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Canada's energy perspectives and policies for sustainable development

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ABSTRACT

A regression analysis is performed to make projections for the Canadian energy production and consumption. These have been increasing and are projected to increase even further in the near future. The primary energy production and consumption are projected to increase by 52% and 34%, respectively, by 2025 over 2004 if business as usual. The amount of fossil energy resources is finite and the extraction, transportation and combustion of fossil fuels cause environmental pollution and climate change. On the other hand, energy plays an important role in the economic and social development of Canada. Canada can develop further from an energy balance point of view, but this alone cannot be sustainable, because of the negative consequences of the major energy use on the environment. Application of energy localization and diversification is a promising solution, but in order to reach that, better energy efficiency and more use of renewable energy are necessary. Instead of non-compulsory policies Canada's policy approach should have more compulsory policies. Only then Canada can be made to develop further in a sustainable manner.

1. Introduction

Canada is an energy-intensive country: the energy sector is an important part of Canada's economy in terms of investment, trade, income generation and employment [1]. The Canadian energy demand and production is increasing further every year. Canadian primary energy production increased from 11,495 PJ to 16,594 PJ between 1990 and 2004, an increase of 44%. In the same period the Canadian primary energy consumption increased from 9229 PJ to 11,617 PJ, which is an increase of almost 26% [2]. Not only the Canadian energy consumption has been increasing every year, but also the worldwide energy consumption has been increasing rapidly, because energy is an essential input to all forms of economic and social activities and plays an important role in the economic and social development of a country. The major energy demand of fossil fuels has major consequences. One of the main issues is that the amount of fossil resources is finite and that it is not sure how long these fossil fuels are available for future generations. Another main environmental problem caused by the major energy consumption is the emission of toxic chemical pollutants, greenhouse gases like CO_2 and other air pollutants. These cause climate change and environmental pollution of air, land and water, which has a negative impact on the health of humans and all other life forms on earth.

Sustainable development (developing sustainable or achieving sustainability) means the satisfaction of present needs without compromising the ability of future generations to meet their own needs [3,4]. Sustainability can be seen as the final goal: a balance of social and economic activities and the environment. Sustainable development is a mean of reaching total sustainability. A sustainable energy sector has a balance of energy production and consumption and has no, or minimal, negative impact on the environment (within the environmental tolerance limits), but also gives the opportunity for a country to employ its social–economic activities.

Given this definition and the current trends in the energy sector as described above, it can be concluded that the manner Canada is developing at the moment is definitely not sustainable. Essential steps towards a sustainable energy future must be made in order to make Canada develop in a sustainable manner, because little has changed so far in the Canadian energy behaviour and technology. In order to really break the current trends radical changes are needed, small steps are not sufficient to reach the goal. To make these changes, with improvement in the quality of life and with having room for further development and further population and economical growth, the Canadian Government has to step forward and take the lead.

According to Dincer and Dost [5] developing a good energy policy is not possible without enough knowledge of past and present energy consumption and likely future demands. In 1997 Dincer et al. [6] analyzed the current situation of Canada's energy resources and provided future projections, but a decade after their projections it can be concluded that the total Canadian energy production and energy demand has grown even further as they predicted. Other trend analyses are performed by Tutmez [7] and

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Dincer and Dost [5]. Tutmez performed a trend analysis for the projection of energy related carbon dioxide emissions and forecasted the 2025 world's carbon dioxide emissions from fossil fuels between 30,000 and 32,000 million metric ton. Dincer and Dost [5] analysed the close relationship between the GDP, the population of Canada and Canada's energy supply and consumption over the years.

Li [8] concludes that the best approach to the issue of energy, environment and sustainable development is the diversification and localization of energy systems, which is also the best approach to the security of energy. The dominance of a single energy source and system, no matter how "perfect" it might be at a time, would be unsustainable in the long run. Canada has good possibilities to apply energy diversification and localization, but currently Canada is still exporting and importing major amounts of energy and is still very dependent on fossil fuels. An effective energy policy is necessary in order to successfully apply the diversification and localization of energy systems. According to Tampier [9] green power marketing is not an effective green power policy, because the impact of voluntary green power programs is very limited. Rivers and Jaccard [10] have the same opinion about the low effectiveness of marketing, but according to them even subsidies are not effective policies. Without a major change towards more compulsory policies, it will be unlikely that Canada will shift towards more usage of renewable energy and better energy efficiency. Karimi [11] agrees: "As long as the current energy source is doing the job (at a very low price), there will be a resistance to change by Canadian inhabitants and companies, especially when it takes time, money and effort". He also states that complete reliance on voluntary programs will not be effective and that voluntary programs must be complemented by regulations.

There are many studies about energy statistics and the effectiveness of energy policy, as indicated early. However, not much is directed towards how Canada is able to develop further in a sustainable manner from an energy point of view. The policy of the Canadian Government is of major importance for a sustainable development of Canada. Therefore the goal of this study is to find out how Canada can develop further in a sustainable manner from an energy point of view and what the role of the Canadian Government must be to reach these goals.

As stated by Dincer and Dost [5] developing a good energy policy is not possible without enough knowledge of past and present energy consumption and likely future demands. Therefore some statistics about the current situation will be analysed. Historic data will be used to perform a regression analysis. The outcome of that analysis is an equation, which will be used to make predictions of the future developments in the energy sector. Using this prediction the room for further development will be analysed. This will be done from two points of view: from an energy balance point of view (balance between energy production and consumption) and from an environmental impact point of view. This knowledge about the future situation provides more knowledge about what the government will have to do, in order to take care of further sustainable growth.

Although energy policy must be considered as a global issue, because the result of energy policy is dependant on global effort, this paper will focus on Canadian energy policy only and analyses only Canadian historic data. Linear regression analysis is used as the method for performing a trend analysis, because this method is suitable to predict the mean future data.

2. Canadian energy statistic analysis

The energy data is analysed by performing a trend analysis, which is an analysis that tries to predict the future movements based on past data [7]. First some historic data is analysed and presented in a graph. Then a linear regression analysis is made to represent these data into an equation of the form

$$y = a_0 + a_1 \times x$$

The goodness of fit of the regression analysis (R^2) is the percentage of variance in the dependent variable projected by the equation. The significance level (F) of the regression analysis must be below 0.05 in order to be able to assume that the projected equation is statistically significant and thus useful. If the significance level is below 0.05, then the equation can be used to estimate future projections.

2.1. Historic projections compared with actual data

In 1997 Dincer et al. [6] analyzed the then situation of Canada's energy resources and provided future projections. A decade after their projections it can be concluded that the Canadian energy production and energy demand has grown beyond what they predicted, with the production and consumption of coal as the only exception. For example Dincer et al. [6] predicted the 2004 oil production and consumption at 4284 PJ and 2689 PJ, respectively, while the actual 2004 oil production and consumption were 5869 PJ and 4763 PJ, which means an underestimation of 37% and 77%, respectively. Figs. 1–3 show the regression lines, for total primary energy consumption and total energy production for coal, natural gas and oil, as projected by Dincer et al. [6] and the actual historic data based on the Energy Statistics Handbook 2006 [2].

2.2. Regression analysis and future projections

Based on historic data from the Ministry of Natural Resources Canada [12] and the Energy Statistics Handbook 1996 and 2006 [2,13] new predictions can be made, using a regression analysis. However, comparing previous projections with actual historic data showed that these expectations can again be too low. The predictions will be made for energy production per fuel type and primary energy demand per fuel type. The economic and demographic development of a country are closely linked to the increased use of energy, hence it is important monitoring developments in this area as well.

2.2.1. Predictions for energy production per fuel type

Canada has secure, reliable and diverse sources of energy available, namely oil, gas, coal, uranium and hydro. This availability makes Canada the fifth largest energy producing country in the world, behind the United States, Russia, China and Saudi-Arabia (www.iea.org). Canada does not only produce enough energy for its own major energy demand, but also export significant amounts of energy, mainly to the United States. From 1989 to 1998, the value of energy products averaged about 10% of total exports [4]. Given the historic data of the energy production per fuel type Fig. 4 can be made, presenting the historic fuel consumption and the trend lines, which are made using a regression analysis.

The energy production (all in PJ) can be modelled with the following regression functions:

$$\text{Crude oil} = -28.28 \times 10^3 + 143.9 \times \text{year} \quad (1)$$

$$\text{Natural Gas Liquids (NGL)} = -39.21 \times 10^3 + 19.92 \times \text{year} \quad (2)$$

$$\text{Natural Gas} = -432.0 \times 10^3 + 219.4 \times \text{year} \quad (3)$$

$$\text{Coal} = 49.47 \times 10^3 - 23.96 \times \text{year} \quad (4)$$

$$\text{Total energy production} = -751.4 \times 10^3 + 383.6 \times \text{year} \quad (5)$$

The regression equation that describes the production of nuclear and hydro is not significant, because the F-value is 0.09, which is higher than the 0.05 significance level. Therefore the relation