

Novel Trigeneration Analysis Model (TAM) for Assessing Optimal Cooling and CCHP Scenarios in Urban New Developments

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Abstract

This paper provides an overview of a novel Trigeneration Analysis Model (TAM) developed at London South Bank University (LSBU) using Visual Basic for Applications (VBA) language in MS Excel. TAM provides a user-friendly mechanism for evaluating multiple variants of tri-generation or CCHP scenarios and quantifying the energy, cost and carbon savings relative to a conventional base case solution. It integrates a number of complex parameters pertaining to the building/development, systems, and key financial, technical and environmental variables. It can also be used to predict the optimal capacity per square metre (W/m^2), net present value per square metre ($£/m^2$) and carbon savings per square metre ($kgCO_2e$ saved/ m^2) for different development and technology scenarios with different heat/cooling-to-power ratios. Thus, TAM can be a useful tool for supporting decision making on optimal cooling solutions including trigeneration for urban new developments. The main elements of TAM, its capabilities and limitations are presented in this paper. Some of the scenarios modelled using TAM are presented to highlight its functionalities.

Keywords: Tri-generation Analysis Model (TAM), trigeneration, combined cooling heat and power (CCHP), CO_2e savings, heat/cooling-to-power ratio.

1. Introduction

The assessment of trigeneration systems in order to identify the optimal solutions for urban new developments at the early stages of design continues to be a challenge for decision makers. While several tools exist for the feasibility assessment of trigeneration systems, a majority of them are useful for specific applications, and most of them require the user to have detailed information about the development and the system [1].

The development of TAM was initiated in 2008 at LSBU as part of a study for the London Development Agency (LDA) in an attempt to address some of the uncertainties around where tri-generation works best. The study for the LDA was concluded in 2009, a full report [2] was produced and also a paper [3] which summarised the original findings. Further research was subsequently launched and is on-going at LSBU to further evaluate optimal tri-generation solutions for urban new developments using TAM and validate the findings of the original study. As part of the on-going research, TAM was improved including additional functionalities. A second paper [4] presented some of the results from the on-going study in terms of optimal capacity (W), net present cost per kilogram saved ($£/kgCO_2e$ saved), net present value ($£$) and carbon ($kgCO_2e$) savings, each on a per square metre basis.

TAM aids the comparative analysis of applying a set of trigeneration system types on specific development types. The different configurations of system type and control strategy are identified as scenarios within TAM and assessed against a base case scenario in terms of

cost and carbon simultaneously. TAM also aids the sensitivity analysis of key input parameters. Thus, TAM can help investment decisions on the adoption of trigeneration systems to be made at the conceptual stage of developments when there is little or insufficient data for a detailed feasibility study.

2. The Structure of TAM

The architecture of TAM is illustrated in Figure 1, while the default opening screen of TAM is shown in Figure 2.

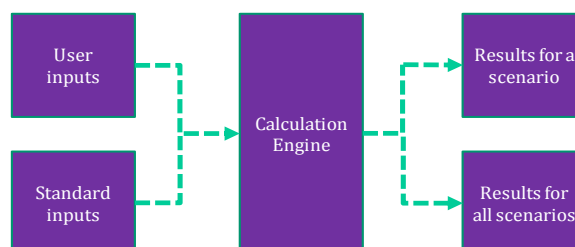


Figure 1 The Architecture of TAM

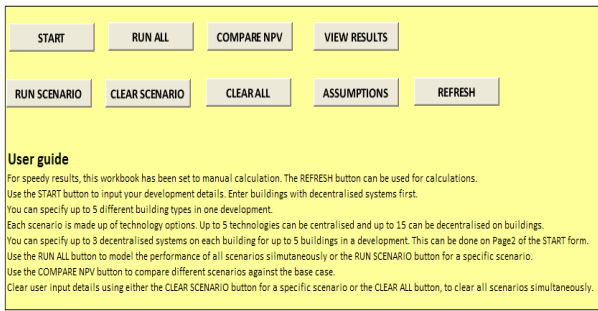


Figure 2 Opening Screen of TAM

Inputs to the tool are broadly classified into User Inputs and Standard Inputs. These can be created or edited on two separate forms/interfaces called the User Inputs Screen and the Standard Inputs Edit Screen. The User Inputs Screen allows the user to specify details about the development such as the types of buildings that comprise the development and their gross internal floor areas. The user also indicates the likely technology scenarios to be considered by selecting from a drop-down menu. Each scenario is a configuration of system type and control strategy. System types include gas boiler, vapour compression chiller, CHP, single effect absorption chiller, double effect absorption chiller; while the types of control strategies available in TAM are presented in Figure 3.

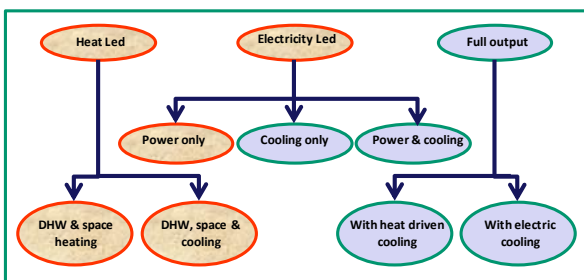


Figure 3 System Control Strategies in TAM

On the other hand, the Standard Inputs include fuel prices, build costs, carbon factors and systems efficiencies. While TAM has in-built data for the standard inputs which are mostly based on legislation and other published guidance. The user may choose to edit any of the standard inputs in a simple interface. This functionality of TAM enables the user to easily conduct a sensitivity analysis to determine the level of risk associated with the results.

3. Modelling of Trigeneration Scenarios

By integrating the user and standard inputs in a series of calculation steps, TAM carries out a technical, financial and environmental assessment for the various scenarios and produces results. The results are produced as a comparison of the various scenarios against a conventional base case in terms of energy, carbon and cost savings per annum.

Example result from TAM comparing various trigeneration scenarios for a single development in terms of carbon savings is shown in Figure 4.

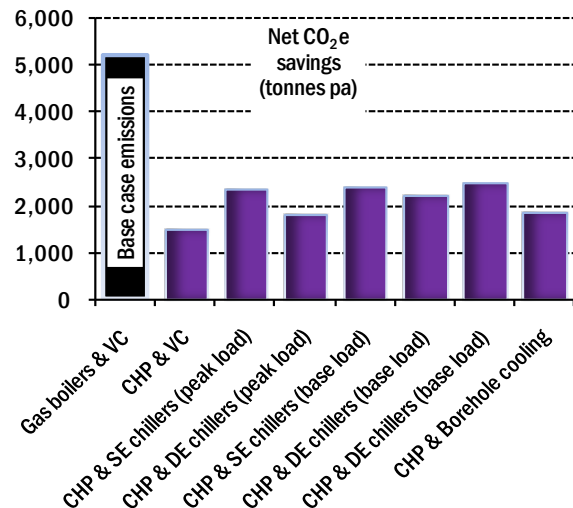


Figure 4 Example Result from TAM - All scenarios for a single development

For the application of TAM as a predictive tool, it was used to generate the optimal capacity per square metre (W/m^2), net present value per square metre ($£/m^2$) and carbon savings per square metre ($kgCO_2e$ saved/ m^2) for different development and technology scenarios with different heat/cooling-to-power ratios. Example result is shown in Figure 5.

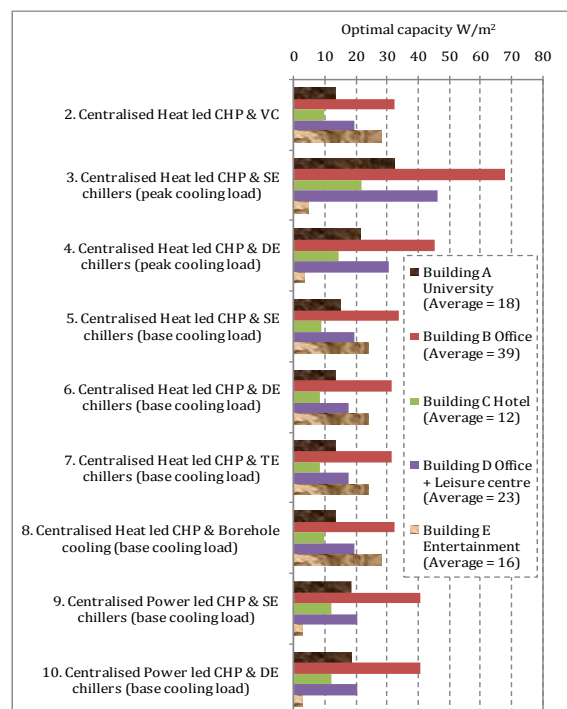


Figure 5 Example Result from TAM - All scenarios for multiple developments

4. Conclusions

A novel Trigeneration Analysis Model (TAM) has been developed at LSBU using VBA language in MS Excel. It differs from existing trigeneration feasibility analysis tools by providing a user-friendly mechanism for

evaluating multiple variants of tri-generation scenarios and quantifying the energy, cost and carbon savings relative to a conventional base case solution. TAM achieves this by integrating a number of complex parameters pertaining to the building/development, systems, and key financial, technical and environmental variables. It is also useful as a tool for predicting the

optimal capacity per square metre (W/m^2), net present value per square metre ($£/m^2$) and carbon savings per square metre ($kgCO_2e$ saved/ m^2) for different development and technology scenarios with different heat/cooling-to-power ratios. This functionality informs investment decisions on optimal cooling solutions including trigeneration for urban new developments.

References

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