2014 4th International Conference on Future Environment and Energy
IPCBEE vol.61 (2014) © (2014) IACSIT Press, Singapore
DOI: 10.7763/IPCBEE. 2014. V61. 1

Low Carbon Energy Scenario Development in Vietnam

Nguyen Thai Hoa[+], Kei Gomi and Yuzuru Matsuoka

Graduate School of Engineering, Kyoto University, C cluster, Kyoto-Daigaku-Katsura, Nishikyoku, Kyoto 615-8540, Japan

Abstract. In this paper the authors proposed a low carbon energy scenario (2030LCE) to reduce CO_2 emission from energy activities in 2030 in Vietnam. We used a quantification model, namely Extend Snapshot tool (ExSS), to show an inventory of base year CO_2 emission and how much CO_2 emitted and can be reduced in energy sector with introduction of low carbon countermeasures. In business as usual case (2030BaU), primary energy demand and CO_2 emission in 2030 will represent 3.8-time and 6.4-time increases, respectively, from 2005 values, indicating that this is not a sustainable scenario from the viewpoint of either the environment or energy security. In 2030LCE, which introduces low carbon countermeasures will be applying in Vietnam in future, CO_2 emission in 2030 decrease by 34% from 2030BaU level. In which, 50 $MtCO_2$ (28%) reduction in industry, 67.7 $MtCO_2$ (29%) in transportation, 38.7 $MtCO_2$ (22%) in center power supply, 28.5 $MtCO_2$ (16%) in residential sector and 10.0 $MtCO_2$ (6%) in commercial sector. Detail of low carbon countermeasures by sector corresponding to related National Policies contributing to each one is also introduced in this study in order to achieve 2030LCE scenario.

Keywords: Low carbon, Energy, Mitigation, Vietnam

1. Introduction

Huge amount of greenhouse gases (GHG) emission caused almost by economic development activities have been seriously affect life, production and environment all over the world especially in Vietnam and its impacts are a threat to poverty reduction as well as the achievements of the Millennium Development Goals in the country (Kreft et al., 2010 [1]; Dasgupta et al., 2007 [2] and Stern, 2006 [3]). To become a modern industrialized country by 2020, Vietnam is expected to accelerate its production activities, in other words, the country will consume a significant energy. The energy structure of Vietnam is going to change substantially. This may result in larger amount of GHG emission, which makes global climate system become worse. Being aware of this problem, government of Vietnam identified that responding to climate change is a key challenge to the country's development progress. Regarding to energy sector, there are several policies and regulations to develop the energy sector while promoting a clean environment such as "National Target Program on Energy Conservation and Efficiency [4], "Law on Energy Efficiency (EE) and Conservation" [5], and other master plans on renewable energy [6], nuclear power [7], and national plan on power development [8] and bio-energy development [9], etc. Additionally, the Green Growth Strategy [10], which has been approved by the Prime Minister of Vietnam, indicated that GHG emission in energy activities should be reduced by 20 to 30% compared to business as usual case. There is, however, no concrete countermeasure to achieve those targets. Therefore, a scenario of low carbon energy for Vietnam in 2030 has been developed in this study (Nguyen et al., 2012) [11]. In order to do that, main objectives are defined (i) to deduce socio-economy, energy and CO_2 emission of Vietnam in base year 2005; (ii) to quantify socio-economic and energy activity level in 2030; (iii) to estimate CO_2 emission in 2030BaU and 2030LCE; and (iv) to propose mitigation actions includes a set of technological and quantified countermeasure, and related National Policies contributing to each countermeasure in 2030.

[+] Corresponding author. Tel.: + 81 75 383 3370; fax: +81 75 383 3371.
E-mail address: nguyen.hoathai.5z@kyoto-u.ac.jp or envi_koneko@yahoo.com.

2. Methodology and Assumptions

In order to create a low carbon energy scenario, we applied a method based on the idea of "back casting", which sets a desirable goal first in order to determine the direction of energy activities, and then seeks the way to achieve it (Gomi et al., 2010 [12] and 2011 [13]). Quantification tool, namely Extended Snapshot Tool (ExSS), which was developed by Gomi et al. (2010) [12], was used to estimate CO_2 emission in energy sector in Vietnam. ExSS is a bottom-up engineering type model, and formulated as a system of simultaneous equations, and given a set of exogenous variables and parameters, solution is uniquely defined. In this study, only CO_2 emission from energy consumption is calculated, even though, ExSS can be used to estimate other GHG and environmental loads such as air quality. An input-output approach is applied in order to determine output of industries. Passenger transport demand can be estimated from population, trip generation, modal split and average trip distance data. Freight transport demand is calculated from output of manufacturing industries. The activity level of each sector, energy demand by fuels is determined with three parameters i.e energy service demand per driving force, energy efficiency and fuel share. The study estimates energy demand and CO_2 emission of five sectors namely residential, commercial, industry, transport (passenger and freight), and power supply and generation.

Table 1: Quantitative socio-economic assumption in 2030

Indicator	**Quantification (2030BaU scenario)**	**Tendency to**
Population	104 million people	Growth rate at 0.9 % per annum
Demographic composition	[Male] 0-14: 8%, 15-64: 35.9%, 65+: 5.8% [Female] 0-14: 7.7%, 15-64: 35.2%, 65+: 7.4%	Number of male births are higher than female births
Average number of persons per household	3.5 (4.2 in 2005)	Slight decrease in average size of household
GDP	6.5%	Average annual growth rate during the period 2005 - 2030
Industrial structure	[Agriculture, Fishery, Forestry]: 17% (22% in 2005) [Industry, Construction]: 43% (41% in 2005) [Service]: 40% (37% in 2005)	Sectoral share of primary industry has a decrease trend, whilst secondary and tertiary industry has an increasing trend.
Demand structure	Contribution of export in GDP: 29% (29% in 2005)	Export maintains its share in GDP
Transport	Passenger transport: [Train] 0.1%, [Bus] 0.6%, [Waterway] 0.6%, [Car] 0.3%, [Motorbike] 8.3% [Walk & Bike] 90%, [Aviation] 0.1%	Drastically increase of private vehicles especially motorbike and car
	Freight transport: [Train] 2%, [Waterway] 27%, [Truck] 71%	Keep its role the same as the base year 2005

3. Results

3.1. A snapshot of socio-economic development in Vietnam in 2030

With annual growth rate of 0.9%, population in 2030 increased 1.3 times compared to 2005, whereas increasing of household number was slightly larger because of smaller size of household. With annual growth rate of 6.5%, GDP increased more than 5 times in 2030 compared to 2005. In which, GDP contributed by secondary and tertiary sectors increased much higher than one contributed by primary sector. Passenger and freight transport increased 2.4 and 6.1 times in 2030 compared to 2005, respectively. Freight transport would increase faster than passenger transport because of rapid development of secondary industry sector.

3.2. Energy demand and CO_2 emissions

3.2.1. Final energy demand

Results show that the annual total final energy requirement of residential, commercial, industrial and transport sectors is expected to increase annually at 5.1% (2030BaU) and 4.0% (2030LCE) over the outlook period, from 44Mtoe in 2005 to 154Mtoe in 2030BaU scenario and 120Mtoe in 2030LCE scenario. The projected final energy demand growth in 2030BaU scenario is higher than the past decade of 4.4% between 1995 and 2005. The share of oil in final energy demand is projected to increase rapidly, accounting for 40% and 35% of total energy demand in 2030BaU and 2030LCE scenarios, respectively, as a result of increased travel activities in transport sector. It is followed by electricity and coal which account for 24% and 23% of

total energy demand in 2030BaU and 2030LCE scenarios, respectively. The demand for electricity and coal is driven by increased economic activity, urbanization and rural electrification program. Although, there is a promotion of renewable energy in electricity generation (nuclear, solar and wind powers) in both 2030BaU and 2030LCE scenarios, the share of renewable energy in total final energy still decrease as more population has access to modern energy, resulting in a reduction of the demand for traditional fuels (biomass, rice husk and charcoal etc.,) for cooking. The share of traditional fuels in total final energy consumption would reduce from 52% in the base year 2005; to 14% in 2030BaU scenario and 18% in 2030LCE scenario. Regarding to the target of being the industrialization country, energy demand in industrial sector is expected to increase dramatically and being the largest consumer of final energy - almost 41% and 45% in 2030BaU and 2030LCE scenarios, respectively. The share of energy demand consumed by residential sector is projected to reduce substantially from 59% in 2005 to 30% in 2030BaU scenario and to 32% in 2030LCE scenario, as a result of biomass being replaced by commercial energy sources. It is followed by transport sector, accounting for 23% and 16% in 2030BaU and 2030LCE scenarios, respectively. The finding shows that the shares of industrial and transport sectors are expected to increase in future, while the share of residential sector decreases. This is because of continued trends of industrialization and increasing population and travel demand. It can be said that energy consumption of industrial and transport sectors highlight the important role of these sectors in Vietnam's energy sector in future. Compared to other sectors, the share of final energy consumption of commercial sector is smaller, which account for only 6% in 2030BaU scenario and 7% in 2030LCE scenario.

3.3. Primary energy demand

The primary energy demand is projected to increase 3.8 times from 52Mtoe in 2005 to about 197Mtoe in 2030BaU scenario, increasing annually at 5.5% over the outlook period. Commercial energy sources are expected to increase rapidly and surpass traditional energy sources (straw, husk, charcoal and so on) in 2005, account for more than 80% of the primary energy mix. Consequently, the share of biomass is decrease substantially from 45% in 2005 to 13 and 16% in 2030BaU and 2030LCE scenarios, respectively. This could be explained by the fact that due to improved living standards and rural electrification, a huge amount of population will have access to modern energy, resulting in a reduction in biomass demand.

Among the fossil fuels, petroleum products are expected to continue to account for the largest share in total primary energy demand, mainly utilized in the transportation and industrial sectors. Coal and natural gas demand are projected to be major driven by sharp increase of the electricity and industrial sectors, accounting for almost 33% and 14% of total primary energy demand, respectively in 2030BaU scenario. The shares of nuclear and solar and wind are projected to account for 2% and 6% in 2030BaU and 2030LCE scenarios, respectively.

3.4. Electricity generation mix

The demand for electricity is expected to increase significantly in the future, from 9% in 2005, to approximately 24% and 23% of total final energy requirements in 2030BaU and 2030LCE scenarios by the year 2030, respectively. The increasing electricity demand is attributed to increased economic activities, population growth and urbanization. As identified a key dynamic for industrialization of the country's economy, the industrial sector is primarily responsible for increased electricity demand, accounting for more than 50% of total electricity consumption in both 2030 scenarios. Moreover, residential sector is ranked as the second largest electricity consumer because of the population grow, high income lead to high energy service demand as well as improvement in access to national electricity grid, accounting for 35% (2030BaU) and 33% (2030LCE) of total electricity consumption.

From 2005 to 2030, the share of hydro is expected to decrease from 19% to 14 and 15% in 2030BaU and 2030LCE scenarios, respectively. By contrast, coal-fired electricity generation is expected to increase considerably and take a biggest share at 46% and 40% in 2030BaU and 2030LCE scenarios, respectively, an almost two-fold increase over 2005. The share of gas-fired electricity generation is projected to decrease to nearly 27% in both 2030 scenarios. Meanwhile, the share of nuclear power is expected to increase to 2% in 2030BaU scenario and 6% in 2030LCE scenario. The increase of nuclear and renewable energy, which are substituted for coal, are considered as an important role to play in ensuring the security of energy supply,

through a diversification of fuel mix and in making energy activities towards low carbon economy. In addition, other renewable energy such biomass, solar and wind are expected to produce electricity in 2030 and the share of them accounts for 7% in both 2030BaU and 2030LCE scenarios.

Table 2: CO_2 reduction by sectors/countermeasures

Sector	Low-carbon countermeasure	Identidied implementtation intensity (%)		Emission reduction ($MtCO_2$)	Related National Policy
Residential sector	Energy efficiency home appliances				Law on Energy Efficiency and Conservation [5]
	High energy efficiency air condition	Diffusion ratio	70	1.6	
	High energy efficiency cooking stove			5.9	
	Coal-cooking stove	Diffusion ratio	25		
	LPG cooking stove	Diffusion ratio	40		Law on Energy Efficiency and Conservation [5]
	Biomass cooking stove	Diffusion ratio	55		
	Electricity cooking stove	Diffusion ratio	40		
	High energy efficiency lighting (Compact fluorescent lamps substitute incandescent light)	Diffusion ratio	60	2.3	
	High energy efficiency refrigerator	Diffusion ratio	60	0.9	Law on Energy Efficiency and Conservation [5]
	High energy efficiency water heating			0.9	
	Coal - water heating	Diffusion ratio	25		
	Oil - water heating	Diffusion ratio	67		
	Biomass - water heating	Diffusion ratio	55		Law on Energy Efficiency and Conservation [5]
	Solar water heating	Diffusion ratio	10		
	Energy efficiency improvement of electric appliances	Diffusion ratio	60	1.2	
	Energy saving behavior			4.3	Energy consumption: saving 3% to 5% (2006-2010) and 5% to 8% (2011-2015) [4]
	Cooling (Energy service demand reduction ratio 17%)	Diffusion ratio	100		
	Heating (Energy service demand reduction ratio 17%)	Diffusion ratio	100		
	Hot water (Energy service demand reduction ratio 17%)	Diffusion ratio	100		Energy consumption saving 15% (2020) and 30% (2030) [14]
	Cooking (Energy service demand reduction ratio 17%)	Diffusion ratio	100		
	Other home electric appliances	Diffusion ratio	100		
	Other fuel shifting			11.3	Share of household using renewable energy in cooking 50% (2010), 80% (2020) [6]
	Total			**28.5**	
Commercial sector	High energy efficiency air condition	Diffusion ratio	70	1.2	Law on Energy Efficiency and Conservation [5]
	High energy efficiency lighting	Diffusion ratio	40	0.3	
	High energy efficiency refrigerator	Diffusion ratio	80	1.1	
	High energy efficiency water heating			1.0	
	Coal - water heating	Diffusion ratio	50		
	Oil - water heating	Diffusion ratio	57		
	Solar water heating	Diffusion ratio	15		
	Energy efficiency improvement of electric appliances	Diffusion ratio	60	0.6	Law on Energy Efficiency and Conservation [5]
	High energy efficiency cooking stove	Diffusion ratio		0.8	
	Coal-cooking stove	Diffusion ratio	50		
	LPG cooking stove	Diffusion ratio	57		
	Electricity cooking stove	Diffusion ratio	50		
	Energy saving behavior			1.8	Energy consumption: saving 3% to 5% (2006-2010) and 5% to 8% (2011-2015) [4]
	Cooling (Energy service demand reduction ratio 20%)	Diffusion ratio	100		
	Heating (Energy service demand reduction ratio 20%)	Diffusion ratio	100		
	Hot water (Energy service demand reduction ratio 20%)	Diffusion ratio	100		Energy consumption saving 15% (2020) and 30% (2030) [14]
	Cooking (Energy service demand reduction ratio 20%)	Diffusion ratio	100		
	Other electric appliances	Diffusion ratio	100		
	Other fuel shifting			3.2	
	Total			**10.0**	
Industrial sector	Energy efficiency equipments			23.5	In dustry 50% cleaner production technology will be applied and energy saving 8-13% (2020); almost cleaner production technology will be applied (2050) [14]
	High energy efficiency boiler	Diffusion ratio	40-50		
	High energy efficiency furnace	Diffusion ratio	35-65		
	High energy efficiency motor	Diffusion ratio	60		
	Energy saving (Energy service demand reduction ratio 20%)			10.9	
	Other fuel shifting			15.7	
	Total			**50.0**	
Passenger transport sector	Energy effciency in transport mode	Diffusion ratio	30-50	13.4	
	Bio fuel (from oil to bio fuel)	Diffusion ratio	3	0.3	Using bio-energy, meeting 0.4% (2010), 1% (2015) and 5% (2025) of oil and gasoline demand in country [9]
	Modal shift			9.6	Shift from high intensity energy to lower intensity in transportation 40% (2020) and 80% (2050) [14]
	From vehicle to train	Share of train = 0.1% (base year = 0.04%)			Inceasing public transport 5-7% in medium and large cities: 35-35% (2020) and 50% (2050) [14]
	From vehicle to bus	Share of bus = 2.3% (base year = 0.33%)			
	From vehicle and ship to walk and bike	Share of walk & bike = 93% (base year = 90%)			
	Total			**23.4**	
Freight transport setor	Energy effciency in transport mode	Diffusion ratio	30-50	23.9	Shift from high intensity energy to lower intensity in transportation 40% (2020) and 80% (2050) [14]
	Bio fuel (from oil to bio fuel)	Diffusion ratio	5	1.1	
	Modal shift			4.0	
	From large vehicle to train	Share of train = 5%			
	From large vehicle to ship/boat/ferry	Share of ship = 30%			
	Total			**29.0**	
Power generation sector	Improvement of CO_2 intensity of power generation			**38.7**	PDPVII [8]
	Generation efficiency improvement				
	Coal	Generation efficiency = 45%			
	Oil	Generation efficiency = 38%			
	Gas	Generation efficiency = 42%			
	Transmission lost reduction	Transmission lost = 7% (base year = 11%)			Tranmission lost complies to N1- criterion (PDPVII) [8]
	Fuel shifting				
	From fossil fuel to nuclear				In 2030: total capacity of nuclear power plant will be 15000 MW (10% of total power generation) [7]
	From fossil fuel to renewable energy				Share of renewable energy in power generation: 0.6% at present to 3.5% (2010), 4.5% (2020) and 6% (2030) [6]
Total				**179.5**	

3.5. CO_2 emission

GHG emissions in energy sector increased 6.4 times of that of 2005 in 2030BaU scenario, and 4.2 times the 2030LCE scenario. GHG emission is expected to increase rapidly as a result of increasing use of fossil fuels. The total emissions in 2005 were about 81 $MtCO_2$. This figure is expected to increase to 522 and 342 $MtCO_2$ by 2030BaU and 2030LCE scenarios, respectively. The major contributors to GHG emission include industrial sector (49% of total CO_2 emissions in 2030BaU scenario), followed by transport and residential sectors which account for 21% and 22% of total CO_2 emissions in the 2030BaU scenario, respectively.

3.6. Potential mitigation of CO_2 emission in 2030

A portfolio of low carbon countermeasures was introduced to reduce CO_2 emission as shown in table 2. The total mitigation value of 179.5 $MtCO_2$ in 2030LCE corresponds to 34% reduction from the emissions level in 2030BaU. In which, 50 $MtCO_2$ (28%) reduction in industry, 67.7 $MtCO_2$ (29%) in transportation, 38.7 $MtCO_2$ (22%) in center power supply, 28.5 $MtCO_2$ (16%) in residential sector and 10.0 $MtCO_2$ (6%) in commercial sector. Improvement of carbon intensity in both energy supply and demand and improvement of energy efficiency on the demand side will be especially effective. Detail of each low carbon countermeasures are shown in Table II.

4. Conclusion

Low carbon energy in 2030 in Vietnam has been calculated in this study. The middle-term energy supply and demand perspective has been analyzed, taking into account latest energy-related national policies. The finding shows that energy demand, especially fossil fuel demand, will continue expanding in line with economic growth. Therefore, the importance of shifting from fossil fuel to other less carbon intensity fuel and applying clean technologies and replacing almost low-efficiency motors, devices and equipment will increase in future in Vietnam. Low carbon energy scenario in Vietnam in 2030 can bring opportunities of co-benefits apart from direct CO_2 emission reduction (34% reduction in 2030LCE compared to 2030BaU). Such co-benefits, like improved ambient air quality and health benefits work towards minimizing social cost.

5. Acknowledgements

This research was supported by the Environment Research and Technology Development Fund (S-6-1) of the Ministry of the Environment, Japan. The authors would like to express our gratitude for their support.

6. References

[1] Kreft, S., Harmeling, S., Bals, C., Zacher, W., van de Sand, K., 2010. The Millennium Development Goals and Climate Change: Taking stock and looking ahead. Germanwatch <http://germanwatch.org/klima/klimdg10e.pdf>.

[2] Dasgupta, Susmita et al. (2007). The Impact of Sea Level Rise on Developing Countries. A Com parative Analysis. World Bank Policy Research Working Paper 4136, February 2007.

[3] Stern, Nicholas (2006). The Economics of Climate Change: The Stern Review. Cambridge et al.

[4] National Target Program on Energy Conservation and Efficiency. Decision no. 79/2006/QD-TTg dated 2006.

[5] Law on Energy Efficiency and Conservation. Decision no.50/2010/QH12 dated 2010.

[6] Master Plan for Renewable Energy Development for the period up to 2015, with outlook to 2025.

[7] Master Plan on Nuclear Power Development up to 2030 (MPND). Decision no. 906/QD-TTg dated June 17th 2010.

[8] National Master Plan for Power Development Plan for the 2011-2020 period with the vision to 2030 (PDPVII).

[9] Bio-energy development for the period up to 2015, outlook to 2025 (BIED).

[10] National Green Growth Strategy. Decision no. 1393/QD-TTg dated September 25th 2012.

[11] Nguyen, T.H., et al., 2012. A low carbon society development towards 2030 in Vietnam.

[12] Gomi, K., et al., 2010. A low-carbon scenario creation method for a local-scale economy and its application in Kyoto city. Energy Policy 38 (9): 4783-4796.

[13] Gomi K, et al., 2011. A systematic quantitative backcasting on low-carbon society policy in case of Kyoto city. Technol Forecast Soc Chang 78:852–71.

[14] National Climate Change Strategy. Decision no. 2139/QD-TTg dated December 5th 2011.