Renewable and Sustainable Energy Reviews 30 (2014) 661–671

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Review of energy models to the development of an efficient industrial energy model

O.A Olanrewaju [a,*], A.A Jimoh [b]

[a] Tshwane University of Technology, Faculty of Engineering and Built Environment, Department of Industrial Engineering, Pretoria, South Africa
[b] Tshwane University of Technology, Faculty of Engineering and Built Environment, Department of Electrical Engineering, Pretoria, South Africa

ARTICLE INFO

Article history:
Received 19 April 2013
Received in revised form
24 September 2013
Accepted 11 November 2013
Available online 30 November 2013

Keywords:
Energy models
Industries
Potential
Policy-makers

ABSTRACT

Presently, there are huge challenges in the presence of the global energy sector, especially in the energy intensive industries that entail a huge collection of energy use, which makes energy security a vital worry. This study analyses various energy models, taking into consideration their various gaps which led to the development of an integrated model for assessing energy efficiency potential in the industrial sector. The resulting developed model will not only serve as a tool for long-term planning to ensure that energy supply is available to meet the demands of targeted economic growth, it will also give policy-makers in the industrial energy management an alertness on how to monitor, control and manage energy consumption.

Contents

1. Introduction

Industries remain a significant contribution to the social and economic growth of a country. In contrast, industries remain indicted for the quick depletion of limited fossil fuels and the pollution of the surroundings [1]. The consumption of energy in industries is due to a series of activities like processing and assembly, space conditioning, and lighting. Natural gas and petroleum products used as feed stocks to generate non-energy products are among industry energy usage [2]. 60% of energy used in industries can be attributed to both developing and countries in economic transition [3]. The utmost consumption of total energy goes to process heating in a manufacturing process. This is followed by machine drives and boiler heating processes [4].

* Corresponding author. Tel.: +27 7 9089 4923.
E-mail addresses: dlp4all@yahoo.co.uk, olanrewajuoa@tut.ac.za (O. Olanrewaju).

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http://dx.doi.org/10.1016/j.rser.2013.11.007

The interpretation of energy used in the industry is shared into classes of indirect, direct process, and direct non-process uses. Energy consumption varies considerably amongst the various sectors of production in the industries. Around a fifth of universal revenue is created unswervingly by manufacturing industry, and approximately half of the consumption from households depends on products from industries. But upturn in the standard of living made possible through industrial development has emanated at an environmental price. Before the late 1960s, energy use per capita had gone up nine-fold over the previous 200 years as stated and interpreted by UNIDO [5]. Substantial efforts have been created in order to better comprehend the energy efficiency potentials of industries [3]. Increasing energy efficiency in the industries is a crucial basis for green industry globally [5].

To date, energy used in the industries and its efficiency potentials remained predominantly examined by applying energy efficiency indicators and benchmarking methods [3]. The objective of benchmarking has become an important part of the strategic planning process. Industries have to evaluate the energy efficiency of their processes via an international comparison. On the basis of these results, the industries undertake in-depth analyses of their plants to identify further potentials to improve energy efficiency. An important step towards a highly energy efficient facility is a thorough evaluation of a plant's energy efficiency performance and a good knowledge of the existing optimization potentials within a plant [6]. Best practice technology data are obtained from benchmark curves for some sectors. Though, benchmark curves are limited to a portion of universal production, not permitting a comprehensive analysis to be conducted [3]. The differing local conditions also constitute a limitation to benchmarking. The industrial sector and its potential energy saving are thus a focus for the energy future. In the context of this article, a model as an analytical tool to estimate the possible industrial energy potential is reviewed.

Reduction in energy consumption is not a new item on the political agenda. The oil crisis that confronted the industrialized world in the 1970s have forced scientists and policymakers to think about a future that could draw on alternative energy sources and reduce its energy consumption [7].There are several methods for tackling the energy-related problems that impede the sustainable development of our society [7]. One of these methods is to improve the efficiency of energy consumption by developing suitable models for proper analysis and assessment. For energy efficiency potentials to be derived in pursuit of sustainable development, a suitable model is needed which is the focus of this article.

To tackle the tasks of obtaining industrial energy efficiency potential, it is imperative to understand what drives changes in industrial energy consumption [5]. A starting point is by examining some aggregate energy indicators that display energy usage divided by a ration of activity that propels energy demand. This is known as the aggregate final energy intensity. This indicator monitors energy efficiency development [8].

The technical literature of energy model is too broad. This is demonstrated by literature survey and diagnostic examination in print by various researchers. An in-depth appraisal of the literature is therefore outside the area of this research as the focus here is to develop a new model that has the capability to detect or point out opportunities for improving on energy efficiency. A critical review of the past work is undertaken focusing only on literature relevant to the goal of this article. The various models reviewed are based on the following criteria:

(1) Analysis of historical data.
(2) Predicting future energy consumption.
(3) Optimization of energy use for adequate assessment of industrial energy potential.

The next section discusses the relevance of the various energy models to energy analyses and assessment, which is the foundation of this research. Section 3 is devoted to the gaps of the various energy models with respect to their adequacy to detect opportunities for improving energy efficiency within an industry. These gaps form the basis for the design and development of the new model in this work. Section 4 describes the two types of energy efficiency models (micro and macro) with the further derivation of a proposed macro-model, which is a hybrid of IDA–ANN–DEA, to analyze industrial energy use.

2. Relevance of energy models to energy analyses and assessment

Some energy efficiency advocates believe that almost all the problems could be solved, or ameliorated [9] through the use of energy efficiency models. Estimating the potential for energy efficiency improvements and associated energy savings are primary to the preparation, growth, execution and appraisal of energy efficiency [10] models. Energy models were though not established for the similar purposes – some concentrate on improved energy supply system design assuming a level of demand forecast, better comprehension of the current and imminent demand–supply communications, energy and environmental communications, energy–economy communications and energy system planning. Others had concentrated on energy demand analysis and forecasting [11].

Several key questions therefore immediately arise regarding the role of models supporting energy efficiency within a portfolio of prospective energy models. There is a need to know the types of energy efficiency models that have been implemented, and how well has each of these models worked in terms of saving energy? To address the question, we perform a comprehensive review of some macro-economic energy models, with a focus on the development of an efficient model. A huge amount of tools or methods are already established and functional in the literature in the direction of energy efficiency analysis. These methodologies have considered historical data analyses, prediction technique and optimization analysis as assessment criteria. This section develops a working pattern of the analysis and assessment of energy efficiency. It lays the conceptual basis for developing the method for analysis, which can be applied to evaluate energy consumption in the industrial sector. Our analyses suggests that designing a model of energy efficiency potential that accounts for the policy goal of reducing energy consumption will result in considerable savings potential. More importantly, recent experience has shown the potential for energy efficiency and conservation to extensively reduce energy use [10].

3. Various energy models and their gaps

This section focuses on the various energy models and their gaps. These models include decomposition models, predictive models, optimization models and the hybrid models.

3.1. Historical data analysis for energy potential

Regarding analysis of historical data to determine energy saving potential, it appears that decomposing the factors responsible for energy consumption through Index Decomposition Analysis (IDA) has been studied by various researchers for this purpose. The theory of IDA is related to the use of economic index numbers to the analysis of inputs of price and quantity levels to variations in aggregate commodity consumption [12].