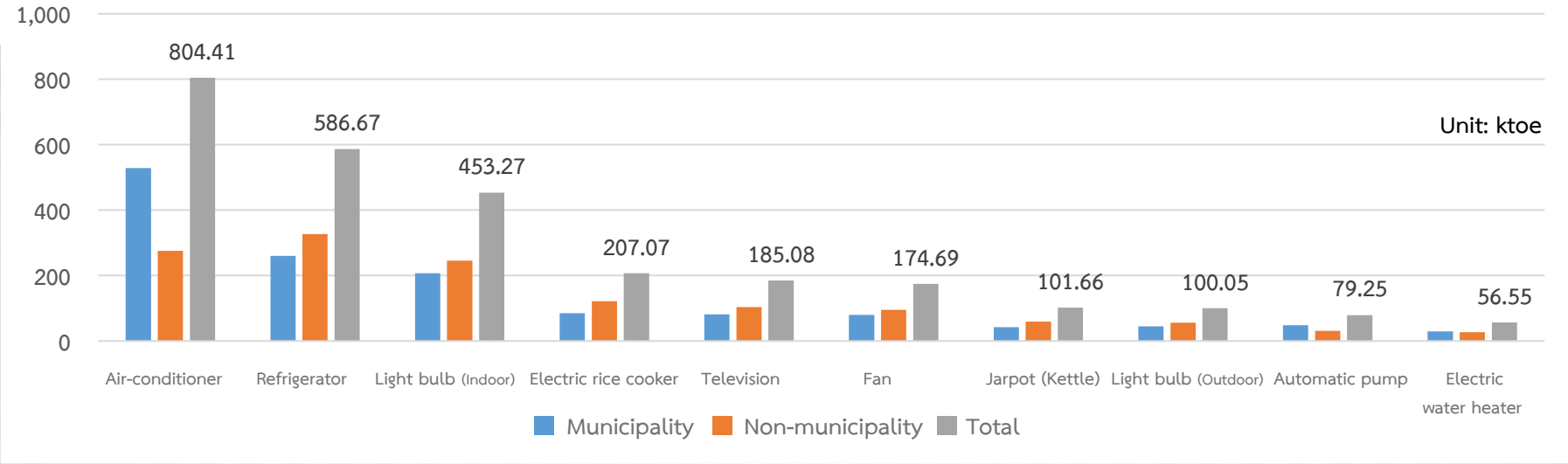
No. Households of BMA
Total : 3,898,842 HH
Urban : 3,355,237 HH
Rural : 543,605 HH

PERCENTAGE OF HH ON TYPE DWELLING (%)

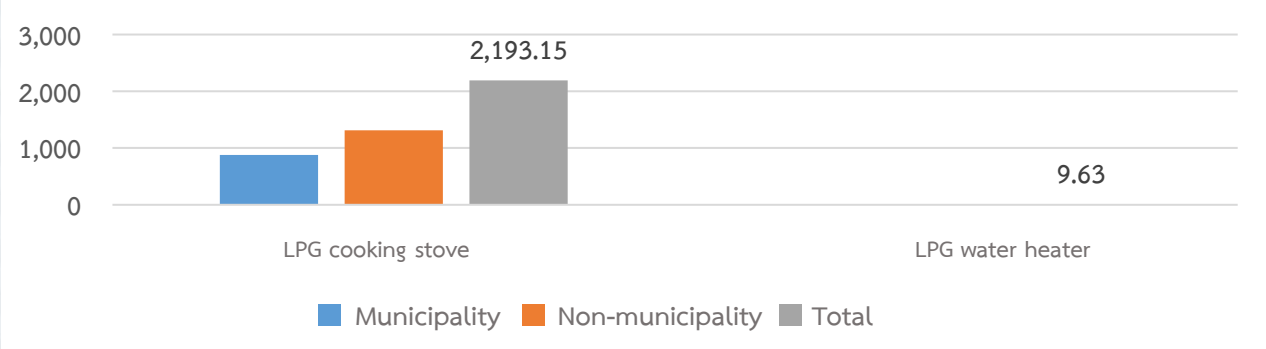


Note: Not to scale

Whole Kingdom: HH Electricity consumption (2018 data)



Whole Kingdom: HH Petroleum consumption (2018 data)



No	Appliances	LPG consumption					
		Municipality		Non-municipality		Total	
		Million Litre	ktoe	Million Litre	ktoe	Million Litre	ktoe
1	LPG cooking stove	1,394.61	878.80	2,085.81	1,314.35	3,480.42	2,193.15
2	LPG water heater	6.37	4.01	8.92	5.62	15.29	9.63
Total		**1,400.98**	**882.81**	**2,094.73**	**1,319.97**	**3,495.70**	**2,202.78**

Estimation of HH Electricity Consumption and Potential Savings (Air Conditioning, Television, Lighting (Indoor & Outdoor))

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Unit : GWh

Appliance	Type	Electricity Consumption (By region)						Measure	Potential Electricity Saving (By region)					
		Central	North	Northeast	East	South	Total		Central	North	Northeast	East	South	Total
Air-conditioner	Wall-mounted	4,223	622	456	314	488	6,102	No.5 Label	19	1	0	1	0	21
	Ceiling	379	2	8	4	27	421		4	0	0	0	0	4
Television	CRT TV	148	107	245	62	67	628	CRT to LED	71	49	112	30	30	292
	Plasma TV	117	21	52	8	45	243		0	0	0	0	0	0
	LCD TV	158	69	78	18	48	371		0	0	0	0	0	0
	LED TV	129	41	43	21	29	264		0	0	0	0	0	0
Lighting (Indoor)	Incandescent	71	27	22	11	25	156	Incandescent, FL to LED	60	23	18	9	21	130
	Fluorescent	1,181	500	888	194	409	3,172		887	375	670	147	307	2,387
	Compact fluorescent (CFLs)	75	54	46	27	45	247		0	0	0	0	0	0
	LED	25	10	7	4	9	56		0	0	0	0	0	0
Lighting (Outdoor)	Incandescent	27	8	12	4	15	65	Incandescent, FL to LED	22	7	10	3	13	55
	Fluorescent	229	88	179	31	95	623		170	66	133	23	70	462
	Compact fluorescent (CFLs)	24	14	22	8	20	88		0	0	0	0	0	0
	LED	10	3	3	1	4	20		0	0	0	0	0	0

Survey results

Electricity consumption




6,523 GWh + 556 ktoe (52%) + 1,506 GWh + 128 ktoe (12%) + 3,632 GWh + 309 ktoe (29%) + 796 GWh + 68 ktoe (6%) = 12,457 GWh 1,061 ktoe

Potential savings




25 GWh + 2 ktoe (1%) + 292 GWh + 25 ktoe (9%) + 2,517 GWh + 214 ktoe (75%) + 517 GWh + 44 ktoe (15%) = 286 GWh

HH Electricity Consumption and Potential Savings : Air conditioner

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Survey results

Electricity consumption in “Air conditioner” : 6,523 GWh

Measure–> Replace with all No.5-labeled air conditioners

Electricity potential saving in “Air conditioner” : 25 GWh

Considered by type and time period

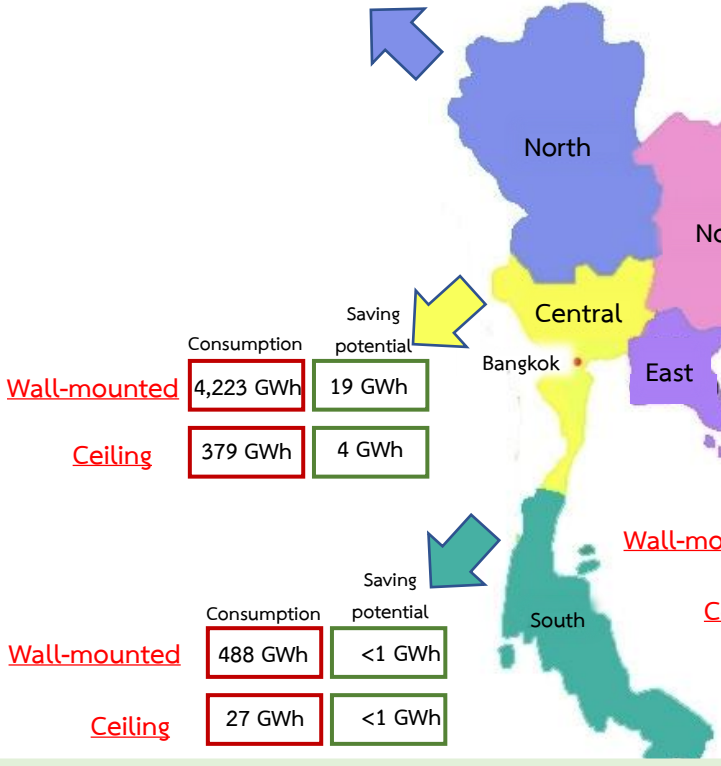
Air conditioner Type: Wall-mounted

	Consumption	Saving potential
06.00 – 12.00	684 GWh	11 GWh
12.00 – 18.00	811 GWh	5 GWh
18.00 – 24.00	4,067 GWh	5 GWh
24.00 – 06.00	540 GWh	0 GWh

Air conditioner Type: Ceiling

	Consumption	Saving potential
06.00 – 12.00	78 GWh	1 GWh
12.00 – 18.00	99 GWh	2 GWh
18.00 – 24.00	221 GWh	1 GWh
24.00 – 06.00	23 GWh	<1 GWh

Classified by region



	Consumption	Saving potential
North – Wall-mounted	622 GWh	1 GWh
North – Ceiling	4 GWh	0 GWh
Northeast – Wall-mounted	456 GWh	<1 GWh
Northeast – Ceiling	8 GWh	<1 GWh
Central – Wall-mounted	4,223 GWh	19 GWh
Central – Ceiling	379 GWh	4 GWh
East – Wall-mounted	314 GWh	1 GWh
East – Ceiling	4 GWh	<1 GWh
South – Wall-mounted	488 GWh	<1 GWh
South – Ceiling	27 GWh	<1 GWh

Real cases: Technology replacement from Fixed Speed to Inverter cannot be calculated due to data limitation (can not detect which on is fixed speed or inverter A/C).

Assumption : If we estimated approximately 5% of total are existing inverter air conditioner. The estimated electricity saving potential from technology replacement from Fixed Speed 95% –> Inverter 100% is 1,859 GWh

HH Electricity Consumption and Potential Savings : Television

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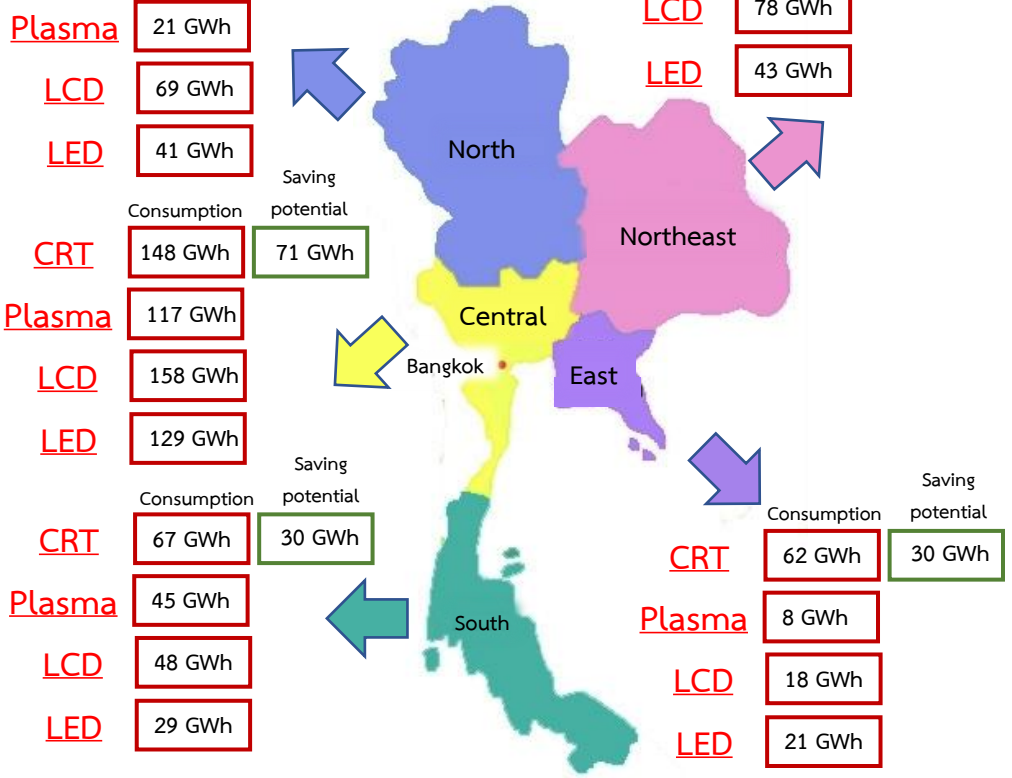
Survey results

Electricity consumption in"Television" : 1,506 GWh

Measure–> replace all size of CRT with 32-inch LED

Electricity potential saving in "Television" : 292 GWh

Classified by region



	Consumption	Saving potential
CRT	107 GWh	49 GWh
Plasma	21 GWh	
LCD	69 GWh	
LED	41 GWh	

	Consumption	Saving potential
CRT	245 GWh	112 GWh
Plasma	52 GWh	
LCD	78 GWh	
LED	43 GWh	

	Consumption	Saving potential
CRT	148 GWh	71 GWh
Plasma	117 GWh	
LCD	158 GWh	
LED	129 GWh	

	Consumption	Saving potential
CRT	67 GWh	30 GWh
Plasma	45 GWh	
LCD	48 GWh	
LED	29 GWh	

	Consumption	Saving potential
CRT	62 GWh	30 GWh
Plasma	8 GWh	
LCD	18 GWh	
LED	21 GWh	

Considered by type and time period

Television type: CRT

06.00 – 12.00		18.00 – 24.00	
168 GWh	77 GWh	393 GWh	182 GWh
12.00 – 18.00		**24.00 – 06.00**	
66 GWh	31 GWh	2 GWh	1 GWh

Television type: Plasma

06.00 – 12.00		18.00 – 24.00	
86 GWh		113 GWh	
12.00 – 18.00		**24.00 – 06.00**	
41 GWh		2 GWh	

Television type: LCD

06.00 – 12.00		18.00 – 24.00	
117 GWh		208 GWh	
12.00 – 18.00		**24.00 – 06.00**	
44 GWh		1 GWh	

Television type: LED

06.00 – 12.00		18.00 – 24.00	
76 GWh		152 GWh	
12.00 – 18.00		**24.00 – 06.00**	
35 GWh		1 GWh	

Electricity Consumption and Potential Savings in Households (Lighting: indoor & outdoor)

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Survey results

Electricity consumption in "indoor lighting" : 3,632 GWh

Electricity consumption in "outdoor lighting" : 796 GWh

Measure–> Replace incandescent/FL with LED bulb

Electricity potential saving in "indoor lighting": 2,517 GWh

Electricity potential saving in "outdoor lighting": 517 GWh

Considered by type

indoor lighting

Type: Incandescent — 156 GWh | 130 GWh

Type: FL — 3,172 GWh | 2,387 GWh

Type: CFL — 247 GWh

Type: LED — 56 GWh

Outdoor lighting

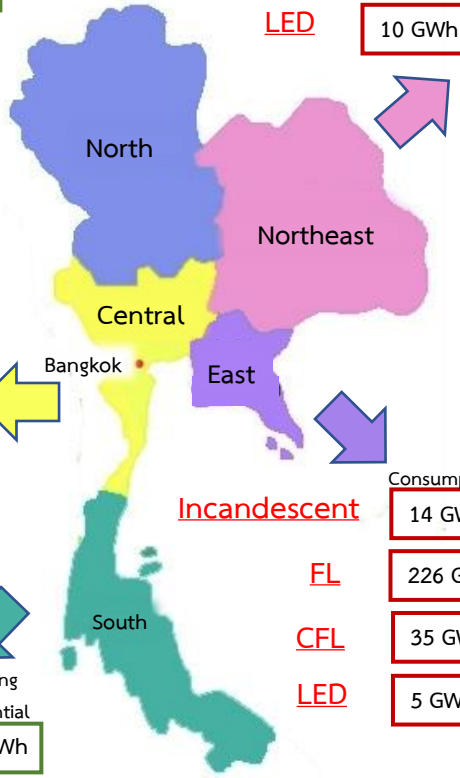
Type: Incandescent — 65 GWh | 55 GWh

Type: FL — 623 GWh | 462 GWh

Type: CFL — 88 GWh

Type: LED — 20 GWh

Classified by region



North	Consumption	Saving potential
Incandescent	34 GWh	28 GWh
FL	1,067 GWh	803 GWh
CFL	68 GWh	
LED	10 GWh	

Northeast	Consumption	Saving potential
Incandescent	35 GWh	29 GWh
FL	589 GWh	441 GWh
CFL	68 GWh	
LED	12 GWh	

Central	Consumption	Saving potential
Incandescent	98 GWh	80 GWh
FL	1,410 GWh	1,057 GWh
CFL	99 GWh	
LED	35 GWh	

East	Consumption	Saving potential
Incandescent	14 GWh	12 GWh
FL	226 GWh	171 GWh
CFL	35 GWh	
LED	5 GWh	

South	Consumption	Saving potential
Incandescent	40 GWh	34 GWh
FL	504 GWh	378 GWh
CFL	65 GWh	
LED	13 GWh	

Conclusions

- ***This study focus on the 2018 household energy survey in all regions of Thailand with >7,000 houses and estimate the potential energy savings from***
  - (i) Replace the existing air conditioner into hi efficiency (No.5 labeling)
    - → Resulted in 25 GWh potential savings (all regions)
  - (ii) Replace the existing into new technology (i.e. LED TV and LED Lighting)
    - → Resulted in 292 GWh potential savings (CRT to 32" LED TV)
    - → Resulted in 2,517 GWh potential savings (Switch to LED indoor)
    - → Resulted in 517 GWh potential savings (Switch to LED outdoor)
- ***Air-conditioner was key electricity consumption, followed by fridge & light bulb.***

- ***We also focuses on the consumption in the context of energy efficiency appliances "probability to change" as our poverty indicators.***
- ***Energy Efficiency Poverty here means "less accessible" to higher EE appliances from the income and area types context.***
- ***"Probability change" of all seven high energy efficient appliances from different income level have been estimated, by regression.***
- ***We found that the energy expenditure share have "impact" to energy efficient appliances, especially the water heater, inverter air conditioning system, and rice cooking. This factor has less impact in fan and refrigerator.***

Implications

- ***Income level have "impact" to most energy efficient appliances, especially the LED lighting, LED TV, water heater and inverter air conditioning system. However, electricity fan and refrigerator have less impact.***
  - ***→ Due to all HH in Thailand can access to electricity fan and refrigerator because of the label 5 campaign in the last 20 years and both appliances are essential goods.***
  - ***→ Priority setting to promote EE should be set for the rich and the poor***

- ***Fan is widely used in all areas and no significantly difference btw. urban and rural in term of accessibility***
  - ***→ This may due to the low price and air conditioner is substitution good to fan in urban BMA area.***

- ***Financial supported should be carefully considered in case of invertor air conditioner to HH, the less income HH type have less potential to change than high income, while other appliances financial supported have no significantly different btw different income.***

Thank you very much

ありがとうございます

Wongkot Wongsapai
Project director of 2018 Thailand HH energy survey
Email: wongkot.w@cmu.ac.th wongkot@nxpo.or.th

Energy Policy and Planning Office
MINISTRY OF ENERGY