# A LOW CARBON SOCIETY DEVELOPMENT TOWARDS 2030 IN VIETNAM

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# Preface

"Consider low carbon economy and green growth as principles in achieving sustainable development; Greenhouse Gases (GHG) emission reduction to become a mandatory index in social and economic development" is one of the main objective of the National Climate Change Strategy which was approved by the Government of Vietnam in December 2011. In order to contribute implementing this and envision a sustainable low carbon society with a long-term perspective as well as introduce the measures to realize it, we developed a Low Carbon Society (LCS) scenario in 2030 in Vietnam. We applied two quantification models to develop LCS, namely Extended Snapshot Tool (ExSS) and AFOLUB model, which project quantitative and consistent future vision consists of socio-economic indicators, GHG emissions, and low carbon countermeasures. This Vietnam LCS scenario covers both energy and AFOLU sectors.

This study aims to initiate the collaboration with related experts, researchers, authorities and communities to contribute building a LCS in Vietnam. The methods and results of this research, we hope, would be provided to a policy making process as a starting point of discussion and supporting discussions among stakeholders. More realistic and acceptable LCS scenario for Vietnam would be defined from the discussion, evaluation and modification by various stakeholders.

This brochure was prepared mainly by Kyoto University researchers in collaboration with National Institute for Environmental Studies (NIES) - Japan, Institute of Strategy and Policy on Natural Resources and Environment (ISPONRE), the Vietnam Institute of Meteorology, Hydrology and Environment (IMHEN) and Water Resources University (WRU). We are grateful to thank Professor Dao Xuan Hoc in Ministry of Agriculture and Rural Development (MARD) and Dr. Pham Hoang Luong in Hanoi Science and Technology University (HUST) for their cooperation to share valuable information and comments.

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# Executive Summary

This report aims to discuss the possibility of developing a low carbon society (LCS) in Vietnam, which consists of future changes in demography, transport, industry, agriculture, forestry, land use, energy demand and Greenhouse gas (GHG) emissions.

Extended Snapshot Tool (ExSS) and AFOLUB model were used to project GHG emissions from Energy sectors and Agriculture, Forestry and Other Land Use (AFOLU) sectors, respectively.

For energy sector, the methodology involves (i) to deduce the socio-economic indicator, energy demand and GHG emissions of Vietnam in the base year, 2005, (ii) to quantify socio-economic activity level in 2030 according to Vietnam socio-economic development plans and strategies, (iii) to project energy demand and GHG emissions in 2030, and (iv) to propose detail quantitative low carbon countermeasures.

For AFOLU sectors, the methodology involves (i) developing future assumptions of harvested areas of crops, livestock animal, and land use and land use change (LULUCF), (ii) exploring mitigation potential by countermeasures in AFOLU sectors up to 2030 under a wide range of Allowable Abatement Costs (AAC) for GHG emission mitigation.

GHG emission was projected in two scenarios: (1) Scenario without low carbon countermeasures (hereinafter referred to as "2030BaU"), which is according to Vietnam socio-economic development plans and strategies towards 2030; (2) Scenario with low carbon countermeasures (hereinafter referred to as "2030CM"), which assumes of employed innovative technologies as well as other low carbon countermeasures to reduce GHG emissions in 2030.

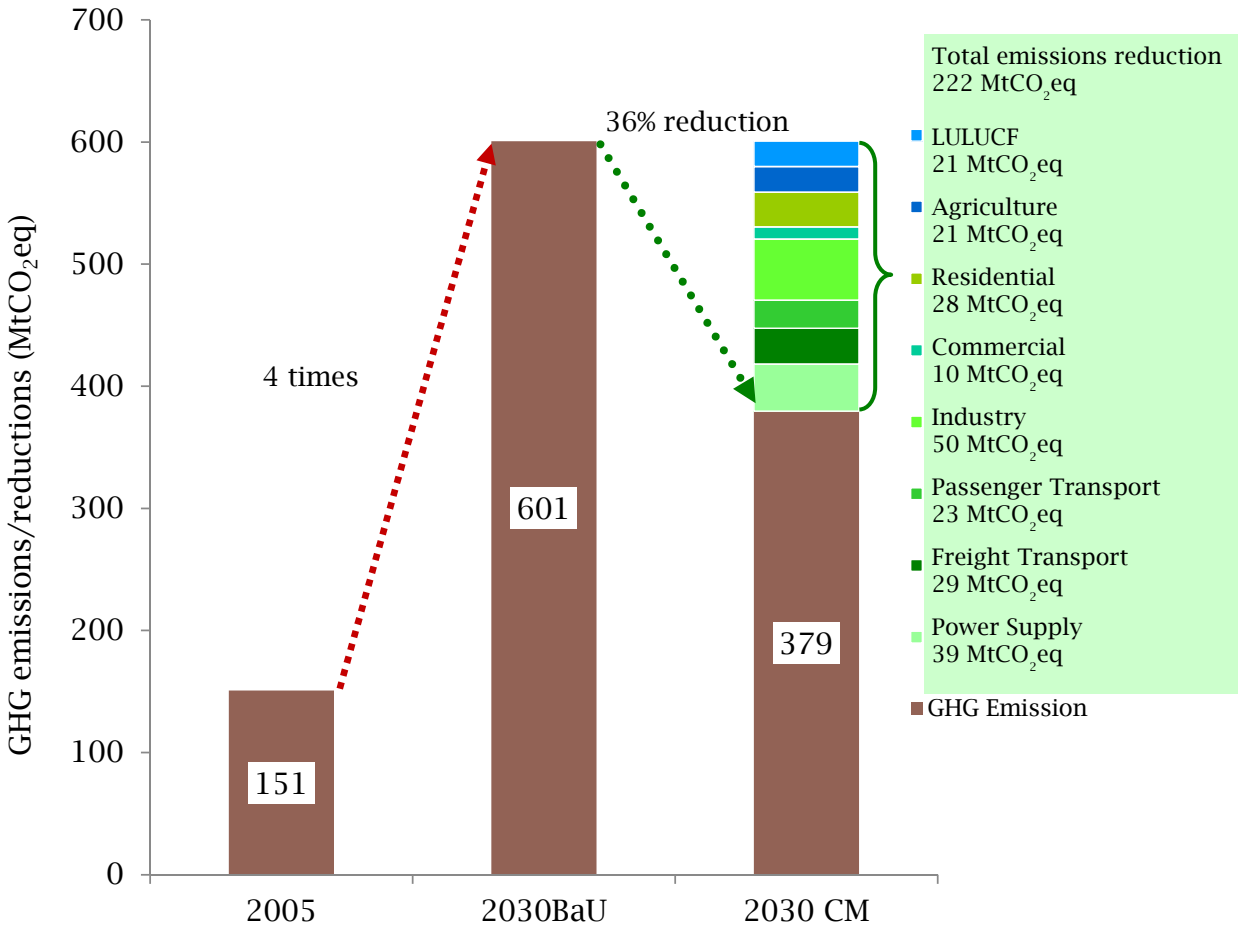


Figure 1. GHG emission and mitigation in Vietnam

Total GHG emission in Vietnam was 151 $MtCO_2eq$ in 2005, on which, 70 and 81 $MtCO_2eq$ come from AFOLU and energy sectors, respectively. Under the 2030BaU scenario, total GHG emission is projected to increases to 601 $MtCO_2eq$ or about 4 times higher than 2005.

In 2005, per capita GHG emissions in Vietnam was 1.8 tones of $CO_2$ equivalent ($tCO_2eq$). In 2030, it is projected to increase to 5.8 $tCO_2eq$ in 2030BaU scenario. It is expected to reduce to 3.7 $tCO_2eq$ under 2030CM scenario

The models estimate that total GHG emission can be reduced to 379 $MtCO_2eq$ in 2030CM scenario through the adoption of countermeasures for mitigating GHG. Total GHG reduction is 222 $MtCO_2eq$ which accounts for 42 and 180 $MtCO_2eq$ from AFOLU and energy sectors, respectively.

To develop a LCS for Vietnam, a package of policy is formulated based on the results of modeling (Figure 2). This policy package encompasses several solutions, is a menu of recommended Actions which are needed to be integrated in the development planning for Vietnam. These Actionss would have to be considered in the background of the developing countries imperative need of effective governance, financing and technology transfer.

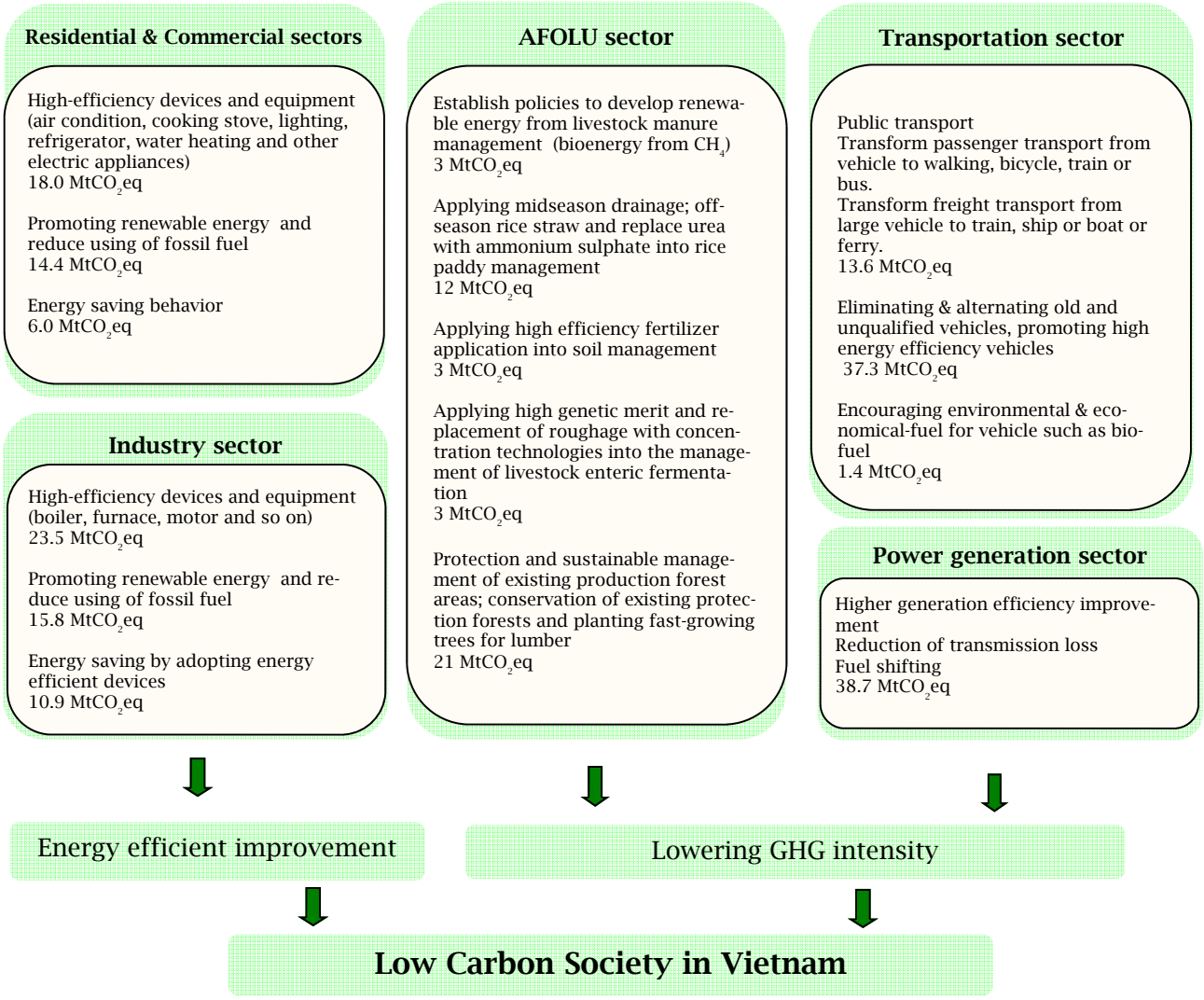


Figure 2. Low Carbon Policy Package for Vietnam

# About Vietnam

## National conditions

***Geography***

Vietnam is located in Southeast Asia with a total land area of 331,690 $km^2$ consisting of thousands of islands and a coast line of approximately 3,260 km. Its climate is under the influence of tropical monsoon.

Vietnam's S-shaped territory extends 1,662 km from north to south with a land area of approximately 331 thousand $km^2$. The country has two major river deltas - the Mekong River Delta and the Red River Delta.

Located in the Red River Delta, Hanoi is the capital of Vietnam and center of the political, culture, science and education. The city covers an area of 3,349 $km^2$ and has a population of 6.1 million with a density of 1,827 people per $km^2$ (according to 2008 statistics).

***Climate***

Vietnam features monsoon tropical climate with annual mean temperature varying from 12.8°C to 27.7°C. Average annual rainfall ranges from 1,400 to 2,400 mm.

Each year, on average, the country is affected by six to eight typhoons or tropical cyclones.

Figure 3. Vietnam and nearby regions

***Water resources***

Taking into account only perennial rivers and streams over 10 km in length, Vietnam has about 2,360 rivers and streams with an average density of 0.6 $km/km^2$. There are nine major river systems in Vietnam. The largest system, Mekong River, enters Vietnam before draining into the East Sea.

Annual flows of all rivers in Vietnam average 835 billion $m^3$. Groundwater reserve is 50 billion $m^3$ per year.

## Socio-economic overview

***Population***

Vietnam is known as one of the most populous nations in Southeast Asia and one of the most densely populated nations in the world. Currently total population is 86.5 million people, growing at a rate of 1.1%. As economic activities become more vigorous, more people continue to flow into cities, lead and the urbanization rate is about 31%.

***Agriculture***

During the first decade of 2000s, agriculture and rural development have been put at the high priority of the country's development strategy for 2001-2010. And the development of agriculture as an engine for growth is vital for the achievement of rural prosperity and livelihood security. The performance of agriculture sectors in the first five year of the development strategy until the year of 2005 has been impressive, it accounts for 22% of GDP, 30% of exports and 60% of employment and the sector grew at an average annual rate of 3.7 percent (World Bank, 2005). It has 331 thousand $km^2$ of land area that make up Vietnam in which 145 thousand $km^2$ are covered with forest. The

land for agricultural production is about 9.4 million hectares, accounting for 28.2% of the national land area. Animal husbandry and cultivation are fundamental sectors of agriculture. The relative contribution of agriculture for the country's economic growth has gradually reduced due to the fast growth of industry and service sectors however it continues to be seen as an important element for sustainable development and poverty reduction.

***Forestry***

Vietnam's forestry has changed dramatically over time: overexploitation and conversion to other uses have eroded the forest resource and depleted its biodiversity. Several decades of intense exploitation and conversion caused forest cover decline from 43 percent in 1943 to about 27 percent in 1990, but then approaching 40 percent in 2009. The loss of mangrove forests has been and continues to be particularly acute, from 4 thousand $km^2$ in 1943 to less than 0.6 thousand $km^2$ in 2008 (Vietnam Development Report, 2011). Almost two decades of forestation programs have reversed the decline, but degradation of natural forests das continued.

Alongside with China, Laos PDR, and Cambodia, Vietnam has focused on reforesting barren land. According to GSO (2006), Vietnam has received over US$200 million from oversea donors for forest development over the years and a significant rise in forest cover from 29.2 percent in 1985 to 37.6 percent in 2005.

By the year 2005, Vietnam has about 15 million hectares of forestland which is officially designated, of which about 13 million hectare are actually forested and the rest remaining consists of bare land and denuded hills (Vietnam Development Report, 2011). Of the forest land about 10 million hectares are classified as natural forests and 3 million hectares plantations. The forest sector contributed only 1 percent of GDP in 2005 excluding forest product processing and unrecorded forest product consumption. Researches have shown that the average value of non-timber forest products in Vietnam's natural forests is about $1 billion.

Figure 4. Vietnam's forest

***Land use***

Land management policy has played an important role as a root for Vietnam's rapid and sustained economic growth and poverty reduction in the last two decades. Land management in Vietnam has gone through dramatic changes since the start of the economic reform process in mid-1980s. Since 1986, "Renovation" process in Vietnam leads to the switch from centralized command economy to a market oriented multi-sector economy. Land is the property of the entire people, but building constructed on the land can be privately owned. It has brought of great socio-economic changes in rural areas such as land use, social division of labour, production organization. In Vietnam, the patterns of land use have changed considerably, particularly shifting from crop cultivation to reforestation alongside national policies that encourage reforestation and the combinations of many local factors.

***Economic growth***

Vietnam stands out as having achieved high economic growth in recent years. Vietnam has experienced satisfactory economic growth despite its economic difficulties during the past decade. In 2005, the GDP grew by over 8.4%. In which, primary sector contributed 20.7%, secondary and tertiary sector contributed 40.2% and 39.1%, respectively. The service sector is becoming an important economic area for Vietnam. Vietnam's GDP reached $53 billion, bringing per capita income to $636 per year, in 2005. According to the Trade Promotion Department (under the Ministry of Trade), foreign direct investment (FDI) rose up to $5.72 billion, an increase of 25% compared to 2004. While this economic prospect offers great opportunities for development of the energy sector in Vietnam, it also raises concerns over the protection of the environment.

Figure 5. Road transport in sub-urban area of Hanoi

***Transportation***

Current transport infrastructure is inadequate to meet Vietnam's rapidly growing needs. To meet the target of industrialization and modernization of the country, the government of Vietnam determines that transportation is extremely important and should go ahead of other sectors.

Road transport is the most advanced in terms of privatization and handles the largest volume about 65% (2005) of domestic passenger and freight transport. Road transport mainly serves the domestic market, while international road transport account for an insignificant share.

Figure 6. Traffic in Hanoi city

Inland waterway transport has been developed due to the natural endowment of dense river and canal network, and it ranked the second which accounts for 25-30% of total domestic transported volume. Other transport are maritime, air and railway transport which accounting for 20% of total transport volume.

***Energy***

In the last few years, Vietnam had rich fossil energy resource such as oil, gas and coal which are non-renewable energy and also well-endowed with renewable in the forms of hydropower, biomass and solar energy which can satisfy the basic needs of energy for the internal socio-economic development as well as partially export to other countries. Energy demand in Vietnam has the annual growth rate of 15% for many years in the past, and 18% have been predicted for the period of 2010-2030 by the Institute of Energy (2006).

Currently, energy is explored, transformed,

transported and used with low efficiency while the self-usage and loss rates are high. Investments in the energy sector can have a substantial impact on water quality, air quality and human health, as experiences show. It becomes increasingly important to address the potential environmental impacts of energy use and related policies.

Electricity consumption in Vietnam grew at 15.3% over 2000-2005. The electricity consumption per capita in 2005 was 538 kWh per year, and is expected to increase up to about 2350 kWh per year by 2020 and over 3096 kWh per year by 2030 (Electricity of Vietnam, 2006, 2008; Institute of Energy, 2006).

Total electricity generation capacity in Vietnam in 2007 was 12948 MW, of which Electricity of Vietnam (EVN) facilities accounted for about 72%, followed by local and foreign independent power producers (24%) and 4% of power was imported.

Figure 7. Electricity grid in Vietnam

***Industry***

Most of the industrial zones in Vietnam are concentrated in three key economic regions, the North, the Central and the South of Vietnam. The major industries of the country are food processing, garments, machinery, fertilizer, shoes, glass, tires, oil, coal, steel, cement and paper.

Figure 8. Song Da concrete enterprise

Figure 9. Residential area in Hanoi city

In 2005, export reached $32.2 billion, while import rose to $36.9 billion. Vietnam's main exports are crude oil, textiles, garments, footwear and aquatic products. Main imports are machinery, equipment, and petroleum products.

***Heath and education***

In 2000, there were 13,117 clinics. Average life expectancy of Vietnamese people is 67.8.

Viet Nam's basic education lasts for 12 years and is divided into three levels of primary, lower secondary and upper-secondary schools. The literacy rate for Vietnamese adults (above 15 years old) is 94%.

# National Environmental Policy on Climate Change

Vietnam has formulated and issued a number of legal documents with the target of attaining the UNFCCC's objective: "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system".

***National Climate Change Strategy***

The Strategy has been approved by the Prime Minister on 05 December 2011, through the Decision number 2139/2011/QD -TTg (PM, 2011b) . Main objectives are:

1) Ensure food security, energy security, water security, and so on in the context of climate change;

(2) Consider low carbon economy and green growth as principles in achieving sustainable development; GHG emission reduction and removal to become a mandatory index in social and economic development.

(3) Take advantage of climate change opportunities for social and economic development; promote climate-friendly behaviors.

(4) Join forces with international communities in addressing climate change; increase international cooperation to address climate change effectively.

***National Target Program to Respond to Climate Change (NTP-RCC)***

The program has been approved by the Prime Minister on December 2008, through the Decision Number 158/2008/QD-TTg (PM, 2008). This program comprehensively addresses climate change effects, impacts and adaptation responding to sea level rise and GHG emission mitigation. Its general objectives are: (1) To assess climate change impacts on sectors and regions in specific periods; (2) To develop feasible actions plans to effectively respond to climate change in the short-term and long-term to ensure sustainable development of Vietnam; (3) To take opportunities to develop towards a low-carbon economy; and (4) To join the international community's effort in mitigating climate change and protecting the climatic system.

***Environmental Policies***

Vietnam Agenda 21 policies were approved by the Prime Minister and issued through the Decision Number 153/2004/QD-TTg (PM, 2004), regarding to strengthening the legal basis for environmental protection, supporting research and development into, and transfer of, environmentally friendly technologies, and stipulating Vietnam's active participation in international activities related to the 1992 UNFCCC.

The Law on Environmental Protection Number 52/2005/QH11 dated 29th November 2005 (replaces the 1993 Law on Environmental Protection) (National Assembly, 2005).

Clean Development Mechanism (CDM): Kyoto Protocol regulates the creation and trading of emission reduction credits. The CDM is functioning in Vietnam but not yet on a large scale. Barriers to full development of the CDM in Vietnam include lack of awareness in the business community, lack of high -risk investment capital, lack of appreciation among officials of the benefits of CDM projects, and limited capacities. In addition, current regulation requires that all ODA-supported credits under the CDM accrue to the Vietnam Environment Fund and not to the project owners. It is critical that Vietnam addresses these barriers and takes full advantage of the CDM. Many investments in Vietnam could benefit from the CDM. Vietnam has not yet started to explore carbon capture and storage (CCS) technologies, which are expensive, but capacity building related to these important technologies is needed, for example, because the location of power plants built in the near future will determine the potential application of CCS in the long term.

# National Energy Policy

***National Energy Development Strategy (NEDS) in the period up to 2020, perspective up to 2050*** (PM, 2007a)

The NEDS has been approved by the Prime Minister Decision Number 1855/2007/QD-TTg dated December 27th 2007 in order to meet the increasing national electricity demand in a sustainable manner. The main points in this strategy are energy resource development (to strengthen exploration of indigenous resources), security of domestic primary energy supply (to strengthen domestic energy supply capacity), energy conservation and energy efficiency (the specific targets are saving 3% to 5% energy consumption during 2006-2010 and 5% to 8% during 2011-2015), development of renewable energy resource (share of renewable energy in electricity production is account for 3%, 5% and 10% by the years 2010, 2025 and 2050, respectively), environmental protection consideration from damages caused by energy activities and so on.

***National Power Development Plan for period 2011-2020 with perspective up to 2030 (PDP VII)*** ( PM, 2011b).

Decision number 1208/QD-TTg dated July 21st 2011 on approval of the fourth national power development plan prepared by Institute of Energy under the management of Ministry of Industry and Trade (MoIT). This plan is an important legal base for ministries, sectors, local authorities to carry our management, implementation of power development plans, contributing in national socio-economic development.

***Law on Energy Efficiency and Conservation No. 50/2010/QH12*** (National Assembly, 2010)

This Law has been approved by Vietnam National Assembly in June 17th, 2010. The Law includes policies and measures to promote energy efficiency and conservation (EE&C); prescribing EE&C; and the rights, obligations and responsibilities of organizations, households and individuals in EE&C. Subjects of application are focus on organizations, households and individuals using energy in Vietnam.

***Master Plan for Coal Development up to 2015, a vision towards 2025*** (PM, 2008b)

In 2005, MoIT has formulated his master plan, which focuses on coal exploration, production and processing activities along with their specific targets. Moreover, establishing coal market by 2015 in order to enhance the security of energy supply is included.

***Master Plan on Vietnam Oil and Gas Sector Development up to 2015, and orientation up to 2025*** (PM, 2009)

In 2006, MoIT has approved this master plan, whose main points are promotion of oil and gas exploration activities and increasing security of oil and gas supply along with their specific targets. In order to improve the secure and efficient use of oil and gas supply, oil and gas market will be formulated and operated by 2015.

***Master Plan for Renewable Energy Development for the period up to 2015, with outlook to 2025*** (IE, 2008)

The government of Vietnam has formulated this master plan in 2008. This plan evaluates the potential sources of renewable energy in country. One of the specific targets is to increase the share of renewable energy in total primary energy supply by 3.4% (2020) and 7% (2050). The others include increasing the share of renewable energy in power generation 3% (2010), 5% (2025) and 10% (2050).

***Master Plan on Nuclear Power Development up to 2030*** (PM, 2010)

The Prime Ministry of Vietnam has approved this plan through the Decision Number 906/QD-TTg, dated June 17th 2010, regarding to which targeted at gradually building and developing Nuclear power sector in Vietnam. According to this Master Plan, there will be 13 Nuclear Power plants in 2030 in Vietnam, with total capacity of 15,000 MW, comprising 10% of total electrical capacity.

# Agriculture, Forestry and Land-use Policy

Since *doi moi* in 1986, Vietnam has moved from a centrally planned economy where agricultural production was under the control of the State to a socialist-orientated market economy where farm households have more individual control over their production activities. A series of policies and laws in the agricultural sector, especially concerning land use were issued. The most important policies were the Land Law (1993) and its revised versions (1998, 2001), the new Land Law (2003) and Ordinances 64/CP (1993) and 02/CP (1994) of the government dealing with the regulation of agricultural and forestry land allocation. There were also other policies that were directly related to land issues as well as supportive policies indirectly related to land issues.

Currently, agricultural land in Vietnam is considered to be owned by the people as a whole and 'the State is the representative of the people's ownership of land'. In Vietnam there are ceilings on land holdings, and agricultural land tax must generally be paid on land held over the land limit. The agricultural land use tax in Vietnam was based on Decree 031/SL (1951). This has changed to be a tax on both land and land use benefits since the Ordinance on Agricultural Tax (1983) and the Tax on Agricultural Land Use Law (1993) were issued.

In 2003, the exemptions and reductions to the agricultural land use tax were announced under Resolution 15/2003/QH11 (17 June 2003) and Ordinance 129/2003/ND-CP (3 November 2003).

Forestry policy was set at priority consideration of country's policies. In 1998, the government's main policy for forestry investment has been the Five Million Hectare Reforestation Programme, in which three million ha for protection forest and two million for production forest. However, first one was almost reached while second target was failed. Moreover, inappropriate planning, lack of budgeting, corruption caused the failure of the progamme.

In the year 2007, under a national review, the program was amended and a new Policy on Production Forest Development was introduced to provide subsidies for growing timber and support for forest infrastructure and extension services. The Prime Minister has approved Decision No. 18/2007/QD-TTg, Vietnam's Socio-Economic Development Strategy 2001–2010 provides a number of development objectives for the forest sector including increasing overall forest cover to 43%, completing the allocation of forestland to socialize forestry development and promoting forestry-based livelihoods, stabilizing cultivation practices and preventing the destruction and burning of forests, and accelerate commercial reforestation to provide material for domestic and export-oriented industries.

In this strategy of forestry development of Vietnam (VFDS), there are the Program on Sustainable Forest Management and Development; Program on Forest Protection, Biodiversity Conservation, and Environmental Services Development; Program on Forest Products Processing and Trade.

# Concept of "Low Carbon Society"

## What is a "Low Carbon Society"?

A low-carbon society (LCS) is a sustainably developed or developing society on the basis of close, reasonable and harmonious coordination of economic and social development and environmental protection. In the society, environmental protection will be given the same level of attention as other socio-economic development issue.

The concept of a low carbon society has the following attributes:

1. To take actions that are compatible with the principles of sustainable development, ensuring that the development needs are met for all groups within the society.

2. To make an equitable contribution towards the global effort to stabilize the atmospheric concentration of $CO_2$ and other GHG at a level that will avoid dangerous climate change, through deep cuts in global emissions.

3. To demonstrate a high level of energy efficiency and use low carbon energy sources and production technologies.

4. To adopt patterns of consumption and behavior that are consistent with low levels of GHG emission.

A LCS framework has not merely GHG emission reduction. It also helps in achieving national development targets especially effective and sustainable development.

## Climate change activities in Vietnam and why we need LCS

Vietnam, known as one of the poor countries, would be the most seriously affected by climate change, especially by sea level rise. IPCC (2007) estimated that the sea level will rise from 30cm to 1m over the next 100 years. Climate change could increase Vietnam's exposure to extreme weather and could cause a yearly capital loss in Vietnam of up to 17 billion USD (World Bank, 2008).

Being aware of this danger, Vietnam Government signed the United Nations Framework Convention on Climate Change (UNFCCC) in June 1992 and ratified it on 16 November 1994. Vietnam ratified Kyoto Protocol on 25 September 2002. On 17 October 2005, the Prime Minister of Vietnam has issued a Directive on the implementation of Kyoto Protocol to UNFCCC, which instructs various ministries and government agencies, as well as provincial/municipal People's Committee, to effectively implement the Clean Development Mechanism (CDM) of the Kyoto Protocol. Article 12 of the Kyoto Protocol created CDM to assist developing countries including Vietnam in achieving sustainable development. CDM projects in Vietnam play an important role in sustainable socio-economic development, improvement of people's living conditions and poverty reduction through income and employment generation together with environmental protection in the country.

Currently, Vietnam is not obligatorily committed to reduce $CO_2$ emissions but it have to achieve sustainable socio-economic development. In the view of long term development, if it does not have any intervention of abatement countermeasures, Vietnam will contribute a significant $CO_2$ emission which will make global warming worsen. These changes have direct impact on environment, and society in Vietnam. In order to prevent this peril, socio-economic development in Vietnam must go hand in hand with low-carbon society's development.

# Assumptions of the Future Society

## Population and number of household

In this study, the year 2005 was chosen as the base year to analyze current state and is the starting point of projection because of its availability of statistic information in Vietnam. The year 2030 was chosen as the final year of projection and the goal of LCS, because it is also one of the target years adopted current Vietnam national socio-economic development plan. Two scenarios are developed: (1) Scenario without low carbon countermeasures (hereinafter referred to as 2030BaU), which is according to Vietnam socio-economic development plans and strategies towards 2030; (2) Scenario with low carbon countermeasures (hereinafter referred to as 2030CM), which assumes of employed innovative technologies as well as other low carbon countermeasures to reduce GHG emissions in 2030.

The future picture about economy, society, commercial, energy and transport in Vietnam in 2030 is depicted in following parts (Table 1).

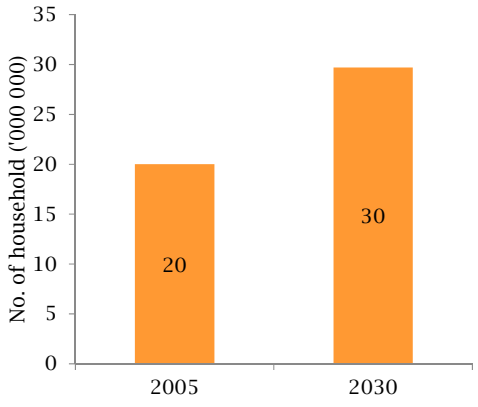


Figure 10. Number of household

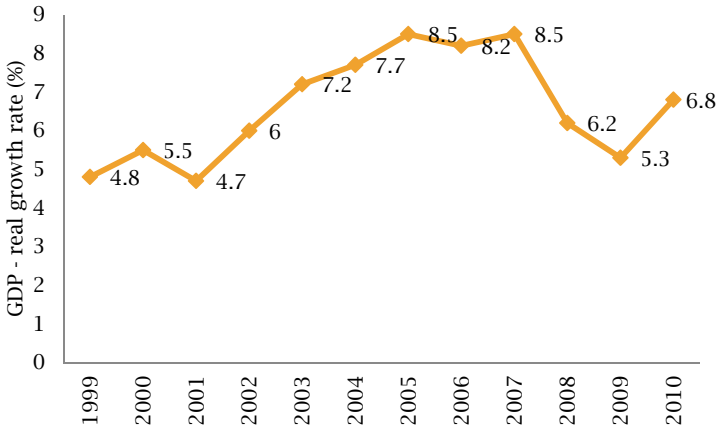


Figure 11. Real GDP growth rate (%) in the period 1999-2010 (CIA, the World factbook)

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 and over: 5.8%<br>[Female] 0-14: 7.7%, 15-64: 35.2%, 65 and over: 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)<br>[Industry, Construction]: 43% (41% in 2005)<br>[Service]: 40% (37% in 2005) | Sectoral share of primary industry has a decrease trend, whilst secondary and tertiary industry have an increasing trend. |
| Demand structure | Contribution of export in GDP: 29% (29% in 2005) | Export maintains its share in GDP |
| Transport | Passenger transport:<br>[Train] 0%, [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:<br>[Train] 2%, [Waterway] 27%, [Truck] 71%, [Aviation] 0% | Keep its role the same as the base year 2005 |

## Macro economy

We referred to the average GDP growth rate for the period 2021-2030 is equal to that of the period 2001-2010 (the 2011-2020 Socio-economic Development Strategy ) of 7.5% (Figure 11). However, the country has been experienced the slow economic growth last several years. Therefore, in this study, we assumed annual average GDP growth rate from 2005 to 2030 is 6.5%.

The economic structure of Vietnam continues to move toward a more industrialized economy as experienced during the last decades (GSO, 2011). According to 2011-2020 Socio-economic Development Strategy, Vietnam will be an industrialized country in 2020. The share of agriculture-forestry-fishery sector is assumed declining, in contrast to the other sectors in 2030 (Figure 12).

Final demands (consumption expenditure, gross fixed capital formation and export) are assumed to increase by a rate of 6.5% (the same as GDP growth rate) of an annual average. Table 2 shows the setting of the other final demand in 2030.

Table 2. Macro-economic indicators (trillion VND)

| Indicator | 2005 | 2030 | 2030/ 2005 |
|---|---|---|---|
| GDP | 818 | 3,963 | 4.8 |
| GDP/capita (mil VND) | 10 | 38 | 3.9 |
| Final consumption | 594 | 2,861 | 4.8 |
| Fixed capital formation | 307 | 1,481 | 4.8 |
| Exports | 562 | 2,713 | 4.8 |
| Imports | 644 | 3,092 | 4.8 |

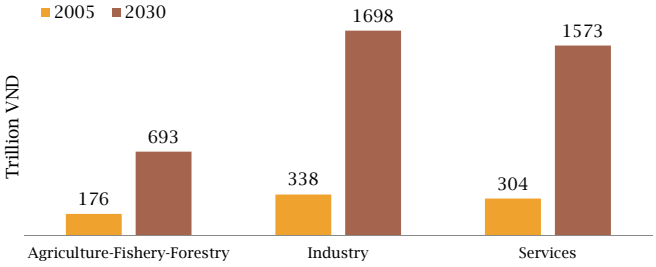


Figure 12. Contribution of industries to GDP in 2030 (trillion VND)

## Transportation

*Passenger transport*

Due to both economic growth and large expansion in population in future, transport demand is projected to progress significantly. Per capita passenger transport demand is assumed to increase from 2 trip/(capita.day) in 2005 to 2.7 in 2030. Therefore, passenger transport volume is estimated to be 103.4 billion trip/year.

The modal shares in passenger transport in 2030 BaU are proposed as follows: [Train] 0%, [Bus] 0.6%, [Waterway] 0.6%, [Car] 0.3%, [Motorbike] 8.3% [Walk & Bike] 90%, [Aviation] 0.1%. We assumed that there is a drastically increase of private vehicles especially motorbike and car compared to the year 2005.

*Freight transport*

In the 2030BaU case, freight transport demand per output by industry is assumed to increase 1.2 times of the base year due to growth of industry sector, accounts for 0.35 tonne/millionVND/day. Freight transport also relies predominantly on roads as and this transport mode is projected to keep its role in future the same as the base year 2005, almost 71% of the total freight volume, followed by domestic waterway accounting for 27% and only 2% by train. Freight volume carried by aviation is negligible. Average distance is assumed to be same as those in 2005.

## Crop harvested area

The principal sources of GHG emissions in the agriculture sector are rice cultivation, livestock, and managed soils.

The future picture about production of agriculture and livestock industry, and land-use change in Vietnam in 2030 is depicted as follows.

In Vietnam, rice was the biggest harvested area, which accounted for 75% and 66% of total harvested areas of crops in 1970 and 1990, respectively (FAOSTAT, 2012). In 2000, Vietnam had 7.7 million hectare of paddy rice, which comprised of 39% of spring paddy, 30% of autumn paddy and 31 % of winter paddy (GSO, 2010). However, due to urbanization and industrialization, harvested paddy rice area declined from 7.7 million hectare in 2000 to 7.4 million hectare in 2005. Harvested paddy rice area in Vietnam is expected to further decrease in the future by 7.3 and 7.2 million hectare respectively in 2020 and 2030 (Figure 13).

Regarding to maize, which is the second large crops in Vietnam, the harvested area increased gradually from 0.7 million hectare in 2000 to more than 1.1 million hectare in 2010. It will reach to 1.4 million hectare in 2020 and keep stable until 2030. Between 2000 and 2010, sugar cane and oil crop areas were almost 0.9 million hectare, accounted for about 7% of total harvested areas. This proportion was assumed to be remained almost the same in future years. Harvested areas of industrial crops (tea, coffee, rubber etc.) increased gradually from 1.0 million hectare and reached 1.1 million hectare in 2010. They were assumed to be constant in the future. Harvested areas of other crops (vegetables, fruits, tree nuts and so on) increased from 2.0 million hectare in 2000 to 2.6 million hectare in 2010 and were assumed to be unchanged in 2020 and 2030.

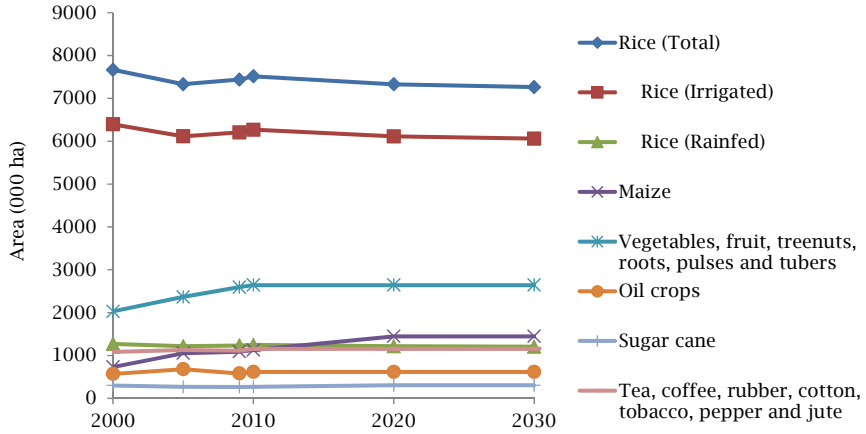


Figure 13. Future scenario of harvested area of crops

## Livestock population

Cattle (buffalo and cow) and poultry (chicken and duck) are the main type of livestock in Vietnam. Between 2000 and 2010, cattle increased from 4.1 million heads to 8.0 million heads, of which dairy cattle accounted for more than 97% of total number of cattle. In order to satisfy for domestic supply, amount of cattle will increase more than 1.7 times between 2010 and 2030 and reach 14 million heads in 2030, of which 1 million heads are dairy cattle and 13 million heads are beef cattle.

Number of buffaloes is still expected to remain at 2.9 million heads from 2010 until 2030.

Number of swine is expected to increase sharply in the future. Ministry of Agriculture and Rural Development (MARD, 2011) planed that there will have 35 and 49 million heads of swine in 2020 and 2030, respectively.

There is no plan to increase the number of sheep, goats and horses in the future, hence amount of those livestock animals in 2030 was assumed to be remained unchanged as that in 2010 (Figure 14).

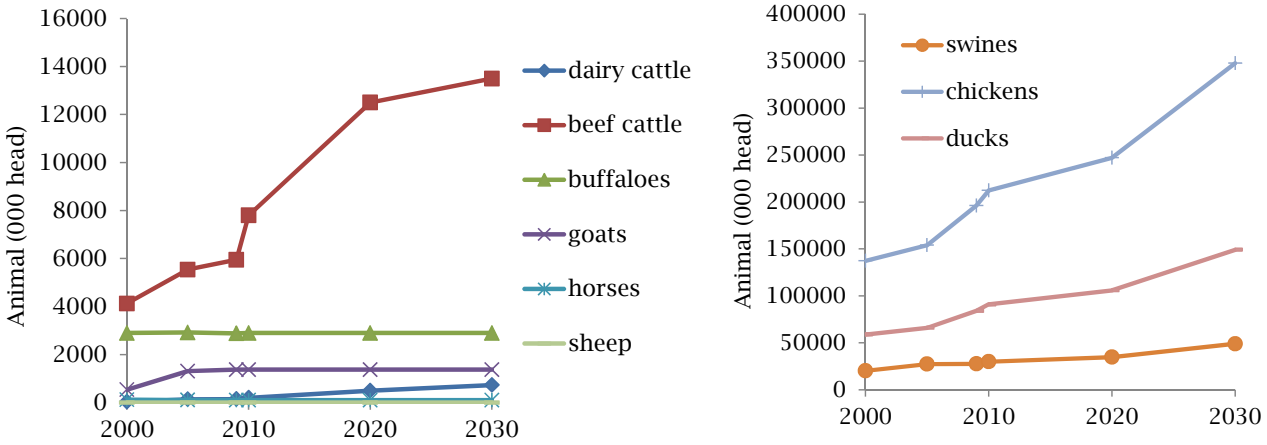


Figure 14. Scenarios of livestock population from 2000 to 2030

## Land use change

In Vietnam, the patterns of land use have changed considerably, particularly as some farmers have shifted from crop cultivation to reforestation which has conducted alongside national policies to encourage reforestation activities.

Forestland increased from 9.3 million hectare in 1990, which equates to 39% of total land area, to 12.6 and 13.6 million hectare in 2005 and 2009, respectively. Cropland areas were increased from 6.1 to 8.1 million hectare between 1970 and 1990 (FAOSTAT, 2012).

According to Ministry of Natural Resources and Environment (MONRE, 2010), forest areas in Vietnam is expected to reach 14.1 and 14.5 million hectare in 2020 and 2030, respectively.

Cropland area will slight decrease from 9.9 to 9.8 million hectare between 2020 and 2030 due to the decline of rice field area. Other land was defined as the land not classified as the other categories. It includes built-up and related land, barren land and other wooded land etc. Other land is calculated as subtracting total of area of forestland, grassland, cropland, settlements and inland water from country area. In this study, we did not take into account emission from fires and natural disturbance.

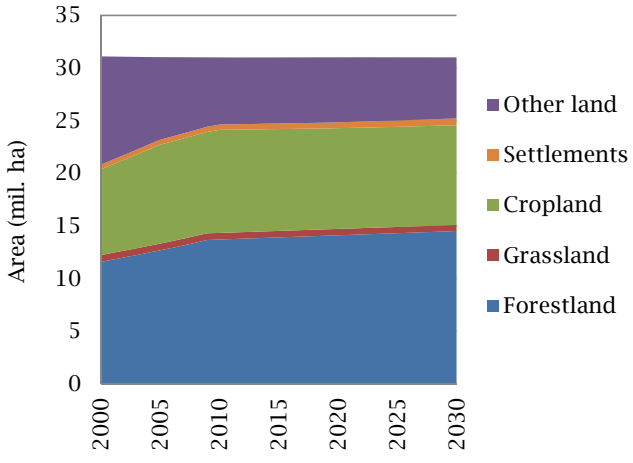


Figure 15. Future scenarios of land use change in Vietnam

# Socio-economic Scenario in 2030

## Scenario quantification

Table 3. shows the main results of the socio-economic indicators in Vietnam in 2030.

With annual growth rate of 0.9%, population in 2030 increased 1.3 times compared to 2005, whereas increase of household number was slightly larger because of smaller size of household. With annual growth rate of 6.5%, GDP increased almost 5 times in 2030 compared to 2005. In which, GDP contributed by secondary and tertiary sectors increased much higher than 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 industry sector in the future.

Output by industry in 2030 was calculated by the model and shown in Table 4.

Table 3. Estimated socio-economic indicators in 2030 in Vietnam

| | 2005 | 2030 BaU | 2030 CM | 2030BaU/2005 | 2030CM/2005 |
|---|---|---|---|---|---|
| Population (million people) | 83.1 | 104.0 | 104.0 | 1.3 | 1.3 |
| No. of households (million) | 20.0 | 29.7 | 29.7 | 1.5 | 1.5 |
| GDP (trillion VND) | 818.5 | 3,963 | 3,963 | 4.8 | 4.8 |
| Gross output (trillion VND) | 1,934 | 9,750 | 9,750 | 5.0 | 5.0 |
| Primary industry (trillion VND) | 404 | 1,684 | 1,684 | 4.2 | 4.2 |
| Secondary industry (trillion VND) | 1,033 | 5,497 | 5,497 | 5.3 | 5.3 |
| Tertiary industry (trillion VND) | 497 | 2,569 | 2,569 | 5.2 | 5.2 |
| Passenger transport demand (million people-km) | 223,981 | 542,687 | 518,028 | 2.4 | 2.3 |
| Freight transport demand (million ton-km) | 38,856 | 235,212 | 235,124 | 6.1 | 6.1 |

Table 4. Output by industry

| | Output (trillion VND) | | | Composition (%) | |
|---|---|---|---|---|---|
| | 2005 | 2030 | 2030/2005 | 2005 | 2030 |
| Primary industry | **404** | **1684** | **4.2** | **21** | **17** |
| Agriculture-Fishery-Forestry | 261 | 1026 | 3.9 | 14 | 11 |
| Mining and quarrying | 143 | 658 | 4.6 | 7 | 7 |
| Sencondary industry | **1033** | **5497** | **5.3** | **53** | **56** |
| Food, beverage & tobaco manufactures | 259 | 1213 | 4.7 | 13 | 12 |
| Other consumer goods | 285 | 1908 | 6.7 | 15 | 20 |
| Industrial materials | 182 | 888 | 4.9 | 9 | 9 |
| Capital goods | 127 | 622 | 4.9 | 7 | 6 |
| Construction | 179 | 866 | 4.8 | 9 | 9 |
| Tertiary industry | **497** | **2569** | **5.2** | **26** | **26** |
| Total | **1934** | **9750** | **5.0** | **100** | **100** |

# Energy Demand in 2030

## 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% (2030CM) over the outlook period, from 44 million tones equivalent (Mtoe) in 2005 to 154 Mtoe in 2030BaU scenario and 120 Mtoe in 2030CM scenario. The projected final energy demand growth in 2030BaU scenario is higher than the past decade of 4.4% between 1995 and 2005.

Regarding to the target of being a industrialized 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 2030CM scenarios, respectively.

The share of energy demand by residential sector is projected to be reduced substantially from 59% in 2005 to 30% in 2030BaU scenario and to 32% in 2030CM scenario, as a result of a reduction of the demand for traditional fuels for cooking. It is followed by transport sector, accounting for 23% and 16% in 2030BaU and 2030CM 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 2030CM scenario.

Figure 16 & 17 show final energy demand and its share by sector.

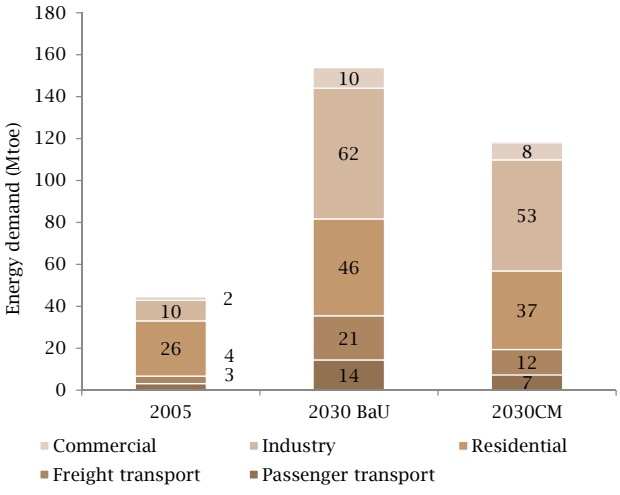


Figure 16. Final energy demand by sector

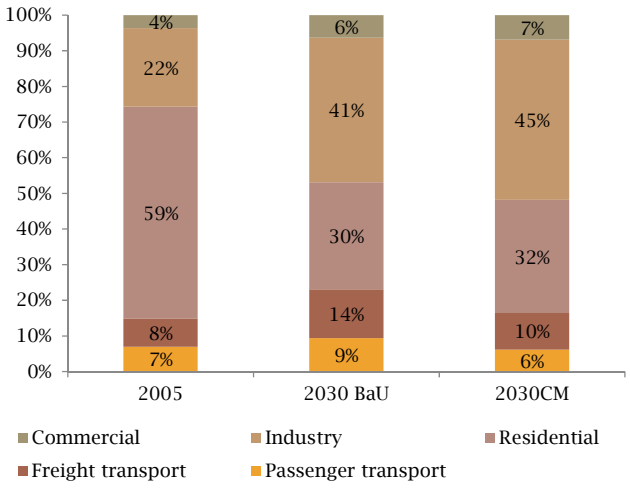


Figure 17. Share of final energy demand by sector

## Primary energy demand

The primary energy demand is projected to increase 3.8 times from 50 Mtoe in 2005 to about 197 Mtoe 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 (biomass) in 2005, account for more than 80% of the primary energy mix. Consequently, the share of biomass is decreased substantially from 46% in 2005 to 13 and 16% in 2030BaU and 2030CM 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 increased 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 & wind are projected to account for 2% and 6% in 2030BaU and 2030CM scenarios, respectively.

Figure 18 & 19 show primary energy demand and its share by fuel.

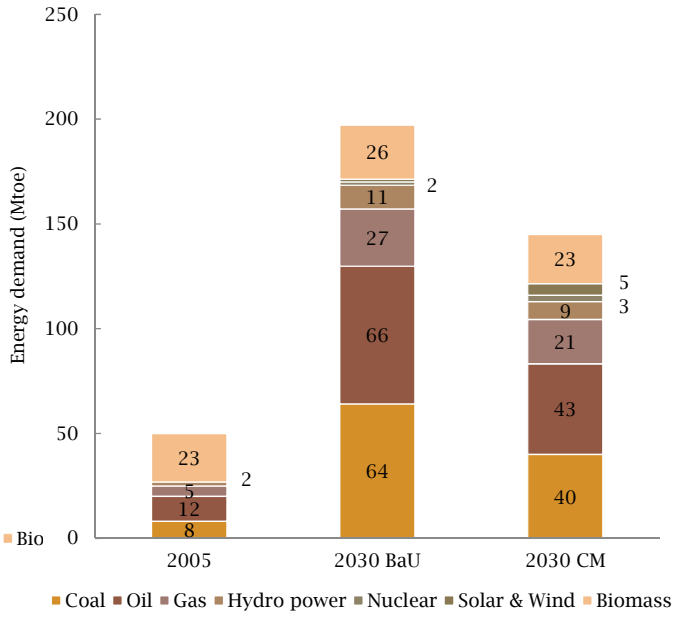


Figure 18. Primary energy demand by fuel

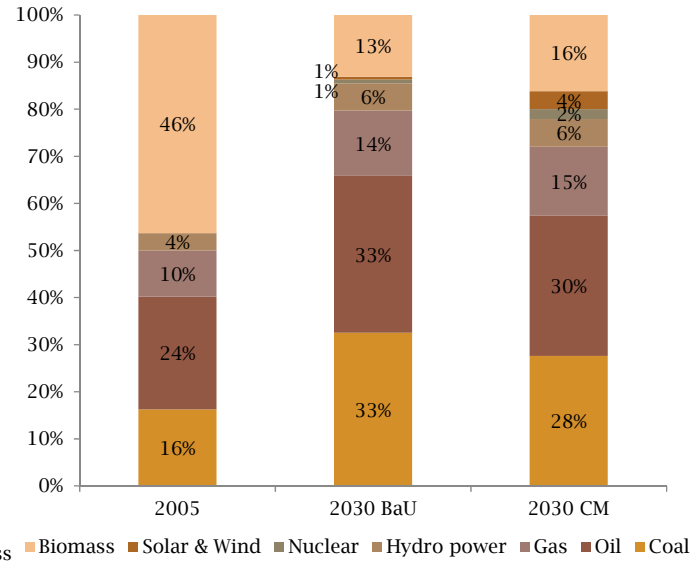


Figure 19. Share of primary energy demand by fuel

## Electricity generation

Figure 20 shows that, from 2005 to 2030, the share of hydro is expected to decrease from 19% to 14% (2030BaU) and 16% (2030CM). By contrast, coal-fired electricity generation is expected to increase considerably and take a biggest share at 46% and 40% in 2030BaU and 2030CM scenarios, respectively, an almost two-fold increase over 2005. The share of gas-fired electricity generation is projected to decrease to 4% and 3% in 2030BaU and 2030CM scenarios, respectively. Meanwhile, the share of nuclear power is expected to increase to 2% in 2030BaU scenario and 6% in 2030CM 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 as biomass, solar and wind are expected to produce electricity in 2030.

Energy demand for electricity generation and share of electricity consumption by sector are shown in Figure 21 and 22.

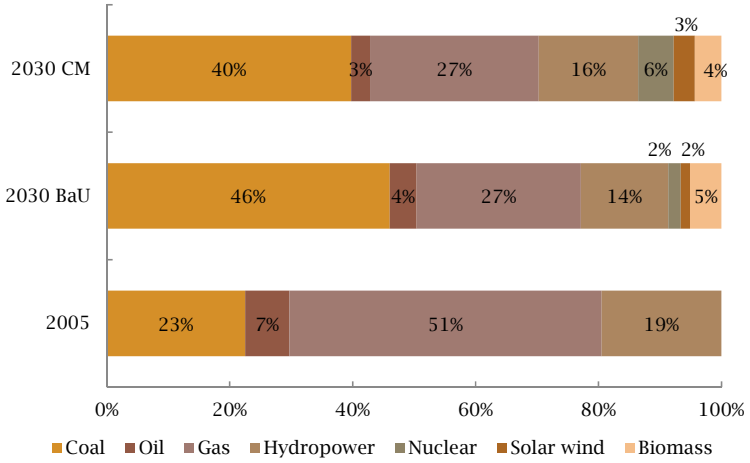


Figure 20. Electricity generation mix

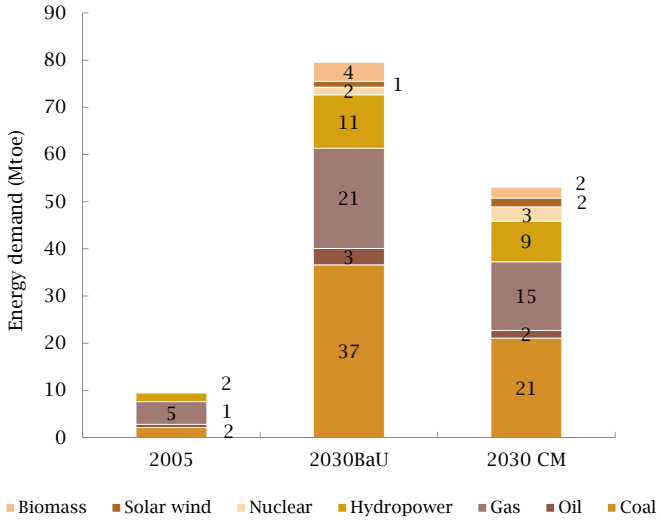


Figure 21. Energy demand for electricity generation

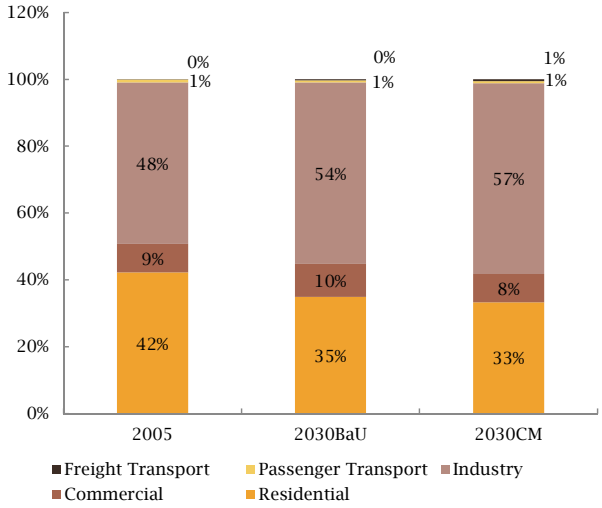


Figure 22. Share of electricity consumption by sector

# GHG Emissions in 2030

The finding shows that total GHG emission in 2030BaU in Vietnam is expected to increase to 601 $MtCO_2eq$ or about 4 times higher than 2005 level.

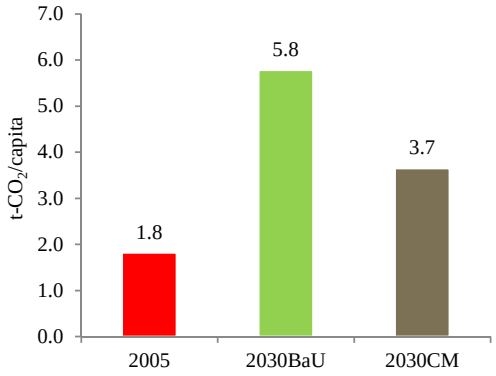


Figure 23. Per capita GHG emissions in Vietnam

In 2005, per capita GHG emissions in Vietnam was at 1.8 $tCO_2eq$. In 2030, this number is projected to increases to 5.8 $tCO_2eq$ in 2030BaU scenario. It is expected to reduce to 3.7 $tCO_2eq$ under 2030CM scenario (Figure 23). GHG emission intensity is 0.18 $tCO_2eq$/billion-VND in 2005.

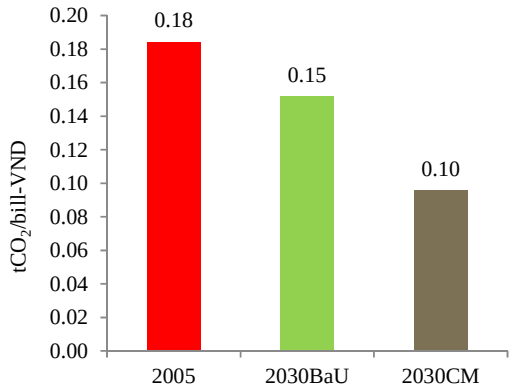


Figure 24. Total GHG emissions in Vietnam in 2030

The GHG emission intensity is further reduced to 0.15 $tCO_2eq$/billion-VND in 2030BaU scenario. In 2030CM scenario records a reduction of almost 50% from base year to achieve 0.10 $tCO_2eq$/billion-VND (Figure 24). Per capita GHG emission shows an increase from 2005 to 2030BaU, but the GHG emission intensity shows a reduction. This is because when GHG emission is estimated against the GDP, a reduction is identified.

## GHG emissions in Energy sectors

GHG emissions in energy sector increased 6.4 times of that of 2005 in 2030BaU scenario, and 4.2 times the 2030CM 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 $MtCO_2eq$. This figure is expected to increase to 522 and 342 $MtCO_2eq$ by 2030 in BaU and CM scenarios, respectively. The major contributors to GHG emission include industrial sector (49% of total GHG emissions in 2030BaU scenario), followed by transport and residential sectors which account for 21% and 22% of total GHG emissions in the 2030BaU scenario, respectively.

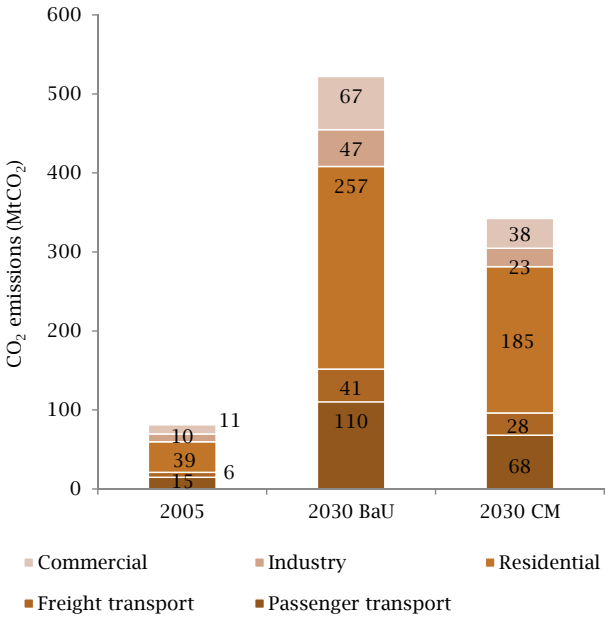


Figure 25. GHG emissions by sector in energy sectors

## GHG emissions in AFOLU sectors

Total GHG emissions in AFOLU sectors in 2030 are expected to reach 79 $MtCO_2eq$.

In agricultural sector, $CH_4$ is the largest GHG emission, followed by $N_2O$. The major sources are rice cultivation ($CH_4$), livestock ($CH_4$ and $N_2O$) and then managed soil ($N_2O$). GHG emissions in agricultural sector in 2000 was 62 $MtCO_2eq$, and gradually increased to 65 and 72 $MtCO_2eq$ in 2005 and 2010, respectively. After that, the emission is expected to increase gradually to 85 $MtCO_2eq$ in 2030.

For LULUCF sector, main source of GHG is from forest and grassland conversion, followed by emission and removal from soils. Total GHG emissions from forestry and land use change are expected to decline gradually from 5 $MtCO_2eq$ in 2005 to 3 $MtCO_2eq$ in 2010, respectively. After 2015, LULUCF is expected to be a net sequestration of $CO_2$, with amounts of -3 and -6 $MtCO_2eq$, respectively in 2020 and 2030.

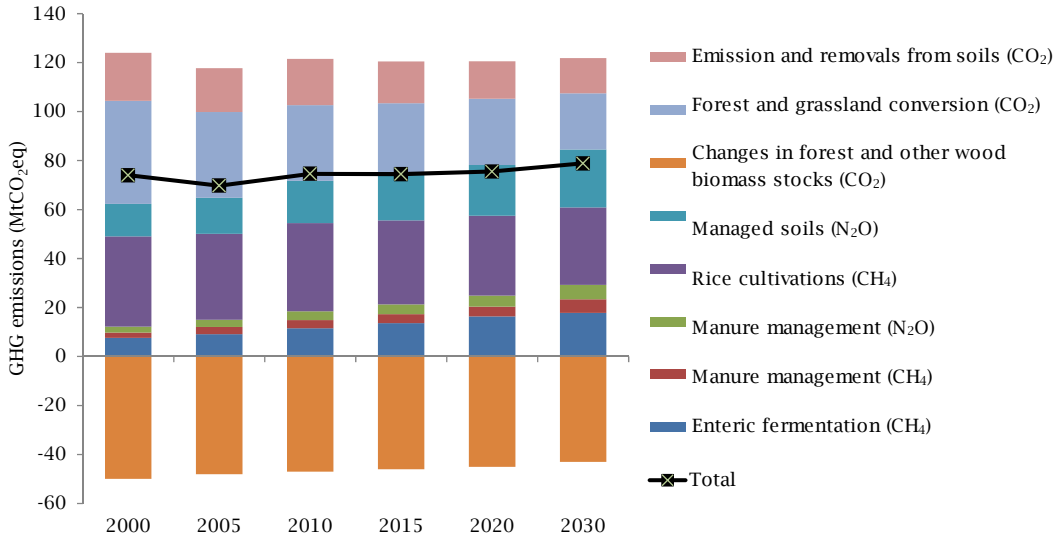


Figure 26. GHG emissions in AFOLU in 2030BaU

# Mitigation Potential in 2030

Total GHG emissions in Vietnam is projected to be reduced from 601 $MtCO_2eq$ in the 2030BaU scenario to 379 $MtCO_2$ in the 2030CM scenario by adoption of low carbon countermeasures for mitigating GHG emissions in 2030 (Figure 27). The reductions of GHG emissions by types of low carbon countermeasures are shown in Figure 28.

In energy sectors, among the countermeasures, energy efficiency improvement and fuel shift in power sectors account for the largest proportion, 38.7 $MtCO_2$, followed by efficient vehicles in freight transport sector (23.9 $MtCO_2$), energy efficiency improvement in industry (23.5 $MtCO_2$).

In AFOLU sector, we have estimated mitigation potential by several Allowable Abatement Costs (AAC) for reduction. In this brochure, for mitigation countermeasures and actions, we discuss only the mitigation potential under 10 USD/$tCO_2eq$. In this case, both agriculture and LULUCF are expected to reduce GHG emissions altogether 42 $MtCO_2eq$ which account for halving 21 $MtCO_2eq$ for each sector.

In order to realize a LCS, Vietnam needs to have new set of strong policies to encourage and promote these low carbon countermeasures.

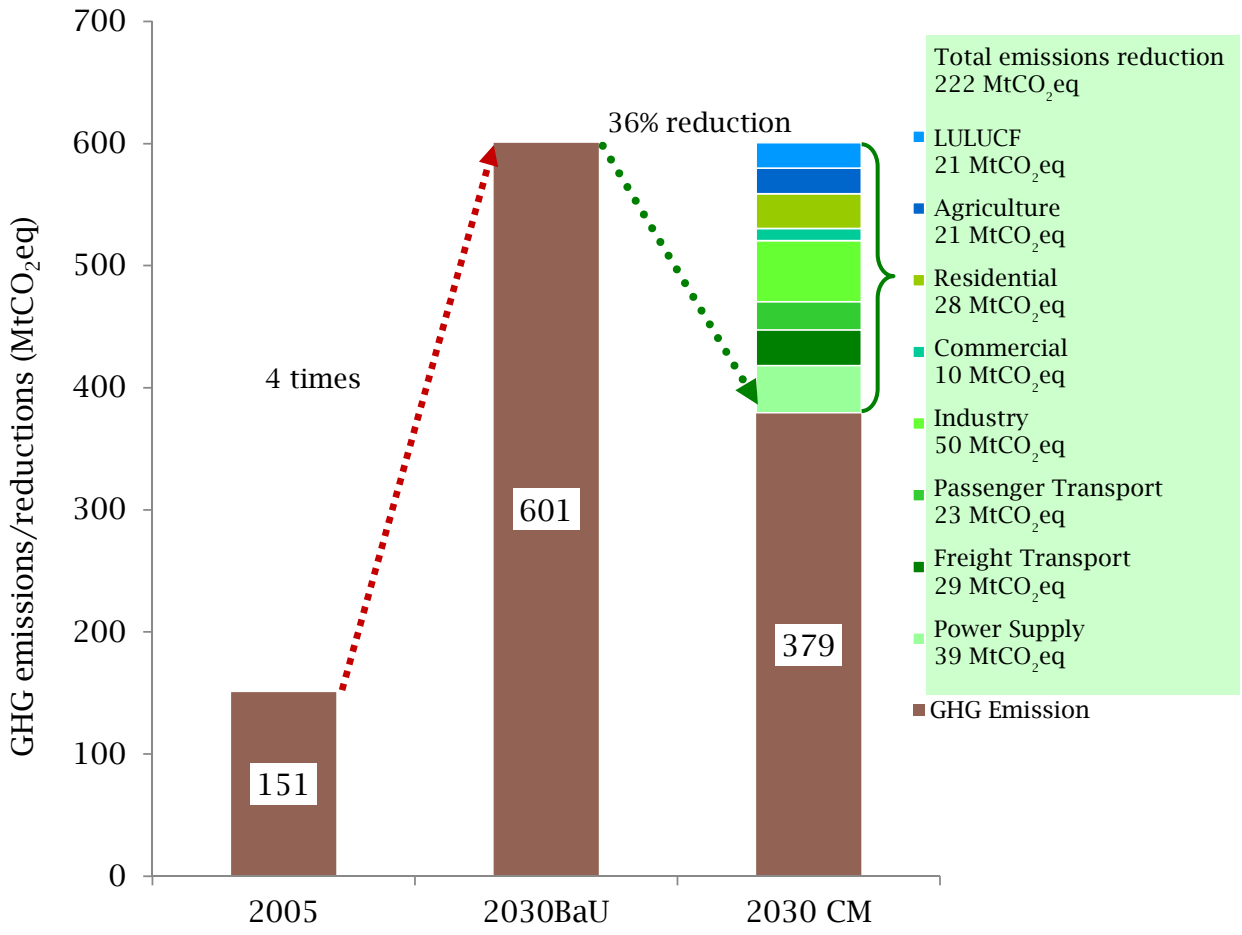


Figure 27. GHG emission and mitigation in Vietnam

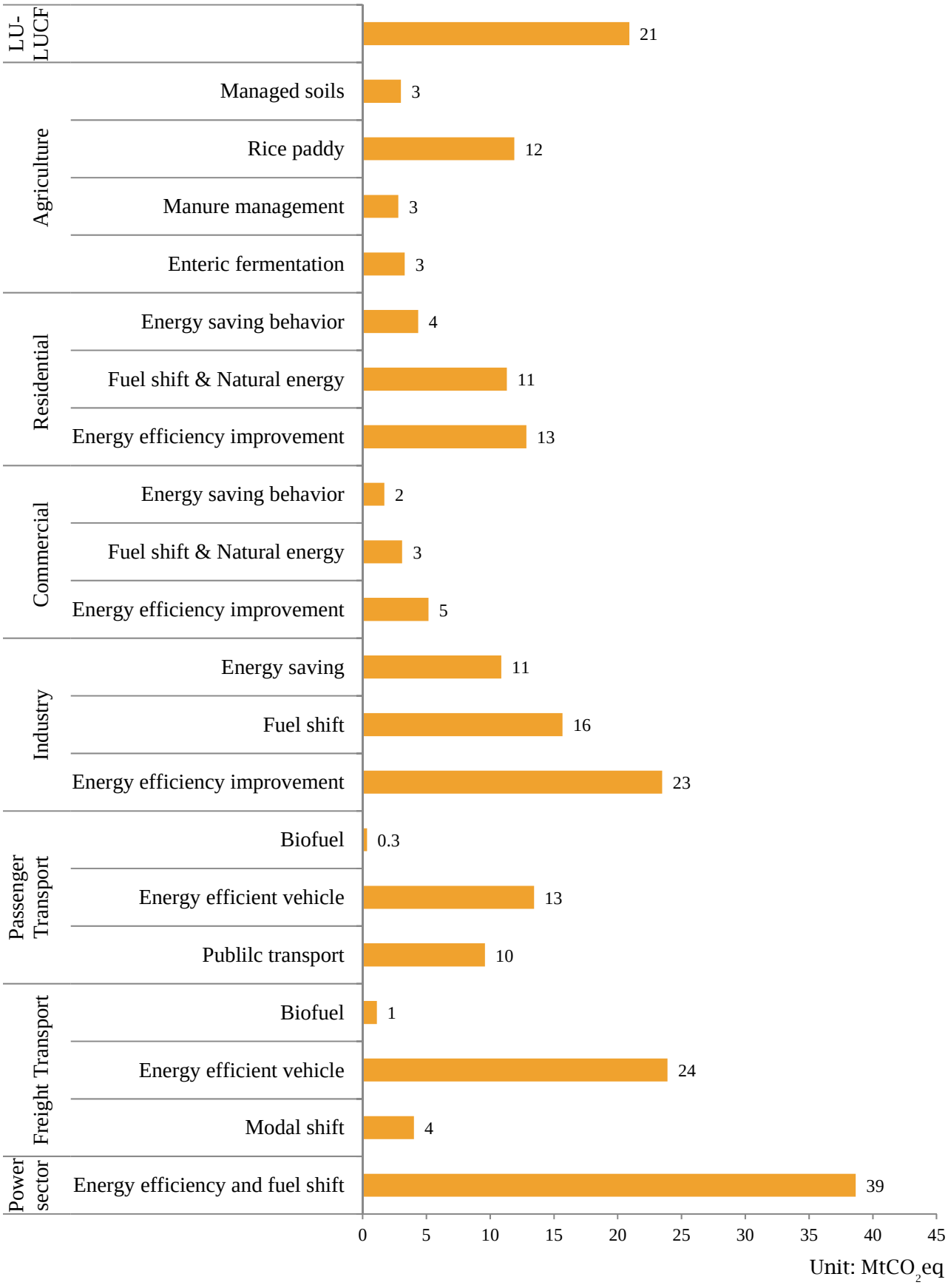


Figure 28. GHG mitigation potential in Vietnam in 2030

# LCS Policy Package for Vietnam

All of proposed low carbon countermeasures can be translated into policy actions through incentives and regulations as explained in low carbon policy package as shown in Figure 29.

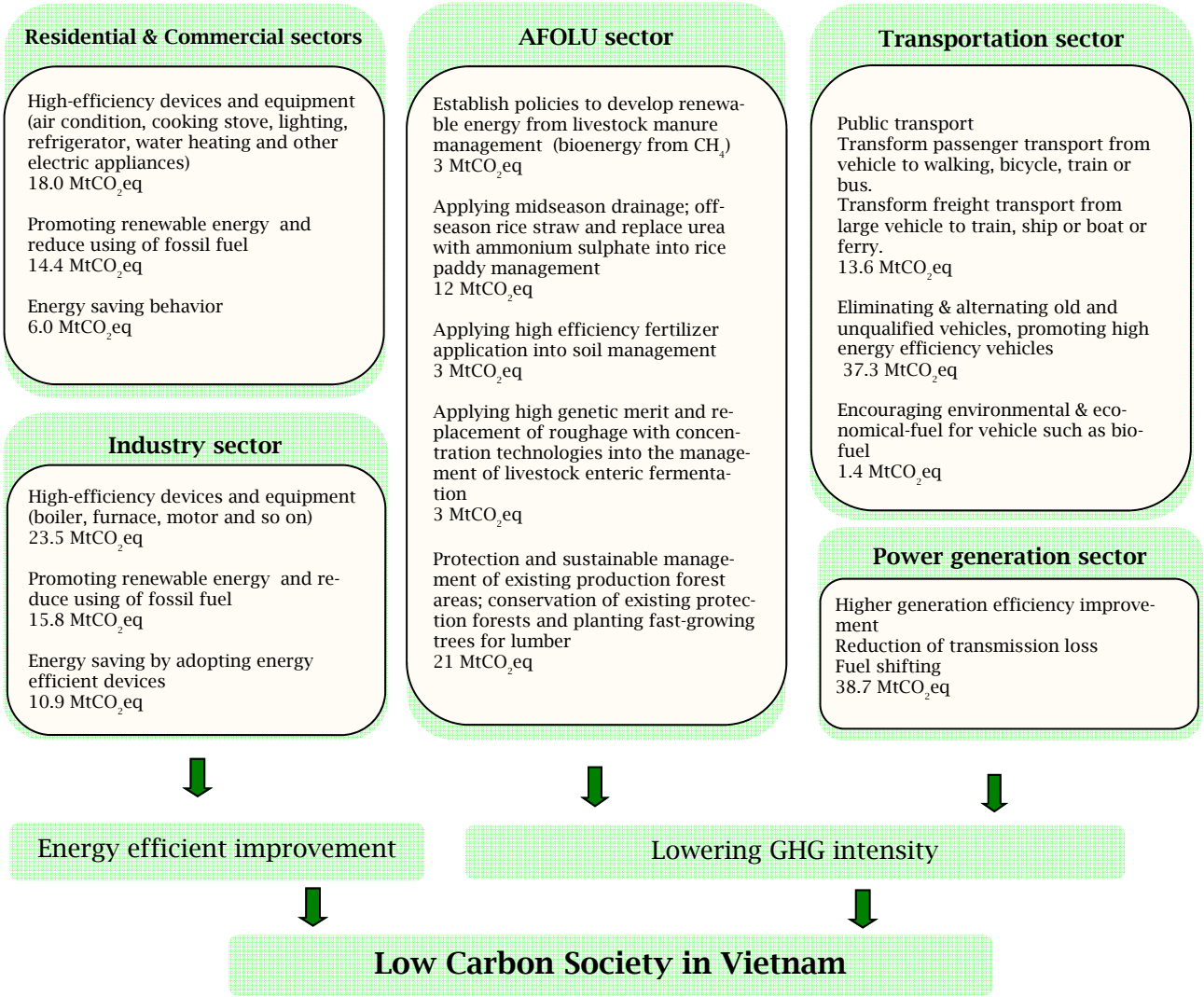


Figure 29. Low Carbon Policy Package for Vietnam

Table 5 . GHG emissions/mitigations in 2030BaU and 2030CM

| Sector | GHG emissions ($MtCO_2eq$) | | GHG emissions reduction |
|---|---|---|---|
| | 2030BaU | 2030CM | |
| AFOLU sectors | **79** | **37** | **42** |
| Agriculture | 85 | 64 | 21 |
| LULUCF | -6 | -27 | 21 |
| Energy sectors | **522** | **342** | **180** |
| Residential sector | 110 | 68 | 42 |
| Commercial sector | 41 | 28 | 13 |
| Industry | 257 | 185 | 71 |
| Transport | 114 | 61 | 53 |
| Total | **601** | **379** | **222** |

# Actions towards LCS in 2030

The LCS policy package encompasses several solutions, is a menu of recommended Actions which are needed to be integrated in the development planning for Vietnam.

These Actions would have to be considered in the background of the developing countries' imperative need of effective governance, financing and technology transfer.

Actions should be compatible with the principles of sustainable development, however not at the cost of the development needs of all groups in the society.

The set of Actions would help in devising dedicated policies in the present and helping in the realization of a LCS vision for Vietnam

These Actions focus on two group of sectors such as energy and AFOLU sectors. Five Actions (A1 to A4 and F) comprise all low carbon countermeasures in AFOLU sector. Six Actions (E1 to E6) are focused on energy sector and include all low carbon countermeasure in this sector.

Detail explanations and the amount of GHG emission reduction of each Action are shown in following sections.

Table 6 . Actions towards LCS in Vietnam in 2030

| **Actions towards LCS in Vietnam in 2030** | | **GHG mitigations ($MtCO_2eq$)** |
|---|---|---|
| **AFOLU sectors** | | **42** |
| Action A1 | Livestock Manure Management | 3 |
| Action A2 | Livestock Enteric Fermentation | 3 |
| Action A3 | Rice Cultivation Management | 12 |
| Action A4 | Soil Management | 3 |
| Action F | Forest and Land Use Management | 21 |
| **Energy sectors** | | **180** |
| Action E1 | Green Building | 14 |
| Action E2 | Convenient Transport | 15 |
| Action E3 | Energy Saving Behavior | 17 |
| Action E4 | Energy Efficiency Improvement | 79 |
| Action E5 | Fuel Shift in Industry | 16 |
| Action E6 | Smart Power Plants | 39 |
| Total | | **222** |

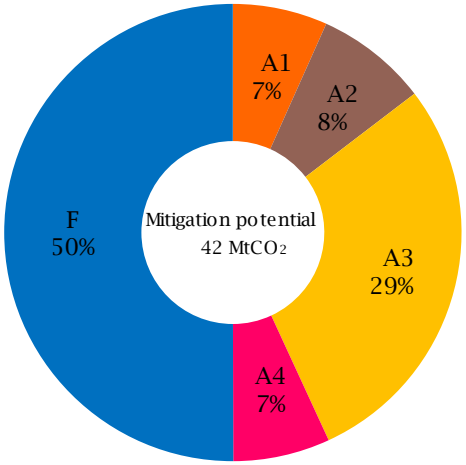


Figure 30. Mitigation potential of AFOLU sector

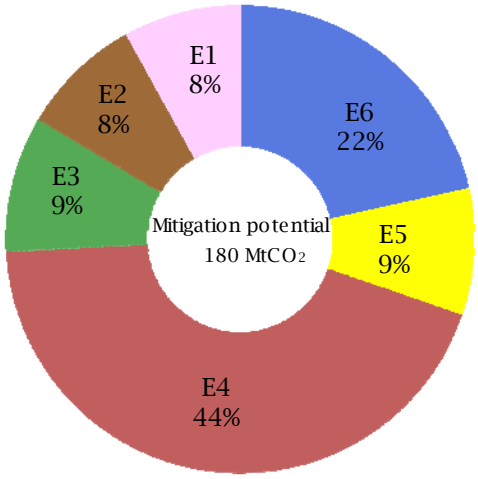


Figure 31. Mitigation potential in Energy sector

# Action A1: Livestock Manure Management

The action "Livestock Manure Management" is expected to reduce 2.8 $MtCO_2eq$ at AAC of 10 $USD/tCO_2eq$, accounts for 7% of total GHG emissions in AFOLU sectors (see Figure 32). The low carbon countermeasures in this action are "daily spread of manure" and "dome digester, cooking fuel and light".

In the former one, anaerobic digestion would reduce GHG emissions if applied to buffalo and dairy cattles manures of currently sorted as liquids/slurries and pig manure kept in pits for longer than a month. The daily spread of manure would bring about GHG emissions reduction in all of these cases, and a small reduction for dairy and pig manures kept in solid storage. In latter countermeasure, dome digesters are designed for small-scale and unheated ones. Generated biogas is typically used by the household for cooking and other household energy needs.

Mitigation in different AAC in Action A1 is shown in table 7.

Total mitigation is no change in deferent AAC of 0, 10 and 100 $USD/tCO_2eq$. However, it can get more mitigation in the case 100 $USD/tCO_2$ of AAC.

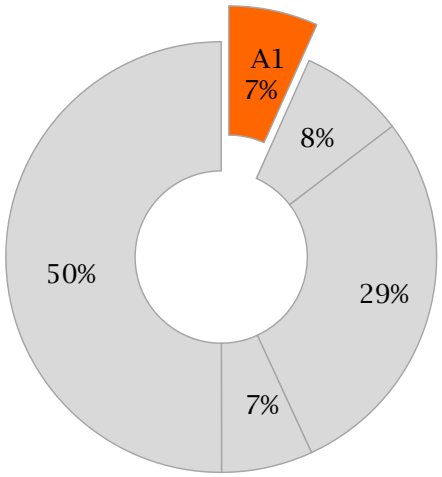


Figure 32. Mitigation potential of Action A1

There is a completion between mitigation countermeasures in term of cost, the cheaper countermeasures are expected to be employed more compare to other.

In the case at 10000)$USD/tCO_2eq$ of AAC, total cost of "dome digester, cooking and light" is higher than that of "daily spread of manure". Therefore, "daily spread of manure" is chosen instead of "dome digester, cooking fuel and light".

Table 7 . Breakdown of emission mitigation in action A1 in different AAC

| Mitigation in 2030 [$MtCO_2eq$] | Allowable abatement cost [$USD/tCO_2eq$] | | | |
|---|---|---|---|---|
| | 0 | 10 | 100 | 100000 |
| Daily spread of manure | 0.0 | 0.0 | 0.0 | 4.9 |
| Dome digester, cooking fuel and light | 2.8 | 2.8 | 2.8 | 0.1 |
| Total | **2.8** | **2.8** | **2.8** | **5.0** |

# Action A2: Livestock Enteric Fermentation

The action "Livestock Enteric Fermentation" is contributed to reduce 3.3 $MtCO_2eq$ at AAC of 10 $USD/tCO_2eq$ in 2030. This action comprises of 2 main countermeasures; namely, high genetic merit and replacement of roughage with concentrates, account for 8% of total GHG emissions in AFOLU sectors (Figure 33).

The "high genetic merit" countermeasure is to improve the genetic merit of dairy cows. As a result, average national yields have increased. One of the major improvements is the ability of the cow to partition nutrients into milk preferentially to maintenance and/or growth. This has undoubtedly resulted in increased efficiency. However, high genetic merit cows can have increased problems with fertility, lameness, mastitis and metabolic disorders, and all these issues will have to be addressed if genetic progress is to be successfully continued. This countermeasure contributes to reduce 0.1 $MtCO_2eq$ at AAC of 10 $USD/tCO_2eq$.

The "replacement of roughage with concentrates" is to increase conversion efficiency. This countermeasure contains high portions of structural carbohydrates with concentrates to improve propionate generation in rumen, contributes to reduce 3.2 $MtCO_2$at AAC of 10 $USD/tCO_2eq$.

Mitigation in different AAC in Action A2 is shown in table 8.

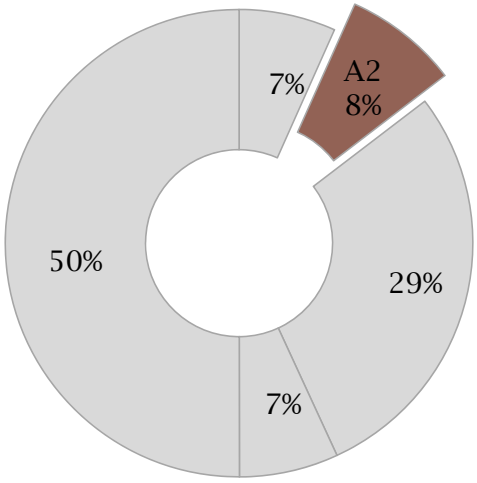


Figure 33. Mitigation potential of Action A2

Figure 34. Feeding cow

Table 8 . Breakdown of emission mitigation in action A2 in different AAC

| Mitigation in 2030 [$MtCO_2eq$] | Allowable abatement cost [$USD/tCO_2eq$] | | | |
|---|---|---|---|---|
| | 0 | 10 | 100 | 100000 |
| High genetic merit | 0.1 | 0.1 | 1.6 | 1.8 |
| Replacement of roughage with concentrates | 3.2 | 3.2 | 2.6 | 2.5 |
| Total | **3.3** | **3.3** | **4.2** | **4.3** |

# Action A3: Rice Cultivation Management

The action "Rice Cultivation Management" has the largest mitigation potential in agricultural sector, accounting for 29% of total GHG emission reduction in AFOLU sectors (Figure 35). This action will contribute to reduce about 11.9 $MtCO_2eq$, on which "midseason drainage" can reduce the biggest amount of GHG emissions in this action about 6.7 $MtCO_2eq$, "fall incorporation of rice straw" accounts for 3.4 $MtCO_2eq$ and "replace urea with ammonium sulphate" accounts for 1.8 $MtCO_2eq$.

$CH_4$ emitted from rice fields can be substantially reduced through modified water management technologies, such as midseason drainage or alternate wetting and drying. In this technology, rice fields are three times within a growing season and surface water layer is 5 to 10 cm for remaining, flooded period. This countermeasure is possible to combine the aims of reducing $CH_4$ emission and saving irrigation water.

The "fall incorporation of rice straw" is aimed to shift straw amendment from in-season to off-season; as a result this process can reduce availability of dissolved organic carbon and thus reducing $CH_4$ emissions.

For countermeasure "replace urea with ammonium sulphate", adding sulfate to soil can increase mitigation potential, which suppresses $CH_4$ generation.

Mitigation in different AAC in Action A3 is shown in table 9.

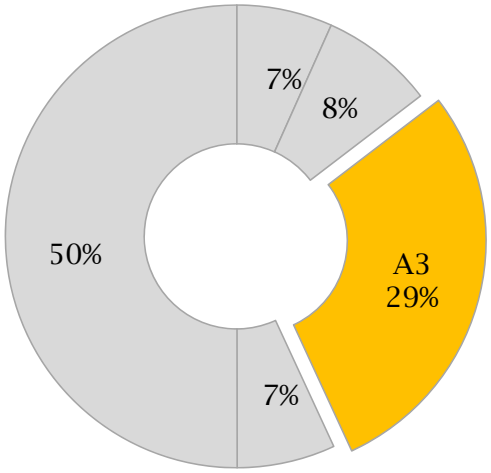


Figure 35. Mitigation potential of Action A3

Table 9 . Breakdown of emission mitigation in action A3 in different AAC

| Mitigation in 2030 [$MtCO_2eq$] | Allowable abatement cost [USD/$tCO_2eq$] | | | |
|---|---|---|---|---|
| | 0 | 10 | 100 | 100000 |
| Replace urea with ammonium sulphate | 0.0 | 1.8 | 1.8 | 1.8 |
| Midseason drainage | 4.7 | 6.7 | 6.7 | 6.7 |
| Fall incorporation of rice straw | 0.0 | 3.4 | 3.4 | 3.4 |
| Total | **4.7** | **11.9** | **11.9** | **11.9** |

# Action A4. Soil Management

The action "Soil Management" is contributed to reduce 2.9 $MtCO_2eq$, accounting for 7% of total GHG emission in AFOLU sectors (Figure 36). This action comprises of 2 main countermeasures; namely, high efficiency fertilizer application and slow-release fertilizer.

High efficiency fertilizer application is expected to reduce 2.9 $MtCO_2eq$. In Vietnam, fertilizer is used excessively, lead to emissions of $CO_2$ and $N_2O$. Therefore, reducing the redundant fertilizers or improving the efficiency of fertilizer use will decrease GHG emissions.

Slow-release fertilizer is more expensive countermeasure, therefore it is expected to apply in the case that higher cost to be paid. Nitrogen is slowly released from coated or tablet fertilizer over a 30-day period following application. This countermeasure will increase efficiency of fertilizer-use .

Mitigation in different AAC in Action A4 is shown in table 10.

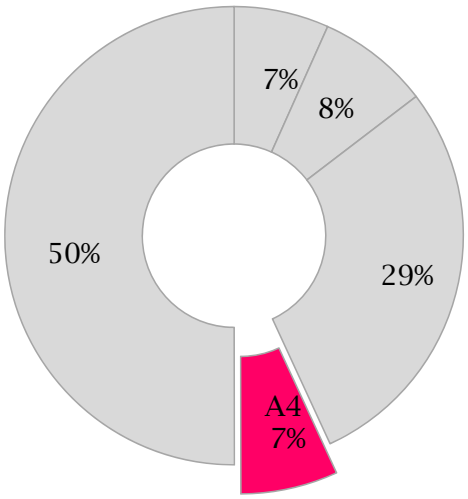


Figure 36. Mitigation potential of Action A4

Table 10. Breakdown of emission mitigation in action A4 in different AAC

| Mitigation in 2030 [$MtCO_2eq$] | Allowable abatement cost [USD/$tCO_2eq$] | | | |
|---|---|---|---|---|
| | 0 | 10 | 100 | 100000 |
| High efficiency fertilizer application | 0.0 | 2.9 | 2.7 | 2.4 |
| Slow-release fertilizer | 0.0 | 0.0 | 0.8 | 2.8 |
| Total | **0.0** | **2.9** | **3.5** | **5.1** |

Figure 37. Agricultural activity

Figure 38 Fertilizer input activity

# Action F: Forest and Land Use Management

The action "Forest and Land Use Management" has the biggest contribution, accounting for 50% of GHG emissions reduction in AFOLU sector, 20.9 $MtCO_2eq$. Main low carbon countermeasures are "protection and sustainable management of existing production forest areas", "conservation of existing protection forests" and "planting fast-growing trees for lumber".

Currently, Vietnam has been taking steps to reduce emissions from deforestation and forest degradation (REDD). Vietnam is one of the countries who obtained approval for a small scale forestation projects under UNFCCC's Clean Development Mechanism (CDM). Planting fast-growing trees for lumber can potentially be developed as CDM project while "protection and sustainable management of existing production forest areas" and "conservation of existing protection forests" are potential REDD projects.

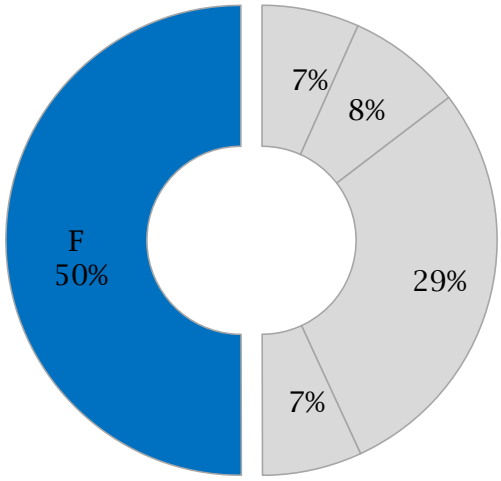


Figure 39. Mitigation potential of Action F

Mitigation in different AAC in Action F is shown in table 11.

Table 11 . Breakdown of emission mitigation in action F in different AAC

| Mitigation in 2030 [$MtCO_2eq$] | Allowable abatement cost [USD/$tCO_2eq$] | | | |
|---|---|---|---|---|
| | 0 | 10 | 100 | 100000 |
| Protection and sustainable management of existing production forest areas | 0.0 | 3.1 | 3.1 | 3.1 |
| Conservation of existing protection forests | 0.0 | 16.5 | 16.5 | 16.5 |
| Planting fast-growing trees for lumber | 0.0 | 1.3 | 1.3 | 1.3 |
| Total | **0.0** | **20.9** | **20.9** | **20.9** |

Figure 40. Forest plantation


Figure 41. Let's protect the forest

# Action E1. Green Building

The "Green Building" action focuses on countermeasures of fuel shifting and renewable energy utilization of two sectors (residential and commercial). This action is expected to reduce 14.4 $MtCO_2eq$, accounting for 8% of total $CO_2$ emission reduction in energy sector (Figure 43). Residential sector can reduce 11.3 $MtCO_2eq$ and commercial sector can reduce 3.1 $MtCO_2eq$.

GHG emission reduction from residential sector accounts for 78% and commercial sector 22%.

Fuel shifting and renewable energy utilization comprise low carbon countermeasures such as biomass cooking, solar heating, and solar water heater etc.

In order to achieve this action, the Government of Vietnam should deploy policies concerning (i) subsidy to introduce renewable energy system (solar and wind energy, photovoltaic power), (ii) low interest loan in investment to building using renewable energy, (iii) environmental performance standard and evaluation of housing and buildings.

Figure 42. "Green space" in Hanoi

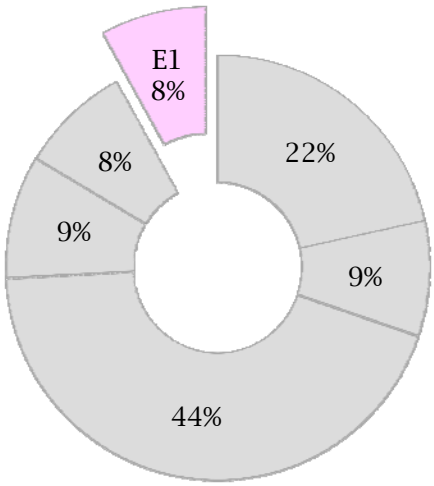


Figure 43. Mitigation potential of Action E1

Table 12 . Breakdown of emission reduction in action E1

| | GHG emission reduction [$MtCO_2eq$] | Contribution in the Action [%] | Contribution in total reduction in energy sector [%] | Contribution in total reduction in Vietnam [%] |
|---|---|---|---|---|
| Residential | **11.3** | 78% | 6% | 5% |
| Heating | 0.4 | | | |
| Hot water | 2.0 | | | |
| Cooking | 8.9 | | | |
| Commercial | **3.1** | 22% | 2% | 1% |
| Heating | 0.5 | | | |
| Hot water | 2.3 | | | |
| Cooking | 0.3 | | | |
| Total | **14.4** | 100% | 8% | 7% |

# Action E2. Convenient Transport

The action "Convenient Transport" primarily comprises of a shift from private vehicles to public transportation (such as from motorbike and car to bus and train) by traffic management system and increased penetration of fuel switch (from gasoline and diesel to electricity and bio-diesel).

This action is contributed to reduce 15.0 $MtCO_2eq$, on which GHG reductions from modal shift (freight transport) is 4.0 $MtCO_2eq$, public transport (passenger transport) is 9.6 $MtCO_2eq$, from promotion of fuel switch (bio-diesel) in both passenger and freight transport is 1.4 $MtCO_2eq$. Total GHG reductions from this action are expected to contribute to 8% of total GHG emission reductions in energy sector in Vietnam.

Policies to encourage this action can be: environmental standards & requirements of vehicles, upgrading transport infrastructure and encouraging environmental & economical-fuel vehicle such as natural gas and hybrid cars, investment to public vehicles, and bold policy to control and reduce the use of motorbikes.

Figure 44. A future public transportation system

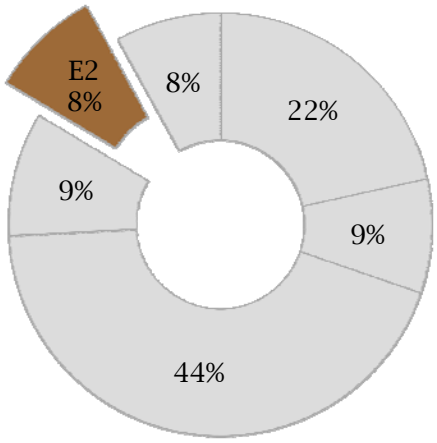


Figure 45. Mitigation potential of Action E2

Table 13 . Breakdown of emission reduction in action E2

| | GHG emission reduction [$MtCO_2eq$] | Contribution in the Action [%] | Contribution in total reduction in energy sector [%] | Contribution in total reduction in Vietnam [%] |
|---|---|---|---|---|
| Passenger transport | **9.9** | 66% | 6% | 4% |
| Bio diesel vehicle | 0.3 | | | |
| Public transport | 9.6 | | | |
| Freight transport | **5.1** | 34% | 3% | 2% |
| Bio diesel vehicle | 1.1 | | | |
| Modal shift | 4.0 | | | |
| Total | **15.0** | 100% | 8% | 7% |

# Action E3: Energy Saving Behavior

The action "Energy Saving Behavior" is projected to reduce 16.9 $MtCO_2eq$ or 9% of total GHG emission reduction in energy sector. Energy saving activities focus on energy services such as cooling, heating, hot water, cooking in commercial and residential sectors, direct heating, steam and motor in industrial sector.

Understanding the importance of energy efficiency in socio-economic development and environmental protection, Vietnam has developed a national program to enhance effective use of energy with emphasize on both, supply and demand sides. Based on the program, we assumed energy service demand reduction ration in residential sector is 17% and those in both commercial and industrial sectors are 20%.

Energy savings in industrial sector is expected to contribute to the highest amount of GHG reduction, accounts for 11.0 $MtCO_2eq$. It is followed by residential and commercial sectors with respectively amount of GHG reductions are 4.3 and 1.7 $MtCO_2eq$.

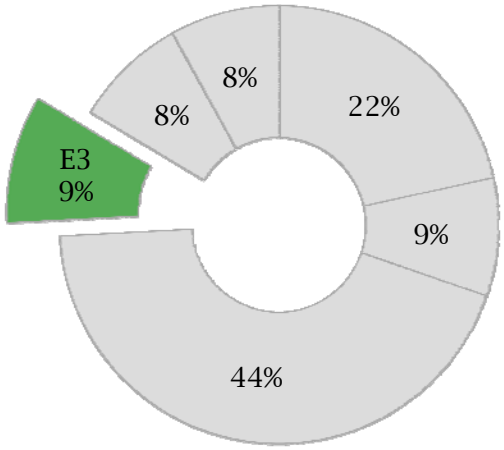


Figure 46. Mitigation potential of Action E3

Table 14. Breakdown of emission reduction in action E3

| | GHG emission reduction [$MtCO_2eq$] | Contribution in the Action [%] | Contribution in total reduction in energy sector [%] | Contribution in total reduction in Vietnam [%] |
|---|---|---|---|---|
| Residential | **4.3** | 26% | 2% | 2% |
| Cooling | 0.1 | | | |
| Heating | 0.1 | | | |
| Hot water | 0.5 | | | |
| Cooking | 3.0 | | | |
| Lighting | 0.2 | | | |
| Refrigerator | 0.2 | | | |
| Other equipment | 0.2 | | | |
| Commercial | **1.7** | 10% | 1% | 1% |
| Cooling | 0.1 | | | |
| Heating | 0.6 | | | |
| Hot water | 0.6 | | | |
| Cooking | 0.1 | | | |
| Lighting | 0.2 | | | |
| Refrigerator | 0.1 | | | |
| Other equipment | 0.1 | | | |
| Industry | **10.9** | | 6% | 5% |
| Furnace | 3.2 | | | |
| Boiler | 3.9 | | | |
| Motor | 2.3 | | | |
| Other | 1.6 | | | |
| Total | **16.9** | 36% | 9% | 8% |

# Action E4: Energy Efficiency Improvement

The "Energy Efficiency Improvement" action is able to reduce GHG emissions in 2030 by 78.8 $MtCO_2eq$ or 44% of total GHG emission reductions in energy sector. The highest amount of GHG emission reduction accounts for transport sector by 37.3 $MtCO_2eq$. It is followed by industry, residential and commercial sectors with respectively amount of GHG reductions are 23.5, 12.8 and 5.2 $MtCO_2eq$.

This action is used to turn the existing or inefficient motors or vehicles into "best available technology" models in all sectors.

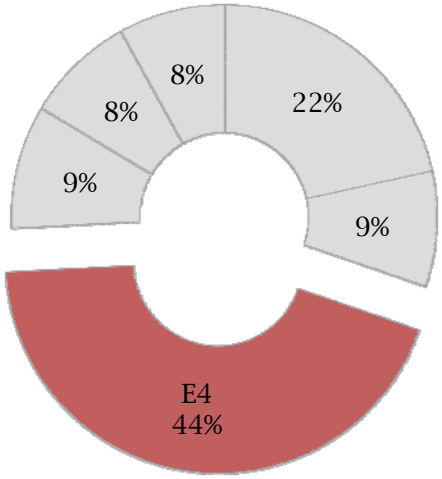


Figure 47. Mitigation potential of Action E4

Table 15 . Breakdown of emission reduction in action E4

| | GHG emission reduction [$MtCO_2eq$] | Contribution in the Action [%] | Contribution in total reduction in energy sector [%] | Contribution in total reduction in Vietnam [%] |
|---|---|---|---|---|
| Residential | **12.8** | 16% | 7% | 6% |
| Cooling | 1.5 | | | |
| Heating | 0.1 | | | |
| Hot water | 0.9 | | | |
| Cooking | 5.9 | | | |
| Lighting | 2.3 | | | |
| Refrigerator | 0.9 | | | |
| Other equipment | 1.2 | | | |
| Commercial | **5.2** | 7% | 3% | 2% |
| Cooling | 0.8 | | | |
| Heating | 1.0 | | | |
| Hot water | 0.8 | | | |
| Cooking | 0.3 | | | |
| Lighting | 1.1 | | | |
| Refrigerator | 0.6 | | | |
| Other equipment | 0.6 | | | |
| Industry | **23.5** | 30% | 13% | 11% |
| Furnace | 14.9 | | | |
| Boiler | 4.8 | | | |
| Motor | 1.0 | | | |
| Other | 2.9 | | | |
| Passenger transport | **13.4** | 17% | 7% | 6% |
| Motorbike | 4.0 | | | |
| Car | 3.4 | | | |
| Bus | 3.8 | | | |
| Train | 0.0 | | | |
| Ship | 0.0 | | | |
| Aviation | 2.2 | | | |
| Freight transport | **23.9** | 30% | 13% | 11% |
| Truck | 23.7 | | | |
| Train | 0.0 | | | |
| Ship | 0.2 | | | |
| Aviation | 0.0 | | | |
| Total | **78.8** | 100% | 44% | 36% |

# Action E5: Fuel Shift in Industry

The action "Fuel Shift in Industry" is projected to reduce GHG emission in 2030 by 15.7 $MtCO_2eq$ or 9% of total GHG emission in energy sector.

Fuel uses in industry sector will be able to shift from high carbon intensity to lower carbon intensive. For instance, fuel switch from coal and oil to natural gas.

To promote mitigation measures of industry sector, incentive to investment in fuel switch is essentially important. Policies for this sector should be focus on tax, subsidy and low interest loans.

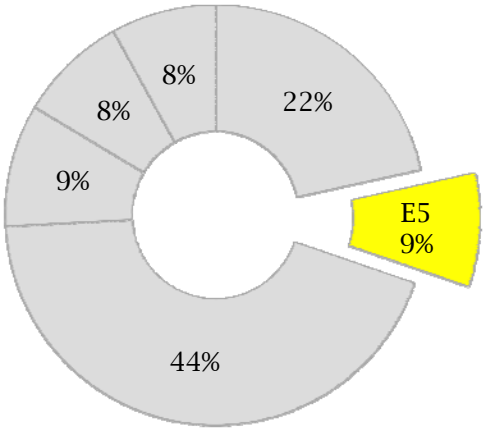


Figure 48. Mitigation potential of Action E5

# Action E6: Smart Power Plants

The action "Smart Power Plants" is projected to reduce GHG emission in 2030 by 26.6 $MtCO_2eq$ or 16% of total GHG emission reduction in energy sector. This action comprises of 4 main countermeasures; utilizing economically efficient domestic energy resources, promoting the use of renewable energies, reducing transmission and distribution loss, and developing nuclear power plant.

The share of high carbon intensity fuel decreased and replaced by lower carbon intensity fuel and renewable energies such as solar & wind and biomass.

The transmission and distribution loss in 2005 was 11.3% and this number is expected to reduce to 9% in 2030BaU scenario and 7% in 2030CM scenario.

Share of nuclear is projected to contribute 10% to generate power in 2030CM scenario.

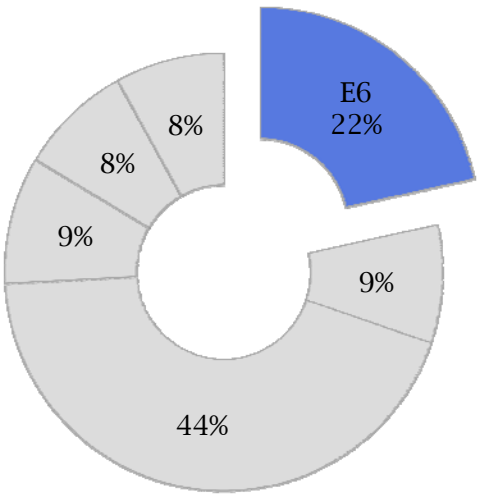


Figure 49. Mitigation potential of Action E6

# Methodology

## A procedure to create LCS scenarios

In order to create a local low-carbon society scenario, We developed a method based on the idea of "back casting", which sets a desirable goal first, and then seek the way to achieve it. Figure 50 shows overview of the method.

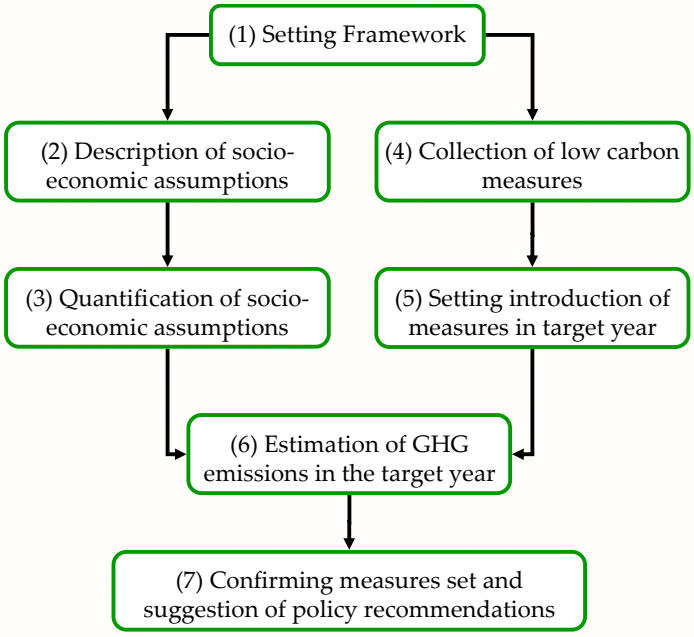


Figure 50. Procedure to create LCS scenarios

**(1) Setting framework**

Framework of a LCS scenario includes; target area, base year, target year, environmental target, number of scenarios. Among them, the base year is compared with target year. The target year should be far enough to realize required change, and near enough to image the vision for the people in the region. In this study, we set the target year of Vietnam, 2030. This is also a suitable time span for a LCS study for the reasons above. As an environmental target, we targeted $CO_2$ from energy use because it will be a main source of GHG emissions from Vietnam in 2030.

**(2) Assumptions of socio-economic situations**

Before conducting quantitative estimation, qualitative future image should be written. It is an image of lifestyle, economy and industry, land use and so on.

**(3) Quantification of socio-economic assumptions**

To estimate Snapshot based on future image of (2), values of exogenous variables and parameters are set. Using those input, ExSS calculates socio-economic indices of the target year such as population, GDP, output by industry, transport demand, and so on.

**(4) Collection of low-carbon measures**

To collect counter measures which are thought to be available in the target year. For example, high energy-efficiency devices, transport structure change such as public transport, use of renewable energy, energy saving behavior and carbon sink. Technical data is required to estimate their effect to reduce GHG emissions. In this research we employed the measure showed in preceding study and national on-going policies.

**(5) Setting introduction of counter measures**

Technological parameters related to energy demand and $CO_2$ emissions, in short energy efficiency, are defined. Since there can be various portfolios of the measures, one must choose appropriate criteria. For example, cost minimization, acceptance to the stakeholders, or probability of technological development.

**(6) Estimation of GHG emission in the target year**

Based on socio-economic indices and assumption of measures' introduction, GHG emissions are calculated.

**(7) Proposal of policies**

Propose policy set to introduce the measures defined. Available policies depend on the situation of the country. ExSS can calculate emission reduction of each counter measure.

Therefore, it can show reduction potential of measures which especially needs local policy. It can also identify measures which have high reduction potential and therefore important.

# Extended Snapshot Tool (ExSS)

Figure 51 shows the structure of the Extended Snapshot Tool (ExSS); seven blocks with input parameters, exogenous variables and variables between modules. ExSS is a system of simultaneous equations. Given a set of exogenous variables and parameters, solution is uniquely defined. In this simulation model, only $CO_2$ emission from energy consumption is calculated, even though, ESS can be used to estimate other GHG and environmental loads such as air quality. In many LCS scenarios, exogenously fixed population data are used. However, people migrate more easily, when the target region is relatively a smaller area such as a state, district, city or town. Population is decided by demand from outside of the region, labor participation ratio, demographic composition and relationship of commuting with outside of the region. To determine output of industries, input-output approach is applied.

For future estimation, assumption of export value is especially important if the target region is thought to (or, desired to) develop led by particular industry, such as automotive manufacturing or sight seeing.

Passenger transport demand is estimated from the population and freight transport demand whereby it is a function of output by manufacturing industries. Floor area of commerce is determined from output of tertiary industries. Other than driving force, activity level of each sector, energy demand by fuels determined with three parameters. One is energy service demand per driving force, energy efficiency and fuel share. Diffusion of counter measures changes the value of these parameters, and so GHG emissions.

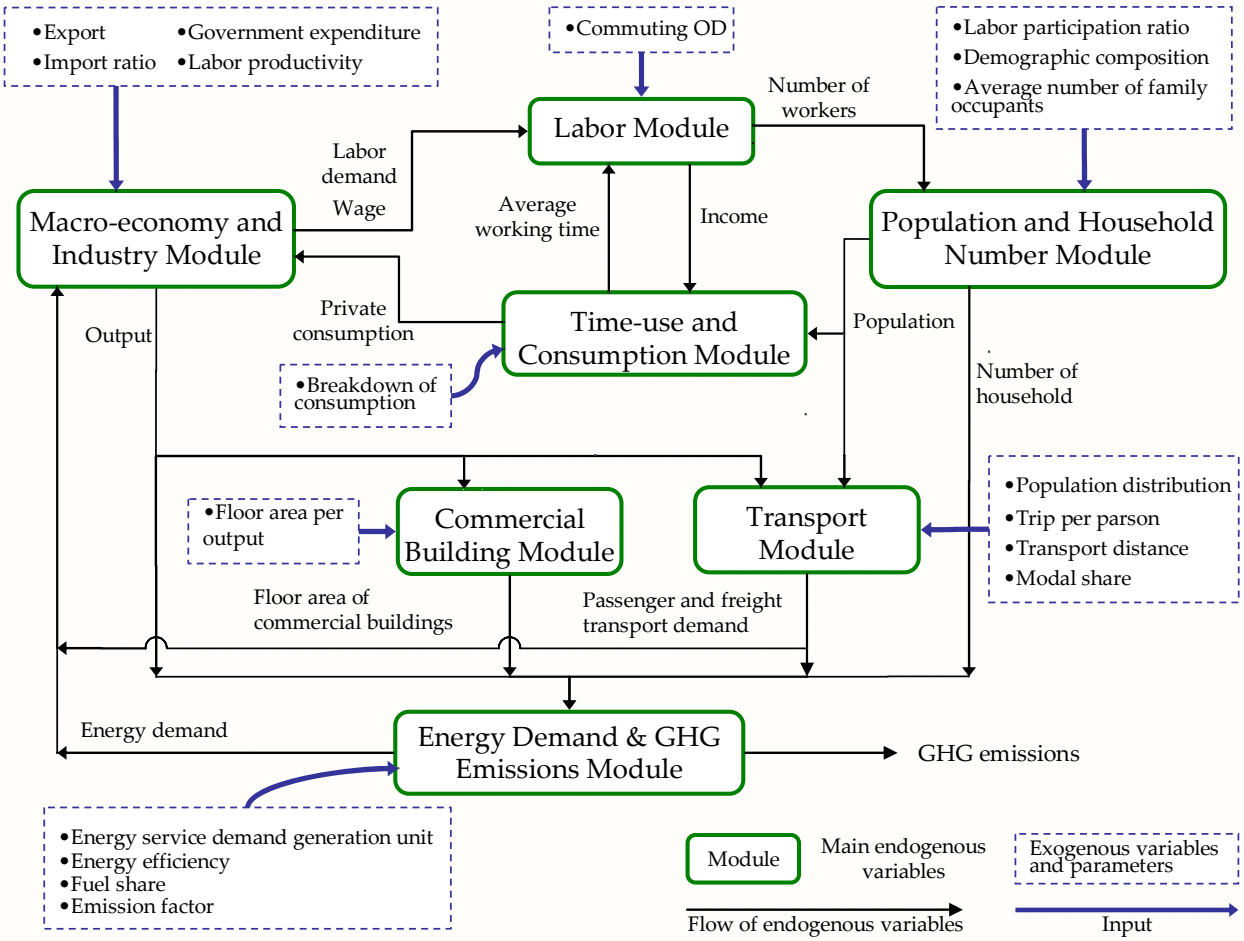


Figure 51. Overview of calculation system of Extended Snapshot Tool

# Agriculture, Forestry and Other Land-use Bottom up (AFOLUB) model

AFOLU Bottom-up model (AFOLUB) is a bottom-up type model to estimate GHG emissions and mitigation potential in AFOLU sectors at country or regional level, dealing with quantified mitigation countermeasures. The emissions and mitigation potential are calculated using a function of Allowable Abatement Costs (AAC), which are representative parameters representing willingness of GHG reduction under several constraints for mitigation costs and mitigation potential. Moreover, the calculation is also based on future assumptions of crops harvested areas, numbers of livestock animal and area of land use change. The model illustrates selection of production countermeasures of the agricultural commodities and mitigation countermeasures by producers (i.e. farmers) based on economic rationality. Mitigation potential is estimated as a result of cost minimization choice of GHG mitigation countermeasures. In the AFOLUB, it is considered that the selection depends not only on cost and mitigation potential but also dependent relation between countermeasures.

The AFOLUB consists of two modules: AGriculture Bottom-up module (AG/Bottom-up) and LULUCF Bottom-up module (LULUCF/Bottom-up).

The AG/Bottom-up calculates GHG emissions and mitigation potential in agricultural production; and energy consumption of agricultural machines; and combination of production and mitigation countermeasures under several AACs.

The LULUCF/Bottom-up calculates GHG emissions from carbon stock change in biomass and soils on the land and those from fire, natural disturbance and peat lands and mitigations by specific countermeasures. The module does not take into account emission from wood harvesting. It is assumed that wood harvesting is not too a large factor to make great impacts on change in land use and change in emission and sink coefficients. The module calculates GHG emission and sink caused by historical land use change. The implementation degree of the countermeasures is calculated based on schemes assumed for mitigation countermeasure selection. The schemes can be set as conditions of allowable minimum mitigation potential or total maximum cost in a certain countermeasure application period.

As shown in Figure 52, the data set input in AFOLUB includes: i) list of countermeasures; ii) characteristics of the countermeasure such as cost, reduction effect, life time, diffusion ratio, energy consumption and recovery; iii) scenarios of crop production, number of livestock animals and area of land use and land-use change; iv) scenarios of fertilizer input, price of commodity and energy, and production technologies; and vi) future assumption on policy such as AAC for GHG mitigation, energy tax rate, subsidy and so on.

Table 16 shows emission sources treated in the AFOLUB model. Emission/sink sources taken into account in the study are enteric fermentation (3A1) and manure management (3A2) of livestock, LULUCF (3B), managed soils (3C4 to 3C6) and rice cultivation (3C7). Target GHG in the study are carbon dioxide ($CO_2$), methane ($CH_4$) and nitrous oxide ($N_2O$). LULUCF sector is considered as a source of both emission and sink of carbon.

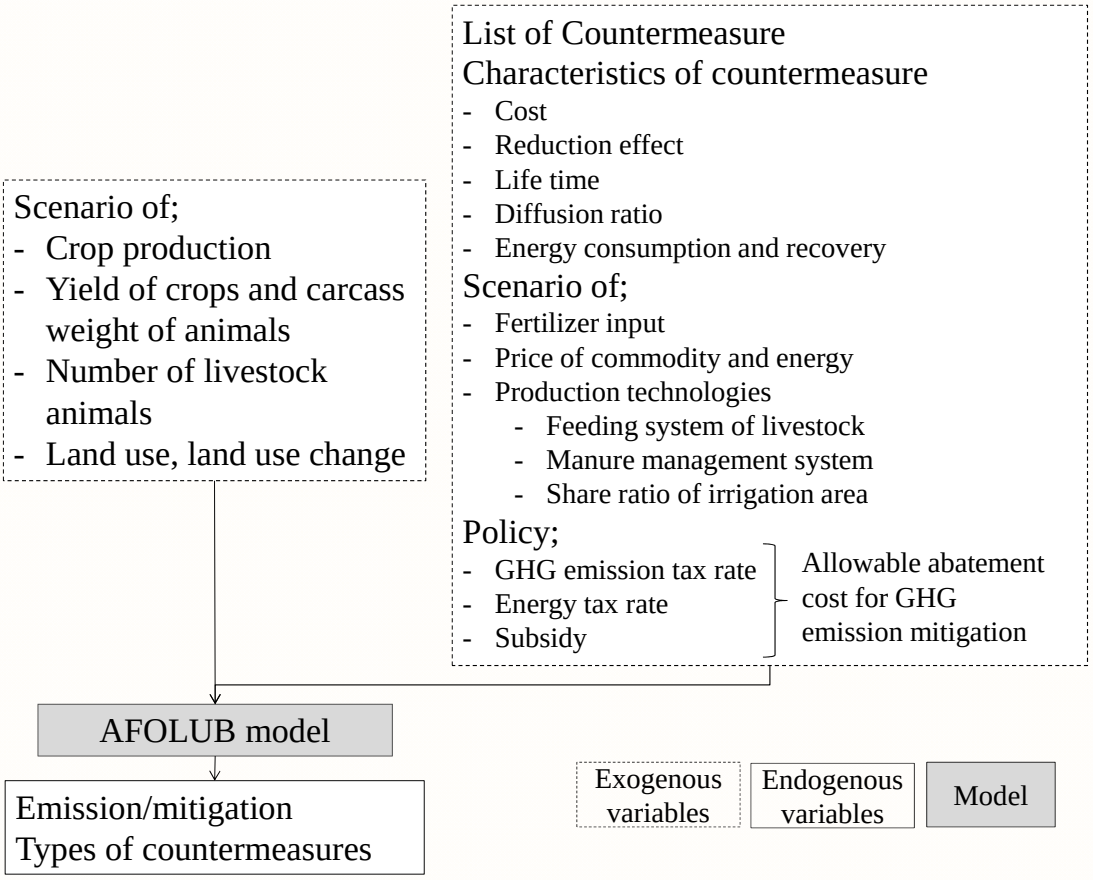


Figure 52. Input and output of AFOLU emission model

Table 16. Emission sources and target GHG in AFOLU model

| Emission sources | Classification | Gases | IPCC category[1] |
|---|---|---|---|
| Enteric fermentation | Dairy cattle, Other cattle, Buffalo, Sheep, Goats, Camels, Horses, Mules, Asses, Swine | $CH_4$ | 3A1 |
| Manure management | Dairy cattle, Other cattle, Buffalo, Sheep, Goats, Camels, Horses, Mules, Asses, Swine, Chickens, Ducks, Turkeys | $CH_4$, $N_2O$ | 3A2 |
| Aggregate Sources and Non-$CO_2$ Emissions Sources on Land | Emissions from Biomass Burning[2] | $CO_2$, $CH_4$, $N_2O$ | 3C1 |
| | Liming[2] | $CO_2$ | 3C2 |
| | Urea Application[2] | $CO_2$ | 3C3 |
| | Direct $N_2O$ emission from Managed soils | $N_2O$ | 3C4 |
| | Indirect $N_2O$ emission from Managed soils | $N_2O$ | 3C5 |
| | Indirect $N_2O$ Emissions from Manure Management | $N_2O$ | 3C6 |
| Rice cultivations | | $CH_4$ | 3C7 |

Note: 1] Emission categories of IPCC(2006), 2] Gray part is not estimated in this study.

# Data Tables

Table A1. Base year information

| Name | Value in 2005 | Unit | Source |
|---|---|---|---|
| Population by age and sex | | person | Population Division - United Nations Population low variant, 2030 for Vietnam |
| Male | | | http://esa.un.org/unpp/p2k0data.asp |
| 0-14 | 12,437,523 | | General Statistic Office of Vietnam (2008) |
| 15-64 | 26,337,179 | | |
| 65+ | 2,101,755 | | |
| Female | | | |
| 0-14 | 11,822,616 | | |
| 15-64 | 27,406,839 | | |
| 65+ | 3,000,388 | | |
| Number of households | 20,020,187 | household | Vietnam Population and Housing Census (2009) |
| Output by industry | | trillion VND | Input-output table 2005 (Trinh Bui, 2009) |
| Agriculture-Fishery-Forestry | 261 | | |
| Mining and quarrying | 143 | | |
| Food, beverage & tobaco manufactures | 259 | | |
| Other consumer goods | 285 | | |
| Industrial materials | 182 | | |
| Capital goods | 127 | | |
| Construction | 179 | | |
| Electric, gas, water, transport, telecommunication, finacial, insurance, private and government services | 497 | | |
| Passenger transport generation per person per day | 2 | trip/capita/day | Assumption |
| Passenger transport generation in 2005 | 60,668 | mil.trips/year | |
| Modal share | | % | |
| Train | 0.04 | | Walter and Michael, 1995 |
| Bus | 0.33 | | Schipper et. al, 2008 |
| Car | 0.2 | | JICA/MoT, 2009 |
| Ship | 0.47 | | General Statistic Office of Vietnam (2009) |
| Motorbike | 2.95 | | |
| Walk & bicycle | 96 | | |
| Domestic aviation | 0.01 | | |
| Average trip distance | | km/trip | |
| Train | 356 | | Schipper et. al, 2008 |
| Bus | 181 | | JICA/MoT, 2009 |
| Ship | 22 | | General Statistic Office of Vietnam (2009) |
| Motorbike | 6 | | |
| Walk | 1 | | |
| Bike | 3 | | |
| Car | 92 | | |
| Domestic aviation | 811 | | |
| Passenger transport demand | | mil p-km | |
| Train | 8418 | | |
| Bus | 36681 | | |
| Ship | 6220 | | |
| Motorbike | 10451 | | |
| Walk & bicycle | 145602 | | |
| Car | 11230 | | |
| Domestic aviation | 5378 | | |
| Frieght transport generation per output | 0.29 | t-output/day | Calculated by total freight transport volume and output of industry |
| Modal share | | % | Calculated by freight transport volume by type of transport |
| Railways | 2.1 | | |
| Road | 71.3 | | |
| Inland waterway | 26.6 | | |
| Domestic aviation | 0 | | |
| Average trip distance | | km/trip | Estimated by freight transport volume, modal share, freight transport generation per output per day, and population |
| Railways | 336 | | |
| Road | 60 | | |
| Inland waterway | 162 | | |
| Domestic aviation | 2156 | | |
| Frieght transport volume | | mil-t/km | General Statistic Office of Vietnam (2008) |
| Railways | 2949 | | |
| Road | 17668 | | |
| Inland waterway | 17999 | | |
| Domestic aviation | 239 | | |

Table A2. Input-output table of Vietnam in 2005 (Unit: Trillion VND)

| No. | Description | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | **Total intermediate consumption** | Consumption | Fixed capital formation | Export | Import | **Total gross output** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | Agriculture-Fishery-Forestry | 30 | 0 | 112 | 11 | 1 | 0 | 0 | 4 | **159** | 83 | 4 | 32 | -17 | **261** |
| 02 | Mining and quarrying | 0 | 3 | 3 | 1 | 10 | 0 | 5 | 3 | **26** | 1 | 0 | 127 | -11 | **143** |
| 03 | Food, beverage & tobaco manufactures | 9 | 0 | 44 | 0 | 0 | 0 | 0 | 9 | **62** | 143 | 13 | 72 | -30 | **259** |
| 04 | Other consumer goods | 3 | 1 | 10 | 160 | 7 | 5 | 8 | 16 | **209** | 35 | -4 | 160 | -115 | **285** |
| 05 | Industrial materials | 29 | 9 | 15 | 38 | 97 | 28 | 78 | 53 | **348** | 37 | 36 | 42 | -282 | **182** |
| 06 | Capital goods | 3 | 5 | 3 | 4 | 5 | 58 | 26 | 37 | **141** | 33 | 41 | 48 | -135 | **127** |
| 07 | Construction | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **0** | 0 | 179 | 0 | 0 | **179** |
| 08 | Private & government services and others | 11 | 24 | 12 | 20 | 16 | 7 | 9 | 71 | **170** | 263 | 37 | 81 | -54 | **497** |
| | **Total intermediate input** | **85** | **42** | **200** | **235** | **137** | **99** | **126** | **193** | **1115** | **594** | **307** | **562** | **-644** | **1934** |
| | Gross value added | 176 | 101 | 59 | 50 | 45 | 29 | 53 | 304 | **818** | | | | | |
| | **Total gross output** | **261** | **143** | **259** | **285** | **182** | **127** | **179** | **497** | **1934** | | | | | |

Table A3. Input-output table of Vietnam in 2030 (Unit: Trillion VND)

| No. | Description | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | **Total intermediate consumption** | Consumption | Fixed capital formation | Export | Import | **Total gross output** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | Agriculture-Fishery-Forestry | 119 | 1 | 526 | 73 | 6 | 0 | 1 | 19 | **745** | 10 | 10 | 156 | -150 | **281** |
| 02 | Mining and quarrying | 0 | 15 | 14 | 9 | 49 | 1 | 25 | 13 | **126** | 1 | 1 | 615 | -89 | **532** |
| 03 | Food, beverage & tobaco manufactures | 34 | 0 | 204 | 2 | 2 | 0 | 1 | 46 | **289** | 31 | 31 | 346 | -105 | **924** |
| 04 | Other consumer goods | 10 | 3 | 49 | 1074 | 32 | 25 | 37 | 82 | **1313** | -9 | -9 | 771 | -328 | **595** |
| 05 | Industrial materials | 115 | 43 | 69 | 256 | 475 | 137 | 375 | 275 | **1745** | 87 | 87 | 204 | -1377 | **-857** |
| 06 | Capital goods | 11 | 23 | 16 | 24 | 25 | 284 | 124 | 194 | **701** | 98 | 98 | 230 | -664 | **-79** |
| 07 | Construction | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **0** | 433 | 433 | 0 | 0 | **866** |
| 08 | Private & government services and others | 43 | 108 | 57 | 134 | 78 | 33 | 46 | 368 | **868** | 132 | 89 | 389 | -378 | **1702** |
| | **Total intermediate input** | **333** | **193** | **935** | **1573** | **667** | **482** | **609** | **997** | **5787** | **783** | **741** | **2713** | **-3092** | **3963** |
| | Gross value added | 693 | 466 | 278 | 335 | 221 | 140 | 257 | 1573 | **3963** | | | | | |
| | **Total gross output** | **1026** | **27** | **75** | **69** | **29** | **16** | **33** | **174** | **9750** | | | | | |

## Table A4. $CO_2$ reduction by sectors/countermeasures in energy sector

| Sector | Low-carbon countermeasure | Identified implementation intensity (%) | | Emission reduction ($MtCO_2$) | |
|---|---|---|---|---|---|
| Residential sector | Energy efficiency home appliances | | | | |
| | 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 | | |
| | 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 | |
| | 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 | | |
| | Solar water heating | Diffusion ratio | 10 | | |
| | Energy efficiency improvement of electric appliances | Diffusion ratio | 60 | 1.2 | |
| | Energy saving behavior | | | 4.3 | |
| | 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 | | |
| | Cooking (Energy service demand reduction ratio 17%) | Diffusion ratio | 100 | | |
| | Other home electric appliances | Diffusion ratio | 100 | | |
| | Other fuel shifting | | | 11.3 | |
| | **Total** | | | | **28.5** |
| Commercial sector | High energy efficiency air condition | Diffusion ratio | 70 | 1.2 | |
| | 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 | |
| | 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 | |
| | 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 | | |
| | 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 | |
| | High energy efficiency boiler | | 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 | |
| | Modal shift | | | 9.6 | |
| | From vehicle to train | Share of train = 0.1% (base year = 0.04%) | | | |
| | 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 | |
| | 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% (base year = 2%) | | | |
| | From large vehicle to ship/boat/ferry | Share of ship = 30% (base year = 27%) | | | |
| | **Total** | | | | **29.0** |
| Power generation sector | Improvement of $CO_2$ intensity of power generation | | | | **38.7** |
| | Generation efficiency improvement | | | | |
| | Coal | Generation efficiency = 45% (base year = 36%) | | | |
| | Oil | Generation efficiency = 38% (base year = 31%) | | | |
| | Gas | Generation efficiency = 42% (base year = 37%) | | | |
| | Transmission lost reduction | Transmission lost = 7% (base year = 11%) | | | |
| | Fuel shifting | | | | |
| | From fossil fuel to nuclear | | | | |
| | From fossil fuel to renewable energy | | | | |
| **Total** | | | | | **179.5** |

Table A5. Final energy demand by sector by fuel in Vietnam

Unit: ktoe

| | Coal | Oil | Gas | Solar&wind | Biomass | Electricity | Total |
|---|---|---|---|---|---|---|---|
| **2005** | | | | | | | |
| Residential | 861 | 726 | - | - | 23,129 | 1,674 | 26,390 |
| Commercial | 333 | 958 | - | - | - | 338 | 1,629 |
| Industry | 4,799 | 2,971 | 100 | - | - | 1,919 | 9,789 |
| Passenger Transport | - | 3,074 | - | - | - | 33 | 3,108 |
| Freight Transport | - | 3,535 | - | - | - | 2 | 3,537 |
| Total | **5,993** | **11,265** | **100** | **-** | **23,129** | **3,966** | **44,453** |
| Share | **13%** | **25%** | **0%** | **0%** | **52%** | **9%** | **100%** |
| **2030BaU** | | | | | | | |
| Residential | 2,618 | 9,169 | - | - | 21,764 | 12,655 | 46,207 |
| Commercial | 2,508 | 3,674 | - | - | - | 3,554 | 9,736 |
| Industry | 22,443 | 14,143 | 6,111 | - | - | 19,658 | 62,355 |
| Passenger Transport | - | 14,190 | - | - | - | 239 | 14,429 |
| Freight Transport | - | 20,954 | - | - | - | 101 | 21,055 |
| Total | **27,569** | **62,131** | **6,111** | **-** | **21,764** | **36,207** | **153,782** |
| Share | **18%** | **40%** | **4%** | **0%** | **14%** | **24%** | **100%** |
| **2030CM** | | | | | | | |
| Residential | 1,700 | 6,693 | - | 2,998 | 18,492 | 9,224 | 39,107 |
| Commercial | 1,890 | 3,239 | - | 627 | - | 2,343 | 8,099 |
| Industry | 15,341 | 12,991 | 6,562 | - | 2,283 | 15,814 | 52,991 |
| Passenger Transport | - | 7,027 | - | - | 75 | 165 | 7,267 |
| Freight Transport | - | 11,668 | - | - | 317 | 148 | 12,132 |
| Total | **18,930** | **41,618** | **6,562** | **3,625** | **21,166** | **27,694** | **119,596** |
| Share | **16%** | **35%** | **5%** | **3%** | **18%** | **23%** | **100%** |

Table A6. Primary energy demand by fuel in Vietnam

Unit: ktoe

| | Coal | Oil | Gas | Hydro power | Nuclear | Solar wind | Biomass | Total |
|---|---|---|---|---|---|---|---|---|
| **Energy demand** | | | | | | | | |
| 2005 | 8,125 | 11,943 | 4,912 | 1,845 | 0 | 0 | 23,129 | 49,954 |
| 2030BaU | 63,185 | 73,433 | 27,070 | 11,230 | 1,604 | 1,203 | 23,796 | 201,522 |
| 2030CM | 43,901 | 46,595 | 22,809 | 8,442 | 3,247 | 5,549 | 17,440 | 147,984 |
| 2030BaU/2005 | 7.8 | 6.1 | 5.5 | 6.1 | - | - | 1.0 | 4.0 |
| 2030CM/2005 | 5.4 | 3.9 | 4.6 | 4.6 | - | - | 0.8 | 3.0 |
| 2030CM/2030BaU | 0.7 | 0.6 | 0.8 | 0.8 | 2.0 | 4.6 | 0.7 | 0.7 |
| **Percentage distribution** | | | | | | | | |
| 2005 | 16% | 24% | 10% | 4% | 0% | 0% | 46% | 100% |
| 2030BaU | 31% | 36% | 13% | 6% | 1% | 1% | 12% | 100% |
| 2030CM | 30% | 31% | 15% | 6% | 2% | 4% | 12% | 100% |

# Appendixes

Appendix 1. Vietnam's environmental policy on climate change

| No | National program, policiy and law | Main ojectives |
|---|---|---|
| 1 | *National Climate Change Strategy (NCCS, 2011); Decision number 2139/QD-TTg dated 05 December 2011* | (1) Ensure food security, energy security, water security, and so on in the context of climate change;<br>(2) Consider low-carbon economy and green growth as principles in achieving sustainable development; GHG emission reduction and removal to become a mandatory index in social and economic development.<br>(3) Take advantage of climate change opportunities for social and economic development; promote climate-friendly behaviours.<br>(4) Join forces with international communities in addressing climate change; increase international cooperation to address climate change effectively. |
| 2 | *National Target Program to Respond to Climate Change (NTP-RCC); Decision number 158/2008/QD-TTg dated on December 2008* | This program comprehensively addresses climate change effects, impacts and adaptation responding to sea level rise and GHG emission mitigation<br>(1) To assess climate change impacts on sectors and regions in specific periods;<br>(2) To develop feasible actions plans to effectively respond to climate change in the short-term and long-term to ensure sustainable development of Vietnam;<br>(3) To take opportunities to develop towards a low-carbon economy;<br>(4) To join the international community's effort in mitigating climate change and protecting the climatic system |
| 3 | *Vietnam Agenda 21 policies; Decision number 153/2004/QD-TTg dated August 17th 2004* | To strengthening the legal basis for environmental protection, supporting research and development into, and transfer of, environmentally friendly technologies, and stipulating Vietnam's active participation in international activities related to the 1992 UNFCCC. |
| 4 | *Law on Environmental Protection; Decision number 52/2005/QH11 dated November 29th 2005* | This Law provides for activities of environmental protection; policies, measures and resources for environmental protection; rights and obligations of organizations, households and individuals in environmental protection |
| 5 | *Clean Development Mechanism (CDM)* | Kyoto Protocol regulates the creation and trading of emission reduction credits. Currently, there have been 78 CDM projects have been approved by CDM Executive Board in Vietnam up to now. (December 2011) |

- Ministry of Natural Resources and Environment (MoNRE) was assigned as a National Focal Agency for participating and implementing UNFCCC and Kyoto Protocol.
- Department of Meteorology Hydrology and Climate Change (DMHCC), which belongs to MoNRE, is the Designed National Authority for CDM in Vietnam.

Appendix 2. Concrete targets of each Energy National Policies and Strategies in Vietnam

| No | Energy Policy and Strategies | | Concrete targets |
|---|---|---|---|
| 1 | *National Energy Development Strategy in the period up to 2020, perspective up to 2050. (NEDS, 2007); Decision number 1855/2007/QD-TTg dated December 27th 2007* | Energy conservation and energy efficiency | Energy elasticity: from 1.46 at present to 1.0 (2015) and 0.8 (after 2020)<br>Energy consumption: saving 3% to 5% during 2006-2010 and 5% to 8% during 2011-2015 |
| | | Primary energy supply | 47.5 to 49.5 Mtoe (2010)<br>100 to 110 Mtoe (2020)<br>110 to 120 Mtoe (2025) |
| | | Renewable energy | Share of household using renewable energy in cooking 50% (2010), 80% (2020) |
| | | Energy trade | Connect regional power grid (2010-2015)<br>Connect gas pipeline network (2015-2020)<br>Capacity of refinery: 25-30 million tonnes crude oil (2020) |
| 2 | *National Power Development Plan for period 2011-2020 with perspective up to 2030. (PDP VII); Decision number 1208/QD-TTg dated July 21st 2011* | Power supply plan | Electricity demand growth rate: 14% per annum (2011-2015); 11% (2016-2020).<br>Electrical production 695-834 billion kWh (2030)<br>Electrical generation from small hydro and renewable energy will be 3,100MW (2020) and 4800MW (2030)<br>Electrical generational from wind power 1000MW (2020) and 6200MW (2030); from biomass 500MW (2020) and 2000MW (2030)<br>Tranmission lost complies to N1- criterion<br>Enrgy elasticity ratio from 2.0 (current) to 1.5 (2015) and 1.0 (2020) |
| 3 | *Master Plan for Coal Development up to 2015, and orientation up to 2025. (MPCD); Decision number 89/2008/QD-TTg dated July* | Coal explration<br>Coal production and processing | Coal reserves in 300m-1000m in depth<br>61-65 million tonnes (2020-2025)<br>Coal demand growth rate 11.2% per annum (2005-2025) |
| 4 | *Master Plan on Vietnam Oil and Gas Sector Development up to 2015, a vision towards 2025.(MPOG); Decision number 233/QD-TTg dated February 18th 2009.* | Oil & gas exploration | Reserve 30-50 million cubic meter a year<br>Reserve in 400m water depth |
| | | Oil & gas supply | 25-30 million tonnes (2006-2010)<br>60-65 million tonnes (2011-2015)<br>30-35 million tonnes (after 2016)<br>Domestic refineries will satisfy petroleum product demands by 2014<br>Oil demand will grow by 8.3% per annum (2005-2025); reaching 19.5 million tonnes in 2025<br>Gas demand will grow by 8.1% per annum (2005-2025); reaching 18.9 billion cubic meters in 2025 |
| 5 | *Master Plan for Renewable Energy Development for the period up to 2015, with outlook to 2025. (MPRE); Instiute of Energy Vietnam (2008)* | Renewable energy sources | Small hydro (2500 MW); solar (3.25MW); wind (500 MW); biomass (400MW); geothermail (240 MW) |
| | | Renewable energy share in primary energy and power generation | (2050)<br>In power generation: 0.6% at present to 3.5% (2010), 4.5% (2020) and 6% (2030) |
| 6 | *Bio-energy development for the period up to 2015, outlook to 2025.(BIED); Decision number 177/2007/QD-TTg dated November 20th 2007.* | Using bio-energy, meeting 0.4% (2010), 1% (2015) and 5% (2025) of oil and gasoline demand in country | |
| 7 | *Master Plan on Nuclear Power Development up to 2030. (MPNP); Decision number 906/QD-TTg dated June 17th 2010* | First nuclear power plant wii be built in 2015 and operate in 2020<br>In 2025: total capacity of nuclear power plant will be 8000 MW (7% of total power generation)<br>In 2030: total capacity of nuclear power plant will be 15000 MW (10% of total power | |
| 8 | *Law on Energy Efficiency and Conservation No. 50/2010/QH12* | The Law includes policies and measures to promote energy efficiency and conservation (EE&C); prescribing EE&C; and the rights, obligations and responsibilities of organizations, households and individuals in EE&C. Subjects of application are focus on organizations, households and individuals using energy in | |

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# A LOW CARBON SOCIETY DEVELOPMENT TOWARDS 2030 IN VIETNAM


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