

Energy Conservation by Retrofitting: An Overview of Office Buildings in Saudi Arabia

Sarah A. Al-Ghamdi¹, Alaa Al-Gargossh², and Khalid A. Alshaibani³

Abstract—Buildings have become one of the fastest growing energy consumption sectors. Energy is used to operate the buildings' systems that are necessary for ensuring the comfort of the building's occupants; such as air-conditioning. In other hand, good energy management will assist to conserve the valuable natural resources and reinforce the global sustainability. The paper discussed the increase of electrical energy consumption in Saudi Arabia due to rapid economic development and the absence of energy conservation measures. Office buildings represent the commercial sector that consumes 14% of the total buildings energy consumption in Saudi Arabia. The new Tariff and the raise of the electricity rates have highlighted the problem of the energy consumption in office buildings and proved the need to develop energy conservation policies for sustainable development. The purpose of this paper is to shed light on some of Saudi retrofitting studies to explore energy conservation opportunities in Saudi office buildings and review some of the international retrofitting studies in order to develop solutions that can be applied in Saudi Arabia. The studies led to the result that the building envelope has a direct effect on electricity and energy consumption and that glazed facades work as a transmittal for heat. In order to analyze the impact of glazing factor in Saudi Arabia and the need for retrofitting, an office building with 36% glazed facade was selected, and some recommendation was discussed to minimize the energy consumption.

Keywords—retrofit, energy conservation, glazing.

I. INTRODUCTION

IN order to achieve a bright energy future with minimal environmental impact, it must be taken into consideration that problems with energy utilization are related not only to global warming, but also to many other environmental concerns as air pollution, acid rain, stratospheric ozone depletion and the main concern is the emission of carbon dioxide (CO₂). Nowadays, improving the energy performance isn't just for saving the environment but due to economic reasons as various organizations in different sectors is constantly under pressure to reduce energy consumption. The reduction in energy consumption leads to reduction in operating costs, and thereby helps to improve the profitability; as energy cost is one of the main cost drivers for businesses [1], [2] and this stands side by side with conserving the valuable natural resources.

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The world three primary economic sectors of energy use are industry, buildings and transportation. Buildings have become one of the fastest growing energy consumption sectors and they are the responsible of more than 33% of the global CO₂ emissions [3]. Thereby, improving the energy performance of existed buildings is undoubtedly considered to be one of the most sustainable and feasible measures for creating sustainable buildings with less energy consumption profiles [3].

Energy is used in buildings to operate its systems that are necessary for ensuring the comfort of the building's occupants; such as air-conditioning, heating and ventilation which all consume over 40% of the total energy, while the rest are used for lighting, elevators and equipment...etc. The good energy management of those systems in a building will assist to conserve the valuable natural resources; where many changes can be made to save energy and money [4]. These changes are called (Green Retrofitting). Low carbon retrofit can be achieved by improving the building envelope and systems with the primary intention of improving energy efficiency, saving money and reducing carbon emissions [4], and any building which performs badly in terms of energy consumption, comfort conditions or environmental impact is a potential candidate for retrofitting [5]. Whatever shortcoming or deficiency in the performance of one of the building systems would have to be compensated by other systems, otherwise the desired objectives would be compromised. The impact of the performance of such systems would be reflected on the quality of the environment, productivity and long-term economies of the facility [6]. Therefore, a total system approach of energy management that considers all systems together and their interaction as one system is critical in achieving the desired objectives of energy efficiency retrofit [6]. There is a wide range of possible retrofit actions, and they all have impact on each other either at the time of installation or after operation. Thereby, choosing the correct combination of actions increases overall effectiveness [5].

There are two key retrofit activities that stand out as major carbon reducing opportunities in multi-occupied commercial properties: The first is low disruption retrofits to the envelope which intended specifically to improve energy efficiency, and the second is accelerated replacement of existing systems and equipment [4]. Assessing the performance and potential of an existing building will indicate which remedial actions will produce the most effective results. Such actions may relate to the building, its systems and its users [5]. However, the building envelope cannot be deduced from its performance alone, because a building and its systems have such complex

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**United States. Congress. Senate.
Committee on Energy and Natural
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Retrofitting of Buildings for Energy Conservation Milton Meckler, 1994 *Retrofitting for Energy Conservation* William H. Clark (II), William H. Clark, 1997 Convert residences and light commercial buildings from energy wasters to energy efficiency New remodelling codes require improvements in energy efficiency Home and building owners want to reduce their energy costs And now with Retrofitting for Energy Conservation construction and design professionals can discover the most up to date plans methods tools and materials for improving energy conservation in existing structures Almost 85% of energy conserving projects are retrofits according to the National Association of Homebuilders Retrofitting for Energy Conservation gives you the tools you need to meet this demand with step by step help in retrofitting any residence or light commercial building for energy savings From assessing the challenge and offering the client options through initial project design and final execution of the building plan this book gives you solutions that meet and exceed code requirements *Optimal Design and Retrofit of Energy Efficient Buildings, Communities, and Urban Centers* Moncef Krarti, 2018-03-27 Optimal Design and Retrofit of Energy Efficient Buildings Communities and Urban Centers presents current techniques and technologies for energy efficiency in buildings Cases introduce and demonstrate applications in both the design of new buildings and retrofit of existing structures The book begins with an introduction that includes energy consumption statistics building energy efficiency codes and standards and labels from around the world It then highlights the need for integrated and comprehensive energy analysis approaches Subsequent sections present an overview of advanced energy efficiency technologies for buildings including dynamic insulation materials phase change materials LED lighting and daylight controls Life Cycle Analysis and more This book provides researchers and professionals with a coherent set of tools and techniques for enhancing energy efficiency in new and existing buildings The case studies presented help practitioners implement the techniques and technologies in their own projects Introduces a holistic analysis approach to energy efficiency for buildings using the concept of energy productivity Provides coverage of individual buildings communities and urban centers Includes both the design of new buildings and retrofitting of existing structures to improve energy efficiency Describes state of the art energy efficiency technologies Presents several cases studies and examples that illustrate the analysis techniques and impact of energy efficiency technologies and controls Retrofitting of Commercial, Institutional, and Industrial Buildings for Energy Conservation Milton Meckler, 1984 Cost-Effective Energy Efficient Building Retrofitting F. Pacheco-Torgal, Claes-Göran Granqvist, Bjørn Peter Jelle, Giuseppe Peter Vanoli, Nicola Bianco, Jarek Kurnitski, 2017-01-03 Cost Effective Energy Efficient Building Retrofitting Materials Technologies Optimization and Case Studies provides essential knowledge for civil engineers architects and other professionals working in the field of cost effective energy efficient building retrofitting The building sector is responsible for high energy consumption and its global demand is expected to grow as each day there are approximately 200 000 new inhabitants on planet Earth The majority of electric energy will continue to be

generated from the combustion of fossil fuels releasing not only carbon dioxide but also methane and nitrous oxide Energy efficiency measures are therefore crucial to reduce greenhouse gas emissions of the building sector Energy efficient building retrofitting needs to not only be technically feasible but also economically viable New building materials and advanced technologies already exist but the knowledge to integrate all active components is still scarce and far from being widespread among building industry stakeholders Emphasizes cost effective methods for the refurbishment of existing buildings presenting state of the art technologies Includes detailed case studies that explain various methods and Net Zero Energy Explains optimal analysis and prioritization of cost effective strategies

Cost-Effective Energy-Efficient Methods for Refurbishment and Retrofitting of Buildings F. Pacheco-Torgal, Claes-Göran Granqvist, Giuseppe Peter Vanoli, Nicola Bianco, Jarek Kurnitski, 2025-01-11 Cost Effective Energy Efficient Methods for Refurbishment and Retrofitting of Buildings Materials Technologies Optimization and Case Studies provides up to date knowledge on this important research field Divided over three key parts the book s chapters cover materials and innovative technologies optimization strategies and actual case study applications that highlight the impact of different climatic conditions social factors and the economic specifications of each retrofit process Emphasis is placed on cost efficiency which is key in any energy retrofit process Taking into consideration key changes in the Energy Performance of Buildings Directive EPBD and the European Union Green Deal on Refurbishment and Renovation this book will be a valuable reference resource for materials scientists architects civil engineers and all those working on cost effective and energy efficient retrofitting and building refurbishment Discusses cost effective energy efficient methods for the refurbishment of existing buildings using state of the art technologies Includes detailed case studies that explain various methods and Net Zero Energy Explains optimal analysis and prioritization of cost effective strategies

Retrofitting University Buildings for Energy Conservation Charles F. Sepsy, Robert H. Fuller, 1975*

Buildings Energy Conservation ,1985

Energy Efficient Building Retrofitting ,2018-05 Nowadays the buildings are responsible for the 40% of the world energy The key aspects to design energy efficient buildings arises from a variety of factors and external pressures such as legislation emissions of ozone depleting gases and public awareness of the pollution of our planet There is a great need among public and private sectors to improve the energy performance of existing public buildings Specifically indoor air quality energy efficiency and thermal comfort conditions are the three main considerations for the good performance of buildings Existing buildings tend to undergo performance degradations change in use and unexpected faults or mal functions over time These events often result in significant deterioration of the overall system performance inefficient operation and unacceptable thermal comfort conditions However a building does not have to be new to be efficient Today s leading building owners are retrofitting buildings and converting existing buildings into models of sustainability Commercial retrofit offers significant opportunities for energy efficiency and sustains ability in the built environment Design of energy efficient and high performance commercial retrofit requires that building performance and

simulation tools are used and integrated with the design process Cost Effective Energy Efficient Building Retrofitting aims to provide building researchers and practitioners with a better understanding of how to effectively conduct commercial retrofit to promote energy conservation and sustainability including real world cases Several general design strategies are provided in the successful completion of sustainable and energy efficient retrofit projects It explores the current market size and why the building retrofit market has not expanded as much in past years Review of past practice and research efforts reveals that though a building retrofit project especially a deep retrofit project is no different than any investment case in business practice past retrofit projects are rarely motivated and convinced by the cost effectiveness of the project but more by building owners desire to green the building

A Retrofit Tool for Improving Energy Efficiency of Commercial Buildings, 2013 Existing buildings will dominate energy use in commercial buildings in the United States for three decades or longer and even in China for the about two decades Retrofitting these buildings to improve energy efficiency and reduce energy use is thus critical to achieving the target of reducing energy use in the buildings sector However there are few evaluation tools that can quickly identify and evaluate energy savings and cost effectiveness of energy conservation measures ECMs for retrofits especially for buildings in China This paper discusses methods used to develop such a tool and demonstrates an application of the tool for a retrofit analysis The tool builds on a building performance database with pre calculated energy consumption of ECMs for selected commercial prototype buildings using the EnergyPlus program The tool allows users to evaluate individual ECMs or a package of ECMs It covers building envelope lighting and daylighting HVAC plug loads service hot water and renewable energy The prototype building can be customized to represent an actual building with some limitations Energy consumption from utility bills can be entered into the tool to compare and calibrate the energy use of the prototype building The tool currently can evaluate energy savings and payback of ECMs for shopping malls in China We have used the tool to assess energy and cost savings for retrofit of the prototype shopping mall in Shanghai Future work on the tool will simplify its use and expand it to cover other commercial building types and other countries

Energy Design Strategies for Retrofitting A. Boeri, E. Antonini, J. Gaspari, D. Longo, 2014-12-15 Providing a coherent and realistic vision of the implications of the energy issue in the future development of our cities places emphasis on the links between very specific and technical topics and the most challenging issues concerning energy savings and the transition to a low carbon society A great part of the built environment in most European cities consists of buildings dating from 60s to early 90s for residential purposes this stock clearly presents several problems related to its functional layout as well as its energy thermal behaviour Applying sustainable and energy savings principles to retrofitting interventions on the stock above is one of the most urgent challenges to be met in the very near future Giving some examples and case studies this book investigates retrofitting interventions in terms of energy balance from design strategies to choice of materials and components from market trends analysis to economical assessment from the targeted energy performance to the energy investments needed for achieving it

The reader will benefit from the real life experiences and related results described in this book and acquire all the tools for a constructive evaluation of the different options available to him/her when faced with retrofitting interventions thanks to a global view of all the issues involved

Retrofitting the Built Environment William Swan, Philip Brown, 2013-08-06 The physical upgrading of the existing domestic and industrial building stock to improve energy performance is an essential part of a transition to a low carbon society Successfully retrofitting buildings to improve energy performance is not simply a technological challenge it is a complex socio technical problem that needs to be addressed in a co ordinated way utilising skills and knowledge from a range of industrial and academic backgrounds Within both the academic and practitioner communities there is a growing understanding of the scale and nature of the problem one which encompasses issues such as policy and regulation people and behaviour supply chain and process as well as issues of technology Retrofitting the Built Environment discusses the factors that impact on the retrofit problem providing a clear analysis of the main issues that the academic and industrial communities must engage with to resolve the problems of domestic energy and retrofit The book is divided into four broad sections Understanding the Problem Policy and Regulation Implementing and Evaluating Retrofit People and Communities Academic and industrial researchers policy makers and industry practitioners will find each section covers a mix of policy technical and social science issues presented by both academic and industry authors giving a wide and detailed perspective of the issue The Editors Will Swan is a Senior Lecturer in Buildings Retrofit in the School of the Built Environment at the University of Salford He leads a number of projects in the field of sustainable retrofit covering a number of topics including monitoring behaviour and retrofit project delivery as part of Salford's Applied Energy and Buildings Research Group He sits on the Greater Manchester Buildings Group and also is Chair of the Retrofit Innovation Group Philip Brown is Director and Senior Research Fellow at the Salford Housing Urban Studies Unit SHUSU at the University of Salford He is the lead academic on end use energy demand within the Applied Energy and Buildings Research Group and sits on Greater Manchester's Low Carbon Economic Area group for Customer Engagement

Status of Federal Energy Conservation Programs United States. Congress. Senate. Committee on Energy and Natural Resources. Subcommittee on Energy Conservation and Regulation, 1977

Identifying Retrofit Projects for Buildings United States. Office of Energy Conservation and Environment, 1976

Retrofitting Homes for Energy Conservation NAHB Research Foundation, 1975

Retrofitting for Optimal Energy Performance Tantau, Adrian, 2019-06-14 Retrofitting expresses in a traditional approach the process of improving something after it has been manufactured constructed or assembled These systems integrate new technologies new functions and new services that increase the energy performance in existing private public and commercial buildings Retrofitting for Optimal Energy Performance is a comprehensive reference source that examines environmentally conscious technologies and their applications in advancing retrofitting practices Providing relevant theoretical frameworks and the latest empirical research findings in the area it highlights an array of topics such as climate change energy

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