ISSN 2616-5872 Vol.4, Issue 8: 63-66, DOI: 10.25236/AJEE.2022.040812

# A Practice Evaluation and Discussion on the Application of the UK TIMES Model

**Xinyu Li**

*Bartlett School of Environment, Energy and Resources, University College London, Gower Street, London, WC1E 6BT, the United Kingdom*

***Abstract:*** *UK TIMES is a model of the UK energy system developed by UCL and the UK Department of Business, Energy, and Industrial Strategy. The UK TIMES model depicts the UK's energy system, from fuel extraction and trade to fuel processing and transport, power generation and all final energy demand. The model generates scenarios for the evolution of the energy system based on different assumptions around demand evolution, future technology costs, measured energy system costs, and all greenhouse gases related to the scenarios. In order to understand and analysis the current application status of this model in practical research, one journal paper about achieving net-zero emissions was selected as an example to be analysed. This paper will summarise the main features and key findings of the modelling exercise. At the same time, the paper will place this analysis in the broader research context by briefly drawing on other literature and describe how well the analysis follows best practice guidelines. Finally, this essay will provide three specific suggestions to the authors as to how they might improve their analysis. Clear justification for these recommendations will also be provided.*

***Keywords:*** *UK TIMES energy systems model, best practice guidelines, scenario sensitivity analysis, model-based analysis*

## 1. Introduction

The main purpose of this essay is to outline the analysis using the UK energy system model and evaluate the full analysis process in detail. Basically, the article is divided into three main parts. It will first consider the main characteristics of modelling exercises, including aims, objectives and methods. Furthermore, it will describe how the analysis method is widely used to the general insight that generates energy and environmental strategies. It will then critically analyse how well the model-based analysis follows best practice guidelines and explain where the guidelines are met and where they are not in detail. Finally, it will provide three specific suggestions to improve the authors' analysis. Clear justification with convictive reasons will be given as well.

In the selected journal paper, Pye et al use the UK integrated energy system model, UKTM for analysis. The UK TIMES model has developed over the past few years by the UCL Energy Institute. It is based on the TIMES model generator. UKTM is the successor to the UK MARKAL model. During the development of this model, the entire design of UK MARKAL was reviewed and revised. So UKTM provides new capabilities such as realignment of sectors based on research and policy issues. To be able to examine different scenario baselines, tax, policy, and barrier rates are added to the base model using separate modules. It was used to inform the UK Government's Clean Growth Strategy in 2017. In addition, Energy system optimisation models are a key tool for policy analysis. DeCarolis et al formalise best practices for optimal modelling of energy systems[1]. DeCarolis et al draw on their collective modelling experience and conduct an extensive literature review to develop best practices for optimisation modelling of energy systems. They outline key steps in the modelling process to help implement the guiding principles, including how to formulate research questions, set spatiotemporal boundaries, consider appropriate model characteristics, conduct, and improve analyses, quantify uncertainty, and communicate insights. They explain and develop a set of formal guidelines for ESOM applications.

The UK Times model details are shown in Figure 1.

ISSN 2616-5872 Vol.4, Issue 8: 63-66, DOI: 10.25236/AJEE.2022.040812

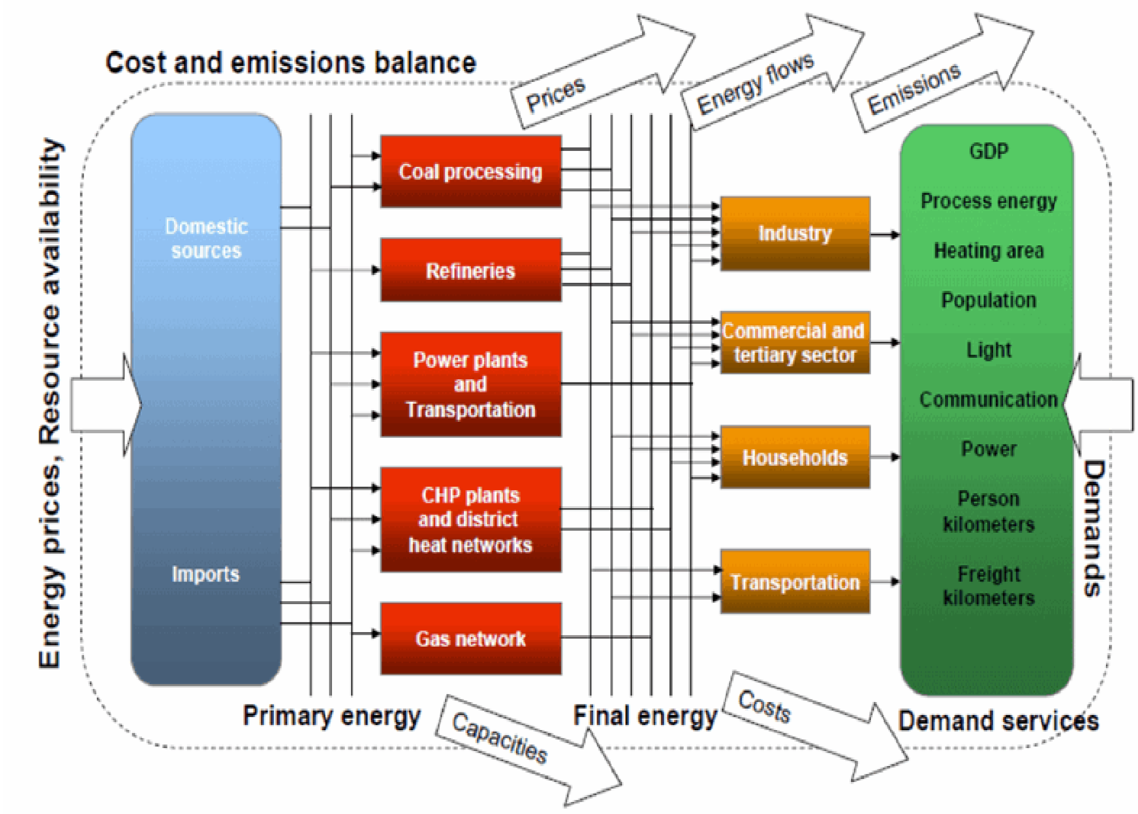


*Figure 1: The UK Times model*

## 2. Main characteristics of modelling exercises

The Paris Agreement sets long-term goals of protecting the climate at the national level. At the same time, it also requires a radical transformation of a net-zero emission energy system by 2100. To achieve net-zero greenhouse gas emissions by 2100, it is crucial to assess the decarbonisation analysis targets of the post-2050 period. Simultaneously, to avoid blindsiding of challenge and lack of ambition, the UK needs to reassess ambitious decarbonisation pathways. In energy modelling, the UKTM is used for analysis to provide fundamental insights for energy and environmental policies.

In the modelling exercise, the first thing to do is to formulate research aims. The aim is to identify which low-carbon technologies and fuel choices have the most significant impact on the UK energy system's long-term development under the ambitious decarbonisation pathway. The objective of the modelling exercise is to conduct a scenario sensitivity analysis by using UKTM module. The analysis is carried out step by step to implement the objective of energy system transformation. The analysis is first to confirm the research goals and prepare the model. The next critical step is to identify key uncertainties. Then, it builds the model and runs the model. Finally, the results are analysed and improved by experienced modelers.

Best practice guidelines for energy system modelling analysis aim to guide conduction of analysis. The formal guidelines can be widely applied to conduct model-based analysis. It can provide insight for energy and environmental decision-making as well. I will use the best practice guidelines to describe and explain how well the analysis follows the best practice guidelines in detail.

## 3. How the model-based analysis follows best practice guidelines

First, in formulating research questions, UKTM-based analysis complies with the guiding principles. Before running the UKTM, the authors identified the current primary research purpose accurately. The analysis is based on the background of the Paris Agreement and the goal of controlling the average global temperature not exceeding 2°C. At the same time, the agreement requires to produce 'net-zero' greenhouse gas (GHG) emission system before 2100. If only considering the mitigation targets for 2030

ISSN 2616-5872 Vol.4, Issue 8: 63-66, DOI: 10.25236/AJEE.2022.040812

or 2050, it will be almost impossible to achieve the objectives of net-zero greenhouse gas emissions before 2100. Therefore, the setting of climate targets in the UK has been considered path dependencies and future reassessment of ambition. It supports the decarbonisation analysis of the national climate policy to take into account the post-2050 period. Figure 2 shows the UK's goal of reducing carbon emissions. It also revaluates the ambitions under the nationally determined contributions (NDCs) with a long-term planning horizon. The authors conducted a scenario sensitivity analysis of the UK energy system by using UKTM. This analysis accurately identified the needs and grasped the most critical issues.

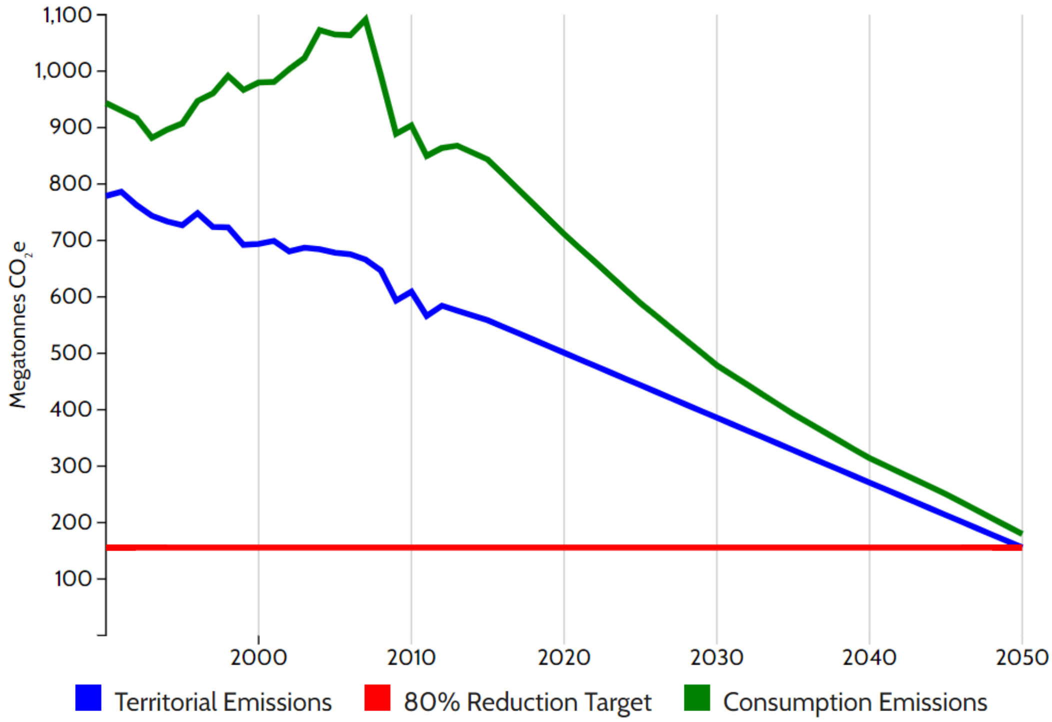


*Figure 2: UK's goal of reducing carbon emissions*

The analysis based on UKTM follows the best practice guidelines well. It determines the model to be selected for analysis based on actual problems. The authors chose the UKTM to determine which low-carbon technologies and resources significantly impact the UK energy system's long-term development under the ambitious decarbonisation approach. They considered and gave a specific description of the UKTM's features in detail. "UKTM presents technology and fuel choices in different energy use areas under the decarbonisation goal. These decisions are based on the best economic choice and are affected by many constraints reflecting the system's characteristics" (Pye et al., 2017)[2]. UKTM is divided into three supplies and five demand parts. All sectors have been calibrated according to the UK's energy balance. Besides, UKTM has a flexible period and can operate in any time range up to 2100. This feature is very beneficial to sensitive analysis methods and can meet the needs of analysis in different periods. However, the authors did not fully consider the model characteristics of UKTM. They did not mention the fundamental omissions of the model. There is not enough explanation for the limitations and might lead to such simplified results.

After the model is established, the modeler will analyse and improve the results. In the process of analysis, simplification is necessary. The entire analysis process is concise and easy to understand. Simultaneously, the analysis structure of the scenario sensitive analysis performance is evident, and the conclusions derived are more readily accepted. The focus of scenario sensitivity analysis is to determine the critical set of system uncertainties. The current policy framework uses the same dimensions of uncertainty to model and expands its ambitions to 2100.

In addition, the sensitivity analysis also iteratively refines problem statements and analysis. It screens and optimises new data or other newly obtained information. The researchers imposed a constraint on the model that the energy system's radical transformation must be reached by 2080. The result proves that developed countries like the United Kingdom need to achieve net-zero greenhouse gas emissions faster than in developing countries. Additionally, the reduction in demand caused by changes in energy service prices has also improved the scenario sensitivity setting. In this refinement stage, important information or details that can improve the quality of analysis are supplemented. It also represents an iterative optimisation process. However, in terms of deleting the aspects that are not important to concern, scenario sensitivity analysis is relatively insufficient. It contains much unimportant information, which increases the complexity of analysis.

The lack of understanding will lead to deviations from the expected results of the prediction of climate change. Therefore, it is very important to clarify uncertainty in the analysis process. Various uncontrollable external factors will have a significant impact on policies and economic benefits. If the uncertainty is ignored, the accuracy of the research and estimates in the analysis will have an adverse effect.

"Sensitivity analysis is the computation of the effect of changes in input values or assumptions, including boundaries and model functional form on the outputs" (Morgan and Henrion, 1990)[3]. Scenario sensitivity analysis considers different scenarios and identifies various uncertainties. First, the fate of the role of nuclear power and CCS technology is pointed out. Bioenergy has also been considered as a critical uncertain factor. "Bioenergy resources have been shown to be the most critical uncertainty for achieving the decarbonisation target cost-efficiently".

## 4. Three recommendations to improve the analysis

Three suggestions for improving the reliability of the analysis will be given. First of all, the thinking and analysis of model features should be more comprehensive. No model is perfect, so analysis of the limitations of the model is indispensable. They should more carefully consider the limitations and considerations associated with the analysis.

Second, the analysis should be continuously filtered and optimised to ensure that the analysis objective can be continuously improved. Moreover, to make sure that the analysis is always concise and easy to understand is very important. It is essential to reassess the modelling methods and objectives in the analysis process. Analysis needs to be iteratively refined through elaboration and simplification. Morgan and Henrion (1990) states that new data or information needs to be continuously filtered and optimised to ensure that the results are always concise and clear. The scenario sensitivity analysis by using UKTM could be better if they cyclically refine their analysis.

Third, the analysis should be a more comprehensive overview of the model's endogenous and exogenous uncertainties. "Consider uncertainties that are both endogenous and exogenous to the model and how they can affect conclusions" (DeCarolis et al., 2017) The possible impacts that brought by these uncertainties could significantly affect the conclusions of the analysis in many ways. Although the authors used sensitivity analysis techniques, the final judgment and warning were not sufficient. Even with rigorous calculations of uncertainty, modelers should strive to outline unresolved warnings.

## 5. Conclusion

In conclusion, the scenario sensitivity analysis by using UKTM complies with the best practice guidelines. Before running the model, the aims, objectives and approach are accurately identified based on the background. The whole structure of the model-based analysis is clear and precise. Uncertainty analysis is performed very comprehensively. The record of the results and module are also apparent and easy to understand. However, the application of UKTM still has some limitations in providing insights into future energy systems development. All of the limitations require modules to consider more about model features and pay more attention to unresolved uncertainties. In general, UKTM-based analysis conforms to the formal guidelines of model-based analysis well.

## References

*[1] DeCarolis, J., Daly, H., Dodds, P., Keppo, I., Li, F., McDowall, W., Pye, S., Strachan, N., Trutnevyte, E., Usher, W., Winning, M., Yeh, S. and Zeyringer, M., (2017). 'Formalizing best practice for energy system optimization modelling'. Applied Energy, 194, pp.184-198.*

*[2] Pye, S., Li, F.G., Price, J. and Fais, B., (2017). 'Achieving net-zero emissions through the reframing of UK national targets in the post-Paris Agreement era'. Nature Energy, 2(3), pp.1-7.*

*[3] Morgan, M. G., and Henrion, M. (1990). 'An Overview of Quantitative Policy Analysis'. Uncertainty: A Guide to Dealing with Uncertainty in Quantitative Risk and Policy Analysis, Cambridge: Cambridge University Press, pp. 16-46. doi: https://doi.org/10.1017/CBO9780511840609.004.*