Kyoto University
Institute of Advanced Energy

THE IMPACT OF RURAL ELECTRIFICATION ON QUALITY OF LIFE: LESSONS FROM SOUTH-EAST ASIA

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Presentation flow

- **Rural electrification and QoL: Lessons from SE Asia**
  1. *Introduction*
     - Electrification and QoL literature
     - SE Asia as a case study
  2. *Inst. of Adv. Energy project on rural electrification in SE Asia*
     - Project history
     - Key countries
     - Current status
  3. *Project outcomes*
     - Key findings
     - Challenges
  4. *Conclusions and way ahead*

Purpose of today's presentation

- Briefly provide a background of RE knowledge
- Review the study of RE approaches in SE Asia
- Present our research project
  - Objectives, approaches, findings, challenges, way forward

Is rural electrification (RE) important?

- Around 850 million people worldwide lack of access to electricity (WB, 2019) / Tot pop 7.7 billion (2019).
- Most live in rural areas of developing countries
- **Common understanding that RE can contribute to:**
  - **Reduce/eradicate poverty (SDG1)**
  - **Have more affordable and clean energy (SDG7)**
  - **Improve health (SDG3)**
  - **Clean water and improve sanitation (SDG6)**
  - **Improve children's education (SDG4)**
  - **Increase productivity, diversify activities, provide higher incomes (SDG8)**
  - **Better opportunities for women (SDG5)**

More about RE relevance…

In addition:

- RE create investment opportunities in energy infrastructure
- RE create spillover effects (beneficial for economic and social development)
- Etc.

RE has also been related to some negative impacts:

- May threaten local practices and culture
- May create environmental and land rights controversies
- May increase inequalities
- Etc.

Key RE articles

- Focus point of some recent illustrative investigations

Article	Focus point	Setting	Cited
Palit (2011)	**Technical, financial, institutional and governance issues**	India, Bangladesh, Nepal, Sri Lanka	239
Schillebeeckx (2012)	**Business models**	Review	74
Dinkelman (2011)	**Employment, production, migration of employed**	South Africa	692
Kooijman-van Dijk & Clancy (2014)	**Production, financial capital, social capital, human capital, physical capital, natural capital**	Bolivia, Tanzania, Vietnam	86
Khandker et al. (2012)	**Time (fuel collection), income, expenditure, poverty, children's schooling**	India	114
Riva et al. (2018)	**Complex relationships with economic and social impacts of RE**	Review	31
Winther (2015)	**Women's empowerment**	Review	21
Winther (2015)	**Overlooked aspects in living condition impacts evaluations (groups, household structures, ethics, prior qualitative examination)**	Mozambique, Tanzania, India	14

Main gaps and findings in RE literature

Known facts

- RE can bring several improvements:
  - Reduce poverty, increase productivity (particularly homes), social activities, human capital (education, skills, etc.), improved public services (water, health clinics, schools), etc.
- Study of effects can become highly contextual:
  - Diversity in ways that electrification has impact living conditions among agents in the process (Winther, 2015).
- Literature is growing with new approaches: key groups, gender interactions, conflicts or problems, **the social process**

Main gaps and findings in RE literature

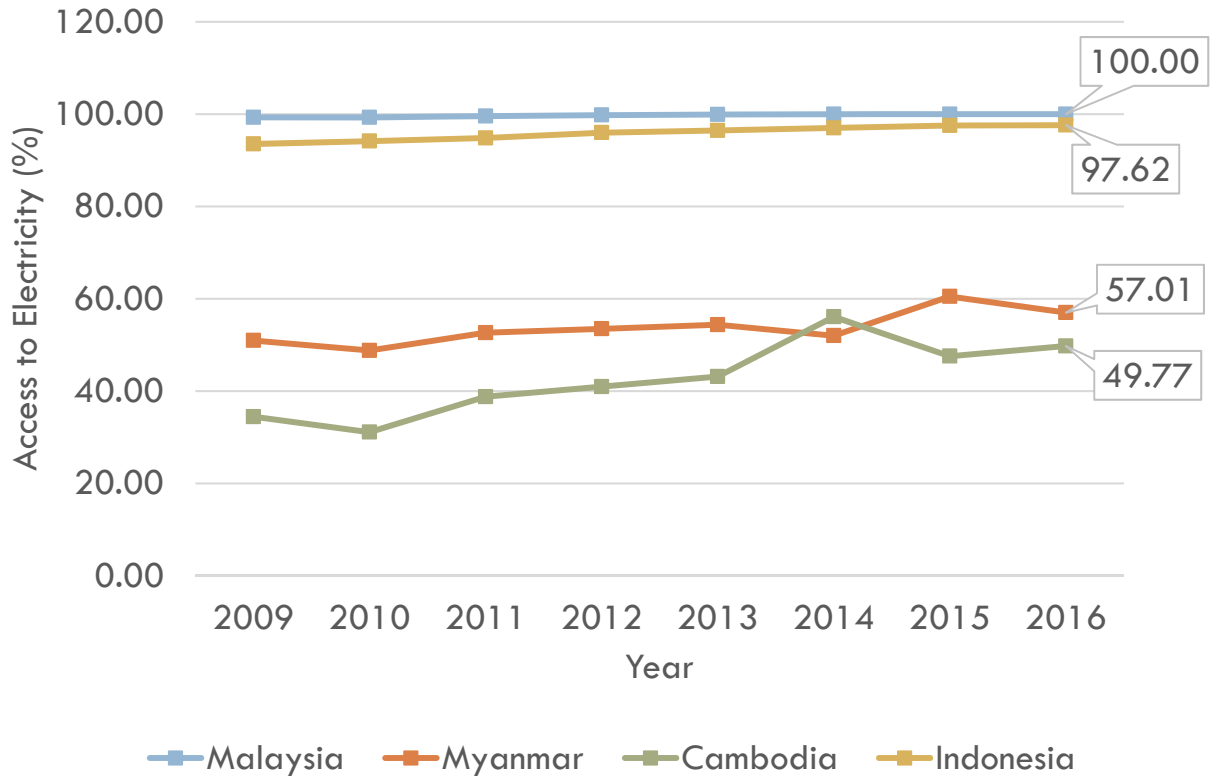
Unclear aspects

- Trade-offs between whos, whats and at which scales
- Further contextual study (concentration in S. Asia and Africa)
- Further dimensions: e.g. human needs, well-being connection, culture conflicts/problems, etc.

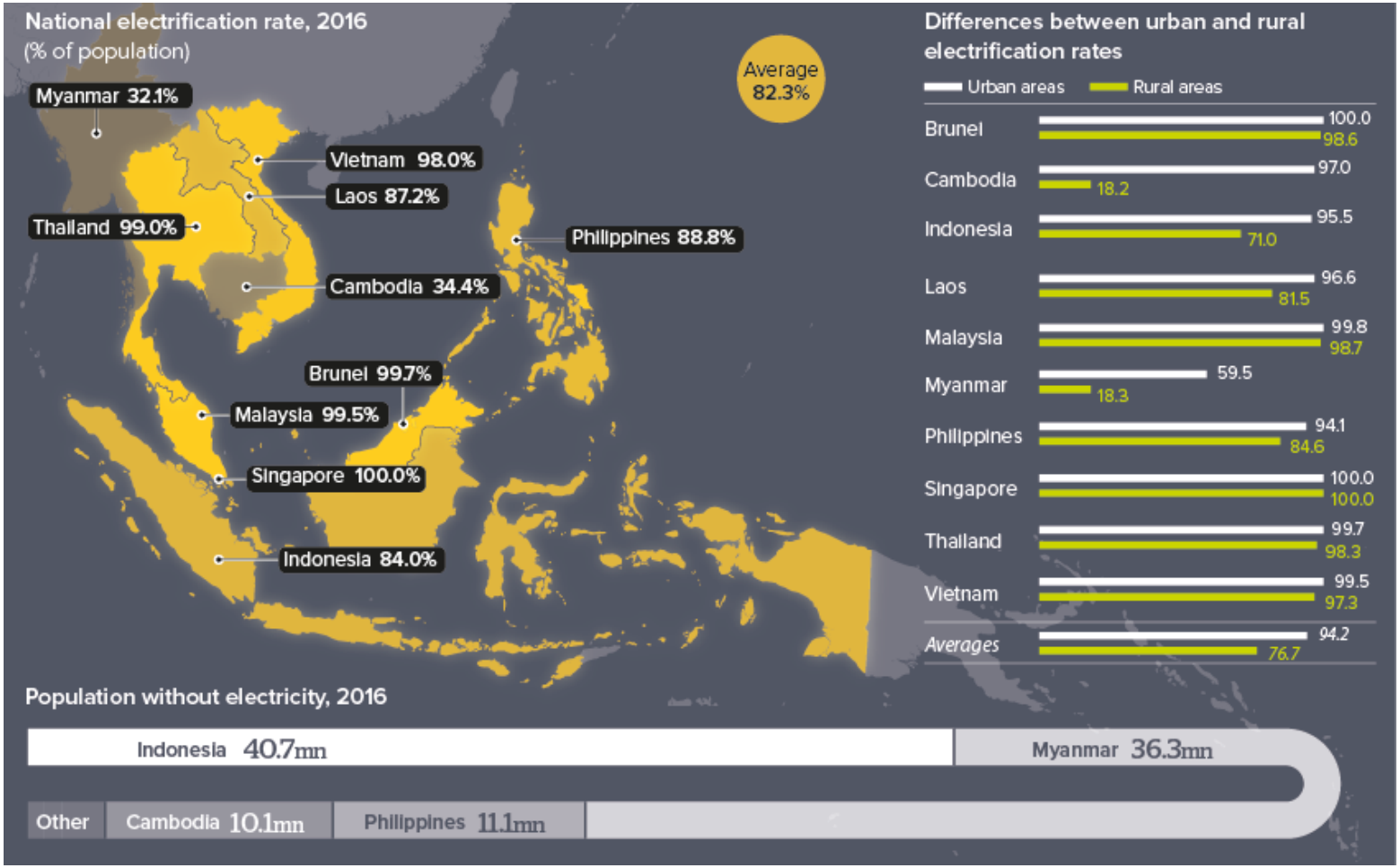
What about South East Asia? (1)

- South East Asia has made remarkable progress towards universal electrification (past 20 years)
- Yet, millions still lack of electric power
- The most vulnerable remain in rural areas

Trends in electrification rates SE Asian countries



Electrification in SE Asia: Rural vs Urban (2)



https://dailybrief.oxan.com/Analysis/GA220581/Uneven-electrification-will-affect-ASEAN-competition

Focus needed in the region

- **Cambodia** and **Myanmar** the most vulnerable cases
  - Electrification disparity translates in uneven opportunities for them in the region.
  - Lower quality of life levels
- Closing the gap is crucial
  - but there are several challenges ahead…

Challenges for electrification in SE Asia

- Lack of financial feasibility (low demand and high installation cost)
  - International aid is needed to advance promotion
- Technical capacities (poor quality products and low human capital building rates)
- Lack of knowledge and social acceptance
- Lack of appropriate policy framework

RE literature focused on SE Asia

- Fewer studies than S. Asia and Africa

Article	Focus point	Setting	Cited
Kooijman-van Dijk & Clancy (2014)	**Production, financial capital, social capital, human capital, physical capital, natural capital**	Bolivia, Tanzania, Vietnam	86
Martin & Sustanto (2011)	**RE and productive uses**	Lao PDR	12
Bhattacharyya (2013)	**RE experience:** grid vs off-grid systems, organizational arrangements	Indonesia, Philippines, Thailand, Vietnam & S. America	8
Van Gevelt et al (2017)	**RE and local preferences:** appliances, communal facilities, productive uses and RE operation models	Malaysia	7
Saing (2017)	**Household consumption, children education by gender** (boys vs girls)	Cambodia	4
Al Faruq et al (2016)	**Human capabilities,** resilience and vulnerabilities	Indonesia	3

Facts and gaps in literature

- Limited information about the region
  - Particularly Myanmar and Cambodia
- Main focus again on productive uses, technology, institutional or governance issues
- But social structures and effects in general less examined, despite being central to RE success

<u>Project targets:</u>

- RE impact from diverse RE schemes in South East Asia
  - Focusing on quality of life (QoL) through diverse measures to understand socio-cultural aspects that intervene in the electrification-QoL nexus

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KU project on rural electrification in SE Asia

- Project and purpose
- Scope and methods
- Findings and challenges
- Way ahead

Project structure

Join partnership to implement rural electrification in ASEAN and evaluate QoL impacts

Myanmar

Cambodia

Indonesia

Philippines

Malaysia

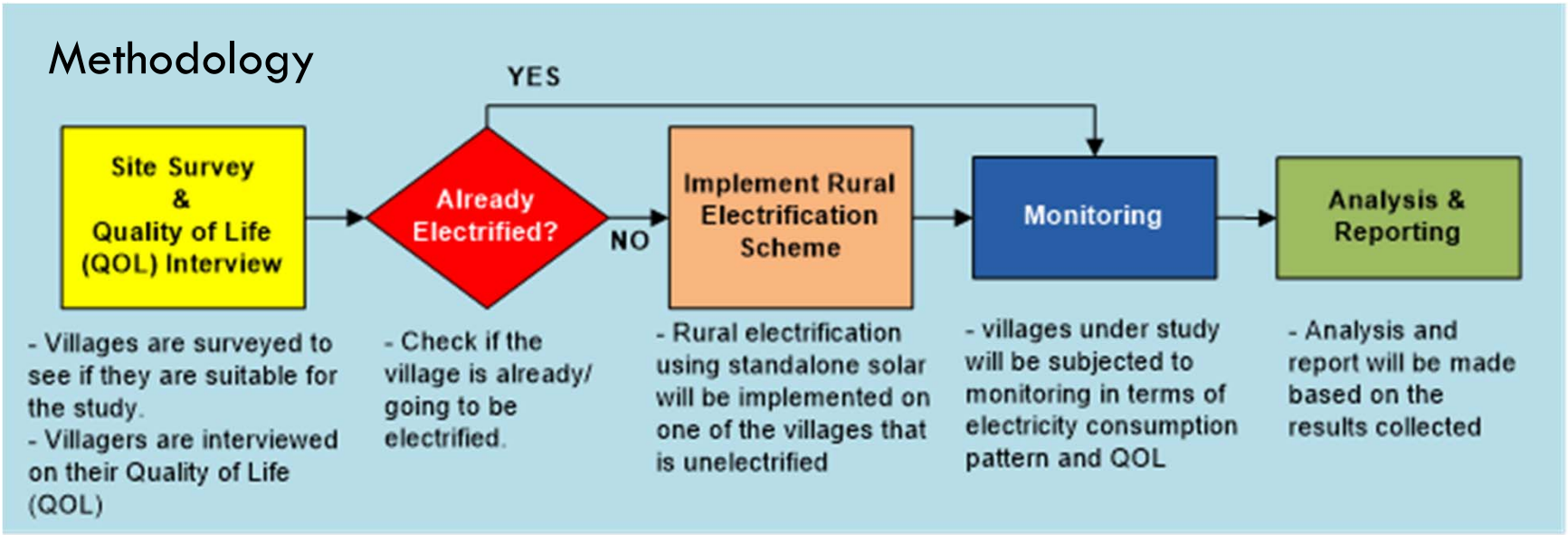
Hitachi Foundation

Project objective

Study on the impacts of different rural electrification schemes on QoL

- Based on “before-and-after” surveys and interviews
- Using objective indicators and subjective QoL
- Different rural electrification schemes
  (grid extension, solar home system, centralized solar system)

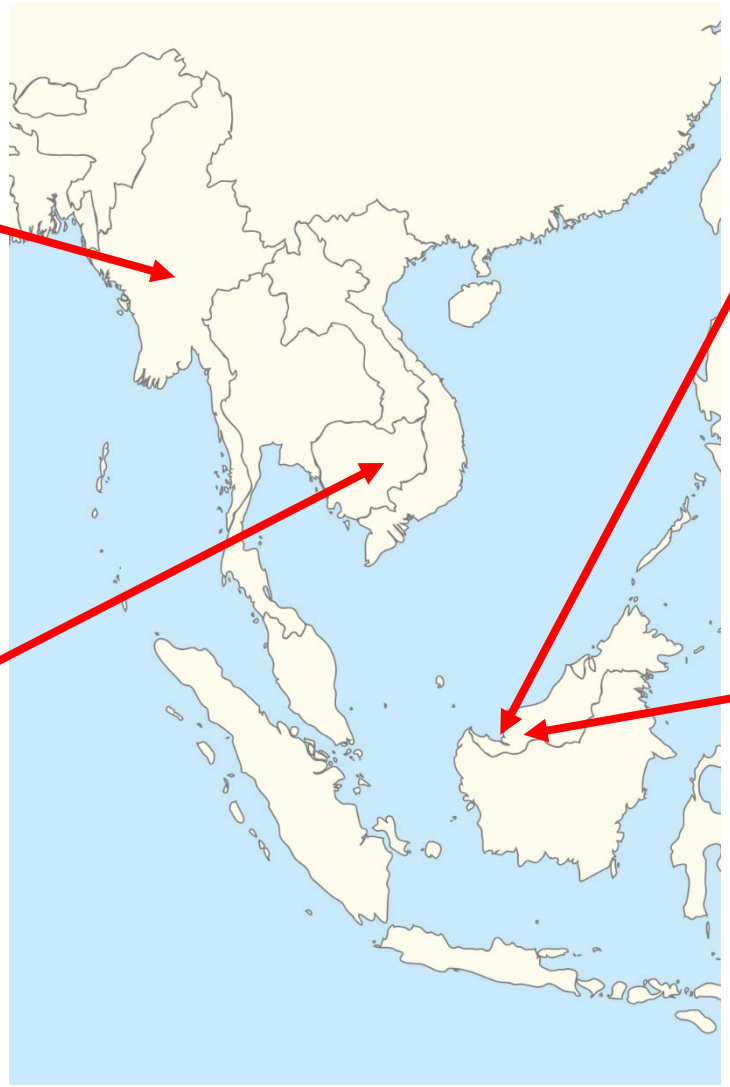
Approach


Methodology
YES
Site Survey & Quality of Life (QOL) Interview
Already Electrified?
NO
Implement Rural Electrification Scheme
Monitoring
Analysis & Reporting
- Villages are surveyed to see if they are suitable for the study.
- Villagers are interviewed on their Quality of Life (QOL)
- Check if the village is already/ going to be electrified.
- Rural electrification using standalone solar will be implemented on one of the villages that is unelectrified
- villages under study will be subjected to monitoring in terms of electricity consumption pattern and QOL
- Analysis and report will be made based on the results collected

Initial case studies (2016- Today)

Oak Pho, Myanmar

Thmor Keo, Cambodia

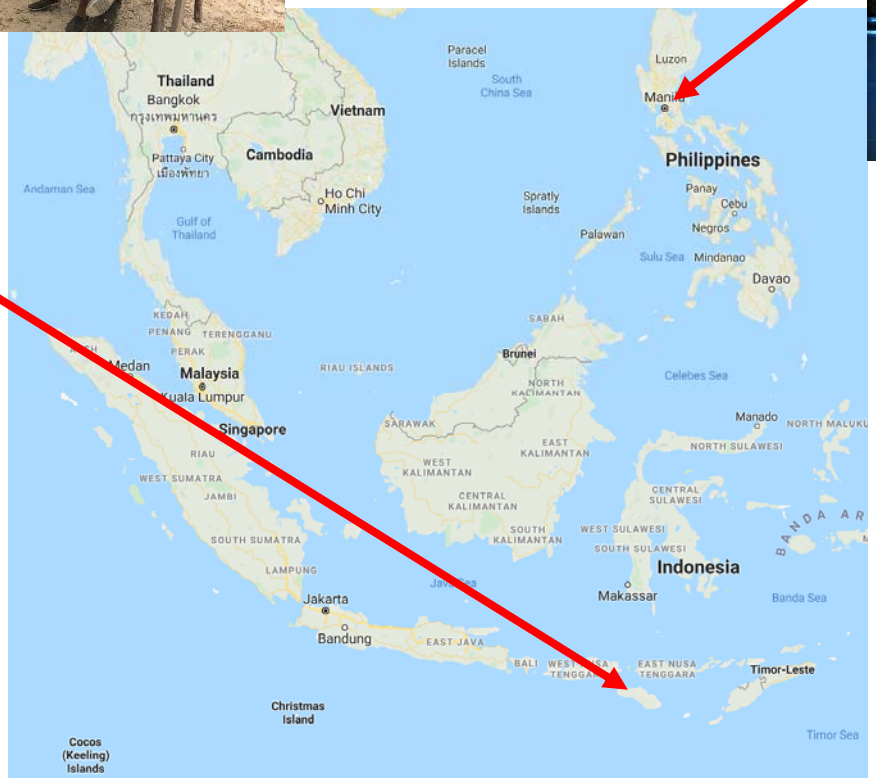


Kampung Sungai Merah, Malaysia

Menangkin, Malaysia

New case studies (2019 - Today)

Sumba, Indonesia



Tanay, Philippines

Rural electrification sites and survey details

Village	Country	Cultural profile	Demographic	Electrification Scheme	Survey / Samples
Kampung Sungai Merah	Malaysia	Iban	20 inhab. Farmers	Solar Home System	Before : **6**
					After(~17 months): **7**
Menangkin		Iban	100 inhab. (22 HHs) Farmers	Grid Extension	Before: **19**
					After(~18 months): **12**
Oak Pho	Myanmar	Barmar	2000 inhab. (400 HHs) Farmers	Centralized Solar System (hybrid mini-grid)	Right after: **19**
					After(~15 months): **35**
Thmor Keo	Cambodia	Khmer	1200 inhab. (215 HHs) Farmers	Grid Extension	Before: **17**
					After(~13months): **21**

Quality of life approaches

Well-being indicators classified into two categories:

1) Objective indicators (more common)
   - Infant mortality rate, life expectancy, mean years of schooling, gross domestic product, gross national income, water access, etc.
2) Subjective well-being
   - Self-reported well-being, satisfaction levels, self-reported health, etc.
   - Composite QoL indices (QoLI): satisfaction level, daily living activities, psychological well-being, health, social relations, economics, aspirations, etc.

- **The project focuses on Subjective well-being (at this stage)**

Quality of life index approach

The QoLI approach follows the Wisconsin Quality of Life Index method (Diamond, 1999).

No	Domains	Scope
1	Background Information	• Demographic information, such as age, gender, education, family member, living place, and occupation
2	General Satisfaction	• General level of satisfaction as well as level of importance on time spent, housing, food, clothing, neighborhood, family and personal safety • Answers are in 5 level Likert scales
3	Occupational activities	• Current occupation and feeling toward these activities. • Answers in 5 level Likert scales
4	Psychological Well-Being	• Perceptions/ feeling on life • Answer in the form of yes/no response.
5	Symptoms /Outlook	• Outlook on life as well as symptoms of stress/anxiety • Answers in yes/no as well as 5 level Likert scale
6	Social Relations	• Social relation between neighborhood, family member, and outsiders • Answers in 5 level Likert scale
7	Money	• Satisfaction level and importance in 5 level Likert scale
8	Personal (family) Properties & Daily Life pattern	• Personal (family) belonging, including TV/radio, refrigerator, cell phone, bicycle/motorbike/car, livestock etc. • The fuel and method for cooking is also asked.
9	Electricity Demand & Affordability	• Electricity demand, current and affordable expenditure for the future expansion
10	Perceived Quality of Life	• The interviewee is asked to rate his/her quality of life on the scale of 1-10, with 1 being terrible and 10 being excellent.

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Six domains used for computing the QoLI

Calculation of the QoLI (1)

a. Satisfaction & importance question. (8 items)

Satisfaction level (SL)

-1 to 1 on a 5 level Likert scale (-1: very dissatisfied, 1: very satisfied)

Importance level (IL)

0 to 1 (0 not important, 1: extremely important)

b. Multiple-choice question

Multiple-choice score (MS)

1: positive response, -1: negative response

c. "Yes-or-No" question

Accomplishment Score (AS)

Positive outlook question: 1: Yes, 0: No

Negative outlook question: -1: Yes, 0: No

Calculation of the QoLI (2)

Domain Score (DS): For Domain 2

$$DS = \frac{(\sum_{i=1}^{m} IL_i \times SL_i) + \left(\frac{\sum_{j=1}^{n} MS_j + \sum_{k=1}^{p} AS_k}{n+p}\right)}{\sum_{i=1}^{m} IL_i}$$

m: satisfaction & importance, *n*: multiple-choice, *p*: Yes-or-No questions

For Domains 3, 4, 6 and 7

$$DS = \frac{\sum_{j=1}^{n} MS_j + \sum_{k=1}^{p} AS_k}{n+p}$$

Calculation of the QoLI (3)

Importance level

Weighting factor (w): Domains 3 to 7: 0 to 1 given on a 5 level scale

Domain 2: Average Domain Score (ADS)

$$ADS_2 = \frac{\sum_{i=1}^{m} SL_i}{m}$$

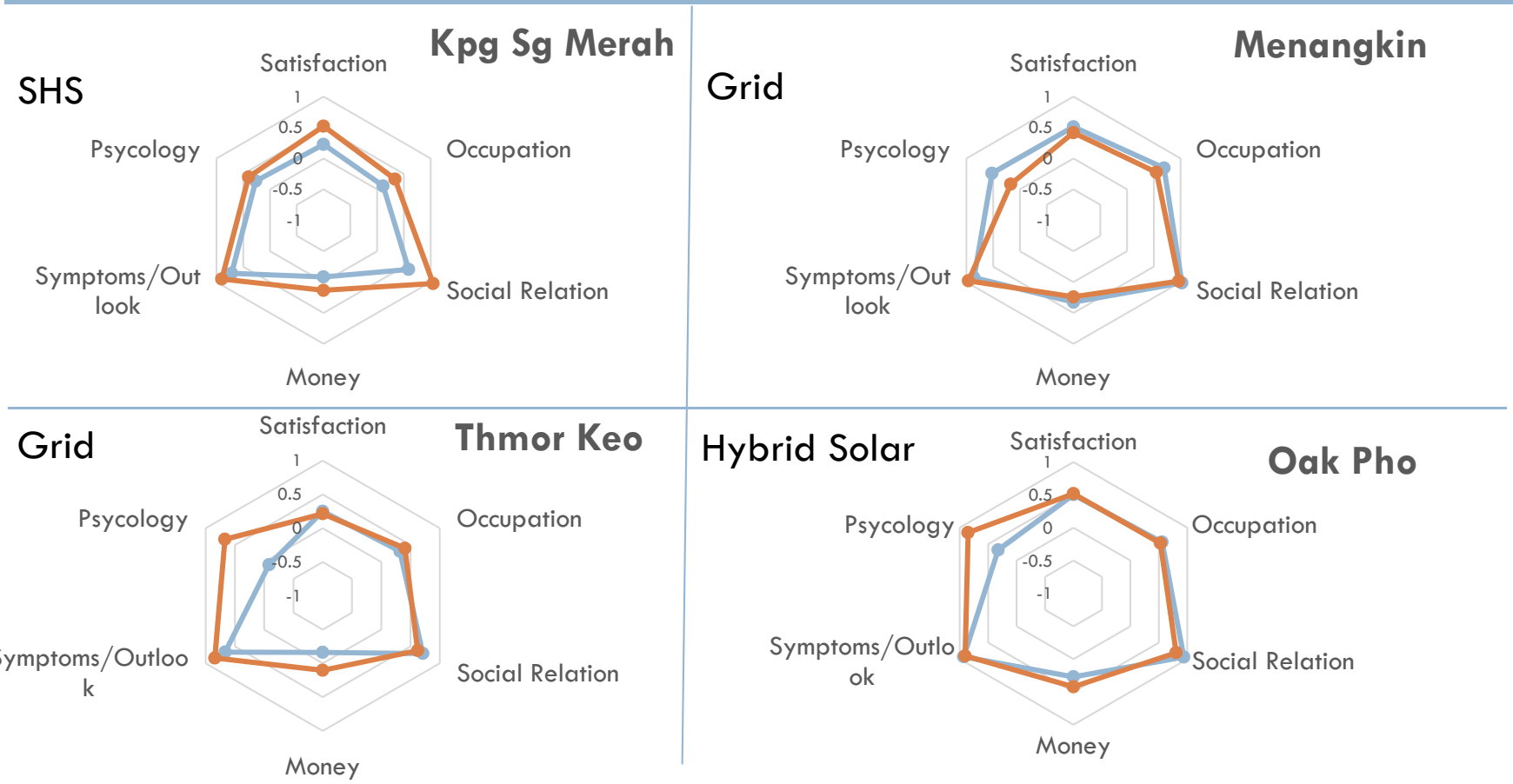
Average Weight Score (AWS), defined as

$$AWS_2 = \frac{\sum_{i=1}^{m} IL_i}{m}$$

The overall quality of life index (QoLI) :

$$\boldsymbol{QoLI = \frac{ADS_2 + \left(\sum_{i=3}^{i=7} w_i DS_i\right)}{AWS_2 + \sum_{i=3}^{i=7} w_i}}$$

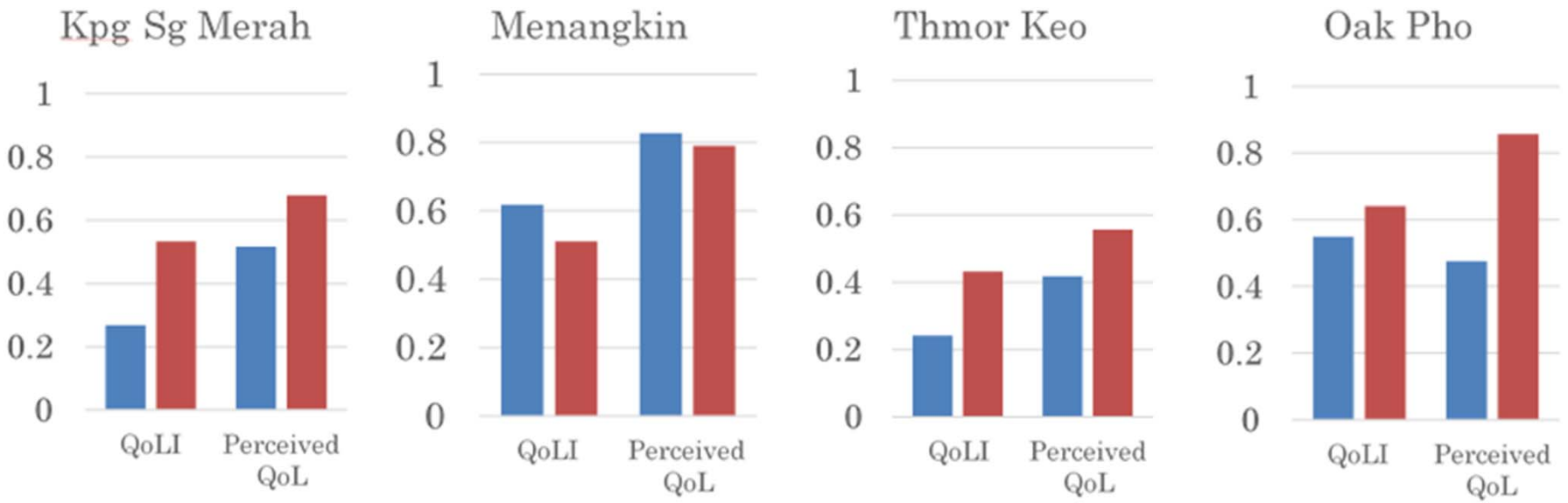
QoLI domains web chart



Before (blue) and After (Red)

- Highest QoL improvement: SHS (Kampung Sungai Merah)

Results: QoLI and Perceived QoL



- QoLI shows the same trend as perceived QoL
  => QoLI reflects the subjective well being felt by the villagers
- Positive changes in most of villages, but drop in Menangkin (grid extension in Malaysia)

Self-reported QoL levels and RE by **country** (1)

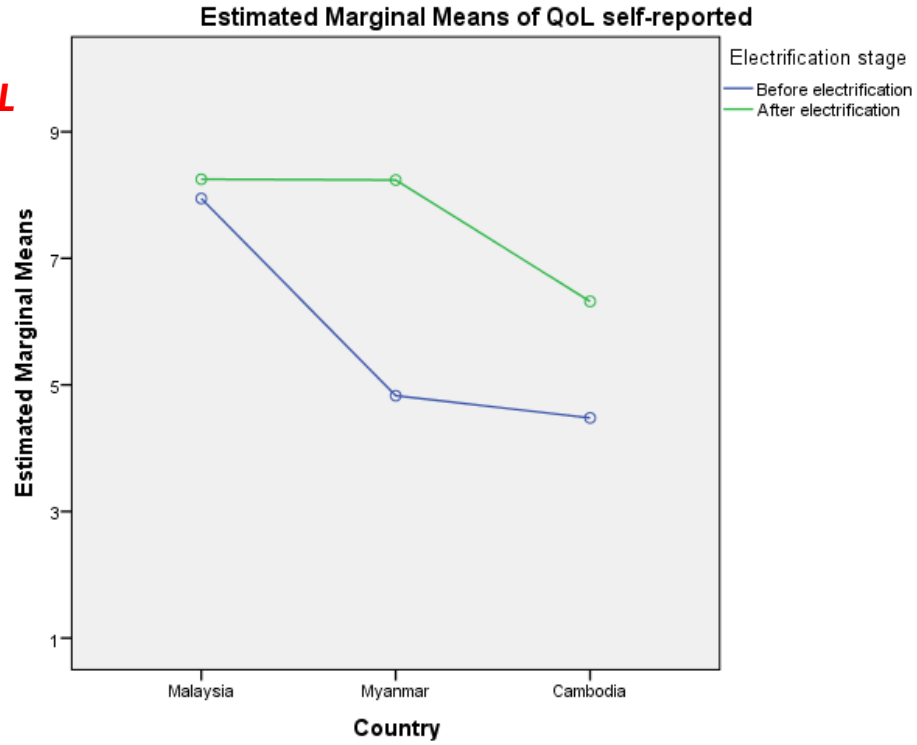
- **Using a two-way ANOVA we measure the effect of electrification and differences by country**
- **In general, the tendency is:**

Electrification associates with higher self-reported QoL levels

Descriptive Statistics

Dependent Variable: QoL self-reported

Electrification stage	Country	Mean	Std. Deviation	N
Before electrification	Malaysia	7.50	2.265	24
	Myanmar	4.84	1.951	19
	Cambodia	4.41	1.970	17
	Total	5.78	2.498	60
After electrification	Malaysia	7.95	1.810	19
	Myanmar	8.29	2.008	35
	Cambodia	6.38	1.987	21
	Total	7.67	2.095	75
Total	Malaysia	7.70	2.065	43
	Myanmar	7.07	2.576	54
	Cambodia	5.50	2.190	38
	Total	6.83	2.460	135



Mean level of self-reported QoL before and after electrification by country

RE and QoL levels by **country** (2)

ANOVA results (plot in previous slide) confirm a significant effect on self-reported QoL even when controlling by countries.

Tests of Between-Subjects Effects

Dependent Variable: QoL self-reported

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	287.395[a]	5	57.479	14.159	.000	.354
Intercept	5496.953	1	5496.953	1354.067	.000	.913
Elec_stage	121.803	1	121.803	30.004	.000	.189
Country	108.064	2	54.032	13.310	.000	.171
Elec_stage * Country	51.205	2	25.602	6.307	.002	.089
Error	523.687	129	4.060			
Total	7108.000	135				
Corrected Total	811.081	134				

a. R Squared = .354 (Adjusted R Squared = .329)

RE and QoL levels by **country** (3)

- Further testing (t-tests) by country confirms that Myanmar and Cambodia have significant changes in the QoL levels, but Malaysia does not.

Independent Samples Test[a]

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
QoL self-reported	Equal variances assumed	.540	.466	-.701	41	.487	-.447	.638	-1.736	.841
	Equal variances not assumed			-.720	40.991	.476	-.447	.621	-1.702	.808

a. Country = Malaysia

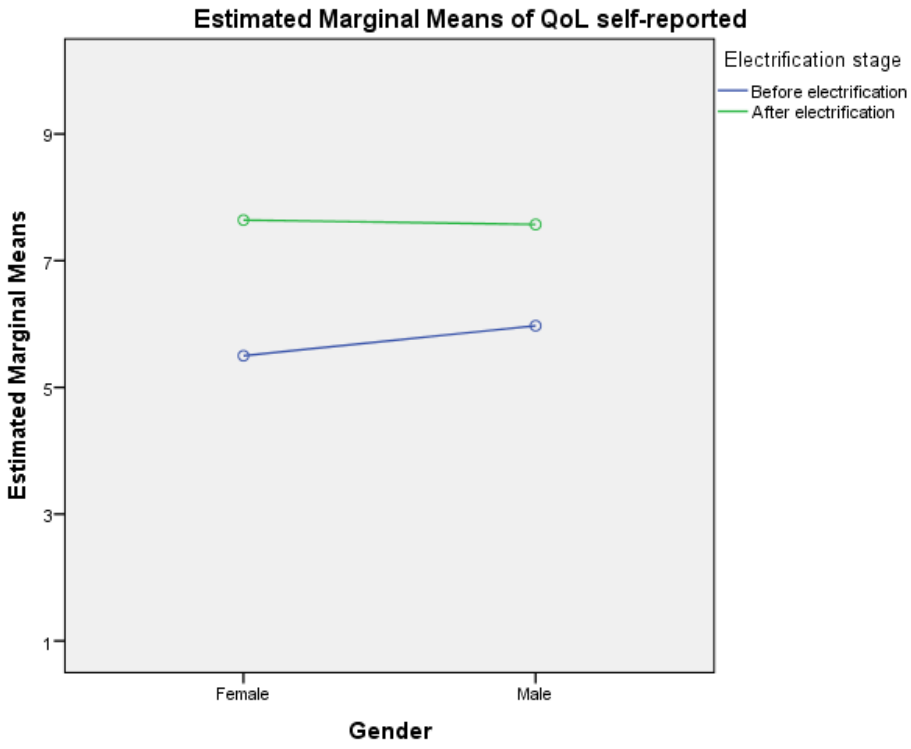
QoL self-reported	Equal variances assumed	.049	.825	-6.076	52	.000	-3.444	.567	-4.581	-2.306
	Equal variances not assumed			-6.130	38.005	.000	-3.444	.562	-4.581	-2.306

a. Country = Myanmar

QoL self-reported	Equal variances assumed	.697	.409	-3.049	36	.004	-1.969	.646	-3.279	-.659
	Equal variances not assumed			-3.052	34.487	.004	-1.969	.645	-3.280	-.659

a. Country = Cambodia

RE and QoL levels **by gender (1)**



- **By gender, we apparently find a similar tendency:**

Higher self-reported QoL levels from electrification

Descriptive Statistics

Dependent Variable: QoL self-reported

Electrification stage	Gender	Mean	Std. Deviation	N
Before electrification	Female	5.50	2.766	24
	Male	5.97	2.324	36
	Total	5.78	2.498	60
After electrification	Female	7.64	1.857	39
	Male	7.57	2.712	21
	Total	7.62	2.171	60
Total	Female	6.83	2.460	63
	Male	6.56	2.571	57
	Total	6.70	2.506	120

RE and QoL levels **by gender (2)**

- ANOVA reports no significant difference, but in fact…

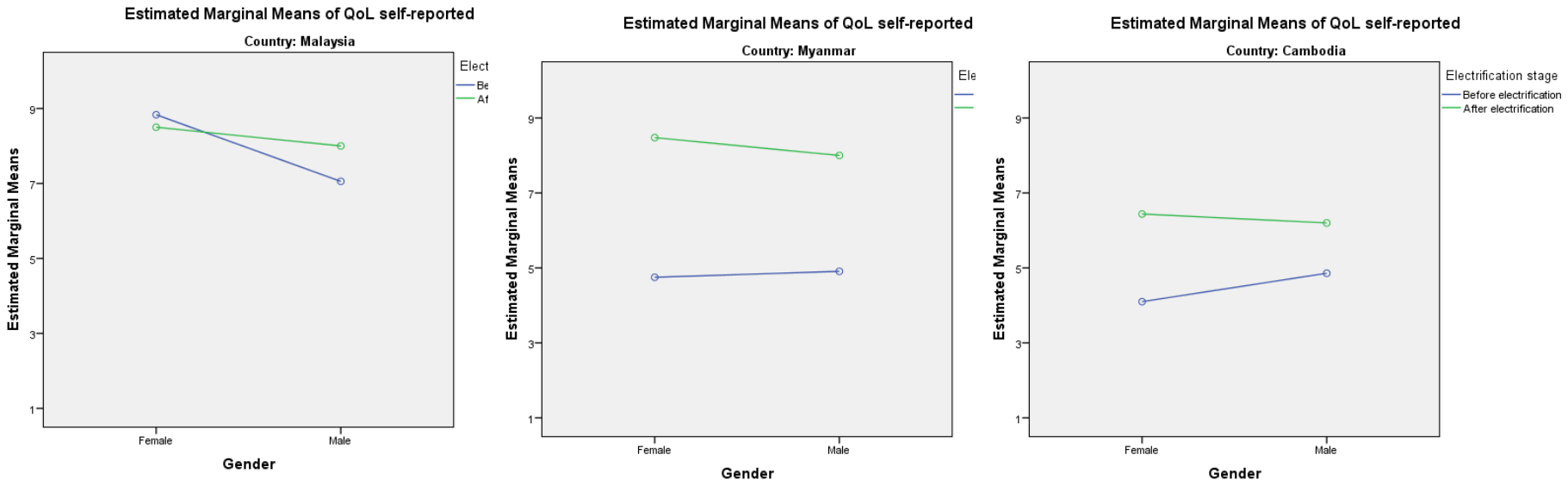
Tests of Between-Subjects Effects

Dependent Variable: QoL self-reported

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	104.111[a]	3	34.704	6.260	.001	.139
Intercept	4989.835	1	4989.835	900.063	.000	.886
Elec_stage	98.030	1	98.030	17.683	.000	.132
Gender	1.136	1	1.136	.205	.652	.002
Elec_stage * Gender	2.057	1	2.057	.371	.544	.003
Error	643.089	116	5.544			
Total	6134.000	120				
Corrected Total	747.200	119				

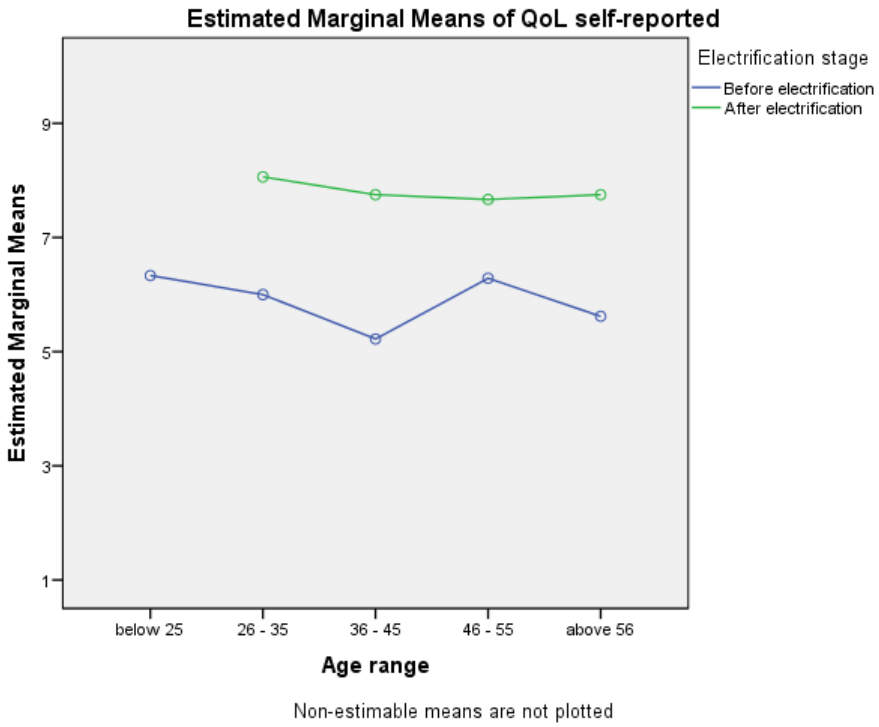
a. R Squared = .139 (Adjusted R Squared = .117)

RE and QoL levels **by gender (3)**



- Further testing by country (t-tests) confirms that Myanmar and Cambodia DO HAVE significant changes, and not in Malaysia.
- **In fact, females observe a slight drop in QoL levels in Malaysia.**

RE and QoL levels **by age (1)**



- **By age ranges, a similar tendency:**
  Higher self-reported QoL levels from electrification
- **Noteworthy that differences are higher for those in the 36-45 year old range**

Descriptive Statistics

Dependent Variable: QoL self-reported

Electrification stage	Age range	Mean	Std. Deviation	N
Before electrification	below 25	6.33	1.528	3
	26 - 35	6.00	2.629	12
	36 - 45	5.22	2.587	9
	46 - 55	6.29	2.431	14
	above 56	5.62	2.655	21
	Total	5.83	2.492	59
After electrification	26 - 35	8.06	1.389	16
	36 - 45	7.75	2.261	12
	46 - 55	7.67	2.871	12
	above 56	7.75	1.603	12
	Total	7.83	2.007	52
Total	below 25	6.33	1.528	3
	26 - 35	7.18	2.229	28
	36 - 45	6.67	2.671	21
	46 - 55	6.92	2.682	26
	above 56	6.39	2.524	33
	Total	6.77	2.479	111

RE and QoL levels **by age (2)**

- Here, ANOVA reports no significant differences, but further testing among groups is still needed

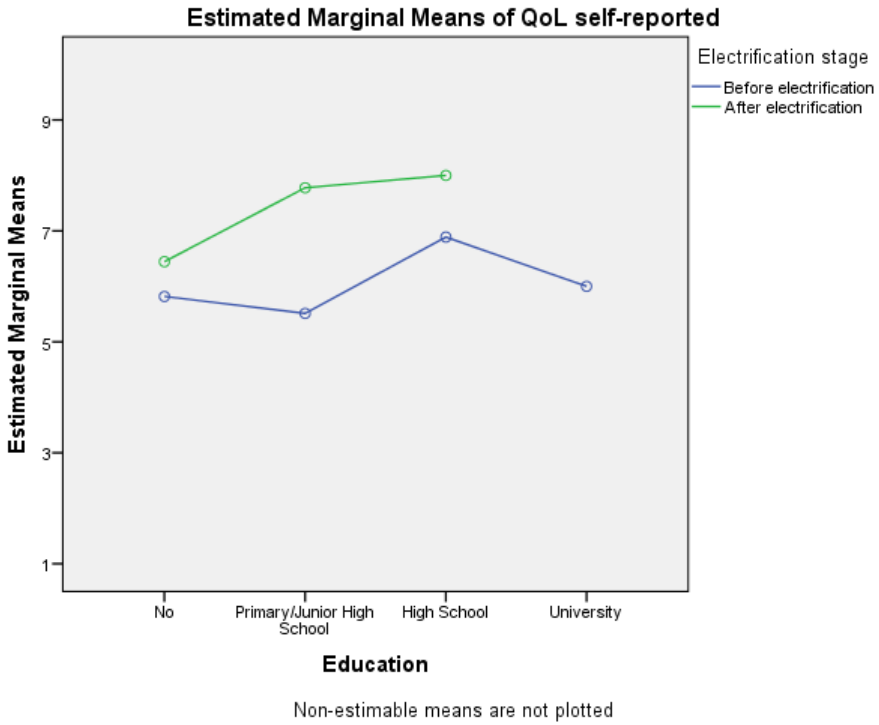
Tests of Between-Subjects Effects

Dependent Variable: QoL self-reported

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	119.774[a]	8	14.972	2.746	.009	.177
Intercept	3160.669	1	3160.669	579.693	.000	.850
Elec_stage	104.866	1	104.866	19.233	.000	.159
Age	5.520	4	1.380	.253	.907	.010
Elec_stage * Age	4.066	3	1.355	.249	.862	.007
Error	556.136	102	5.452			
Total	5757.000	111				
Corrected Total	675.910	110				

a. R Squared = .177 (Adjusted R Squared = .113)

RE and QoL levels **by education level (1)**



- **By education level, a similar tendency:**
  Higher self-reported QoL levels from electrification
- **Noteworthy that differences are higher for those with basic education levels**

Descriptive Statistics

Dependent Variable: QoL self-reported

Electrification stage	Education	Mean	Std. Deviation	N
Before electrification	No	5.82	2.483	11
	Primary/Junior High School	5.51	2.501	39
	High School	6.89	2.619	9
	University	6.00	.	1
	Total	5.78	2.498	60
After electrification	No	6.44	2.698	9
	Primary/Junior High School	7.78	2.120	45
	High School	8.00	1.000	3
	Total	7.58	2.203	57
Total	No	6.10	2.532	20
	Primary/Junior High School	6.73	2.557	84
	High School	7.17	2.329	12
	University	6.00	.	1
	Total	6.66	2.516	117

RE and QoL levels **by education level (2)**

- Also here, ANOVA reports no significant differences, but further testing among groups is still needed

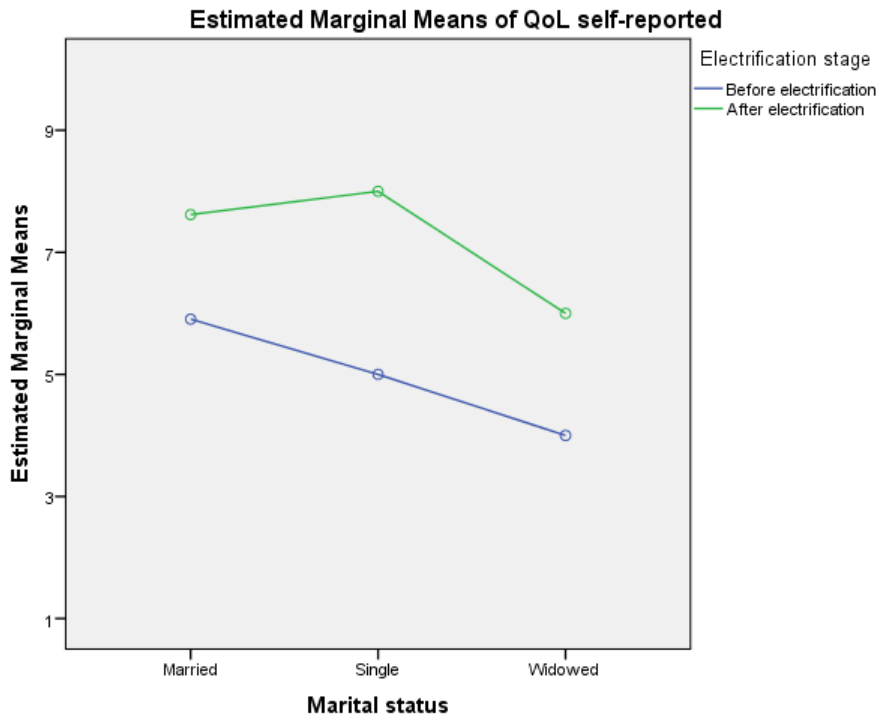
Tests of Between-Subjects Effects

Dependent Variable: QoL self-reported

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	122.056[a]	6	20.343	3.655	.002	.166
Intercept	881.384	1	881.384	158.349	.000	.590
Elec_stage	23.071	1	23.071	4.145	.044	.036
Education	10.904	3	3.635	.653	.583	.017
Elec_stage * Education	12.207	2	6.103	1.097	.338	.020
Error	612.269	110	5.566			
Total	5921.000	117				
Corrected Total	734.325	116				

a. R Squared = .166 (Adjusted R Squared = .121)

RE and QoL levels **by marital status (1)**



- **By marital status, a similar tendency:**
  Higher self-reported QoL levels from electrification
- **Noteworthy that the widowed group is scarce**

Descriptive Statistics

Dependent Variable: QoL self-reported

Electrification stage	Marital status	Mean	Std. Deviation	N
Before electrification	Married	5.91	2.506	53
	Single	5.00	2.608	6
	Widowed	4.00	.	1
	Total	5.78	2.498	60
After electrification	Married	7.62	2.248	55
	Single	8.00	.816	4
	Widowed	6.00	.	1
	Total	7.62	2.171	60
Total	Married	6.78	2.518	108
	Single	6.20	2.530	10
	Widowed	5.00	1.414	2
	Total	6.70	2.506	120

RE and QoL levels **by marital status (2)**

- Once again, ANOVA reports no significant differences, but further testing among groups is still needed

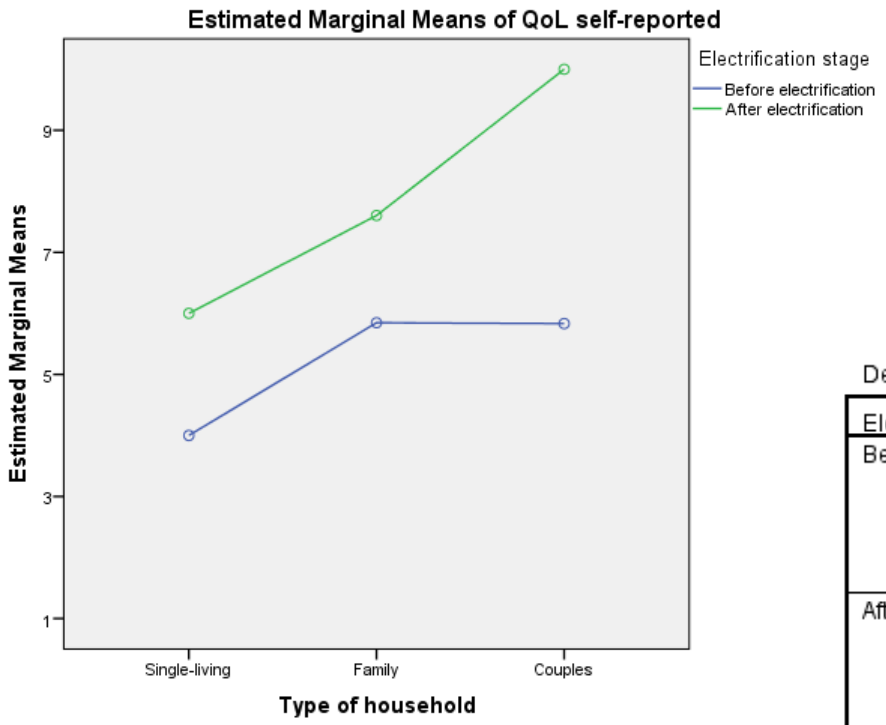
Tests of Between-Subjects Effects

Dependent Variable: QoL self-reported

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	111.690[a]	5	22.338	4.007	.002	.149
Intercept	543.661	1	543.661	97.524	.000	.461
Elec_stage	18.363	1	18.363	3.294	.072	.028
Marital_status	6.562	2	3.281	.589	.557	.010
Elec_stage * Marital_status	3.670	2	1.835	.329	.720	.006
Error	635.510	114	5.575			
Total	6134.000	120				
Corrected Total	747.200	119				

a. R Squared = .149 (Adjusted R Squared = .112)

RE and QoL levels **by type of household (1)**



- **By type of household, a similar tendency:**
  Higher self-reported QoL levels from electrification
- **Noteworthy that the single-living individual household is rare**

Descriptive Statistics

Dependent Variable: QoL self-reported

Electrification stage	Type of household	Mean	Std. Deviation	N
Before electrification	Single-living	4.00	2.828	2
	Family	5.85	2.523	52
	Couples	5.83	2.401	6
	Total	5.78	2.498	60
After electrification	Single-living	6.00	.	1
	Family	7.60	2.176	58
	Couples	10.00	.	1
	Total	7.62	2.171	60
Total	Single-living	4.67	2.309	3
	Family	6.77	2.496	110
	Couples	6.43	2.699	7
	Total	6.70	2.506	120

RE and QoL levels **by type of household (2)**

- Finally for household type, ANOVA reports no significant differences too, but further testing among groups is still needed

Tests of Between-Subjects Effects

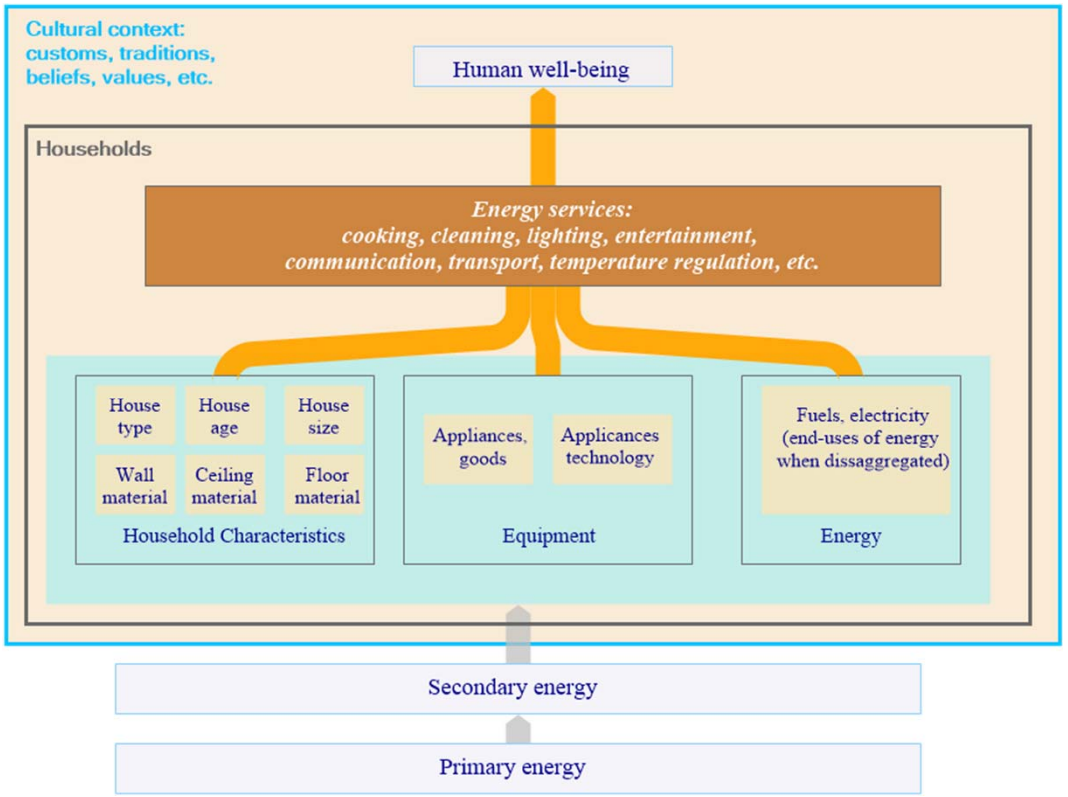
Dependent Variable: QoL self-reported

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	115.718[a]	5	23.144	4.178	.002	.155
Intercept	570.873	1	570.873	103.058	.000	.475
Elec_stage	23.228	1	23.228	4.193	.043	.035
Family_type	12.801	2	6.401	1.155	.319	.020
Elec_stage * Family_type	4.844	2	2.422	.437	.647	.008
Error	631.482	114	5.539			
Total	6134.000	120				
Corrected Total	747.200	119				

a. R Squared = .155 (Adjusted R Squared = .118)

Framework to contextualise results

- To contextualise results a framework is needed where diverse lenses are useful to explain the observed differences.
- One proposal is the view through specific energy services



Challenges in the RE-QoL results

- Complexity in the analysis:
  - Paths in the RE-QoL nexus? (energy services, cultural context)
  - Is there a mediator or suppressing variable?
- Challenges in the development ideology
  - Family life: how many objects form part of social life?
  - Collective systems (systems of exchange of things / energy services)
- Careful examination of possible negative effects
  - Look into people priorities to handle expenses. Have these changed?
- The extent to which questions have potentially disturbed respondents

Conclusions

- Established a collaborative platform to study impacts of different RE schemes on QoL in SE Asian countries:
- Through self-reported QoL results, we have observed differences among countries using Two-way ANOVAS
  - These might reflect differences among RE systems
- Through the QoLI, we have observed diverse magnitudes of well-being change at different domains
- In general results reflect short-term effects, further examination is needed for conclusive results on longer spans.

The way ahead

- Further understanding of domains that report little influence from RE
  - Look into the importance indices placed on QoL domains
  - Examine what has changed in daily life
- Explore cultural meanings in more detail
  - Follow-up local interviews/observations to understand community values that explain outcomes
- Observe the dynamics and change in longer spans

Dissemination

- Articles
  - Ohgaki, H., Farzaneh, H., Rahim, N. A., Che, H. S., Radzi, M. A. M., Wong, W. S., & Hung, L. C. (2015). Study on Quality of Life Change for Rural Community through Rural Electrification by Renewable Energy: Preliminary Result.
  - Ohgaki, H., Che, H.S., Cravioto, J., Kobayashi, S. Farzaneh, H., Rahim, N. A. Impacts Evaluation through Objective and Subjective Measurements in Rural Electrification Schemes in Southeast Asia. (under review)
- Conferences
  - JASTIP Symposium ASEAN-Japan STI collaboration for SDGs (2017)
  - Energy and Society in Transition: 2nd International Conference on Energy Research and Social Science (2019) Phoenix, Arizona

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