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Optimal work force allocation for energy, economic and environmental sustainability in the United Arab Emirates: A goal programming approach

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Abstract

Sustainable development is an important and strategic priority for global nations which requires simultaneously satisfying multiple conflicting objectives involving social, economic, energy, and environmental constraints. Multi-criteria decision analysis using a goal programming approach, is a popular and widely used technique to study real world problems involving conflicting objectives due to modelling simplicity and elegance. In this paper we propose a goal programming model that integrates efficient allocation of labour resources to achieve sustainability objectives relating to economic, energy and environmental goals of the United Arab Emirates by the year 2030. The proposed solution provides mathematical and economic justification with critical insights to prioritize areas for strategic planning and resource allocation to develop and implement amenable strategies for sustainability.

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1. Introduction

An agenda for sustainability requires focused efforts to minimize consumption of natural resources, an increased dependence on renewable energy, sustained efforts to reduce GHG emissions and committed leadership. The interaction between energy consumption, economic growth and its effects on

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environmental degradation requires suitable trade-offs to develop amenable policies. The changing demographics and economic growth are contributors to a steep increase in Green House Gas (GHG) emissions and consumption of natural resources. Despite international efforts to reduce emissions, GHG emissions are growing and accumulating at an accelerating pace due to extensive use of fossil fuel based energy sources [1]. To address the sustainability challenge multiple conflicting objectives on economic development, energy consumption, population, social and environment should be simultaneously considered. The objective of this paper is to address some of the criteria towards achieving sustainability goals of the United Arab Emirates (UAE) by the year 2030.

In recent decades the UAE has witnessed remarkable economic growth making it the 7th largest GDP per capita, and the 10th largest oil producing country in the world. The UAE has historically depended on hydrocarbon based revenue since independence in 1971 [2]. To support the rapidly growing economy, increased population and energy needs, the UAE has taken several important initiatives towards economic diversification. In recent years it has heavily invested in non-oil sectors such as technology, infrastructure, education, finance, trade, and manufacturing, to help support long-term sustainability, which provides immunity against oil price fluctuations. Terdiman [3] presents a discussion on the green economy and sustainable development initiatives of the UAE. The UAE Vision 2021 [4] specifically addresses the strong need to develop and promote renewable energy sources advocating lower GHG emissions.

The electricity demand in the UAE has grown from 38600 GWh in 2000 to 79500 GWh in 2009, to 90600 GWh in 2010, with an average annual increase rate of about 8.8% during the last decade [5]. Between the years 2006 and 2011, the annual increase in electricity demand (10.8%) has closely followed the trend in annual population growth of 11% during the same period [5]. The population growth of the UAE has been phenomenal—from 1 million in 1980, to 8.4 million in 2010 and 9.346 million in 2013 [6]. The UAE population constitutes a diverse mix of nationalities and cultures with over 80% expats or non-UAE nationals, with a market heavily dependent on foreign labor for future development and growth. More generally, when comparing the average annual percent change in population, the UAE is placed at 10th among 230 countries with a growth rate of 3.06% [7]. A population growth of this proportion can be directly linked to an increased electricity consumption and over consumption of other natural resources. Conservative estimates predict that the per capita electricity consumption in the Gulf Cooperation Countries (GCC) countries is likely to increase at an annual rate of 2.5% [8]. Electricity generation in the UAE is mainly through natural gas; this leads to severe environmental concerns, including increased production of CO₂, SO₂, and other GHG's and particulate matter. Over 97.5% of power generation across the country comes from natural gas-powered plants [12]. Due to the limited ground water potential, water requirements for the growing population are predominantly met by desalination. Water desalination plants are a significant source of energy consumption, GHG emissions and air pollution [9]. The UAE's CO₂ emissions have increased from 6080 Gg in 1990 to 14690 Gg in 2008 [10]. Of these emissions, the largest contributions were due to power generation [10]. It is interesting to note that the, Middle East and North Africa (MENA) region is regarded as the second most polluted region in the world (following South Asia), which produces the highest CO₂ levels per dollar of output [11]. Population growth and energy consumption are obvious contributing factors to GHG emissions. In 2000, the UAE's total GHG emissions were 128300 Gg of CO₂ equivalent, and the current figures show a 64% increase in total GHG emissions since 1994. In order to meet the long-term emission reduction goals, the top priority is to reduce the need for fossil fuels by investing in clean technologies for energy production. Usage of renewables would present multiple benefits to the UAE, most importantly to reduce the dependence on hydrocarbons.

In this paper we present a goal programming (GP) approach to study the interactions between goals related to electricity consumption (G1), GHG emissions (G2), GDP growth (G3), and number of employees (G4) from various economic sectors and their contribution to the future economic

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