Abstract

All global comparative country studies list Vietnam as a country which will be extremely vulnerable to climate change in the future because of its topography. The metropolis and economic center Ho Chi Minh City (HCMC) north of the Mekong Delta is particularly affected. Even today, HCMC has to struggle with climate-related problems whose impacts are brought about or intensified by shortcomings in managing rapid urban growth, spatial urban planning and urban infrastructure management. The city had a population of 7.1 million persons in 2009 with an average annual increase of 3.3% in the last ten years. As the biggest city in Vietnam, electricity consumption in HCMC accounts for more than 18% of total electricity use in the whole country in 2008. Electricity consumption in residential sector accounted for more than 38% of total electricity consumption of the city. Severe power shortages during summer in the whole country as well as in HCMC have been observed recently. Supplying energy reliably and stably is one of main challenges for economic development in future.

Potential for energy efficiency and conservation in household sector is possibly very significant due to low progress of energy efficiency programs in Vietnam. Energy efficiency options have been long proved as cost effective as compared to supply side options. In general, promotion of energy efficient and conservation measures in household sector is relatively more difficult than in other business sectors due to its small scale and dispersal. Energy efficiency measures in household sector may vary from market based programs to regulatory measures and voluntary measures. The PhD study has strong motivation and focuses mainly on energy demand pattern and potential energy efficiency measures for household sector in HCMC. Bearing in mind that energy efficiency will play an important role for households not only to conserve resources but also to mitigate climate change; the PhD study has the following objectives:

(1) Investigation of energy demand pattern changes and making decomposition analysis of energy consumption in Vietnam and HCM;

(2) Estimation of elasticities for energy demands of households in Vietnam;

(3) Analysis of energy use and energy saving potential of households in HCMC in its relation to dwelling type, income and appliance stock; and

(4) Assessment of energy efficiency options and supporting measures in households by using a long-term energy system model.

In term of research method, the study firstly examined household energy consumption in HCMC by analyzing data from household living standard surveys. Fuel mix and main determinants for the changes in energy consumption of households were found out by employing index decomposition index analysis. Secondly, the PhD study estimated elasticities for electricity and liquefied petroleum gas (LPG) demands by employing a panel estimation. In the current context of energy price vitality, it is useful to get understand on how energy demand reacts to changes in prices, income and other related things. Thirdly, the household questionnaire survey in HCMC brought about in-depth understanding on energy consumption of households in relations to dwelling type, income and appliance stock. Energy saving potential for each dwelling type is also estimated. Finally, the study deals with energy supply and demand balance. MARKAL model was used to analysis impacts of energy efficiency options on cost, resource, emission and spatial development.

The PhD study has achieved its four research objectives by linking these mentioned above analyses.

Firstly, analysis of data from the living standard survey shows that fuel mixes for households in HCMC between 2002-1010 were characterized with large shares of electricity, gasoline and LPG. Kerosene and other biomass energies made up small parts of total energy consumption. The shares for electricity, gasoline and LPG for households in HCMC are some 40, 40 and 20 percent respectively. That contrasts with households in the rest of Vietnam, which still consumed much non-commercial energy for cooking. Fuel mix for households in HCMC did not change much during 2002-2010 thanks to the better living standard of households of the City as compared to other regions. Gasoline demand rose quickly in the meantime to meet increased transport demand.

By applying index decomposition analysis, determinants for the increase in energy consumption of households in HCMC were activity effect during 2002-2008 and intensity effect in 2008-2010. These effects mainly represented the variations in household income and energy prices. In households of HCMC, structure effect had negative impact on energy consumption indicating that households switching to efficient energies. In the current context of energy price volatility, it is useful to see price impacts on household energy consumption. Variations of income and fuel prices are possibly the main determinants for the changes of energy consumption pattern in households.

Secondly, fixed-effects, random-effects and Hausman-Taylor models were used to estimate elasticities for electricity and LPG demands. Hausman-Taylor was recommended due to its capability in dealing with endogenous and time-invariant variables. According to the panel data estimation, elasticities for electric demand are estimated at -0.611, 0.470, and 0.221 with respect to electric price, household income and LPG price. Elasticities for LPG demand are -0.533 and 0.452 with respect to LPG price and household income. Own-price elasticities for both demands are less than unity indicating both products are inelastic demands. The estimation show also significant differences for different regions, including Ho Chi Minh City.

Thirdly, data from the self-conducted household questionnaire survey allowed analysis of energy consumption in relations to dwelling type, income, appliance stock etc… In all five types of dwelling (i.e. rudimental, shop house, row house, apartment and villa), electricity and gasoline contribute the two largest shares followed by LPG uses for cooking. Coal and firewood are being used for cooking and heating in some low-income level dwelling types. Results from statistical analysis show that energy consumptions for household purposes are significantly different in dwelling type. Monthly electricity use intensity from the survey are 4.63 kWh/m2 for rudimental houses, 3.41 for shop houses, 2.40 for row houses, 4.14 for apartments and 2.14 for villas. Monthly energy density from the survey are 26.33 MJ/m2 for rudimental houses, 18.20 for shop houses, 13.45 for row houses, 22.74 for apartments and 11.27 for villas. The intensities are almost significantly different in group means according to analysis of variance (ANOVA) results. Income and having air conditioner have significant impacts on electricity and energy consumptions. Electricity and energy consumption are different significantly for three income groups. Households with air conditioner consumed significantly 1.6 times higher households without air conditioner.

Options for energy saving were built for four main energy uses, such as lighting, air conditioner, refrigerator, and water heating. The four main energy uses make up from 30 percent to 70 percent of total energy use in different dwelling types. Electric use for cooling purpose is quite high in shop houses and villas. Lighting and refrigerator account for about 10 percent while water heating small share of total electricity use. In the energy efficiency case, the current appliances will be replaced with best available appliance in the market in order to examine energy saving potential.

Finally, results from energy system model show that by promoting energy efficient devices in household sector in HCMC, cost can be saved by more than EUR 1.32 billion. CO_2 emissions can be reduced also by about 425 million tons in 2010-2030. SO_2 emission, the main cause for acid rain, reduces by 1.4 million tons in the same period. In term of energy consumption, a large amount of coal can be avoided in energy efficiency scenarios. Coal consumption would reduce by 54 MTOE in the study horizon. All five energy efficiency options included are cost effective without support measures. These options are lighting, air conditioner, window, refrigerator, and water heater. Efficient air conditioner contributes the largest energy saving amount. The second largest is contributed by efficient lamps. Efficient appliances in households are economic viable. To promote these efficient appliances, it needs to overcome the two main barriers, which are availability and quality of efficient appliances.

About 1.2 GW can be reduced by 2020 and more than 6.6 GW by 2030 if energy efficient devices would be highly penetrated in households of HCMC. Avoided capacity is mainly coal fired power plants in the South of the country. It is estimated that about 3 big coal fired power stations with total capacity of 6GW can be avoided in the energy efficiency scenario. Moreover, one gas fired station with capacity of 630 MW would be avoided in the Central, which consumed expensive imported gas from abroad. In the output of the model, the largest impact of energy efficiency of household is coal power development, especially coal power plant in the South of the country, where energy efficiency options would take place. Reductions in coal power capacity also help country enhance its energy security by reducing coal import from abroad.

Energy efficiency activities reduce the land use for power development by 103 ha by 2020 and up to 467 ha by 2030. In the energy efficiency scenario, quantity of resettled people reduces by 315 persons by 2020 and 2,055 persons by 2030. CO_2 and SO_2 emissions can be saved in the energy efficiency scenario. Energy efficiency activities are able to reduce 7 million tons of CO_2 in 2020 and up to 78 million tons in 2030. Further expansion of energy efficiency in households may help the country reduce lots of its energy consumption and power capacity building, especially removing potentially harmful nuclear power plants in future (more than 6.6 GW avoided by energy efficiency options as compared to total nuclear power capacity of 10.7 GW by 2030). Moreover, energy efficiency mitigate issues associated with the development of power plants such as land occupied, displaced communities, emissions which raise social disparities throughout the country.