

Article

A Holistic Framework for Developing Expert Systems to Improve Energy Efficiency in Manufacturing

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Abstract: Amid growing environmental and societal concerns about energy use, companies face increasing pressure to adopt sustainable manufacturing practices. The European Union's guiding principles, aimed in part at achieving climate neutrality and fostering green growth, underscore the need for systematic, data-driven approaches to energy efficiency. This involves the measurement, monitoring, and analysis of energy data. However, identifying efficiency potentials often relies on expert knowledge, which is becoming increasingly scarce due to skilled labor shortages. Expert systems offer a solution by consolidating and analyzing data to automatically identify energy-saving opportunities. These systems leverage stored expertise, applying it to measurement data to generate actionable insights, while their explicit knowledge representation and transparent reasoning facilitate knowledge transfer. Despite their potential, most expert systems are developed intuitively and tailored to specific applications, limiting their broader adoption. To address this, we propose a holistic framework for systematic expert system development, supported by defined personas and an expert system shell serving as a software template. The framework is demonstrated and evaluated through its application in a metalworking process chain.

Keywords: sustainability; knowledge-based system; energy management; energy analysis; knowledge management; fuzzy reasoning



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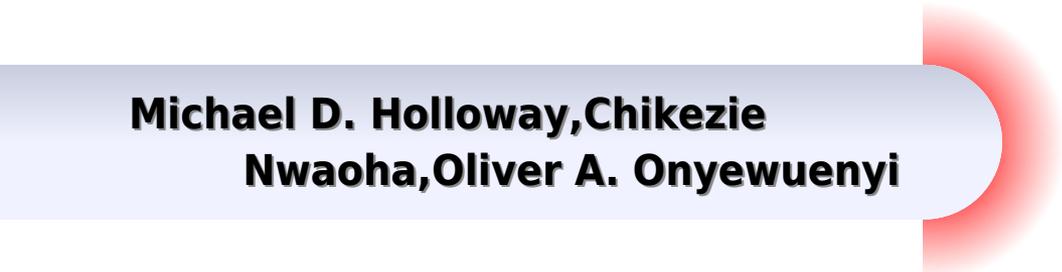
1. Introduction

Climate change poses a significant global challenge, threatening ecosystems, economies, and societies alike. In response, the 2015 Paris Agreement set the target to limit global warming to 1.5 °C, aiming to mitigate the risks of extreme weather events and irreversible tipping points [1]. This goal necessitates coordinated and effective actions at both national and international levels. The European Union (EU) has positioned itself as a global leader in climate action, with its European Climate Law mandating a reduction in greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels [1]. This commitment underscores the EU's pursuit of climate neutrality by 2050 as part of its broader Green Deal agenda [1]. Germany, as the world's third-largest economy and the largest in the EU (by gross domestic product) [2], has historically contributed approximately five percent of global warming-related emissions since industrialization [3] and therefore bears particular responsibility for climate action. Consequently, Germany has responded by committing to ambitious greenhouse gas emission reductions of 65% through its Federal Climate Action Act [4]. This effort aligns closely with the EU's broader objectives.

Central to these efforts is the industrial sector, a cornerstone of the EU and Germany's green transitions. In Germany, it is the second-largest source of energy-related greenhouse

Developing Expert Systems For Manufacturing

**Michael D. Holloway, Chikezie
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Developing Expert Systems for Manufacturing Julie Wallin Kaewert, John M. Frost, 1990 *Handbook of Expert Systems Applications in Manufacturing Structures and rules* A. Mital, S. Anand, 2013-03-08 This book is aimed at both researchers and practitioners and provides a collection of expert systems in manufacturing and production engineering along with their knowledge base and rules We believe that inclusion of the knowledge base and associated rules is essential if practitioners are to derive full benefit from these expert systems This unique book is the result of our belief and the efforts of our distinguished colleagues who subscribe to this philosophy A total of 15 different expert systems are included in this book These expert systems are preceded by an introductory chapter written by Kuo Preface XVII Mital and Anand The expert system rules are included on a floppy disk in ASCII and can be easily accessed These rules and the description of the expert system's structure should assist the users in customizing these systems Overall the expert systems included in this volume cover a fairly wide variety of manufacturing and production engineering topics *Developing Expert Systems for Project Evaluation in Small Manufacturing Businesses* T. G. Catsatos, Management Sciences, 1986 Research and Development in Expert Systems VIII British Computer Society. Specialist Group on Expert Systems. Technical Conference, 1991-10-17 This volume contains the refereed and invited papers from the eleventh annual conference of the British Computer Society's Specialist Group on Expert Systems held in London in September 1991 Design and Development of Expert Systems and Neural Networks L. R. Medsker, Larry Medsker, Jay Liebowitz, 1994 This book gives readers and practitioners the tools they need to develop appropriate applications and systems It also explores managing and institutionalizing expert system development and usage Expert Systems in Manufacturing Dimitris N. Chorafas, 1992 For engineers and functional managers who have no previous experience with expert systems explains how to implement them in manufacturing companies to improve computer aided design production planning and scheduling quality assurance marketing and other aspects of the business No bibliography Annotation copyright by Book News Inc Portland OR *Expert Systems and Related Topics* Marlene A. Palmer, 1990-01-01 This comprehensive reference to all areas of expert systems and applications plus advanced related topics lets you spend your time reading expert systems literature rather than searching for it It gives you a source of historical perspectives and outlooks on the future of the field Whether you are a manager a developer or an end user or researcher *Expert Systems and Related Topics Selected Bibliography Guide to Information Sources* puts all the sources of expert systems literature at your fingertips **Computerworld**, 1986-07-14 For more than 40 years Computerworld has been the leading source of technology news and information for IT influencers worldwide Computerworld's award winning Web site Computerworld.com twice monthly publication focused conference series and custom research form the hub of the world's largest global IT media network **Applied Mechanics Reviews**, 1991 **Developing Expert Systems for Business** Guy Benchimol, Pierre Lévine, Jean-Charles Pomerol, 1987 **Expert Systems in Production and**

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