

# Develop a Scenario for Da Nang as a Low Carbon City

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**Abstract**—The Vietnam Intended Nationally Determined Contributions (INDC) sets the target to reduce 8-25% of total emissions in 2030 compared to Business as Usual (2030BaU). Therefore, the study of developing a Low Carbon City (LCC) for Da Nang aims to respond the national target. Two scenarios are developed for the socio-economic vision of Da Nang by 2030, with the projection of energy consumption and carbon dioxide (CO<sub>2</sub>) emission in energy-related categories such as Residential, Commercial, Transportation, and Industry. The study shows that with proposal of five actions including 32 projects, Da Nang can reduce 19% total CO<sub>2</sub> emission in countermeasure scenario (2030CM). This result is expected to be useful for researchers and policy-makers who are interested in developing the Climate Change Action Plan (CCAP) and to support the vision of building green growth for Da Nang city.

**Index Terms**—Low carbon city, INDC, Da Nang, Viet Nam

## I. INTRODUCTION

Recently, major cities in Vietnam are required to localize the initiatives of the Intended Nationally Determined Contributions (INDC) to the United Nations Framework Convention on Climate Change (UNFCCC). The aim of INDC is to reduce 8-25% of total emissions in 2030 compared to Business as Usual (BaU). In line with the target, the Vietnam Green Growth Strategy (Decision 1393/QĐ-TTĐ approved by the Vietnamese Prime Minister in September 2012) aims to ensure efficient and sustainable economic growth in Vietnam while making significant contributions towards implementing the national climate change strategy. Moreover, the National Target Program for Climate Change Response (Decision 158/QĐ-TTĐ approved by the Vietnamese Prime Minister in December 2008) requires local governments to develop Climate Change Action Plans (CCAP). The CCAP is necessary and should be integrated with the middle- and long-term master plan of socio-economic development, specific sectoral development plans (such as transportation, industry, power, agriculture, etc.) as well as water and waste management.

Two scenarios are developed for the socio-economic vision of Da Nang by 2030, with the projection of energy consumption and CO<sub>2</sub> emission in energy-related categories such as Residential, Commercial, Transportation, and Industry. They are 2030BaU (Business as Usual) and 2030CM (Countermeasures). The 2030BaU scenario, where countermeasures for greenhouse gas (GHG) emissions reduction are not introduced, reflects the situation in which both, the levels of commitments to climate-friendly-energy

production and technological breakthroughs are relatively low. Specially, countermeasures are assumed the same level as in 2013. On the other hand, the 2030CM scenario, which additional low carbon countermeasures are introduced in order to assess the reduction effects of GHG emissions. The socioeconomic assumptions about population, industrial structure, and economic growth are common to both scenarios. Information from many domestic sources is used to calibrate the parameters for base year 2013. In target year 2030, Extended Snapshot Tool (ExSS) is applied for the projection of future energy consumption and CO<sub>2</sub> emission in energy-related categories.

## II. METHODOLOGY

In order to identify the necessary actions, an “integrated modeling” based on “back-casting” approach is used. The back-casting approach sets a vision of the future society as a goal, and then seeks a pathway towards achieving that goal. We used ExSS (Extended Snapshot tool) for socio-economic indicators, energy related sectors. Information collection is the first step in the modeling work.

Socio-economic information as well as environmental information for the base year (2013) was collected and analyzed in order to estimate current carbon emissions. Besides this, feasible low carbon measures for Da Nang low carbon in the year 2030 were also collected.

For the future projection, information is based on planned developments, as the model estimates socio-economic activity levels including population, number of households, land area, transport demand and other variables. Based on the collected information, GHG emissions are calculated with or without countermeasures.

ExSS is a simplified simulation model for low carbon study and projects socio-economic activity, energy demand and supply, GHG emissions and emission reduction by measures. While each part of the tool is relatively simple, it can describe whole picture of future society as a LCC in a quantitative and consistent manner with a greater flexibility than many other models. It also can consider most of the low carbon measures existing and expected in near future. In this simulation model, 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. 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

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and fuel share. Diffusion of counter measures changes the value of these parameters, and so GHG emissions.

### III. RESULTS

#### A. Demography

Following the goal is to develop Da Nang into a major city for the economy and to make Da Nang the socio-economic center of central Vietnam. The estimation of social and economic growth is based on the Study on Integrated Development Strategy for Da Nang City and Its Neighboring Area in the Socialist Republic of Vietnam (DaCRISS) [1]. With assumption of population growth rate of 3%, Da Nang's population is projected to be more than 1.64 million people, which about 1.66 times increase on the base year's population 2013 [2]. Household size in 2030 is assumed by 3 persons/household (smaller than the calculated value for 2013, which is 3.4), the total number of households increases 1.9 times, reaching about 548 thousand households in 2030.

#### B. Economy

Da Nang has recorded remarkable changes in economic development. The economic structure of Da Nang city continues to shift towards the industries and services. According to the development targets in Da Nang's development master plan, it is estimated that the gross domestic product (GDP) in 2030 will increase 4.91 times compared to 2013. In 2013, the commercial sector dominates the GDP share with 64.4%, followed by industrial sector with 34.5%. In 2030, due to the increase of growth rate in commercial compared to agricultural sectors, the share of commercial in total GDP increase to 65.2%, while the share of industry decreases to 33.9%, with a small share of less than 1% of total GDP is from agriculture. This economic structure follows the current trend and future vision of Vietnam towards the tertiary industrial economy. The GDP per capita of Da Nang in 2013 is around 52 mil. Dongs, and increases 2.97 times by 2030. The GDP per capita in 2030 reaches 154 mil. Dongs due to the rapid GDP growth (9.7% per annual). In 2030, export and import in Da Nang expected to increase 4.83 and 4.75 times compared to those in 2013, respectively. Final consumption increases 4.83 times, in which main consumption is from households for industrial commodities and services while the government consumption is mainly for science, technology, and other services.

#### C. Transport Demand

The transport demand in 2030 increases dramatically from 8,642 to 12,426 million person per kilometer (mil.per.km) of passenger transport and 2,563 to 18,637 million ton per kilometer (mil.ton.km) of freight transport compared to 2013 due to the increasing population and industrial activities.

In passenger transport, there is a rapid increase of demand on car to 3.61 times, even motorbike still dominates. The share of public transport by trip increases from 0.6% in 2013 to 10.0% in 2030BaU and reaches 24.5% in 2030CM due to the contribution of public bus system.

Freight transport relies predominantly on roads and followed by waterway [3]. We assumed that the share of

waterway by trip will increase in freight transport modes in 2030, in which road is still dominates and contributes to 80%, followed by waterway with 20% contribution.

#### D. Final Energy Consumptions

Energy balance table in 2013 and 2030 for Da Nang was estimated based on information in the DaClimb report [4], Energy Balances of non-OECD 2014 FIG [5] and Nguyen [6].

The annual total final energy consumption of residential, commercial, industrial and transport sectors is expected to increase from 702 kilo tonnes oil equivalent (ktoe) in 2013 to 2,527 ktoe in 2030BaU scenario and 2,010 ktoe in 2030CM scenario.

The share of energy consumption by residential sector is projected to be reduced substantially from 11% in 2005 to 4.6% in 2030BaU and 2030CM scenarios, as a result of a reduction of the traditional biomass fuels for cooking. In transport sector, energy consumptions are accounting for 50.1% and 47.6% in 2030BaU and 2030CM scenarios, respectively.

The finding shows that the energy shares of industrial and commercial sectors are expected to increase in future, while the share of residential and transport sectors decrease. This is because of continued trends of industrialization and increasing travel demand per person.

The energy intensity by GDP reduces from 13.6 toe/bil. Dongs in 2013 to 10.6 toe/bil. Dongs in 2030BaU and 8.5 toe/bil. Dongs in 2030CM due to the lower increasing rate of energy consumption compared to the rapid growth of GDP. This reduction follows the target to reduce 1% to 1.5% per year as mentioned in Decision 1393/QD-TTg for "National Green Growth Strategy".

In 2030BaU, the total energy consumption is 1.73 times higher than 2013, increasing from 6,972 ktoe to 12,056 ktoe. In which, industry is still the main energy consumer with 59.4% (1.83 times increase), followed by transport sector with 20.4%. Commercial sector has the highest speed of energy consumption with 2.18 times increase and its share is 10.1%.

In term of energy consumption mix, there is a switch from coal and oil consumption to natural gas and electricity. However, coal and gas are still main energy sources with the share of coal and oil consumption from 68.2% in 2013 to 67.0% in 2020BaU, especially for industrial activities. A small share of total final energy consumption is from biomass for some purposes in residential and commercial sectors.

#### E. GHG Emissions in Da Nang City

Emission factors in this study were referred to 2006 IPCC Guidelines for National Greenhouse Gas Inventories [7].

In the year 2013, estimated GHG emission is about 2.7 MtCO<sub>2</sub>eq. In 2030BaU, total GHG emission increased up to 10.7 MtCO<sub>2</sub>eq, about fourfold increase from 2013. In which, the major contributors to GHG emission include industrial sector (46.2% of total GHG emissions in 2030BaU scenario), followed by transport, commercial and residential sectors which account for 37.1%, 9.3% and 7.5% of total GHG emissions in the 2030BaU scenario, respectively.

In 2030CM, emissions estimated reduced by 19% from the 2030BaU emissions. In which, highest reduction is attributes

to transport sector (46%), followed by industry (38%), commercial (8%) and residential (8%).

TABLE I: CLIMATE CHANGE ACTIONS (KtCO<sub>2</sub>) FOR DA NANG CITY

TABLE 1. CLIMATE CHANGE ACTIONS (ktCO <sub>2</sub> ) FOR DA NANG CITY				
Action		Project	Sector	Emission reduction (ktCO <sub>2</sub> eq)
1 Smart Industry	1-01	ESCO (Energy Saving Company) project for industries	Industry	192.4
	1-02	Installation high energy efficiency facilities (such as compressors and motors)	Industry	204.3
	1-03	Regional energy supply system	Industry	108.3
	1-04	Improvement of kiln and furnace technology	Industry	272.0
		Total		777.0
2 Smart Building	2-01	Installation of insulated glasses to commercial buildings	Commercial	6.4
	2-02	Installation of insulated glasses to households	Residential	5.1
	2-03	Introduction of incentive to low energy buildings	Commercial	2.0
	2-04	Introduction of insulating material to houses	Residential	32.3
	2-05	Energy efficiency technology applied to buildings	Commercial	5.5
	2-06	Introduction of solar water heater to commercial buildings	Commercial	21.4
	2-07	Introduction of solar water heater to households	Residential	23.5
		Total		96.2
3 Energy Efficiency	3-01	ESCO (Energy Saving Company) project for commercial buildings	Commercial	27.8
	3-02	High efficiency lighting in public lighting	Commercial	4.2
	3-03	High efficiency lighting in commercial buildings	Commercial	49.8
	3-04	High efficiency lighting in households	Residential	32.8
	3-05	High efficiency air conditioners (such as air conditioners with inverter controllers) in commercial buildings	Commercial	31.2
	3-06	High efficiency air conditioners (such as air conditioners with inverter controllers) in commercial households	Residential	23.8
	3-07	Promotion of energy-efficient appliances	Residential	63.8
		Total		233.4
4 Smart Transport	4-01	Promotion of eco-driving with digital tachographs	Transport	28.7
	4-02	Wide-range traffic control	Transport	3.9
	4-03	Expansion of frequencies and routes of bus transportation	Transport	5.3
	4-04	Development of Bus Rapid Transit (BRT)	Transport	2.7
	4-05	Shift to CNG bus	Transport	6.1
	4-06	Introduction of electric motorbikes	Transport	32.0
	4-07	Promotion of energy-efficient vehicles (cars for passenger)	Transport	52.4
	4-08	Promotion of energy-efficient vehicles (motorbikes)	Transport	73.3
	4-09	Promotion of energy-efficient vehicles (trucks)	Transport	348.4
	4-10	Development of water freight transport system	Transport	398.8
		Total		951.5
5 Green Energy	5-01	Introduction of photovoltaic power generation to commercial buildings	Commercial	4.7
	5-02	Introduction of photovoltaic power generation to households	Residential	4.7
	5-03	Introduction of small-scale hydropower generation (at water distribution stations)	Commercial	1.6
	5-04	Introduction of wind power generation	Commercial	9.8
		Total		20.8
Total				2,078.9

In 2013, per capita GHG emissions in Da Nang was 2.7 tCO<sub>2</sub>eq, though, in BaU scenarios, it is projected to increase up to 6.5 tCO<sub>2</sub>eq. In 2030CM scenario it can be reduced to 5.2 tCO<sub>2</sub>eq.

In 2013, estimated GHG emission intensity is 51.6 tCO<sub>2</sub>eq/bil.dongs. In 2030BaU, emission intensity decreased to 42.2 tCO<sub>2</sub>eq/bil.dongs mainly because of greater share of tertiary industry in GDP. In 2030CM scenario, which introduces implementation of the projects and actions, emission intensity is estimated to 34 tCO<sub>2</sub>eq/bil.dongs.

#### F. GHG Emission Reduction by Actions

GHG emission reduction in Da Nang city by Actions is shown in Table I. Detail of each Action is described below:

**Action 1. Smart Industry.** Low carbon projects regarding promotion of energy efficient equipment and fuel shift in the industry sector is included in Action 1. Total reduction of GHG emissions by this action is 777 ktCO<sub>2</sub>eq. Improvement of kiln and furnace technology such as waste heat recovery is one of the main project in Action 1. This project contributes to

reduce 272 ktCO<sub>2</sub>eq.

**Action 2. Smart Building.** This action covers low carbon projects related with diffusion of low-energy houses and buildings. This action can reduce 92 ktCO<sub>2</sub>eq. Energy demand in houses and buildings through projects such as diffusion of energy management system and installation of insulated glasses. Introduction of insulating material to houses is a project that reduce the largest GHG emission in this action. Introduction of solar water heater to houses and buildings is also main projects in this action to reduce fuel demand. CO<sub>2</sub> emission from houses is reduced by 23 ktCO<sub>2</sub>eq through 20% diffusion of solar water heater.

**Action 3. Energy Efficiency.** Projects about promoting energy efficient device and appliance like lighting and air conditioners for houses and buildings are covered in Action 3. Total reduction of GHG emission by this action is 233 ktCO<sub>2</sub>eq. For instance, replacement of conventional lighting by high efficient one such as LED lighting in houses and buildings contributes to reduce 87 ktCO<sub>2</sub>eq.

**Action 4. Smart Transport.** It is estimated that projects in Action 4 can reduce 952 ktCO<sub>2</sub>eq in total, which is the largest reduction among all actions. This action covers variety of projects regarding both passenger and freight transportation. Not only improvement of fuel efficiency of vehicles but also promotion of modal shift to public transportation and deployment of CNG bus are listed. Projects for freight transport such as promotion of energy-efficient trucks have large potential to reduce GHG emissions, because GHG emission from freight transport sector is more than twice as high as that from passenger transport sector. Development of water freight transport system is aimed to shift freight transportation from truck to ship. Meanwhile, projects like introduction of electric motorbike and CNG bus contribute to reduce GHG emission from passenger transport.

**Action 5. Green Energy.** This action covers projects for increasing electric power generation by renewable energy including photovoltaic power, wind power and small-scale hydropower. Total reduction of GHG emission by Action 5 is 21 ktCO<sub>2</sub>eq. Photovoltaic power generation systems are assumed to install on rooftop of houses and buildings. Hydropower generation is introduced to public facilities such as water distribution station.

#### IV. CONCLUSIONS

Several main output of the study can be drawn out as below:

In 2030BaU, Da Nang is expected under the rapid growth of driving forces such as population, transport demand, and industrial activities; the total GHG emissions increases 4.01 times, from 2,665 ktCO<sub>2</sub>eq in 2013 to 10,687 ktCO<sub>2</sub>eq.

In 2030CM, the total GHG emissions reduction is 19%, accounting for 2078 ktCO<sub>2</sub>eq. Da Nang can reduce such emissions reductions by implementing 35 projects grouped in five actions.

By implementing five climate change actions, namely; Smart Industry (4 projects), Smart Building (7 projects), Energy Efficiency (7 projects), Smart Transport (10 projects)

and Green Energy (4 projects), Da Nang can reduce 19% total GHG emissions in 2030CM (between the 10-20% national reduction target as declared in the Green Growth strategy and within 8-25% mentioned in the Vietnam's INDC).

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