European Proceedings of
Finance and Economics
EpFE
www.europeanproceedings.com
e-ISSN: 2672-8958

DOI: 10.15405/epfe.23081.21

ISEBA 2022
International Symposium & Exhibition on Business and Accounting 2022

MEASURING THE IMPACT OF ECONOMIC MODERNIZATION ON ENERGY EFFICIENCY IN MALAYSIA

Nor Salwati Othman (a)*, Yugavathi Gunasaeran (b)
*Corresponding author

(a) College of Business Management and Accounting, The Energy University, Muadzam Shah Pahang, Malaysia, norsalwati@uniten.edu.my
(b) College of Graduate Studies, The Energy University, Malaysia, gunasaeranyuga@gmail.com

Abstract

Energy efficiency is vital to the progress of GHG emission reduction. However, the role of modernization in improving energy efficiency and emission reduction in Malaysia is still being researched. The main objective of this study is to measure how economic modernization affects energy efficiency in Malaysia. In this case, modernization is represented by industrialization growth, urbanization growth, and income growth. The F-Bound co-integration analysis is utilized to determine the existence of a long-run interaction among the variables. Then, dynamic regression is used to measure the strength of the relationships between modernization indicators and energy efficiency. The result shows the existence of a long-run relationship between energy efficiency and economic modernization. Income growth significantly improves energy efficiency in the short-run and long-run. Conversely, urbanization growth and industrialization growth negatively impact energy efficiency. The study's results have major policy implications for Malaysia's decision-makers in accelerating the country's growth toward achieving a high-income nation status, thus facilitating Malaysia's transition to a carbon-free economy.

Keywords: Energy efficiency, modernization, urbanization, national income, industrialization

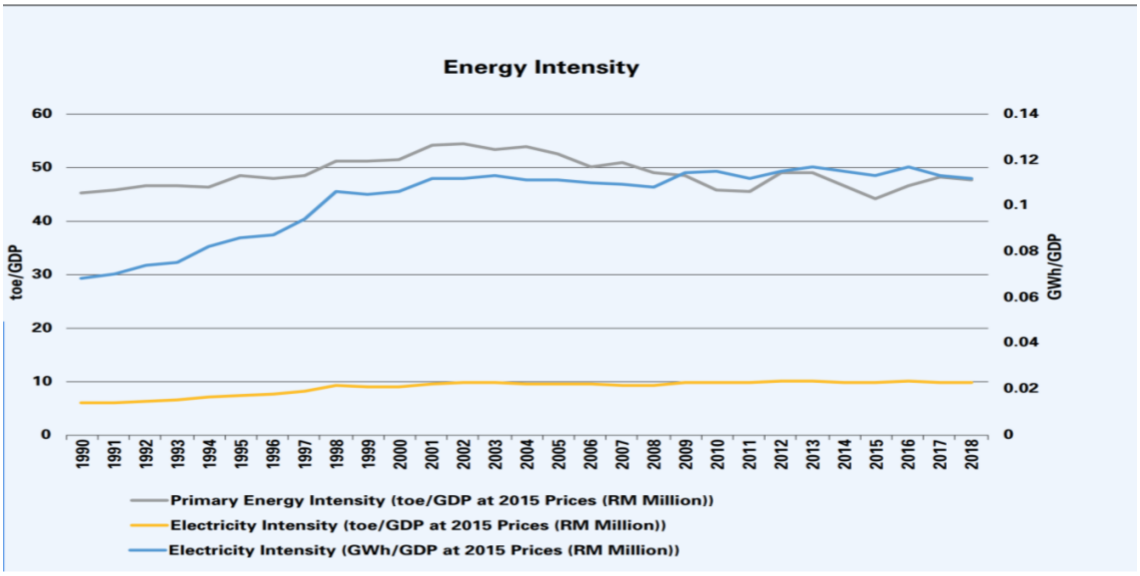
https://doi.org/10.15405/epfe.23081.21
Corresponding Author: Nor Salwati Othman
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2672-8958

1. Introduction

Carbon dioxide emissions are the primary source of the climate change on a global scale. It is widely acknowledged that emissions must be reduced promptly to prevent worsening effects of the climate change such as extreme weather and interrupted of ecological condition. In this regard, the Paris Agreement adopted in December 2015 aims to limit the increase in the average global temperature to 1.5°C (Tanaka & O'Neill, 2018).

Accordingly, Malaysia has unreservedly committed to lowering its intensity of greenhouse gas (GHG) emissions by 45% from 2005 levels by 2030 (Energy Commission, 2019). The country also aims to attain carbon neutrality in 2050 (Povera & Yunus, 2021). However, achieving carbon neutrality by 2050 is a challenging task. One of the solutions is to improve energy efficiency, which is possible if the energy required to carry out particular tasks decreases continuously. To encourage the adoption of energy efficiency in the public and private sectors, the National Energy Efficiency Action Plan 2016–2025 was created. Its goal is to reduce the growth of electricity demand by 8% over the course of 10 years, resulting in a total reduction of GHG emissions of 38 million tonnes of carbon dioxide equivalent (MIDA, 2022). Additionally, extended through 2023 are the Green Investment Tax Exemption (GITE) for using green technology services and the Green Income Tax Allowance (GITA) for purchasing green technology assets. (The STAR, 2021).

In such a scenario, improvement in energy efficiency is crucial in reducing the environmental pressures. However, the data reported in Figure 1 on energy intensity (declines in energy intensity are a proxy for efficiency improvements) do not provide convincing evidence that the status of energy efficiency may improve in the future.



Source: Energy Commission (2020)

Figure 1. Malaysia's energy intensity

Malaysia's modernization process makes meeting energy and environmental targets more complicated. Modernization is a universal trend of human civilizations toward development. The process of modernization encompasses a variety of activities, such as technical advancement, industrial

https://doi.org/10.15405/epfe.23081.21
Corresponding Author: Nor Salwati Othman
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2672-8958

upgradation, and improvements to the environment and living conditions (Li et al., 2019). In China, modernization is viewed as a process of social rebirth connected to the alteration of the distinctive features of traditional civilizations, such as paradigm shifts in the economics, communication, environment, and axiology (Rošker, 2019). In Malaysia's case, urbanization and industrial and economic development represent the modernization process because the urbanization, industrialization, and economic transition occurs in tandem with technical advancement, industrial upgrading, and improvements in the environment and living standards.

It is critical to investigate the relationship between energy efficiency and economic modernization to design energy efficiency and carbon neutrality policies during Malaysia's modernization. Thus, the main objective of this research is to measure how economic modernization impacts energy efficiency. In this case, energy efficiency is measured by the reduction in energy used to perform certain economic and social activities. This examination is carried out using dynamic regression via ARDL and FMOLS models. In addition, the novelty of this work is in embedding the role of modernization and its impact on energy efficiency. To the best of the researcher's knowledge, there are very few reviews addressing this issue. Most of the previous research focused on the impact of economic modernization on environmental quality.

The structure of this paper is as follows. Section 2 reviews the past studies. Section 3 and 4 provide the research methodology and result analysis, respectively. Section 5 concludes with a summary of concrete outcomes, relevant policy implications, and pathways for further research in this area.

2. Literature Review

Modernization represents the general tendency toward progress within human civilizations; it consists of a range of processes including industrial upgrading, technological progress, and improvements in the environment and living standards (Li et al., 2019). The modernization theory recognizes urbanization, industrialization, and economic development as part of modernization because of the transmission process embedding the aforementioned criteria.

Commonly, the urbanization, industrialization, and economic development process are accompanied by an increase in energy demand because of the vital role of energy in every inch of economic activity. However, the transmission mechanisms of urbanization, industrialization, and economic development are different. For example, urbanization growth is associated with an increase in energy efficiency. However, on the other side, urbanization worsens the level of energy efficiency.

As elaborated by Lv et al. (2020), urbanization is a process in which people move from rural to urban areas, consumer behaviour and lifestyle change, increased adoption of electric appliances, economic structure change due to agricultural mechanisation and expansion of energy-intensive industry, infrastructure construction and maintenance, transportation growth due to long-distance mobility and commuting, and urban logistics and service are all factors. Therefore, this transmission process was predicted to create high energy demand (Shah et al., 2020). From another perspective, the transmission of the urbanization process is more complex. The urbanization process along with technological improvement and economies of scale resulted in improvement of energy efficiency and reduced the overall energy used (Lv et al., 2020). For instance, Shah et al. (2020) scientifically examined the empirical relationship between emission, urbanization, and energy intensity in Pakistan from 1980 to 2017 and discovered that urbanization

https://doi.org/10.15405/epfe.23081.21
Corresponding Author: Nor Salwati Othman
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2672-8958

growth impacted energy intensity positively, or in other words, urbanization reduced energy efficiency. For the case of China, Li et al. (2018) and Lv et al. (2020) also found a similar finding. In contrast, Markandya et al. (2006) measured the impact of urbanization on energy efficiency in 12 Eastern European countries and discovered a negative relationship between the variables.

In terms of industrial development, He et al. (2021) investigated the ability of China's industrial sector energy efficiency to combat environmental pollution and discovered that industrial restructuring reduced pollution by improving energy efficiency. However, Imran et al. (2020) found a negative relationship between energy efficiency and the production of cotton in Pakistan.

From another perspective, Song and Zheng (2012) measured the driver of energy intensity in China and revealed that rising income played a significant role in reducing energy intensity via improvements in energy intensity. Similar findings were found by He et al. (2021) who measured the role of energy efficiency in combating environmental pollution in China and Chang et al. (2018) for the case of OECD countries. Conversely, a study by Pan et al. (2013) revealed the improvement in China's economic development negatively impacted the level of energy efficiency, mainly in coal consumption.

In sum, previous literature found inconsistent impacts of modernization on energy efficiency due to the different stages of urbanization and industrial and economic development. The interactions between the variables become more complex with the disruption of technological improvement and economies of scale. The current research intends to measure the impact of modernization on energy efficiency in Malaysia. Based on the finding, this research can determine the ability of technology and economies to scale to impact the modernization transition.

3. Empirical Model and Methodology

This study intends to measure the impact of economic modernization on energy efficiency. In this case, modernization is proxied by income growth, urbanization growth, and industrialization growth. This is because modernization involves continuous transformation processes from the traditional to the modern form in terms of technology, economy, communication, lifestyle, and civilization (Li et al., 2019). The framework of the study is illustrated in Figure 2.

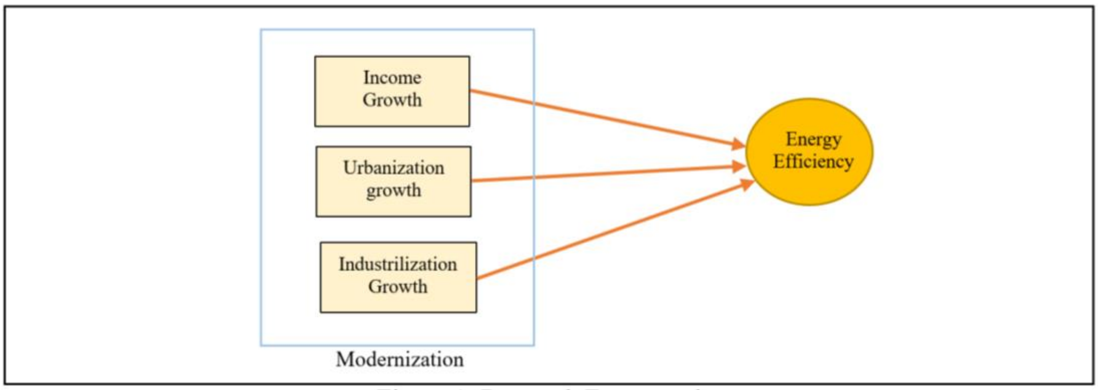


Figure 2. Framework of the research

https://doi.org/10.15405/epfe.23081.21
Corresponding Author: Nor Salwati Othman
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2672-8958

Alternatively, the empirical model can be written as equation 1:

$$\ln EEt = \ln\alpha 1 + \alpha 2\ln Gt + \alpha 3\ln URt + \alpha 4\ln INt + \varepsilon \quad [1]$$

where lnEE, lnG, lnUR, and lnIN represent the natural logarithm of energy efficiency, income, urbanization, and industrialization growth, respectively. Then, αi [i = 1,2,3,4] represents the elasticities of the explaining variables that also indicate a positive impact on energy efficiency, and vice versa. The larger the elasticity coefficient, the larger the impact on energy efficiency (Xu et al., 2020). Figure 3 summarizes the econometric procedures implemented in this research to verify the hypotheses and accomplish the study's objectives (for details, see Bekhet & Othman, 2017, 2018).

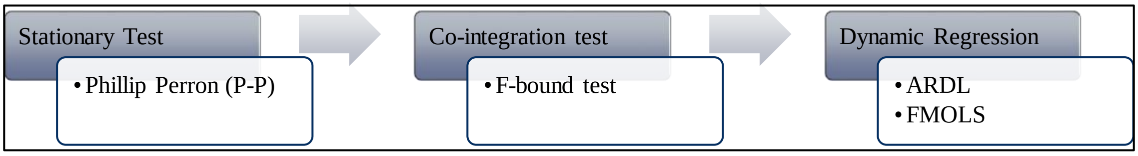


Figure 3. Estimation procedure

4. Result Analysis

The stationarity level of the data set was assessed by utilizing the Phillip Perron (P-P) test, and the results are illustrated in Table 1. It shows that all variables (lnEE, lnG, lnIN) are substantially stationary [I(1)] at 1% except for lnUR, which is stationary at I(0). These results are similar with majority of the earlier studies that utilized financial and macroeconomics variables (Bekhet & Othman, 2017, 2018).

Table 1. The stationary result

Variable	Level	P-P statistic	Critical value			Decision
			1%	5%	10%	
lnEE	$I(0)$	-2.25	-3.60	-2.93	-2.60	I(1)
	$I(1)$	-7.10***				
lnG	$I(0)$	-1.12				I(1)
	$I(1)$	-4.68***				
lnIN	$I(0)$	-1.29				I(1)
	$I(1)$	-4.25***				
lnUR	$I(0)$	-2.97**				I(0)
	$I(1)$	-0.54				

Note: ***, **, * indicate 1%, 5%, and 10% level of significant respectively. Type of test = ADF statistic.
Source: Output of EWIEWS package version 12.

Next, the optimum lag was determined by using Akaike Information Criterion (AIC) as suggested by Sugiawan and Managi (2016). The AIC statistic revealed the appropriate lag length to be used is 3. Then, the F-bound test assessment was utilized to measure the co-integration relationship between energy efficiency and its determinants. In the current case, the F-bound test is the best option compared to other kinds of co-integration techniques due to the combination of I(0) and I(1) levels of stationarity and the small

https://doi.org/10.15405/epfe.23081.21
Corresponding Author: Nor Salwati Othman
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2672-8958

sample size, which is equivalent to 41. Table 2 presents the result of the F-Bound test. The result shows the presence of long-run relationships between the variables at the 5% significance level over the 1980–2020 period. This is because the calculated F-statistic for the model is higher than the upper bound critical value at the 5% level of significance.

Table 2. Result of F-bound test

Model	F-Stat.	Critical Value			Decision
		Level	I(0)	I(1)	
Model 1: lnEE/ lnG,lnIN,lnUR	4.51**	10%	2.59	3.34	Co-integrated
		5%	3.1	4.08	
		1%	4.31	5.54	

Note: ***, **, * indicate 1%, 5%, and 10% level of significant respectively. Type of test = F-bound test.
Source: Output of EWIEWS package version 12.

The long-run elasticities between lnEE, lnG, lnIN, and lnUR are being measured using the error correction model. The estimated results are shown in Table 3. It shows that lnG has a positive significant impact on lnEE, which means economic development improves the level of energy efficiency and reduces the energy used in Malaysia due to technological improvement and economies of scale. However, when employing the FMOLS, the same result was attained (refer to Table 5). This finding is consistent with He et al. (2021) and Song and Zheng (2012) but inconsistent with Pan et al. (2013).

On the other hand, lnIN and lnUR show negative significant impacts on lnEE. It implies that urbanization and industrial development increase the energy demand due to infrastructure construction and maintenance, transportation growth from long-distance mobility and commuting, and urban logistics and service. This development does not move in line with technological improvement and economies of scale, or the magnitudes of urbanization and industrial development are bigger than the magnitude of technological improvement. These findings are in line with Markandya et al. (2006) and Imran et al. (2020) but in contrast with He et al. (2021), Lv et al. (2020), Shah et al. (2020), and Li et al. (2018).

Regarding the short-run scenario, lnG shows a positive significant impact on lnEE. The ECM coefficient has a negative value, which means that over time, there is a 58% adjustment toward the long-run equilibrium. Besides, urbanization development was identified as a major factor influencing energy efficiency, followed by economic development and industrialization development.

Table 3. Long run and short run ımpact on energy efficency

Variables	**Level Equation Case 2: Restricted Constant and No Trend**		
	Coefficient	**t-Statistic**	**Prob.**
Long -Run			
lnG	0.37	2.25	0.03
lnIN	-0.26	-3.94	0.00
lnUR	-0.81	-2.23	0.03
C	-3.00	-12.47	0.00
Short-run			
ΔlnG	0.51	4.42	0.00
ECT(-1)	-0.58	-5.02	0.00
ECT = lnEE- (0.37*lnG -0.26*lnIN -0.812*lnUR – 3.00)			

https://doi.org/10.15405/epfe.23081.21
Corresponding Author: Nor Salwati Othman
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2672-8958

The robustness of the model was confirmed by running several diagnostic tests, as presented in Table 4. All tests showed that the model satisfies the expected econometric qualities, including a valid functional form and residuals that are normally distributed, serially uncorrelated, and homoscedastic (Law, 2008).

Table 4. Results of reliability test

Test	F-Stat/ Probability	Decision
Normality test	1.85 (0.39)	H_0: Normal distributed
Breusch-Godfrey Serial Correlation test	0.04 (0.95)	H_0: No serial correlation
ARCH-Heteroscedasticity test	0.001 (0.97)	H_0: No Heteroscedasticity
Ramsey RESET test	0.57 (0.45)	H_0: Model has a correct functional form.

Additionally, the cumulative sum of recursive residuals (CUSUM) and the cumulative sum of squares of recursive residuals (CUSUMSQ) were used to investigate the stability tests of the coefficients. The results exhibited the CUSUM and CUSUMSQ curves are still within the 5% significance level's critical bounds (see Figure 4). The stability of the error correction model's long-run and short-run coefficients is specified by these statistical features.

Table 5. Long run impact on energy efficency

Dependent Variable: LE
Method: Fully Modified Least Squares (FMOLS)
Sample (adjusted): 1981 2020
Included observations: 40 after adjustments
Co-integrating equation deterministics: C
Long-run covariance estimate (Bartlett kernel, Newey-West fixed bandwidth = 4.0000)

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
LG	0.492597	0.105562	4.666410	0.0000
LIN	-0.234872	0.045280	-5.187090	0.0000
LUR	-1.094241	0.224933	-4.864750	0.0000
C	-2.944503	0.173317	-16.98912	0.0000
R-squared	0.718185	Mean dependent var		-3.876689
Adjusted R-squared	0.694701	S.D. dependent var		0.060908
S.E. of regression	0.033654	Sum squared resid		0.040773
Long-run variance	0.001445			

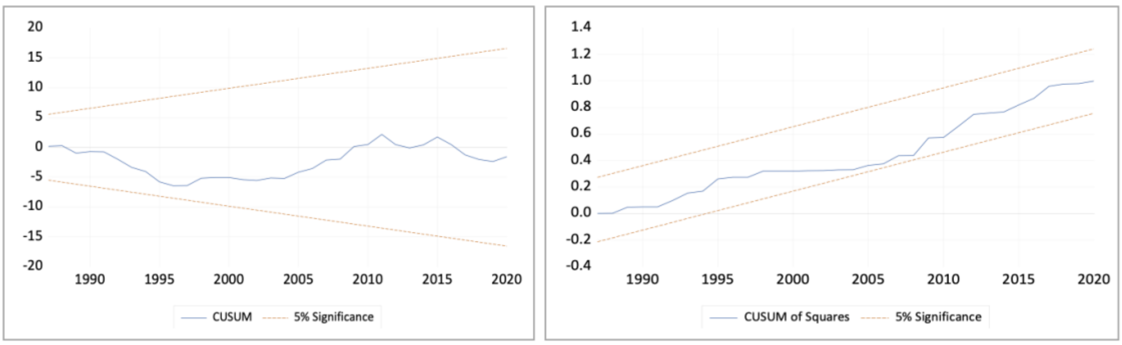


Figure 4. CUSUM and CUSUMSQ statistics

https://doi.org/10.15405/epfe.23081.21
Corresponding Author: Nor Salwati Othman
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2672-8958

5. Conclusion and Policy Implications

Modernization involves a broad pattern of social growth that takes place within human civilizations and is characterized by advancements in technology, the industrial sector, and the environment along with higher living standards. Urbanization, industrialization, and economic growth are among the indicators that represent the modernization criteria. These activities could bring either positive or negative consequences to the environment, mainly in terms of greenhouse gas (GHG) emissions. As the role of energy continues to increase in supporting all economic and social activities, energy efficiency becomes key in making progress on GHG emission reduction. In this regard, Malaysia has made a commitment to cut its greenhouse gas emissions by 45% from 2005 levels by 2030. The National Energy Efficiency Action Plan 2016–2025 was initiated to encourage the adoption of energy efficiency in public and private sectors by reducing the electricity demand growth by 8% over 10 years with a total GHG emission reduction of 38 million tonnes of carbon dioxide equivalent. This research attempts to quantify the influence of modernization on energy efficiency in Malaysia in order to help meet the country's energy and environmental goals. In addition, understanding what drives the change in Malaysia's energy efficiency is imperative for forecasting the future trend and designing effective policy instruments that can promote energy efficiency.

To find out whether the variables have long-run interactions, the F-Bound co-integration analysis is used. Then, dynamic regression is used to measure the strength of the relationships between modernization indicators and energy efficiency. The result shows the existence of a long-run relationship between energy efficiency and economic modernization. Income growth significantly improves energy efficiency in the short-run and long-run. Conversely, urbanization growth and industrialization growth negatively impact energy efficiency. The study's results have major policy implications for Malaysia's decision makers in accelerating the country's growth toward attaining a high-income nation status, allowing Malaysia to transition easily to a carbon-free economy. To do so, Malaysia needs to improve the technology know-how, specifically in terms of the expertise, products, and systems involved in the urbanization transition process. The country also needs to enhance the technology involved in the industrial transition and the economies of scale. This research only focuses on a linear relationship between modernization and energy efficiency. Thus, future researchers are suggested to measure the nonlinear relationship between the aforementioned variables.

Acknowledgments

The authors would like to acknowledge IRMC UNITEN for awarding a BOLD2021 grants for funding this research.

References

Bekhet, H. A., & Othman, N. S. (2017). Impact of Urbanization Growth on Malaysia CO_2 emissions: Evidence from the Dynamic Relationship. *Journal of Cleaner Production*, *154*, 374-388. https://doi.org/10.1016/j.jclepro.2017.03.174

Bekhet, H. A., & Othman, N. S. (2018). The Role of Renewable Energy to Validate Dynamic Interaction Between CO_2 Emissions and GDP Toward Sustainable Development in Malaysia. *Energy Economics*, *72*, 47–61. https://doi.org/10.1016/j.eneco.2018.03.028

https://doi.org/10.15405/epfe.23081.21
Corresponding Author: Nor Salwati Othman
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2672-8958

Chang, C. P., Wen, J., Zheng, M., Dong, M., & Hao, Y. (2018). Is higher government efficiency conducive to improving energy use efficiency? Evidence from OECD countries. *Economic Modelling*, *72*, 65-77. https://doi.org/10.1016/j.econmod.2018.01.006

Energy Commission. (2019). National Energy Balance. https://meih.st.gov.my/

Energy Commission. (2020). Malaysia Energy Statistics Handbook. https://www.st.gov.my/

He, Y., Liao, N., & Lin, K. (2021). Can China's industrial sector achieve energy conservation and emission reduction goals dominated by energy efficiency enhancement? A multi-objective optimization approach. *Energy Policy*, *149*, 112108. https://doi.org/10.1016/j.enpol.2020.112108

Imran, M., Özçatalbaş, O., & Bashir, M. K. (2020). Estimation of energy efficiency and greenhouse gas emission of cotton crop in South Punjab, Pakistan. *Journal of the Saudi Society of Agricultural Sciences*, *19*(3), 216-224. https://doi.org/10.1016/j.jssas.2018.09.007

Law, S. H. (2008). Does a country's openness to trade and capital accounts lead to financial development: Evidence from Malaysia. *Asian Economic Journal*, *22*(2), 161–177. https://doi.org/10.1111/j.1467-8381.2008.00273.x

Li, K., Fang, L., & He, L. (2018). How urbanization affects China's energy efficiency: a spatial econometric analysis. *Journal of Cleaner Production*, *200*, 1130-1141. https://doi.org/10.1016/j.jclepro.2018.07.234

Li, S., Zhou, C., & Wang, S. (2019). Does Modernization Affect Carbon Dioxide Emissions? A Panel Data Analysis. *Science of the Total Environment*, *663*, 426-435. https://doi.org/10.1016/j.scitotenv.2019.01.373

Lv, Y., Chen, W., & Cheng, J. (2020). Effects of Urbanization on Energy Efficiency in China: New Evidence from Short Run and Long Run Efficiency Model. *Energy Policy*, *147*, 111858. https://doi.org/10.1016/j.enpol.2020.111858

Markandya, A., Pedroso-Galinato, S., & Streimikiene, D. (2006). Energy intensity in transition economies: Is there convergence towards the EU average? *Energy Economics*, *28*(1), 121-145. https://doi.org/10.1016/j.eneco.2005.10.005

MIDA (Malaysia Industrial Development Authority). (2022). Energy Efficiency and Energy Conservation. https://www.mida.gov.my/industries/services/green-technology/energy-efficiency-and-energy-conservation/

Pan, H., Zhang, H., & Zhang, X. (2013). China's provincial industrial energy efficiency and its determinants. *Mathematical and Computer Modelling*, *58*(5-6), 1032-1039. https://doi.org/10.1016/j.mcm.2012.09.006

Povera, A., & Yunus, A. (2021, September 27). Malaysia to become carbon-neutral by 2050. *News Strait Times.* https://www.nst.com.my/news/nation/2021/09/731278/malaysia-become-carbon-neutral-2050

Rošker, J. S. (2019). *Following his own path: Li Zehou and contemporary Chinese philosophy*. SUNYPress.

Shah, S. A. R., Naqvi, S. A. A., & Anwar, S. (2020). Exploring the linkage among energy intensity, carbon emission and urbanization in Pakistan: fresh evidence from ecological modernization and environment transition theories. *Environmental Science and Pollution Research, 27*(32), 40907-40929. https://doi.org/10.1007/s11356-020-09227-9

Song, F., & Zheng, X. (2012). What drives the change in China's energy intensity: Combining decomposition analysis and econometric analysis at the provincial level. *Energy Policy*, *51*, 445-453. https://doi.org/10.1016/j.enpol.2012.08.044

Sugiawan, Y., & Managi, S. (2016). The environmental Kuznets curve in Indonesia: Exploring the potential of renewable energy. *Energy Policy*, *98*, 187-198. https://doi.org/10.1016/j.enpol.2016.08.029

The STAR. (2021). Gearing up for energy efficiency. https://www.thestar.com.my/business/business-news/2021/12/13/towards-more-efficient-use-of-energy

Tanaka, K., & O'Neill, B. C. (2018). The Paris Agreement zero-emissions goal is not always consistent with the 1.5 °C and 2 °C temperature targets. *Nature Climate Change, 8*(4), 319-324. https://doi.org/10.1038/s41558-018-0097-x

Xu, F., Huang, Q., Yue, H., He, C., Wang, C., & Zhang, H. (2020). Reexamining the Relationship between Urbanization and Pollutant Emissions in China based on the STIRPAT Model. *Journal of Environmental Management*, *273*, 111134. https://doi.org/10.1016/j.jenvman.2020.111134