

# Household Perceptions of Renewable Energy Adoption in Response to the Rise of Residential Electricity Demand in Thailand

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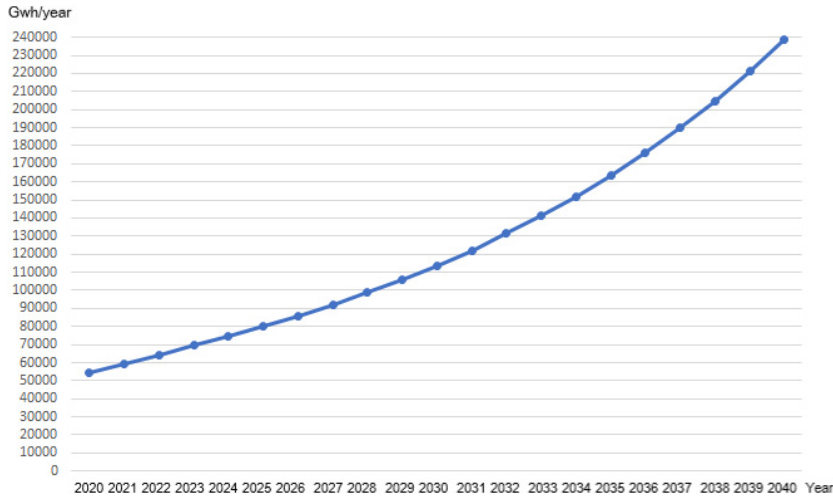
**Abstract.** The pandemic changed the lifestyle of people to more online approaches. This results in more electricity demand that requires effective management. The rising demand urges governments worldwide to consider renewable energy for electricity generation to minimize environmental impacts and global warming issues. This study utilizes the systematic review to extract key factors affecting households' adoption of renewable energy in response to the rise of residential electricity demand in Thailand. The best-worst method is performed to determine the important weights of key factors so that the Thai government can establish suitable plans to enhance the adoption. The analysis results reveal that economic-related factors, including investment cost, operating cost, and financial incentives, are top-ranked for households when making adoption decisions. Specifically, the investment cost of renewable energy like solar power and biomass in Thailand is high compared with many Asian countries. The operating and maintenance costs are also high due to limited technology and skills. It is suggested that the government promote campaigns related to renewable energy, like solar power and biomass, to enhance the adoption rate and achieve the country's green targets.

## 1 Introduction

The world has changed since the outbreak of the COVID-19 pandemic. Lifestyles and work practices shift towards online platforms, and more electronic devices are utilized in daily life, increasing electricity demand. In Thailand, the residential sector significantly contributes to the electricity demand, specifically during and after the pandemic. Kaewfak and Chinda [1] developed a system dynamics (SD) model to examine the trend of electricity demand during and after the COVID-19 pandemic in the residential sector in Thailand. They concluded that the demand will increase by one time in the next 10 years and become three times higher in the next 20 years (see Fig. 1). They also stated that the increase in electricity demand will continue to rise after the pandemic due to changes in human lifestyles.

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**Fig. 1.** Trend of residential electricity demand in Thailand [1].

The rise of electricity demand in Thailand raises concerns about energy availability, climate change, and global warming, as electricity generation still relies on non-renewable energies like coal and natural gas. The Thai government has initiated several plans and strategies to mitigate the global warming crisis, aiming to reduce greenhouse gas (GHG) emissions by up to 40% and increase the share of renewable energy to 35% by 2030, achieving carbon neutrality by 2050, and reaching net-zero emissions by 2065. This net-zero target is consistent with many in Asian countries like Indonesia, Nigeria, and India, but much later than those like Japan, the USA, and the UK, which aim to achieve the target by 2050 [2].

The residential sector is in Thailand's second-highest electricity consumption rank in the past 10 years, following the industrial sector, representing about 25% of total consumption [3]. The demand rises by 6% annually on average, with the residential sector having the highest growth rate of 9.1% in 2023. The rising demand urges using renewable energy to minimize the environmental impacts of electricity generation. The Department of Renewable Energy Development and Energy Efficiency [2] has set the target that by 2037, half of the electricity generation must come from renewable energy sources. In 2022, Thailand's share of renewable energy in electricity generation was only 10-14%, mainly from biomass, solar, wind, and hydropower (domestic and imported). Specifically, biomass and solar power have received much attention in recent years for several reasons, such as lower solar power installation costs, improved solar technologies, and waste generation [3].

In the residential sector, households are encouraged to install solar rooftops and utilize biomass to lower the demand for the electricity grid and GHG emissions. However, the adoption rate of solar energy is still low in Thailand for several reasons. Limited technologies, government subsidies and support, and public awareness are crucial to achieving successful solar energy adoption. Tunpaiboon [3] agreed that cost effectiveness, technological advancements, energy independence, and urbanization are key market drivers for successful solar adoption. Public opposition is key to waste-to-energy implementation due to concerns about hazardous gases and air pollutants from solid waste combustion and investment cost.

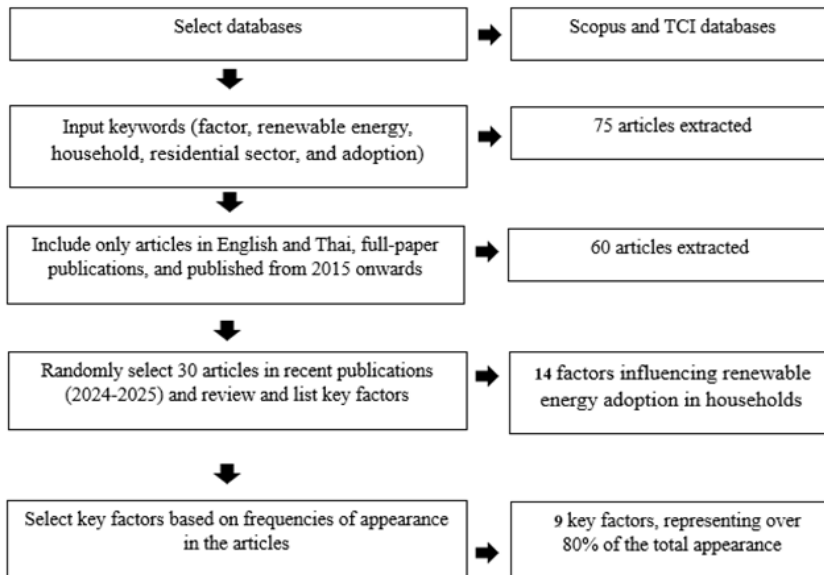
To better understand the challenges and barriers to adopting renewable energy, specifically solar and biomass energies, in households, it is crucial to list the key factors affecting the adoption decisions and rank their importance to establish proper plans. This study performs a systematic literature review to list key factors influencing the adoption of renewable energy in the residential sector and utilizes the best-worst method to rank the best

and worst factors based on households' perceptions. The study results are linked with the governments' strategies to suggest a way to enhance the adoption of renewable energy in this sector.

## 2 Literature review

This study follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement to identify key factors influencing household adoption of renewable energy. The Scopus and Thai Journal Citation Index Center (TCI) databases are used as major data sources. Scopus is an extensive database that many authors use to conduct literature review and retrieve relevant articles based on a search query related to the research objectives. Conversely, TCI is Thailand's database for Thai and English publications.

The process involves identifying relevant search keywords and creating search queries within the databases, screening search results using filters, such as languages, document types, and publication dates, and downloading the identified articles. The search was conducted during May – June 2025. The initial search by inputting keywords, namely factor, renewable energy, household, residential sector, and adoption in the "article title, abstract, keyword" section, yields 60 articles. The search is limited to English articles and the publication dates from 2015 onwards. It is noted that the extracted articles include studies from Thailand and other countries. The extracted articles are further screened using manual screening to facilitate keyword searches within the downloaded articles and help screen out irrelevant ones. In this study, 30 articles published in 2024-2025 were skimmed by manually downloading the articles and examining key factors. Duplicated or similar terms, such as solar power, solar energy, and solar rooftop, are grouped manually into a single term. The groupings of the duplicated terms were discussed with colleagues working in this field before confirming the groupings and avoiding possible bias (see Fig. 2).



**Fig. 2.** Key factors selection using a systematic review.

The results yield 14 key factors influencing household renewable energy adoption, representing 80% of the total factor list. The cut-off level of 80% is a standard parameter employed in various scholarly journals. After that, the list of 14 factors is input into the

Scopus database to list the frequencies of appearance of each factor in 60 articles previously extracted. The final nine most prevalent factors influencing the renewable energy adoption of households are listed: environmental concern, investment cost, financial incentive, attitude towards renewable energy, government policy, operating cost, existing technology, peer influence, and family income; see Table 1.

- Environmental concern (ENV): Renewable energy, such as solar and wind power, is a common source for the electricity sector in Thailand to minimize CO<sub>2</sub> emissions and environmental impacts. Chayutthanabun *et al.* [4] commented that renewable energy should be encouraged in electricity generation to minimize environmental impacts.
- Investment cost (INV): Solar power's high investment cost limits its applicability in the residential sector in Thailand. Iamtrakul and Kritsanawonghong [5] agreed that solar power is not widely used in Thailand due to its high initial investment.
- Financial incentive (INT): Public financial incentives should be strengthened and prioritized to accelerate small-scale and community-based renewable energy models. The National Energy Policy Committee promoted a \$0.07/kWh incentive program for excess energy generated by residential solar power installations [6]. However, this incentive is low compared to the installation cost, resulting in a few residential customers joining the program.
- Attitude towards renewable energy (ATT): Attitude is an indicator of renewable energy utilization in communities. Jotaworn *et al.* [7] mentioned that householders have a positive attitude towards renewable energy, though it may increase their electricity bills.
- Government policy (POL): To increase the share of renewable energy, several government policies have been initiated, such as the Alternative Energy Development Plan, Power Development Plan, and National Energy Policy [7].
- Operating cost (OPR): Operating cost is a financial metric in the feasibility analysis of hybrid energy systems for communities in Thailand. Stolarski *et al.* [8] stated that a change in operating costs highly affects the profitability of solar power utilization.
- Existing technology (TEC): The Thai government must develop clear technology-specific targets to ensure all communities have access to reliable, clean, affordable electricity. Iamtrakul and Kritsanawonghong [5] stated that technology improvement is rarely addressed when considering renewable energy adoption.
- Peer influence (PER): Strong neighbor networks and peer effects are crucial for solar energy adoption. O'Shaughnessy *et al.* [9] stated that peer effects strongly influence rooftop solar adoption, specifically high-income households.
- Family income (INC): The demand for solar home systems in cities is limited by consumers' awareness, lack of sufficient income to support and maintain the system, lack of technical knowledge, and uncertainty in after-sales services. Haq *et al.* [10] commented that a family's financial condition affects the acquisition of renewable energy equipment.

The nine factors are used with the best-worst method to rank their importance so that the government and related stakeholders may develop successful implementation plans.

**Table 1.** Nine factors extracted from the systematic review and frequency analysis.

Factor	Frequency (%)	Cumulative frequency (%)
Environmental concern	13.3	13.3
Investment cost	10.6	23.9

Financial incentive	9.7	33.6
Attitude towards renewable energy	8.8	42.5
Government policy	8.8	51.3
Operating cost	8	59.3
Existing technology	8	67.3
Peer influence	7.1	74.3
Family income	6.2	<b>80.5</b>
Market uncertainty	4.4	85
Electricity price	4.4	89.4
Available infrastructure	3.5	92.9
Payoff period	3.5	96.5
Appearance	3.5	100

### 3 Materials and methods

#### 3.1 Best-worst method (BWM)

Several methods may be used to examine key factors and calculate their important weights. For example, Vitharana and Chinda [11] examined key factors affecting lower back pain due to whole-body vibration exposure using exploratory factor analysis (EFA) and structural equation modelling (SEM) approaches. The results reveal five key factors, namely equipment, job related, organizational, personal, social context. The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) may be performed to select green suppliers for the Thai local production. The results pinpointed the importance of product quality, price, and pollution control in the selection process. The Decision-Making Trial and Evaluation Laboratory (DEMATEL) method may be used to examine factors influencing the construction project schedule and concluded that design error is crucial to ensure on-time project completion.

In this study, the best-worst method (BWM) is considered for ranking household perceptions of renewable energy adoption in response to the rise of electricity demand. It is a popular multi-criteria technique based on pairwise comparisons to calculate the weights. The small number of pairwise comparisons and the high consistency rate are the main advantages over other weighting methods. Pamucar *et al.* [12] stated that this method overcomes shortcomings of the AHP, where optimal values of weight coefficients are obtained with  $2n-3$  comparisons in criteria pairs. A small number of comparisons in pairs removes inconsistencies during the criteria comparison. In the BWM, comparisons are performed by comparing the advantages of the best criterion over all other criteria and the advantages of such other criteria over the worst criterion. This eliminates redundant comparisons.

BWM comprises five steps: defining the setoff decision making criteria, getting the experts to define the best and worst criteria, performing the pairwise comparison by

comparing the preferences of the best criterion over other criteria using the scales 1 – 9, where 1 means equally important and 9 means very much more important, comparing the preferences other criteria over the worst criterion using the scales 1 – 9, and computing the weights of the criteria. The calculated weights are confirmed using the consistency ratio that indicates the degree of consistency of the comparisons; see Table 2 [12].

**Table 2.** Acceptable consistency ratio [13].

Comparison matrix	Consistency ratio
1	0
2	0.44
3	1
4	1.63
5	2.3
6	3
7	3.73
8	4.47
9	5.23

### 3.2 Expert selection and data collection

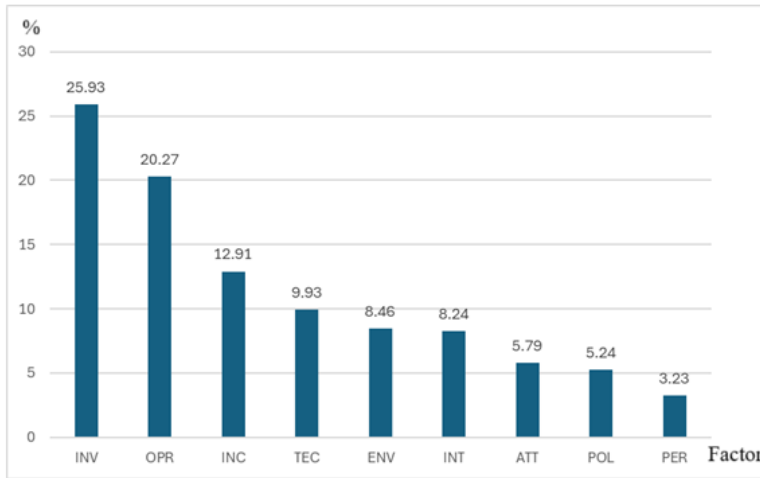
Data collection is performed through interviews with households that are aware of renewable energies and their utilization to minimize the environmental impacts, GHG emissions, and global warming. They are asked to compare the nine factors using the scale 1-9, by comparing the most influential factor with others and the other factors with the least influential factor. Based on Pamucar et al. [12], minimum responses for the BWM are  $2n - 3$ , where  $n$  is the number of criteria considered in the study. As a result,  $(2 \times 9) - 3 = 15$  interviewees were involved in the analysis. They are householders who know about renewable energy, specifically solar cells and biomass, and intend to utilize renewable energy in their premises. Interviews were performed online, and interviewees were informed about the aim and objectives of the study.

## 4 Results and discussion

The interviews were conducted during May - June 2025. The important weights of the nine factors from 15 interviewees are calculated and confirmed with the consistency ratios (see Fig. 3). The final weights of the criteria are calculated using the geometric means; see Fig. 4. The top three most important factors include investment cost, operating cost, and financial incentives. The investment cost is the most crucial (with the important weight of 25.93%) when considering utilizing renewable energy, especially solar and biomass. This is consistent with Iamtrakul and Kritsanawonghong [5], who stated that the investment cost of solar power installation is high in Thailand, which is about \$910/kW. This is higher than in many countries like China, India, and Italy. The investment in a household biodigester is \$150 with a lifespan of two years. The cost could be raised to over \$400/unit for a high-quality biogas.

Criteria Number = 9	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Criterion 5	Criterion 6	Criterion 7	Criterion 8	Criterion 9	
Names of Criteria	ENV	INV	INT	ATT	POL	OPR	TEC	PER	INC	
Select the Best	INV									
Select the Worst	PER									
Best to Others	ENV	INV	INT	ATT	POL	OPR	TEC	PER	INC	
INV	2	1	2	4	2	1	2	6	1	
Others to the Worst	PER									
ENV	3									
INV	7									
INT	4									
ATT	2									
POL	2									
OPR	7									
TEC	6									
PER	1									
INC	7									
Weights	ENV	INV	INT	ATT	POL	OPR	TEC	PER	INC	
	0.10055866	0.16759777	0.10055866	0.05027933	0.07821229	0.18994413	0.10055866	0.02234637	0.18994413	
Input-Based CR	0.03333333	The pairwise comparison consistency level is acceptable								
Associated Threshold	0.3262									

**Fig. 3.** An example of best-worst analysis.



**Fig. 4.** The BWM analysis results.

Households also consider the long-term operating cost and financial incentives of renewable energy utilization (with the important weights of 20.27% and 12.91%, respectively). Gamonwet and Dhakal [6] stated that without financial incentives, such as low loan interest, tax credits, and refunds, investing in a solar power system is not economically feasible. Tunpaiboon [3] commented that technological advancement will assist in lowering the operating cost and improving efficiency. Outdated technology and infrastructure limitations slow the progress of renewable energy adoption.

Interestingly, the results show that government policy and peer influence have the lowest important weights of 5.24% and 3.23%, respectively. Many interviewees mention that supporting policies related to households' renewable energy utilization in Thailand are still weak and not widely promoted. Gamonwet and Dhakal [6] stated that the Ministry of Energy set the power tariff for solar power bought from households at 6 cents/kWh; this is expected to increase the amount of solar power bought from households to more than 90 MW by 2030. This will support the Thai government's plan to utilize renewable energy by 33% by 2030 and 51% by 2037.

## 5 Conclusions

Renewable energy has gained attention in recent years to minimize the requirement of fossil fuels, CO<sub>2</sub>, GHG emissions, and environmental impacts. Electricity generation in Thailand relies heavily on fossil fuels like natural gas and diesel. The rise of residential electricity demand, particularly after the pandemic, urges the government to promote renewable energy like solar power and biomass. This study examines households' perceptions of renewable energy use in response to the rise in electricity demand. Nine key factors are retrieved from systematic literature and frequency analyses: environmental concern, investment cost, financial incentive, attitude towards renewable energy, government policy, operating cost, existing technology, peer influence, and family income. BWM is utilized to determine the important weights of the nine criteria from the expert interviews. The analysis results reveal that investment cost, operating cost, and financial incentives are the top three factors for households when adopting renewable energy. The government should provide incentives and subsidize initial costs to encourage more renewable energy adoption in households. The environmental benefits of using renewable energy should also be promoted to raise awareness and participation in renewable energy campaigns. Using biogas to replace fossil fuels yields benefits when considering economic and environmental effects. Solar systems in Thailand have high investment and maintenance costs and installing them requires specialized skills. The Thai government should promote the use of solar energy to meet the targets set in the country's green policies [13].

The results reveal that households rank peer influence and government policy as the least important factors when making renewable energy adoption decisions. The Thai government should launch and promote related policies to increase household participation in this issue. Such campaigns as the People's Solar Program (where excess energy generated by residential solar power installations may be sold to the government), the income tax deduction of up to \$5800 for the installation of residential solar rooftops, and the Solar Plus Project, where the developers install solar rooftops for households for free to allow the general public to generate and sell electricity, should be promoted to enhance the renewable energy adoption in Thailand to achieve the country's green targets [13].

This study provides a better understanding of household perceptions regarding renewable energy adoption in response to the rise of residential electricity demand. It guides the Thai government and related authorities to an efficient plan for supporting and promoting long-term use of renewable energy in Thailand. This study has some limitations. Data is collected from a limited household. Extending the number of data may yield better results. Key factors retrieved from systematic literature are not limited to the Thai context. Future studies are recommended to examine complex relationships between key factors influencing the adoption decisions, utilizing a dynamic simulation modeling technique or optimization models.

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