Identifying Factors of Energy Usage in Taiwan

Jui-Chen Yu, Lung-Hsing Kuo, Hsieh-Hua Yang, and Hung-Jen Yang,

***Abstract*—**The purpose of this study was to identify the energy use in Taiwan. Logit regression analyses on a large micro-dataset reveal how energy use characteristics can help explain the energy. Using CR5.0 regression models, this paper explored the factors affecting energy demand conditional on energy forms, sectors and sources. Results suggest that explained models could be used as a well foundation for energy policy decision making.

***Keywords*—**Energy Use, Energy Indicators, Model

I. Introduction

IN the search for reduce fossil energy use, energy use is an important information for policy making. Energy is used for many different purposes and different processes. Studies typically focus on direct energy use, while indirect energy use has been addressed in only a few studies.

II. Literature review

To further establishing research foundation, the topic of teaching portfolio, LMS, and server log would be reviewed. The thought of educational modeling would also be introduced for clearing structure requirement of logged data convergence.

A. Energy Indicators

There is a need to create indicators for identifying the specific characters of energy use. Different indicators are purposeful in pointing certain concept. Indicators could only be used as a director because of its essentials..The target of these indicator are listed as follows:

- Economic
- Efficiency
- Security
- Environment

B. Indicators of Energy Economic

There are four indicators discussed in this energy economic indicator session. The first indicator is the total primary energy supply in KLOE quantity. The second indicator is the total final consumption in quantity in KLOE. The third indicator is the total domestic consumption in quantity in KLIO. The fourth indicator is the real GDP in Million NT$.

According to the relationship between real GDP and primary energy supply, between real GDP and total final consumption, and between real GDP and total domestic consumption, the energy economic status could be explored.

C. Indicators of Energy Efficiency

There are nine indicators discussed in this energy efficiency indicator session. The first indicator is the mid-year population in 1000 persons. The second indicator is the per capita energy consumption in LOE. The third indicator is the elasticity of domestic consumption. The fourth indicator is energy productivity in NT$/LOE The fifth indicator is the energy intensity in LOE/NT$1000. The sixth indicator is the per capita electricity consumption in KWh. The seventh indicator is the energy consumption of energy intensive industries in quantity of KLOE. The eighth indicator is the value-added of energy intensive industries in million NT$. The ninth indicator is the energy intensity of energy intensive industries in LOE/KNT$.

According to these eight indicators and the relationship among them, the energy efficiency could be discussed and explored.

D. Indicators of Energy Security

There are thirteen indicators discussed in this energy security indicator session. The first indicator is dependence on imported energy in percent. The second indicator is dependence on oil in percent. The third indicator is the dependence on oil imports in percent. The fourth indicator is the dependence on crude on imports from Middle East in percent. The fifth indicator is the value of oil imports over values of total imports in percent. The sixth indicator is the value of oil imports over values of total exports in percent. The seventh indicator is the value of oil imports over GDP in percent. The eighth indicator is the value of energy imports over value of total imports in percent. The ninth indicator is the value of energy imports over value of total exports in percent. The tenth indicator is the value of energy imports over GDP in percent. The eleventh indicator is the per capita energy imports in NT$. The twelfth indicator is the concentration of energy supply in percent. The thirteenth indicator is the average load in MW.

According to these thirteen indicators and the relationship among them, the energy security could be discussed and

This research was supported by the National Science Council of Taiwan, Republic of China, under grant NSC 99-2511-S-017-003-.

explored.

E. Indicators of Energy Environment

There are five indicators discussed in this energy environment indicator session. The first indicator is the CO2 emission from energy use in 1000MT. The second indicator is the CO2 emission per unit GDP in Kg CO2/ 1000NT$. The third indicator is the CO2 emission per unit domestic energy consumed in MT CO2/ KLOE. The fourth indicator is the per capita CO2 emission per unit domestic energy in MT CO2. The fifth indicator is the electricity emission coefficient in Kg CO2/KWh.

According to these five indicators and the relationship among them, the energy environment could be discussed and explored.

III. METHODOLOGY

A Meta data analysis method was applied to conduct this study. The methodology would be illustrated according to the research problem, data collection, and data analysis.

A. Research problem

The purpose of this study was to establish models of energy use in Taiwan. In the other word, it was intend to find whether the relationship exists among energy indicators..

There were two phases in this study. In the first phase, the trend of energy indicators were identified and explored.. In the second phase, the relations among indicators were examined and model of energy use were created.

B. Data Collection

The data was collected from the websites of Bureau of Energy, MOEA, Taiwan, R.O.C. During may 2010, this research was conducted and the data collected from 1989 to 2009. [1]

C. Data analysis

Mata data analysis was conducted by trend analysis of each indicators and statistical test for model verification. Integrated Database would be an reliable data resource for research.[2,3,4,5]

IV. FINDINGS

In this study, energy use was illustrated according to energy index and the relationship among those indexes. Trend and model were constructed for reveal the energy use.

A.4.1 Trend of Energy Economic

There are four indicators discussed in this energy economic indicator session. The first indicator is the total primary energy supply in KLOE quantity. The second indicator is the total final consumption in quantity in KLOE. The third indicator is the total domestic consumption in quantity in KLIO. The fourth indicator is the real GDP in Million NT$.

Table 1 Total Primary Energy Supply in 1000KLOE

Year	Total Primary Energy Supply (1000KLOE)
1989	50,194.6
1990	53,517.7
1991	57,952.1
1992	60,859.2
1993	64,984.6
1994	68,359.1
1995	71,979.6
1996	75,704.9
1997	79,742.7
1998	85,439.1
1999	88,994.4
2000	96,040.1
2001	100,601.2
2002	105,404.8
2003	108,707.3
2004	113,971.1
2005	115,399.3
2006	118,122.1
2007	124,562.2
2008	119,419.2
2009	117,719.6

According to the relationship between real GDP and primary energy supply, between real GDP and total final

consumption, and between real GDP and total domestic consumption, the energy economic status could be explored.

The trend of total primary energy supply is shown in Figure 1. The value was growing since 1989 until 2007. After 2007, the total primary energy supply drops down.

In table 2, the total final consumption of energy use in Taiwan is shown.

The trend of total final consumption is shown in Figure 2. The value was growing since 1989 until 2007. After 2007, the total final consumption decreases.

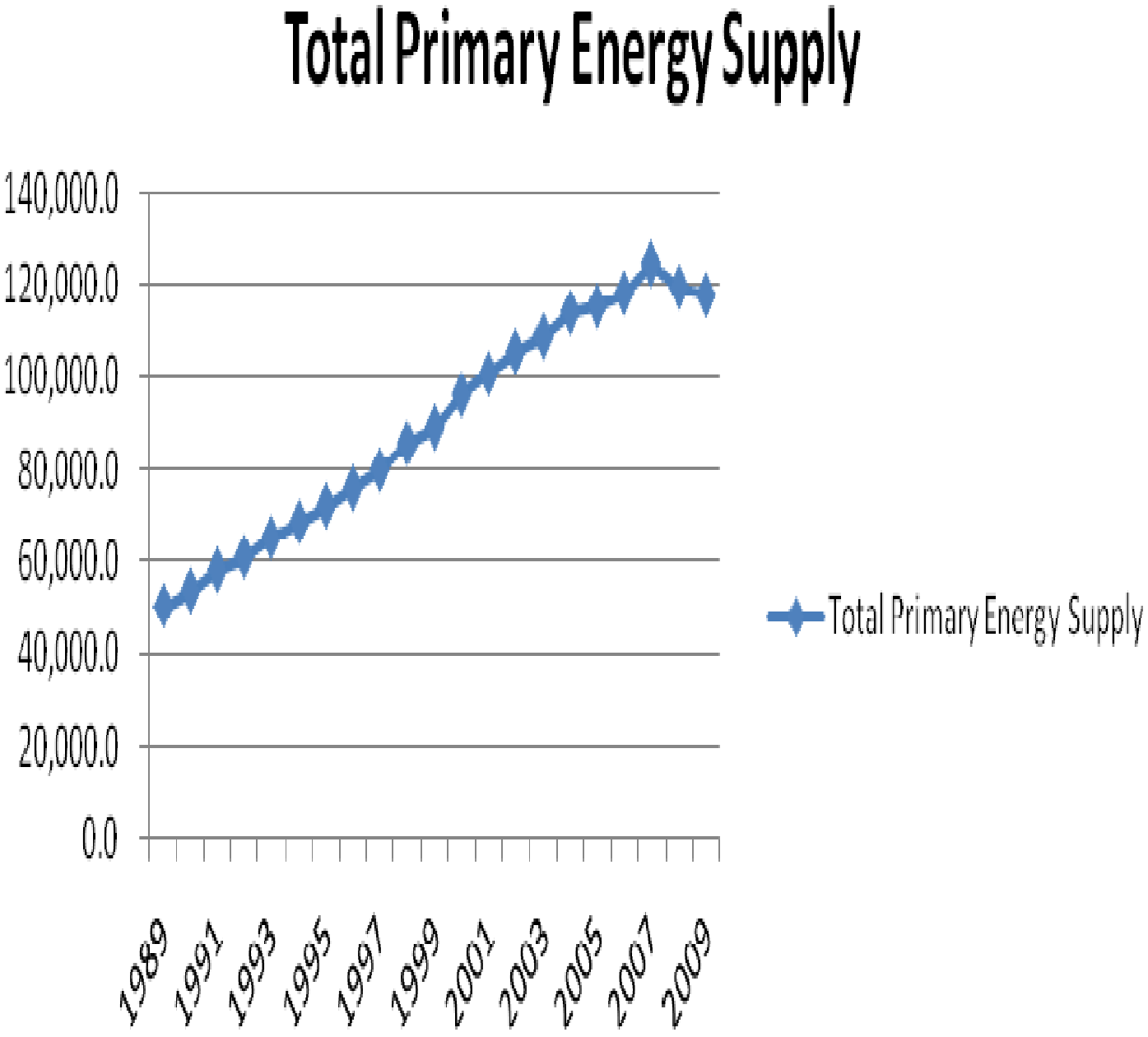

Figure 1Trend of total primary energy supply

Ta

Year	Total Final Consumption (1000KLOE)
1989	43,364.0

1990	46,145.2
1991	49,662.4
1992	53,100.8
1993	55,410.4
1994	58,907.4
1995	62,076.4
1996	65,070.3
1997	68,224.5
1998	72,808.8
1999	76,966.3
2000	83,485.3
2001	88,478.9
2002	92,245.0
2003	95,824.2
2004	99,950.8
2005	101,831.6
2006	104,311.9
2007	109,956.3
2008	107,224.4
2009	104,925.7

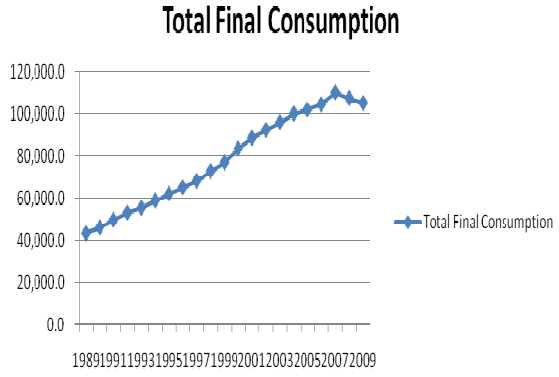

Figure 2 total final consumption in 1000 KLOE

Table 3 Table of total Domestic Consumption

Year	Total Domestic Consumption (1000KLOE)
1989	48,035.8
1990	50,986.7
1991	54,554.7
1992	57,952.6
1993	60,745.1
1994	65,021.4
1995	68,475.5
1996	71,754.8
1997	75,357.3
1998	80,291.0
1999	84,645.1
2000	91,736.5
2001	97,055.2
2002	100,495.0
2003	104,371.5
2004	108,766.3
2005	111,143.5
2006	113,738.6
2007	119,175.8
2008	115,701.2
2009	113,085.2

The trend of total domestic consumption is shown in Figure 3. The value was growing since 1989 until 2007. After 2007, the total domestic consumption decreases.

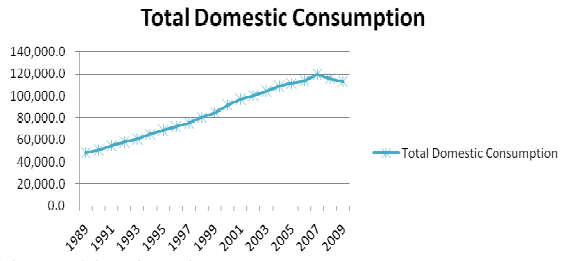

Figure 3Total Domestic Consumption of Energy Use

Table 4 Table of Real GDP

Year	Real GDP Million NT$
1989	N.A.

1990	N.A.
1991	N.A.
1992	6,169,225
1993	6,584,559
1994	7,084,404
1995	7,536,283
1996	7,953,510
1997	8,389,017
1998	8,679,815
1999	9,198,098
2000	9,731,208
2001	9,570,584
2002	10,074,337
2003	10,443,993
2004	11,090,474
2005	11,612,093
2006	12,243,471
2007	12,975,985
2008	13,070,904
2009	12,826,682

The trend of real GDP is shown in Figure 4. The value was growing in most of years. In 2001, 2007 and 2009, the real GDP decreases.

Figure 4 Real GDP

B. Trend of Energy Efficiency

There are nine indicators discussed in this energy efficiency indicator session. In figure 5, figure 6, figure 7, figure 8 and figure 9, the trend of the first five indicators are presented.

Table 5 Mid-year population in 1000 Persons

Year	Mid-Year Population (1,000)
1989	20,006
1990	20,233
1991	20,459
1992	20,656
1993	20,849
1994	21,035
1995	21,215
1996	21,388
1997	21,577
1998	21,777
1999	21,953
2000	22,125
2001	22,278
2002	22,397
2003	22,494
2004	22,575
2005	22,652
2006	22,740
2007	22,828
2008	22,904
2009	22,979

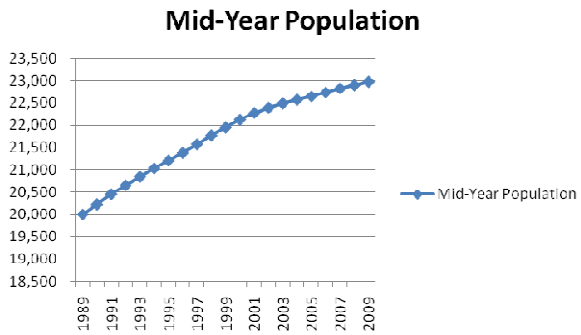

Figure 5 Trend of mid-year population

Year	Per Capita Energy Consumption (LOE)
1989	2,401.13
1990	2,519.98
1991	2,666.60
1992	2,805.68
1993	2,913.64
1994	3,091.11
1995	3,227.69
1996	3,354.99
1997	3,492.48
1998	3,686.96
1999	3,855.83
2000	4,146.28
2001	4,356.55
2002	4,487.09
2003	4,639.99
2004	2,401.13
2005	2,519.98
2006	2,666.60
2007	2,805.68
2008	2,913.64
2009	3,091.11

In figure 6, the trend of per capita energy consumption. The trend shown the decreasing on 2007.

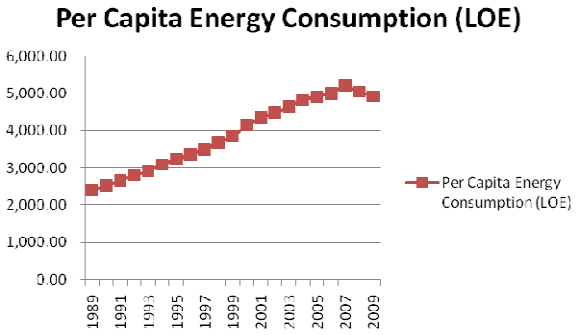

Figure 6 Trend of per capita energy consumption

Table 7 Table of elasticity of domestic consumption

Year	Elasticity of Domestic consumption
1989	N.A.
1990	N.A.
1991	N.A.
1992	N.A.
1993	0.72
1994	0.93
1995	0.83
1996	0.86
1997	0.92
1998	1.89
1999	0.91
2000	1.44
2001	-3.51
2002	0.67
2003	1.05
2004	0.68
2005	0.47
2006	0.43
2007	0.80
2008	-3.99
2009	1.21

In figure 7, the trend of elasticity of domestic consumption. The trend decreased sharply on 2008 and 2001.

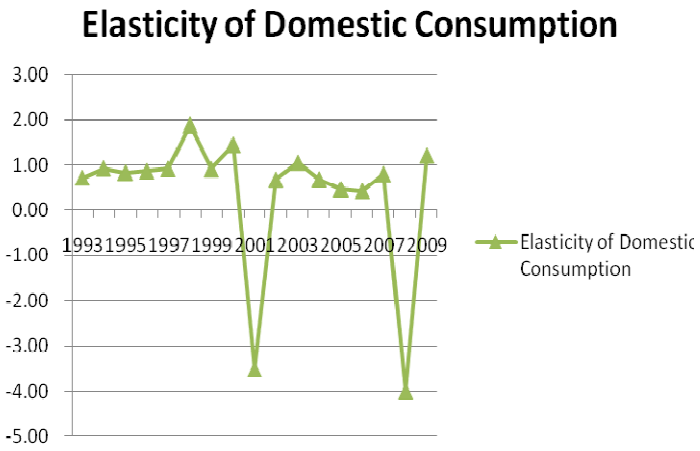

Figure 7 Trend of elasticity of domestic consumption

Table 8 Table of Energy Productivity in NT$/LOE

Year	Energy Productivity (NT$/LOE)
1989	N.A.
1990	N.A.
1991	N.A.
1992	106.45
1993	108.40
1994	108.95
1995	110.06
1996	110.84
1997	111.32
1998	108.10
1999	108.67
2000	106.08
2001	98.61
2002	100.25
2003	100.07
2004	101.97
2005	104.48
2006	107.65
2007	108.88
2008	112.97
2009	113.42

In figure 8, the trend of energy productivity. The trend increases after 2001.

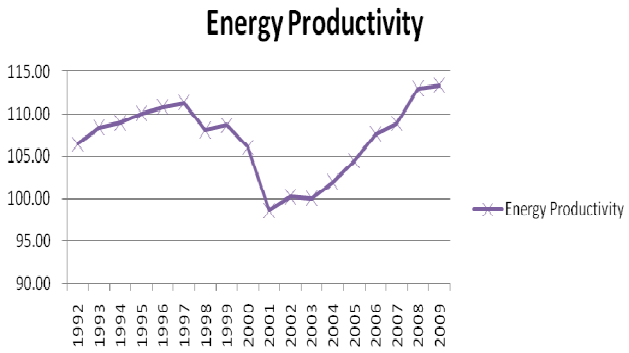

Figure 8 Trend of Energy Productivity

Table 9 Energy Intensity in LOE/NT$1000

Year	Energy Intensity (LOE/NT$1,000)
1989	N.A.
1990	N.A.
1991	N.A.
1992	9.39
1993	9.23
1994	9.18
1995	9.09
1996	9.02
1997	8.98
1998	9.25
1999	9.20
2000	9.43
2001	10.14
2002	9.98
2003	9.99
2004	9.81
2005	9.57
2006	9.29
2007	9.18
2008	8.85
2009	8.82

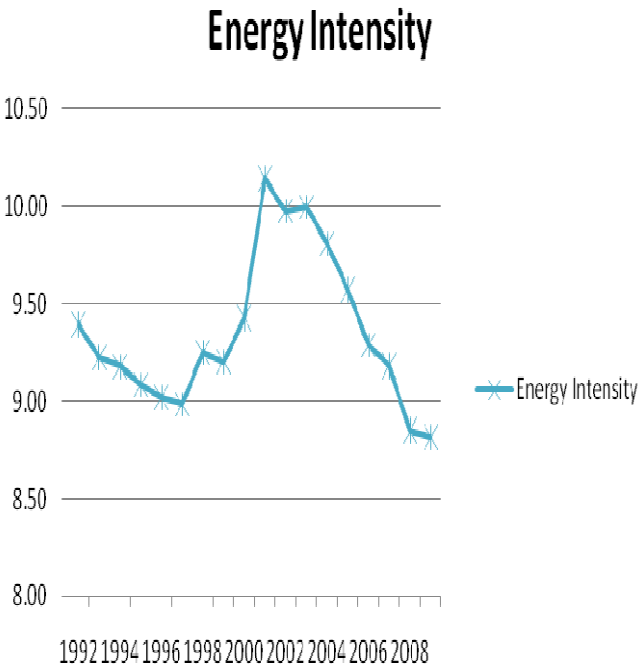

Figure 10 Trend of Energy Intensity

C. Trend of Energy Security

There are thirteen indicators discussed in this energy security indicator session. The first indicator is dependence on imported energy in percent. The second indicator is dependence on oil in percent. The third indicator is the dependence on oil imports in percent. The fourth indicator is the dependence on crude on imports from Middle East in percent. The fifth indicator is the value of oil imports over values of total imports in percent.

The sixth indicator is the value of oil imports over values of total exports in percent. The seventh indicator is the value of oil imports over GDP in percent. The eighth indicator is the value of energy imports over value of total imports in percent. The ninth indicator is the value of energy imports over value of total exports in percent. The tenth indicator is the value of energy imports over GDP in percent. The eleventh indicator is the per capita energy imports in NT$.

The twelfth indicator is the concentration of energy supply in percent. The thirteenth indicator is the average load in MW. In figure 10, the trend of six energy security indicators are presented.

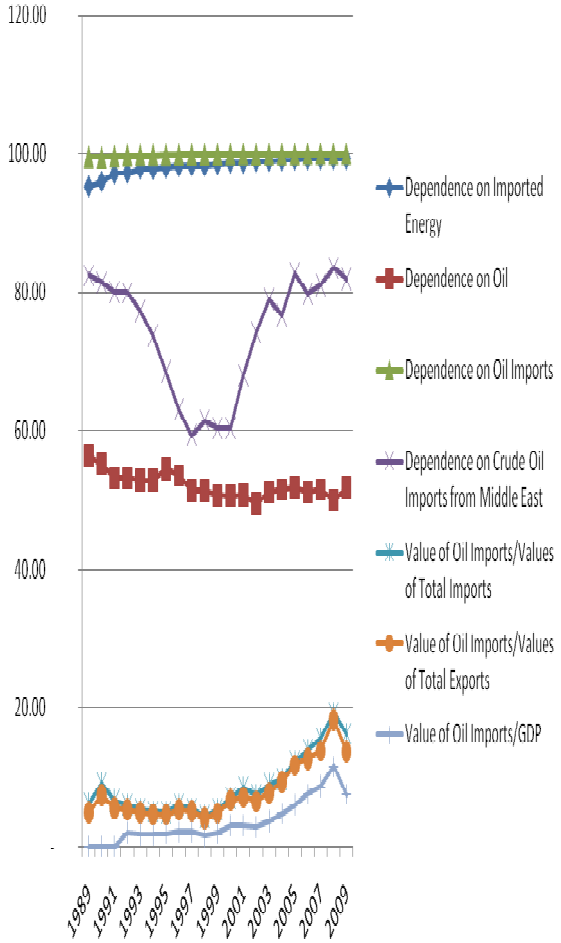

Figure 11 Trend of Energy Security Indicators

D. Trend of Energy Environment

There are five indicators discussed in this energy environment indicator session. The first indicator is the CO2 emission from energy use in 1000MT. The second indicator is the CO2 emission per unit GDP in Kg CO2/ 1000NT$. The third indicator is the CO2 emission per unit domestic energy consumed in MT CO2/ KLOE. The fourth indicator is the per capita CO2 emission per unit domestic energy in MT CO2. The fifth indicator is the electricity emission coefficient in Kg CO2/KWh.

In figure 11, the trend of all five indicators is presented.

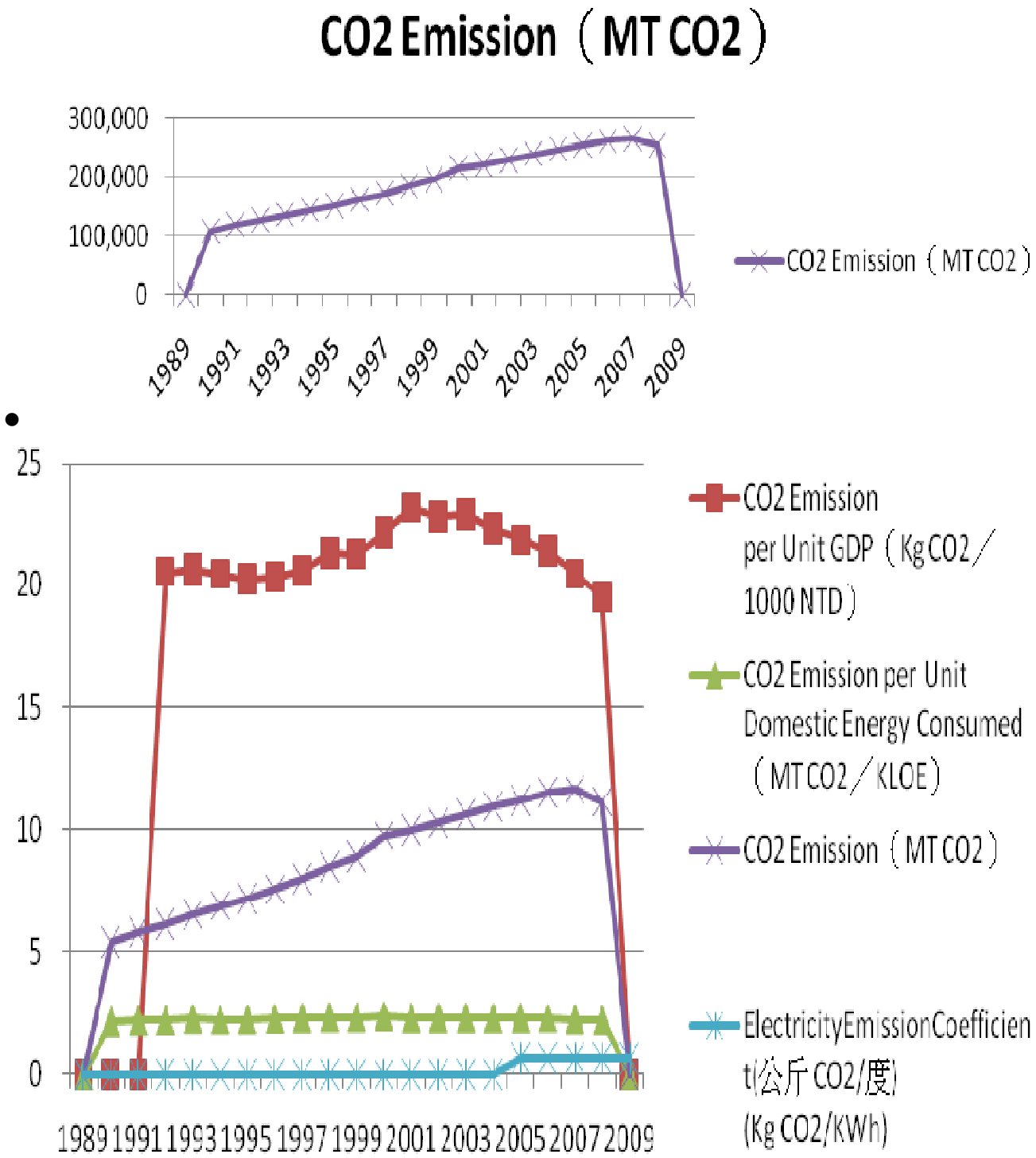

Figure 12Trend of Energy Environment Indicators

V. Conclusions

According to the trend and regression statistical test, the total final consumption could be predicted by selected indicators. The model is listed for reference in table 11. It was concluded that total final consumption could be predicted by population, per capita energy imports, and concentration of energy supply, peak load, and average load.

Table 10 Importance of each factor

V1	V2	Nodes	Importance	Importance	V6
1	0	Concentrationof EnergySupply	0.1498	0.15	0.15
1	0	Average Load(MW)	0.1892	0.19	0.19
1	0	Per Capita EnergyImports (NT$)	0.1955	0.2	0.2
1	0	Population	0.2246	0.22	0.22
1	0	Peak Load(MW)	0.2409	0.24	0.24

In Table 10, the importance of each factors were listed and the importance percentage were illustrated in figure 12.

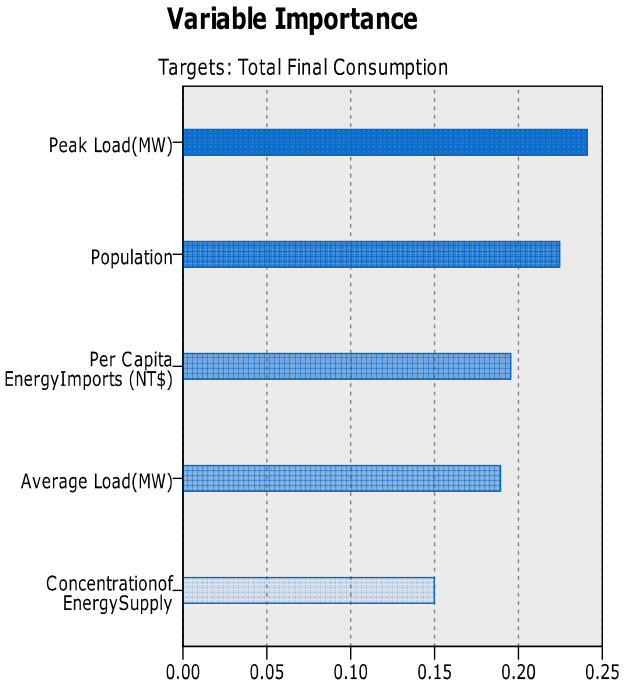

Figure 13 variable importance of each factor

Table 11 Regression Model of Total Final Consumption

Analysis
*Population * 9.763 +*
*Per Capita EnergyImports (NT$) * 0.07287 +*
*Concentrationof EnergySupply * 1819.9 +*
*Peak Load(MW) * 1.429 +*
*Average Load(MW) * 0.6104 +*
-294096.9
Fields
Target
Total Final Consumption
Inputs
Population
Per Capita EnergyImports (NT$)
Concentrationof EnergySupply
Peak Load(MW)
Average Load(MW)

In Table 11, the total final consumption could be predicted according to the equation. It is concluded that concentration of energy supply is the most important factor.

ACKNOWLEDGMENT

The preferred spelling of the word "acknowledgment" in American English is without an "e" after the "g." Use the singular heading even if you have many acknowledgments. Avoid expressions such as "One of us (S.B.A.) would like to thank ... ." Instead, write "F. A. Author thanks ... ." **Sponsor and financial support acknowledgments are placed in the unnumbered footnote on the first page**.

REFERENCES

[1] Bureau of Energy (2010, May) Energy Statistics Handbook 2009, ISSN 1726-3743
[2] Kuo, L.H., Yang, H.J., Yang, H.H., Yu, J.C., & Chen, L.M. (2009). Integration of Heterogeneous In-service Training Data into a Nationwide Database. WSEAS Transactions on Information Science and Applications, 6(6), 976-987. (EI)
[3] Hung-Jen Yang, Lung-Hsing Kuo,Che-Chern Lin, & Huei-Mei Wei (2006) Integrating Databases for Compiling Statistical Yearbook of Teacher Education, WSEAS Transactions on Engineering Education, 3(4), April 2006, ISSN 1790-1979 (EI)
[4] Chu, Y.M., Chen, Y.J., Yang, H.J., Yang, H.H., & Hu, W.C. (2006) A Study of the Intension of Using Computer as a Strategic Resource of Web Searching , WSEAS Transactions on Communications, 5(9), September 2006, ISSN 1109-2742 (EI)
[5] Yang, H.H., Yang, H.J., Wu, W.C., Kuo, L.H.,& Wang, L.H. (2010) A Study of Generating Teaching Portfolio from LMS Logs, WSEAS Transactions on Information Science and Application, 7(4), April 2010, ISSN1790-0832, 573-586. (EI)

Jui-Chen Yu obtained a Master of Science in Technology Education from University of North Dakota and a Ph.D.in Industrial Technology Education

from Iowa State University. She is a senior researcher at National Science and Technology Museum. Her research interests include all aspects of both museum education and technology education.

Lung-Hsing Kuo received his Master (M.E.) in Education (1990~1993) and Ph.D. in Education from (1993~1997) National Kaohsiung Normal University. He is the director of the center for teacher career and professional development in National Kaohsiung Normal University. His research interests include social Science Research Methodology, Continuing Education, Human and social, Youth Study, Emotion development and management, Counseling and Education Issues.

Hung-Jen Yang obtained a Master (M.S.) in Technology Education from University of North Dakota and a Ph.D. in Industrial Technology Education from Iowa State University. He is currently conducting research on knowledge transfer, and knowledge reuse via information technology. His research has appeared in a variety of journals including those published by the WSEAS.

Hsieh-Hua Yang received her Master (M.S.) in Health Promotion and Health Education from National Taiwan Normal University and Ph.D. in Health Policy and Management from National Taiwan University. She is a professor in Health Care Administration at Oriental Institute of Technology. Her research focuses are health behavior, social network and organizational behavior.