Journal of Cleaner Production 142 (2017) 3437–3453

Contents lists available at ScienceDirect

Journal of Cleaner Production

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

Energy audits in industrial processes

Aldona Kluczek [a, *], Paweł Olszewski [b]

[a] Institute for Organization of Production, Faculty of Production Engineering, Warsaw University of Technology, 86 Narbutta Street, 02-524, Warszawa, Poland

[b] Department of Engineering Technology, Mechanical Engineering Technology Program, University of Wisconsin Oshkosh, 800 Algoma Boulevard, Oshkosh, WI, 54901-8644, USA

ARTICLE INFO

Article history:
Received 4 May 2016
Received in revised form
22 October 2016
Accepted 22 October 2016
Available online 9 November 2016

Keywords:
Energy audit
Energy management
Benefits
Industrial energy efficiency
Industrial processes

ABSTRACT

Efficiency improvements such as the adoption of many energy efficiency measures represent a driver for increasing industrial process performance due to related economic costs and significant environmental impacts. The energy audit, a well-known tool for analyzing energy flow and assessing energy saving opportunities, is demonstrated in this paper as one of the steps in an energy efficiency initiative.

The focus of this study is on investigating the outcomes of energy efficiency improvements and analyzing the benefits achieved under various energy efficiency measures from energy audits based on case studies. Specifically, the objectives of the paper are listed as follows: (i) multidimensionality of energy audits for energy conversion, (ii) example tools used for energy audits, (iii) outline of competences of energy auditors. By discussing energy audit structure, new insights into non-energy benefits are defined with very positive outcomes in achieving the reduction of energy consumption and carbon emissions in industrial processes. The results show that the cost-effective and energy conservation potentials represent reduction in energy consumption by 30%, 13%, 70%, 14%, 10%, and 5% respectively for targeted processes used by energy-efficiency investments. The energy-efficiency investment plans were carefully formed based on local realities with the reasonable and acceptable return period of less than 2 years. The paper demonstrated non-benefits for achieving industrial energy efficiency, which should be embodied in the energy auditing framework and considered by plant operations managers during evaluation of energy efficiency investments.

Based on six case studies, competences of energy auditors are also formulated as well.

1. Introduction

Increasing energy costs and environmental regulations are driving efforts to increase energy efficiency in the U.S. manufacturing sector. The industrial sector depends heavily on energy resources to provide power and steam for the conversion of raw materials into usable products.

The need to make changes in the way energy is used and supplied throughout the industrial processes represents the greatest challenge to engineers in moving toward sustainability. A quite different challenge will face those industrial plants in developed countries, which have not looked in detail at energy use before. In the United States of America, where the industrial sector absorbs about 22% of total energy consumption (EIA, 2014), many changes can be done in the way energy is currently used without the complexities involved in the U.S. energy image. In 2014, the total energy consumption amounted to 10.37 × 10^15 kJ (98.3 Quadrillion Btu) (EIA, 2014). The main primary energy sources consumed in the U.S. are petroleum (35%), natural gas (28%), coal (18%), nuclear power and renewables. The EIA (2008) estimates that savings of around 14–22% of energy forecasted to be consumed (36.18 × 10^15 kJ) could be cost-efficiency improvements achieved by 2020 thanks to the implementation of new energy-efficient technologies as well as retrofitting of the existing ones. 2.11 × 10^15 kJ of this savings can be supplied by further efficiency investment (e.g. use of combined heat and power systems technologies) (EIA, 2014).

Because consumption of fuel results from a rapid increase in energy price and greenhouse gas emissions, chances exist in most industrial plants where simple changes can save energy at minimal cost or with substantial savings opportunities. Policies and

* Corresponding author.
E-mail addresses: a.kluczek@wip.pw.edu.pl (A. Kluczek), olszewskip@uwosh.edu (P. Olszewski).

http://dx.doi.org/10.1016/j.jclepro.2016.10.123
0959-6526/