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Analysis of sectoral energy infrastructure projects in Finland

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Abstract

In the Nordic area, Finland is one the main emitters of Co_2, and energy consumption is relatively high, as well. Here, through log-mean divisia index analysis between 2000 - 2009, the main reason behind this issue has been analyzed. As a result, electricity and gas supply, coke, refined petroleum and nuclear fuel have been the main reason for the energy increase. On the other hand, pulp, paper, printing and publishing have significantly decreased. In addition, the energy related emission has been evaluated, and electricity, gas and water supply are highlighted as main items.

Keywords
sustainable decision making; green portfolio management; efficiency analysis; sustainability

1. Introduction

Energy project management has been remarked as one the main derivers of sustainable development policy [1]. The previous studies have shown that the energy consumption is related to the three main factors: production changes, structural changes and efficiency that affect the energy intensity. This research implements indexed decomposition analysis (IDA) to evaluate these factors [2]. First, this research analysis the sectorial energy use for the period 2000-2009. Next, the Co2 energy related emission is evaluated. Finland has made a plan for the reduction of Co2 by 80-95% by 2050 compared to 1990 levels, and this analysis can help the policy makers to better achieve the goals [3].

2. Background

Finnish economy is industrialized, and accompanied with the cold clime the Finnish energy consumption is one of the highest in the IEA. Final energy consumption per capita, is ranked as second highest among Nordic countries and OECD average (after Iceland) [4]. Denmark and Finland are the main emitters of CO2 in the Nordic electricity. Furthermore, the eco-efficiency ranking of Finland is not as high as other Scandinavian countries [5], and it is mainly because of a lower ratio of GDP and CO2 emission relatively, as presented in the figure 1.

Finland is dependent on nuclear and coal-fired power plants in electricity generation. Hydro power is also considered as the second important item in the electricity generation mix. The electricity price is among the lowest in the IEA countries. However, diversity in power generation in high in Finland, and renewable energy plays an important role in Finish energy portfolio. Meanwhile, the largest user of bioenergy in Finland is the pulp and paper industry [6].

Despite the decarburization policies in Finland, coal, oil and natural gas have been important resource for the electricity generation. In compliance with European Union climate and energy targets 20.20.20, Finland aims to reduce domestic GHG emissions by 80% by 2050 from the 1990 level. This target includes 38% (20%Renewables in road transport) renewable energy shares of total energy use [7].

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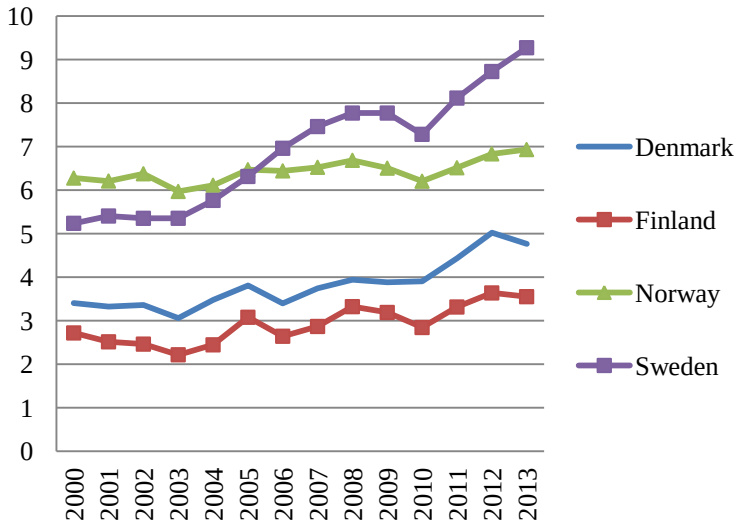

Figure 1. GDP (ppp) (current international $) / CO2 (kt) Co2 emission from fuel combustion - ratio

3. METHOD AND DATA

IDA has gained considerable attention in energy research. This assessment can be done in energy intensity, and CO2 emission, as well. This method can evaluate the changes in energy consumption based on three criteria: changes in the structure of the economy (‘‘change in sectoral share’’), changes in efficiency (intensity or technology effects), and production effect (changes in the production) [8].
IDA method is dived into two main groups and this paper implements LMDI1.

E ——

Where

E_t: total energy consumption for all sectors in year t
$E_{i,t}$: energy consumption in sector i in year t
Y_t: total output in year t
$Y_{i,t}$: output of sector i in year t
$S_{i,t}$: output share of sector i in year t (=Yi,t/Yt)
$I_{i,t}$: energy intensity of sector i in year t (=Ei,t/Yi,t)

Change in total energy consumption between year 0 and year t (out indicated the change in real output, *str* is structural change and *int* intensity change, or changes in efficiency):

ΔEtot = Et - E0 =ΔEout +ΔEstr + ΔEint

According to Ang [6]:

Where:

In case of emission evaluation the relevant IDA equation is

Where

C is the total CO2 emissions
Cij is the CO2 emissions from fuel j in industrial sector i;
Eij is the consumption of fuel j in industrial sector i,
Mij is the fuel-mix
Uij is the CO2 emission factor by

And

$\Delta C_{tot} = C_t - C_0 = \Delta Eact + \Delta Estr + \Delta Eint + \Delta Emix + \Delta Eemf$

Data collection has been thorough WOID data base [9].

4. Results

The results are presented in the table 1. The majority of sectors have growth in the energy consumption. It shows that between 2000-2009 the main increase in energy consumption has been in electricity, gas and water supply (92563 TJ) and Coke, Refined Petroleum and Nuclear Fuel (44960 TJ). However, the max reduction occurred in pulp, paper, printing and publishing industry (-74594 TJ). The overall output effect accounts for 1,443,904 (or 99%) of total increase in energy consumption. In addition, the structural changes (change in contribution if each sector to the total output) involves in the increase in the energy consumption 133,603 (or 7%).
On the other hand, the efficiency effect has acted positively in the reduction of energy consumption 1,426,568 TJ (51%) in means that if there were no energy intensity measure in Finland the consumption would have been 1426568 T more. The overall effect are presented in the figure 2; Finnish industrial energy increased by 7%, or 150,939 TJ from 2000-2009.

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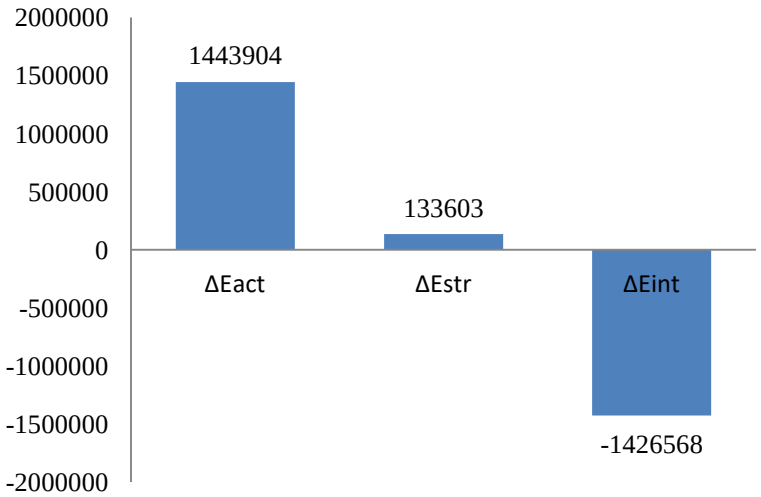

Figure 2. Overall effects contributions

Table1. Total energy consumption 2000-2009 (top5- top less)

Sector	Change in consumption	ΔEact Production effect	ΔEstr Structure	ΔEint Effeminacy effect	Rank
Electricity, Gas and Water Supply	92563	431227	202803	-541466	1
Coke, Refined Petroleum and Nuclear Fuel	44960	400464	102115	-457618	2
Air Transport	36747	32190	5540	-983	3
Chemicals and Chemical Products	30988	51972	3541	-24524	4
Real Estate Activities	19140	27146	6630	-14636	5
⋮					
Mining and Quarrying	-3234	4722	1810	-9766	30
Construction	-3573	22494	2711	-28778	31
Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles	-7962	6393	480	-14835	32
Basic Metals and Fabricated Metal	-13267	60453	-12873	-60848	33
Pulp, Paper, Printing and Publishing	-74595	206756	-162761	-118590	34

Next, this study also has evaluated the CO2 impact of Finnish energy. Table 2 present the sectoral decomposition analysis of each sector. Therefore, for the most influential sectors are: agriculture, hunting, forestry and fishing; pulp, paper, paper, printing and publishing; coke, refined petroleum and nuclear fuel; electricity, gas and water supply; and air and water transports.
Figure 3 present the contribution of five factors in CO2 emission. Emission increased by 4978 kiloton (or 10%). change in the energy mix and emission factor led to reduction in emissions. Therefor activity effect with 32258 kiloton has the maximum of effect to increase the CO2, while intensity has elevated the CO2 by -32397.04 kiloton.

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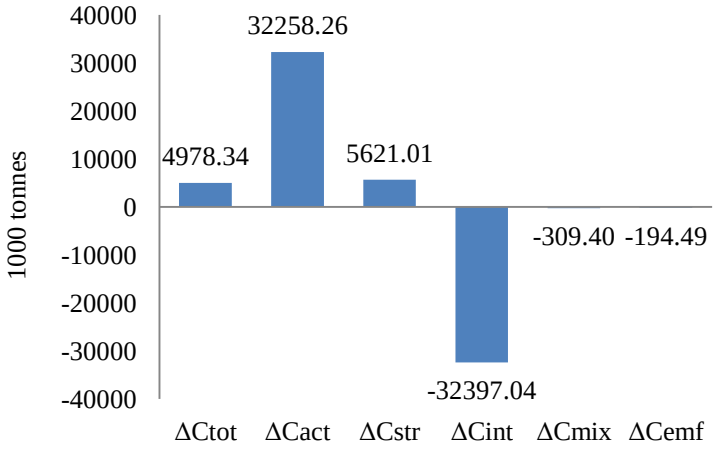

Figure3. Overall effects contributions

Table2. Emission decomposition 2000-2009

Sector	ΔCact	ΔCstr	ΔCint	ΔCmix	ΔCemf
Electricity, Gas and Water Supply	14488	6813	-18191	1167	6
Air Transport	2302	396	-70	0	0
Pulp, Paper, Paper , Printing and Publishing	2249	-1771	-1290	121	22
Coke, Refined Petroleum and Nuclear Fuel	1840	469	-2103	655	-990
Water Transport	1822	-221	-1591	0	0
Agriculture, Hunting, Forestry and Fishing	1525	-473	-1025	-142	-2
⋮					
Transport Equipment	66	-33	-20	-8	0
Electrical and Optical Equipment	59	-36	-2	-45	51
Financial Intermediation	59	-13	-51	-7	0
Textiles and Textile Products	24	-21	5	-20	31
Rubber and Plastics	18	-7	-11	10	97
Leather	3	-3	-2	0	2

5. Conclusion

This study evaluates the energy consumption and Co2 emission in Finland from 2000-2009. The purpose of the study is to assess the reason for the high energy consumption and Co2 emission, as well. Therefore, IDA (LMDI1) is implemented, and energy consumption is divided into three main criteria: changes in the structure of the economy, changes in efficiency, and production effect.

The finding remarks that consumption is mostly affect by production changes and efficiency has a significant mitigating effect. From table 1 it can be perceived that the change in the structure of economy of sector has impact in reduction of energy consumption.

Through this analysis the main users and polluter is identified. The top contributors to energy use are electricity (92563 TJ) and Coke, Refined Petroleum and Nuclear Fuel (44960 tJ) and in contrary Plup (-74595 TJ). Likewise, the decomposition of emissions reveals important elements in energy use trend in Finland. Production effect has been the main reason for the Co2 emission. Electricity, Gas and Water Supply with 14488 kT and transports items (inland;1520, water;1822, air:2302) with 5644 kT has been the highest. However, energy intensity plays an important role in the reduction of Co2 with 32397 kT.

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Biography

Hosein Daneshpour is a project researcher and PhD candidate at university of Vaasa, Finland. He has done his BSc in industrial engineering, and also fulfilled MSc in the field of environmental energy technology at Lappeenranta University of technology in Finland. His research interests are project portfolio optimization, risk management, open innovation, green management, and co-creation in project business.
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