Enhanced Knowledge in Sciences and Technology Vol. 3 No. 1 (2023) 207-215

EKST

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/ekst
e-ISSN : 2773-6385

Comparative Analysis of Energy Efficiency Action Plans of Malaysia and Ireland Using Text Mining

Kimberly Chan Li Kim[1], Khuneswari P Gopal Pillay[2*]

[1] Fuze Ecoteer Outdoor Adventures Sdn. Bhd.
(Perhentian Turtle Project)
171, Kampung, Pulau Perhentian Kecil,
22300 Besut, Terengganu, MALAYSIA

[2] Department of Mathematics and Statistics,
Faculty of Applied Sciences and Technology,
Universiti Tun Hussein Onn Malaysia (Pagoh Campus),
84600 Pagoh, Muar, Johor, MALAYSIA

*Corresponding Author Designation

DOI: https://doi.org/10.30880/ekst.2023.03.01.024
Received 15 January 2023; Accepted 11 April 2023; Available online 3 August 2023

Abstract: The growing population and energy demand across the globe has become a significant concern to the environment as it continues to strain non-renewable resources. The National Energy Efficiency Action Plan (NEEAP) aims to achieve energy efficiency targets across EU has recently been adopted by Malaysia in 2015. The current problem is the energy consumption of Malaysia increases every year and is the highest consumer in Asia while Ireland is responsible for 30 per cent of greenhouse gas emissions in the European Union (EU) because its economy is based on agriculture. The objectives of this research are to identify topic models of the initiatives in the action plans using Non-Negative Matrix Factorization, to generate a word cloud of the common terms in the action plan and to identify the key differences of the focus between the two action plans. The text from the action plan is pre-processed and text mining is carried out with Python programming language using the natural language toolkit, SpaCy and scikit-learn libraries. Both Malaysia and Ireland showed the energy and efficiency as the most frequent in the word cloud, followed by electricity and industrial, and transport, building, and public respectively. This showed a link between the topics and the frequent words appearing in the action plan. The objectives of this research were achieved, and text mining was able to find differences between the two action plans. Potential measures for future NEEAPs for Malaysia with a topic prediction model using NMF can be learned from the action plans of other developed and developing countries and N-grams can be used to extract collocation of words to create a sophisticated word cloud.

*Corresponding author: khuneswari@uthm.edu.my

Keywords: Text Mining, Energy Efficiency Action Plan, Non-Negative Matrix Factorization, Word Cloud

1. Introduction

Energy has evolved over the centuries more so due to the advanced complexity of human society. The growth of the human population meant a higher demand and necessity for energy [1]. Generating energy from non-renewable resources has left a concerning impact on the environment. It was described as terminals between energy-driven capitalism and the many tipping points of climate change [2]. The economic growth of a country comes with the risk of higher carbon dioxide emissions, and conversely reduced emissions poorly affect the economy [3]. Energy efficiency action plans have been an important strategy to mitigate the trade-off and manage energy consumption by delivering greater output with minimal input [4]. It can improve energy savings, environmental sustainability, and energy security [5]. However, the alternatives to energy consumption have been more focused in developed countries which plays an effect on the development of other countries [6]. Malaysia faces a gap in economic strength compared to developed countries. The gap affects the ability to catch up with the sustainable development goal of affordable and clean energy, which is why improvements in energy efficiency (EE) are a vital and fundamental step to achieving the objective [7].

In recent years, Malaysia was found to be the highest energy consumer in Asia and only 8 per cent of the total energy composition was renewable energy (RE). In accordance with the Paris Agreement in 2015, Malaysia released a 10-year NEEAP over aggressive energy consumption [8][9]. The economy of Ireland was driven by agriculture which accounts for over 30 per cent of the greenhouse gas (GHG) emissions in the European Union (EU) [10]. The top nine energy-efficient countries in EU scored between 0.9998 to 1 while Ireland in tenth place scored 0.8576 and had a large projection difference in carbon dioxide emissions by 0.816 per cent [3].

These evaluations have placed Ireland under immense pressure despite ranking as the top ten energy-efficient countries in the EU. Malaysia is taking its first step in EE with initiatives that tackle the smallest yet significant issues. Active EE efforts are not done alone but collectively. The awareness and involvement of energy consumers also play a role in improving energy savings in all sectors and ensuring a sustainable future for Malaysia.

The research focuses on the comparison between the NEEAP of Malaysia and Ireland using text mining approaches. The objective is to identify topic models of the initiatives in the action plans using the Non-Negative Matrix Factorization, to generate a word cloud of the common terms used in the action plans, and to identify the key differences of the focus between the action plans. At the time of writing, Ireland has released four NEEAPs [11] while Malaysia has one. The progressive improvements of Ireland can be a steppingstone for Malaysia to be in the ranks as an energy-efficient country.

2. Methodology

The text in the NEEAP of Malaysia and Ireland underwent text pre-processing followed by text mining approaches such as N-gram and NMF topic modelling. Libraries such as Natural Language Toolkit, SpaCy and scikit-learn were used in the Python programming language to carry out the methodology. This study proposes Non-Negative Matrix Factorization and Word Cloud as exploratory tool to compare the content from NEEAP documents in both countries.

2.1 Text pre-processing

Prior to text mining applications, text must undergo pre-processing. The pre-processing includes tokenization, lowercase conversion, punctuation removal, stopwords removal, parts-of-speech tagging, and lemmatization [12]. Figure 2 shows the process of the text-preprocessing.

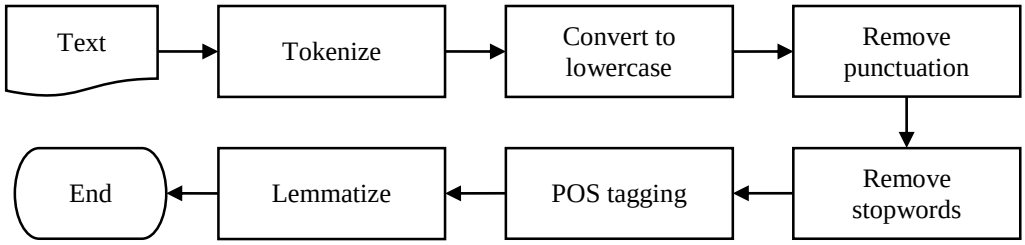

Figure 1: Flowchart process of the text pre-processing

The text is first tokenized which removes white space in the document and breaks the text to identify tokens. Next, the words containing uppercase are converted into lowercase and the punctuation is removed from the corpus. Stop words that do not provide significant meaning to the corpus are also removed. Parts of speech tagging, or POS tagging is a process that grammatically tags tokens to its corresponding part of speech. Lastly, the remaining tokens are lemmatized to extract the root words.

2.2 Non-Negative Matrix Factorization

Non-Negative Matrix Factorization (NMF) is a statistical method that reduce the dimension of a text. It is a topic modelling approach that creates insightful topics of unstructured bodies of text [13]. NMF decomposes the word matrix and encodes a latent structure to cluster text documents [14]. The text will be vectorized using the Term Frequency – Inverse Document Frequency (TF–IDF) before creating the NMF algorithm to build topic models.

To extract TF–IDF, the frequencies of a term that appear in the text document is multiplied with the number of documents that the term appears in, that is, the inverse document frequency. Since the method is carried out using the scikit-learn library in Jupyter, the IDF (Eq. 1) is as follows:

$$IDF(t) = \log\frac{1+n}{1+df(t)} + 1 \qquad Eq.1$$

The result from the TF–IDF is then applied to the factorization as illustrated in Figure 1 [15].

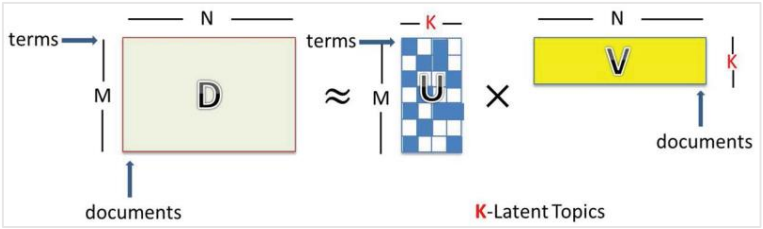

Figure 2: Non-negative matrix factorization

2.3 Word Cloud

Word cloud is an easy way to display the frequencies of words visually. The font size represents the occurrence of the words found in the text document [16]. Other aesthetic features of a word cloud are colour and layout that could better communicate the dynamic semantic relations of words [17].

3. Results

The results of the text mining approaches for the NEEAPs of Malaysia and Ireland is presented below and the results from these two countries are further compared and discussed.

3.1 Malaysia

```
Topic 0:
efficiency growth malaysia building project efficient sector development
Topic 1:
management facility audit green implement large commercial technology
Topic 2:
building tariff gas new barrier co generation power
Topic 3:
co reduce demand electricity efficiency reduction development malaysia
Topic 4:
market penetration expect per annual total base equal
Topic 5:
rm cost action national benefit efficiency million total
Topic 6:
initiative key label programme appliance efficient promotion meps
Topic 7:
standard equipment minimum audit efficiency meps performance campaign
Topic 8:
efficiency action national implementation use monitor unit data
Topic 9:
audit large government consumption total market annual save
```

Figure 3: Non-negative Matrix Factorization of NEEAP Malaysia

Figure 3 is the NMF model output obtained of 10 topics from the NEEAP Malaysia text. The topics are distinct with top 8 keywords found from the corpus and are translated with better comprehensive topics in Table 1.

Table 1: Translations of NMF topics of NEEAP Malaysia

Topic	Translations of NMF topics
0	Electric efficient buildings development project
1	Audit large commercial facility
2	CO2 generation tariff
3	Reduce electricity demand
4	Total annual market of energy consumption
6	Efficient appliances consumer campaign/key initiative
7	Audit efficiency performance standard of industry equipment
8	Monitor NEEAP projects
9	Audit government savings

The topic models are closely related as a chain of events. The first topic is about developing energy efficient buildings as it can significantly reduce the life cycle energy demand. Topic 1 is to audit large commercial facilities as it consumes the most energy out of all sectors and to solve this issue is by adopting carbon taxation which punishes high energy consumers [8] [18]. A regular energy audit of industry sectors equipment to ensure that commercial sectors comply with the energy efficiency standards of performance. Besides that, housing and buildings can benefit from the main key initiatives of the NEEAP, that is the 5-star electric efficient appliances. In turn, the overall demand and consumption can be reduced as mentioned in Topic 3 with continuous monitoring of the actions planned in the NEEAP. To summarize, the NMF approach found topics about electricity demand and savings, auditing energy consumption, consumer campaigns and projects.

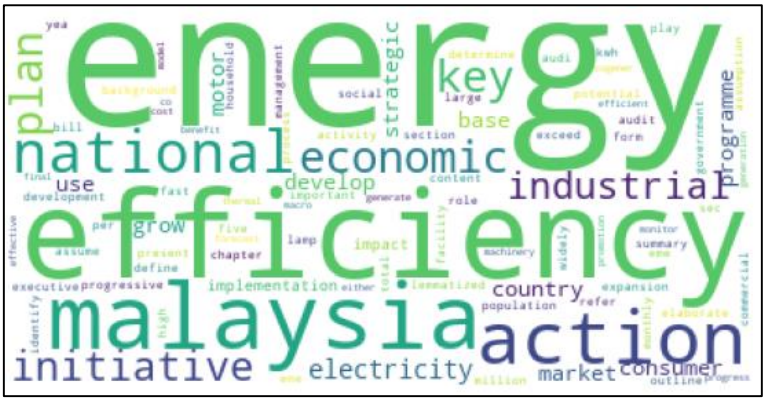

Figure 4: Word Cloud of NEEAP Malaysia

Figure 4 shows the top 100 words found in the National Energy Efficiency Action Plan of Malaysia and Ireland. The words ‘energy’, ‘efficiency’, ‘Malaysia’, ‘national’, ‘action’, and ‘plan’ are frequently mentioned in the NEEAP Malaysia text as its name suggests. Apart from that, the action plan emphasized on ‘key’, ‘initiative’, ‘economic’, ‘industrial’ and ‘electricity’ as its first steps toward improving the energy efficiency in Malaysia.

3.2 Ireland

```
Topic 0:
scheme home ber support efficiency community fund measure
Topic 1:
building dwelling regulation performance housing requirement renovation part
Topic 2:
demand system transmission network tso distribution service generator
Topic 3:
vehicle fuel emission bus tax fleet car new
Topic 4:
public sector target efficiency body neeap consumption saving
Topic 5:
transport city travel public investment centre people sustainable
Topic 6:
audit seai small register train support business industry
Topic 7:
market product eu regulation implementation directive efficient legislation
Topic 8:
meter supplier customer tariff smart must electricity gas
Topic 9:
heat renewable scheme electricity gas ireland grid heating
```

Figure 5: Non-negative Matrix Factorization of NEEAP 4 Ireland

Figure 5 is the NMF model output obtained of 10 topics from the NEEAP 4 Ireland text. The topics are distinct with top 8 keywords found from the corpus and are translated with better comprehensive topics in Table 2.

Table 2: Translations of NMF topics of NEEAP 4 Ireland

Topic	Translations of NMF topics
0	BER, home efficiency support scheme
1	Building/Housing renovation regulation
2	Transmission System Operator (TSO)
3	New fuel bus
4	Public sectors saving target
5	Sustainable transport
6	SEAI support
7	EU directive
8	Electricity smart meter
9	Heating grid

The NMF topics for NEEAP 4 Ireland contain distinct categories. Topic 7 is the European Union policing energy efficiency since the SAVE Directive [19]. Topic 0 refers to the Building Efficiency Rating (BER) certificate to support the nearly zero energy building (NZEB) initiative [20] by improving the renovation regulations, smart meter installment, and a temperature optimal heating grid [21]. Ireland has also put focus on the transportation sector to develop renewable fuel for electric buses as a sustainable transport [22]. Besides that, the electric power transmission system operation (TSO) of Ireland is EirGrid and the Sustainable Energy Authority of Ireland (SEAI) provides support to businesses to improve energy efficiency. To summarize, the NMF approach found topics focused on home improvements, transportation, and national bodies/agencies were mentioned.

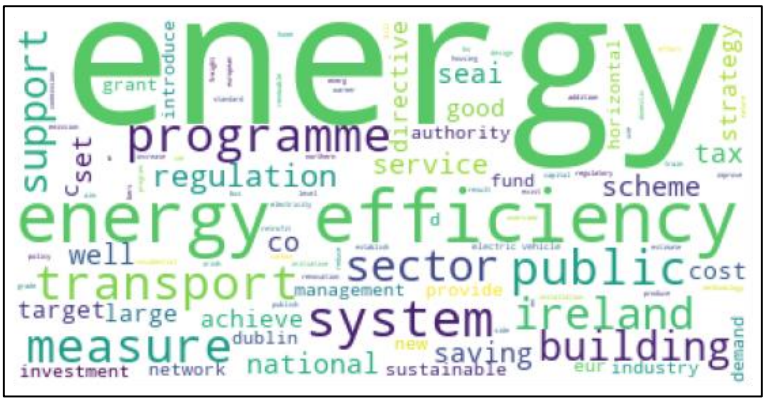

Figure 6: Word Cloud of NEEAP 4 Ireland

Similar to NEEAP Malaysia, energy is the most frequently occurring word in the action plan. The sectors ‘transport’, ‘building’ and ‘public’ are more focused on compared to the other sectors in the action plan. The Sustainable Energy Authority of Ireland (SEAI), ‘seai’ is the main government body that promotes sustainable energy development that aims to provide ‘support’, ‘scheme’ and ‘system’ and to implement ‘measure’ and ‘programme’ to improve energy efficiency.

3.3 Comparison Analysis of Content

There is a difference in the NMF topic models between Malaysia and Ireland. Malaysia focuses on auditing energy consumption and promoting energy-efficient appliances as initiatives to improve and reduce the energy consumption of Malaysia. On the other hand, Ireland fourth action plan focuses on improving homes and buildings with multiple energy efficient options and introduce sustainable transportation. Besides that, government bodies were part of the significant keywords in NEEAP 4 Ireland such as TSO and SEAI while no government bodies were mentioned in NEEAP Malaysia.

There are also findings in the word cloud that show the differences between the two action plans. First, Malaysia focuses on the industry sector which is notable as it is one of the sectors that consumes the most energy while Ireland focuses on the transport, public and building sectors. Second, Malaysia focuses on electricity initiatives to improve energy efficiency as the economic status of the country is continuously thriving. In contrast, Ireland plans to provide support and to achieve targets.

The comparisons of the textual content in the NEEAPs of Malaysia and Ireland showed differences between a developing and developed country. Noting again that Ireland has four action plans and the text used in this research is the fourth action plan. Ireland's energy efficiency has improved throughout the years that Malaysia could look up to. An example would be involving some government bodies involved in the action plans such as Tenaga Nasional Berhad (TNB), as well as efforts to introduce more sustainable and renewable energy in the composition. Table 3 is the summary of these differences between the two actions plans of Malaysia and Ireland.

Table 3: Summary of the content between actions plans of Malaysia and Ireland

NEEAP Malaysia	Content	NEEAP 4 Ireland
Audit energy consumption Energy-efficient appliances	Initiatives	Home improvements Sustainable bus
Industrial	Sectors	Transport Public Building
None	Bodies	TSO SEAI

4. Conclusion

In conclusion, this study is focused on the comparison of energy efficiency action plans between Malaysia and Ireland using text mining. Malaysia's first and only NEEAP is compared to the fourth NEEAP of Ireland to determine the key differences between a developed and developing country. There are three objectives to the study using two text mining approaches for content analysis, which are Non-Negative Matrix Factorization (NMF) and Word Cloud. As a result, all three objectives were achieved.

The NMF approach to find topic models of initiatives in the two action plans was achieved and the results showed that the topics are very different. Malaysia has more focus in reducing the demand of electrical energy through 5-star electrical appliances and auditing the energy consumption of different sectors. Meanwhile, Ireland has home and building improvements and the development of a renewable fuel cell bus. Besides that, the word cloud identified 'Energy' and 'Efficiency' were the highest occurring words for both Malaysia and Ireland. The following frequent words for Malaysia are 'industry', 'electricity' and 'key initiative' while for Ireland are 'transport', 'building' and 'public'. Malaysia is targeting energy savings mostly on one sector compared to the others while Ireland has three. The result from the text mining approaches showed that there is a difference between the content in the action plans of a developed and a developing country.

The recommendations to improve the text mining approaches of the energy efficiency action plans are a topic prediction model and N-grams. The prediction model can learn from action plans of other developed or developing countries action plans and predict the topics found in Malaysia. The prediction of topics can contribute to drawing out future NEEAPs of Malaysia by learning from the initiatives and measures of other countries. Secondly, N-grams can find collocation of words which can be employed into word clouds to visualize clearer and sophisticated frequencies of terms found in the text.

Acknowledgement

The authors would also like to thank the Faculty of Applied Sciences and Technology, Universiti Tun Hussein Onn Malaysia for its support.

References

[1] V. Smil, Energy and Civilization: A History. Massachusetts: The MIT Press, 2018.

[2] J. Diamanti, Climate and Capital in the Age of Petroleum: Locating Terminal Landscapes. New York: Bloomsbury Academic, 2022.

[3] C. C. Lu and L. C. Lu, "Evaluating the energy efficiency of European Union countries: The dynamic data envelopment analysis," Energy & Environment, vol. 30, no. 1, pp. 27–43, 2019.

[4] K. C. W. Hor and M. K. Rahmat, "Analysis and recommendations for building energy efficiency financing in Malaysia," Energy Efficiency, vol. 11, no. 1, pp. 79 – 95, 2017.

[5] M. Reuter, M. K. Patel, W. Eichhammer, B. Lapillonne and K. Pollier, "A comprehensive indicator set for measuring multiple benefits of energy efficiency," Energy Policy, vol. 139, 2020.

[6] H. Sun, B. K. Edziah, A. K. Kporsu, S. A. Sarkodie and F. Taghizadeh-Hesary, "Energy efficiency: The role of technological innovation and knowledge spillover," Technological Forecasting and Social Change, vol. 167, 2021.

[7] E. G. Popkova and B. S. Sergi, "Energy efficiency in leading emerging countries and developed countries," Energy, vol. 221, 2021.

[8] N. A. Abd Rahman, S. N. Kamaruzzaman and F. W. Akashah, "Scenario and strategy towards energy efficiency in Malaysia: A review," International Conference on Built Environment and Engineering 2018, vol. 266, 2019, https://doi.org/10.1051/matecconf/201926602012.

[9] M. Vaka, R. Walvekar, A. K. Rasheed and M. Khalid, "A review on Malaysia's solar energy pathway towards carbon-neutral Malaysia beyond Covid'19 pandemic," Journal of Cleaner Production, vol. 273, 2020.

[10] J. Glynn, M. Gargiulo, A. Chiodi, P. Deane, F. Rogan and B. Ó Gallachóir, "Zero carbon energy system pathways for Ireland consistent with the Paris Agreement," Climate Policy, vol. 19, no. 1, pp. 30–42, 2018.

[11] Goverment of Ireland, "National Energy Efficiency Action Plan (NEEAP)," June 2020. [Online] Available: https://www.gov.ie/en/publication/93ee2-national-energy-efficiency-action-plan-neeap/

[12] L. Hickman, S. Thapa, L. Tay, M. Cao and P. Srinivasan, "Text Preprocessing for Text Mining in Organizational Research: Review and Recommendations," Organizational Research Methods, vol. 25, no. 1, pp. 1–33, 2020, doi:10.1177/1094428120971683.

[13] P. Suri and N. R. Roy, "Comparison between LDA & NMF for event-detection from large text stream data," 2017 3rd International Conference on Computational Intelligence & Communication Technology (CICT), 2017, doi:10.1109/ciact.2017.7977281.

[14] M. Ailem, A. Salah and M. Nadif, "Non-negative matrix factorization meets word embedding," Proceedings of the 40th International ACM SIGIR Conference on Research and Development in Information Retrieval – SIGIR '17, 2017, doi:10.1145/3077136.3080727.

[15] Y. Chen, H. Zhang, R. Liu, Z. Ye and J. Lin, "Experimental explorations on short text topic mining between LDA and NMF based schemes," Knowledge-Based Systems, vol. 166, pp. 1–13, 2019.

[16] S. Lohmann, F. Heimerl, F. Bopp, M. Burch and T. Ertl, "ConcentriCloud: Word Cloud Visualization for Multiple Text Documents," 2015 19th International Conference on Information Visualisation, 2015, doi:10.1109/iv.2015.30.

[17] W. Cui, Y. Wu, S. Liu, F. Wei, M. X. Zhou and H. Qu, "Context-Preserving, Dynamic Word Cloud Visualization," IEEE Computer Graphics and Applications, vol. 30, no. 6, pp. 42–53, 2010.

[18] K. Y. Wong, J. H. Chuah and C. Hope, "As an emerging economy, should Malaysia adopt carbon taxation?" Energy & Environment, vol. 30, no. 1, pp. 91–108, 2019.

[19] M. Economidou, V. Todeschi, P. Bertoldi, D. Agostino, P. Zangheri and L. Castellazzi, "Review of 50 years of EU Energy Efficiency Policies for Buildings," Energy and Buildings, vol. 225, 2020.

[20] J. Goggins, P. Moran, A. Armstrong and M. Hajdukiewicz, "Lifecycle environmental and economic performance of nearly zero energy buildings (NZEB) in Ireland," Energy and Buildings, vol. 116, pp. 622–637, 2016.

[21] P. Harney, D. Gartland and F. Murphy, "Determining the optimum low-temperature district heating network design for a secondary network supplying a low-energy-use apartment block in Ireland," Energy, vol. 192, 2019, doi:10.1016/j.energy.2019.

[22] T. A. Gunawan, I. Williamson, D. Raine and R. F. D. Monaghan, "Decarbonising city bus networks in Ireland with renewable hydrogen," International Journal of Hydrogen Energy, vol. 46, no. 57, pp. 28870–28886, 2021.