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Energy use analysis in the presence of quality of life, poverty, health, and carbon dioxide emissions

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ABSTRACT

Access to clean energy has a positive impact on societies, whereas excessive extraction of fossil fuels along with population growth, traps the world into serious problems. Global energy strategy is a manner to find a balance between positive and negative impacts of energy on societies, especially their quality of life. This paper proposes a framework to choose a decent global energy strategy in the presence of five factors including final energy consumption, quality of life, poverty, health, and carbon dioxide emissions. The core of the framework is "Trade-off Analysis", which its outputs are analyzed by three defined scenarios in the presence of total population. According to the results, mitigation of carbon dioxide emissions and preservation of the natural energy sources are two factors with a higher priority to encourage developed countries to reduce energy consumption. In case of developing countries, in addition to the two previous factors, the poverty and quality of life are next priorities. For pre-developing countries, the first priority is poverty reduction, then health and quality of life improvement. Thereby, the paper proposes the eco-sufficiency and eco-efficiency policies for developed and developing countries respectively, while energy poverty policy for pre-developing countries.

1. Introduction

Excessive extraction of fossil fuels along with population growth faces societies of its negative impacts. These impacts include, but not limited to the environmental degradation, climate-change risks, and burden of diseases associated with fossil fuel combustions. In contrast, access to clean energy has positive impacts on societies, social structures and their changes [1]. Moreover, the social structure within a society determines the foundation of interactions, which bring about the QoL [2]. Objective QoL is a multi-faceted social concept which is affected by economy, environment, education health, and energy.

Energy and Poverty: Energy, itself, does not move the people out of poverty, but energy access is a pre-requisite for economic growth, unemployment decline, health and educational promotion, and poverty reduction ([3], chapter two, GEA [4]). Nevertheless, people capabilities and the fair allocation of resources determine how effectively people utilize the clean energy to promote their QoL [5,6], and reduce poverty.

Energy and Environment: Fossil fuels account for 64% of the world greenhouse gases, while the share of CO_2 emissions due to fossil fuels is 84% (chapter three, GEA [4]). Industrialization and excessive use of natural resources have increased about three times, the atmospheric concentration of CO_2, from 0.96 ppm/year in 1959 to 2.93 ppm/year in 2016 [7]. Greenhouse gas emissions due to excessive use of fossil fuels, which causes global warming, has the harmful effects on human life, ecosystems. This is while the QoL level in some developed countries has reached to the saturation point [8], and reduction in the level of production and consumption is required to maintain sustainable world. Furthermore, developing countries have a lot of potential to save energy and reduce the CO_2 emission [9,10]. Therefore, it is required to adopt an effective GES regarding to the energy resources while maintaining acceptable QoL in a society. This study considers the CO_2 emissions associated with the excessive use of fossil fuels and its negative impact on the environment.

Energy and Health: Access to the energy contributes a positive impact upon human health, but the energy burden causes some health risks [11], especially in pre-developing countries. Extraction and combustion of the coal and biomass (solid fuels) have the largest health impacts [12]. Poor combustion of fossil and biomass

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Nomenclature

CDM	Clean Development Mechanism
CO2pc	CO2 emission per capita
CP	Central Point of energy consumption
DALY	Disability-Adjusted Life Year
DALYpc	DALY per capita
EC	Energy Consumption
FA	Factor Analysis
FEC	final energy consumption
FECpc	Final Energy Consumption per capita
GDP	Gross Domestic Product
GEA	Global Energy Assessment
GES	Global Energy Strategy
GNI	Gross National Income
HDI	Human Development Index
IEA	International Energy Agency
IGCC	Integrated Coal Gasification Combined Cycle
IHR	Infant Health Rate
IMR	Infant Mortality Rate
IWA	Improved Water Access
Kgoe	Kilograms of oil equivalent
LEB	Life Expectancy at Birth
MACC	More Advanced Combined Cycle
MYS	Mean Years of Schooling
OECD	The Organization for Economic Co-operation and Development
PAF	Population Attributable Fractions
PPP	Purchasing Power Parity
$Q.L._{CP}$	QoL value in central point
$Q.L._{fa}$	QoL indicator extracted by factor analysis
QoL	Quality of Life
SDGs	Sustainable Development Goals
SRES	Special Report on Emission Scenarios
TP	total population
USC	ultra-supercritical
WHO	World Health Organization

fuels, is the major factor of five million premature deaths per year and more than 5% of all ill-health (chapter four, GEA [4]). Significant part of these health impacts occur in the poor countries where people suffer from poverty, lack of access to clean energy sources, indoor air pollution due to traditional fuels combustion, and low QoL. Adoption either a wrong energy policy interventions or improper management will worsen the condition for poor people [13], and endanger their health.

However, the imbalance between the limited energy sources and energy demand[1] [14] calls for an international cooperation and collaboration [15], to have an efficient GES, while maintaining human development programs (SDGs, 9th and 17th goals [16]). Increase in the energy consumption along with population growth poses the following question:

I-Which GES effectively response the world energy demand in the presence of the limited energy resources, and the aforementioned concerns?

This paper proposes a framework to answer the question above. The main part of the framework relies on the "Trade-off" analysis module, in which data belong to the five factors[2] are analyzed in terms of the six types of country classifications (pre-developing, developing, developed, Ref.1, Ref.2, and Ref.3; please see Appendix A). *It is called trade-off analysis, because of balancing among these factors, which their optimum states are incompatible*. In other words, trade-off analysis module analyzes a change of these factors in terms of six classes.

The fundamental idea behind the trade-off analysis is to model QoL against FECpc data, which results in three types of country for the world. Furthermore, three types of reference countries are proposed to shed light on the trade-off analysis. These reference countries show relatively a higher QoL compared to other countries with the same amount of FECpc. Therefore, three country classifications and three types of reference countries are the core of the Trade-off analysis. Poverty, health, CO_2 emission, QoL, and FECpc are analyzed in terms of these six types of countries. Then, the results of the trade-off analysis are considered as an input to propose appropriate GES.

[1] The IEA projection shows the global energy increases by one-third from 2010 to 2035, which the share of China and India is 50% of the growth.

[2] Final energy consumption, QoL, poverty, health, and CO_2 emissions.

2. Literature review

Energy is an inevitable part of the human life and prerequisite for human development and poverty reduction, whereas it has a negative impact on the environment. Greenhouse gas emissions due to fossil fuels threaten the environment and ecosystem through global warming and climate change. On the other hand, disease burden related to the climate change such as heat, coastal flooding, diarrhoeal disease, malaria, dengue and undernutrition, imposes a severe condition on societies [17].

Analysis of poverty reduction, environmental protection along with a suitable energy policy were investigated by Schubert et al. [18]. The analysis finally led to three development policies at national and international scope. These development policies contained the mitigation of climate change, transformation of the energy system in developing countries, and adaptation finance to climate change. Technology transferring to developing countries was one of their proposed steps to mitigate global greenhouse gas emissions. Transferring of CDM was conditioned by the "CDM Gold Standard" tool as a sustainable method for poverty reduction.

The relationship between global warming and human health was investigated by Tang et al. [19]. Their research measured the human damage factors associated with CO_2 emissions. Variations of the climate change, population growth, and economic development were analyzed to measure the human damage factor. Accordingly, they conducted four scenario families (A1B, A2, B1, and B2) of the SRES [20]. These scenarios were implemented in the presence of the GDP, variation of CO_2 emissions, and population growth variables until 2100. They measured the influence of increasing temperature, relative risk, mortality, the number of deaths, and DALY on the human risk factors [21]. Their results demonstrated the malnutrition, and malaria are two great risk factors among six others for three regions of Asia, Africa, and Middle East.

To better manage environmental health, and estimate the disease burden associated with climate change, quantitative methods were used by Yoon et al. [22]. For this reason, the annual average of rising temperature was forecasted until 2100, by the regression model. Then, population attributable fractions were exerted to extract the environmental DALY. The results from the regression model and the environmental DALY were combined to analyze the burden of disease associated with the climate change for future