Asia-Pacific
Economic Cooperation

Advancing Free Trade
for Asia-Pacific Prosperity

APEC Low Carbon Model Town (LCMT) Project Dissemination Phase 2

Feasibility Study Report – Davao City, Philippines

APEC Energy Working Group

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List of Abbreviations

2W	Two-Wheeler
4W	Four-Wheeler
APEC	Asia-Pacific Economic Cooperation
BEMS	Building Energy Management System
BERDE	Building for Ecologically Responsive Design Excellence
CHP	Combined Heat and Power
CO_2	Carbon Dioxide
Cogen	Cogeneration
COP	Coefficient of Performance
DCS	District Cooling System
DHS	District Heating System
DES	District Energy System
EE	Energy Efficiency
EFLH	Equivalent Full Load Hours
EMS	Energy Management System
EV	Electric Vehicles
GHG	Greenhouse Gas
GSHP	Ground Source Heat Pump
GWh	Gigawatt hour
ha	Hectare
HVAC	Heating, Ventilation and Air Conditioning
JICA	Japan International Cooperation Agency
kg	Kilogram
km	Kilometre
KWh	Kilowatt Hour
LCM	Low Carbon Measures
LCMT	Low-Carbon Model Town
MSW	Municipal Solid Waste
m/s	Metre per second
m	Metre
m^2	Metre square
m^3	Metre cube
MW	Mega Watt
O&M	Operation and Maintenance
PHP	Philippine Peso
PV	Photo Voltaic
RA	Republic Act No.
RE	Renewable Energy
tCO_2	Tons of Carbon dioxide
TOD	Transit Oriented Development
TOE	Tons of Oil Equivalent
ToR	Tons of Refrigeration
USD	United States Dollar

WtE	Waste to Energy
^{0}C	Degree Celsius

1 Executive Summary

The APEC region has been witnessing increasing urbanization in recent years and this trend is expected to continue in the near future as well – level of urbanization in all APEC economies was 68.5% in 2010, which will increase to 80.9% by 2050. The growing rate of urbanization has led to increased energy consumption – primary energy consumption in 2008 witnessed an 84.2% and 26.2% increase over 1990 and 2000 consumption levels respectively. With the expected growth in urbanization, the energy consumption levels is expected to carry on the upward trajectory in the future as well, leading to increased CO_2 emission. In the near future, this trajectory of CO_2 emission will reach harmful levels as well as lead to other detrimental effects that will lead to decreased Quality of Life for the citizens.

In order to address the CO_2 emission Ministers attending the 9th APEC Energy Ministers Meeting (EMM9) in 2010 observed that "Introduction of low-carbon technologies in city planning to boost energy efficiency and reduce fossil energy use is vital to manage rapidly growing energy consumption in urban areas of APEC". This led to the development of APEC Low-Carbon Model Town (LCMT) Project to encourage creation of low-carbon communities in urban development plans and share best practices for making such communities a reality. Subsequently, Low-Carbon Model Town concept for 7 cities have been prepared and refined over 7 phases along with development of APEC Low-Carbon Town Indicator (LCT-I) System for evaluation of low-carbon interventions. As the following step to the LCMT concept, the project dissemination was initiated to accelerate the dissemination of low-carbon town for managing rapidly growing energy consumption in the APEC region and reduce corresponding CO_2 emission. The current project constitutes Phase 2 of Project Dissemination wherein two volunteer towns in Viet Nam (Da Lat) and Philippines (Davao) have been nominated.

In order to proceed with the development of Low Carbon Development (LCD) Strategy and subsequent feasibility study of the recommended low carbon interventions, the baseline assessment of the volunteer town, Davao was undertaken. This included analysis of geographic and demographic data; administrative structure; local economy; basic infrastructure, energy and resources; land-use structure and policies and targets related to low carbon strategies relevant to the volunteer town.

Overview of Volunteer Town: Davao (Philippines)

As shown in the figure below, this project will conduct Feasibility Study for the volunteer town Davao city in the Philippines:

Source: Google earth

Figure 1: Davao City

Davao City is highly urbanized city in the island of Mindanao, Philippines. The city has a total land area of 2,443.61 square km, making it the largest city in the Philippines in terms of land area. It is the third-most populous city in the Philippines after Quezon City and Manila, the most populous city in the economy outside Metro Manila, and the most populous in Mindanao.

It is geographically situated in the province of Davao del Sur and grouped under the province by the Philippine Statistics Authority, but the city is governed and administered independently from it. The barangay is the smallest local government unit in the Philippines. Each barangay is headed by a Barangay Captain. The Davao city is comprised of 182 barangays grouped into 11 administrative districts and 3 political (or congressional) districts.

The city serves as the main trade, commerce, and industry hub of Mindanao, and the regional center of Davao Region.

Policies and targets related to Low carbon strategies:

The Government of the Philippines has formulated following policies in order to minimize the GHG emissions of the economy:

Table 1: Summary of Policies

Policies	Sectors Covered	About Policy
Comprehensive Land Use Policy (2013-2022)	• Industry • Agriculture • Tourism • Waste Management • Water Resources	This plan helps in making decisions on public and private land development, the expenditure of public funds, availability of tax policy (tax incentives), cooperative efforts and issues of pressing concern, such as farmland preservation or the rehabilitation of older neighborhood areas.
Philippine Energy Efficiency Action Plan for 2016–2020	• Industrial • Transport • Commercial buildings • Residential buildings	Domestic energy efficiency action plans are intended to estimate the total energy consumption, planned energy efficiency measures, and the improvements each economy expect to achieve in order to minimize their present energy consumption
Power Development Plan 2016-2040	Power Sector	Government imposes power development plan (PDP) to develop the domestic energy security and to promote the renewable energy and energy conservation programs. The 2016-2040 Power Development Plan (PDP) provides the long-term outlook on the demand and supply requirements in the three major Grids, namely: Luzon, Visayas and Mindanao.
Philippine Energy Plan 2016-2030	• Fuel Supply • Renewables • Oil and Gas	The Department of Energy (DOE) initiated the formulation of the 2016-2030 sectoral energy roadmaps that will set out specific actions and directions to drive the sector forward.
Renewable Energy Roadmap 2017-2040	Renewable Sector	To achieve the objectives of RE roadmap, the DOE with its stakeholders headed by the Domestic Renewable Energy Board (NREB) formulated the NREP which summarizes the 20-year aspirational targets from biomass, solar, wind, hydropower, geothermal and ocean energy.
Davao city Transport Roadmap	Different modes of transport	The Roadmap sets the framework, over the next 20 years with a focus on the first 10 years, for transport networks and systems to be integrated and be more efficient.

Policies	Sectors Covered	About Policy
Davao Regional Development Plan 2017-2022	• Agriculture • Industry	The Davao Regional Development Plan, 2017–2022 was formulated through a series of consultations to ensure that the Region's development issues and concerns were identified and considered in the formulation of policies, strategies, targets and programs.

CO_2 Emission Estimation in the Base Year 2017 (Business as Usual Scenario):

In 2017, the economy's total final energy consumption (TEFC) reached 25.7 million tons of oil equivalent (MTOE), up by 4 percent from its 2016 level of 24.7 MTOE. Transport and Buildings are the major energy consuming sector in Davao. The table below demonstrates the energy consumption in transport and buildings sector for both the cities:

Table 2: Summary of energy consumption in transport and building sector

DAVAO	in KTOE							
Sector	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017 (Est.)**
Transport	130	130	136	143	148	171	185	**195**
Residential	128	130	133	136	138	142	147	**149**
Commercial	43	44	46	49	55	55	63	**66**
Agriculture	6	5	5	6	6	7	7	**8**
Total	**307**	**308**	**319**	**334**	**347**	**374**	**402**	**418**

The total GHG emission from the energy consumed for the Davao city for the year 2017 is **3.53 Million Tons of CO_2**. According to the Philippine Statistics Authority, GHG emission of the Philippines in the year 2017 was 118.5 Million tons of CO_2, which means Davao city contributes to approximately 3% of the total GHG emissions of the entire economy.

Low Carbon Measures Suggested:

In order to minimize the GHG emissions in the Davao city, the project team has proposed following low carbon measures for different sectors of the economy:

Table 3: Proposed list of low carbon measures

Sector	BAU Scenario (GHG Emission in 2030 $MTCO_2$)	Low Carbon Interventions (LCI) Proposed	GHG Emissions post LCI implementation (in 2030)
Transport	0.915	Implementation of Odd & Even Road Rationing Scheme for private cars only	0.777
Untapped Energy	1.13	12 MW of Waste to Energy plant in the Davao city	1.09
Buildings (Residential and Commercial)	0.881	Implementation of energy efficiency building codes	0.798
Energy Management System	1.17	Implementation of Building Energy Management System	1.05

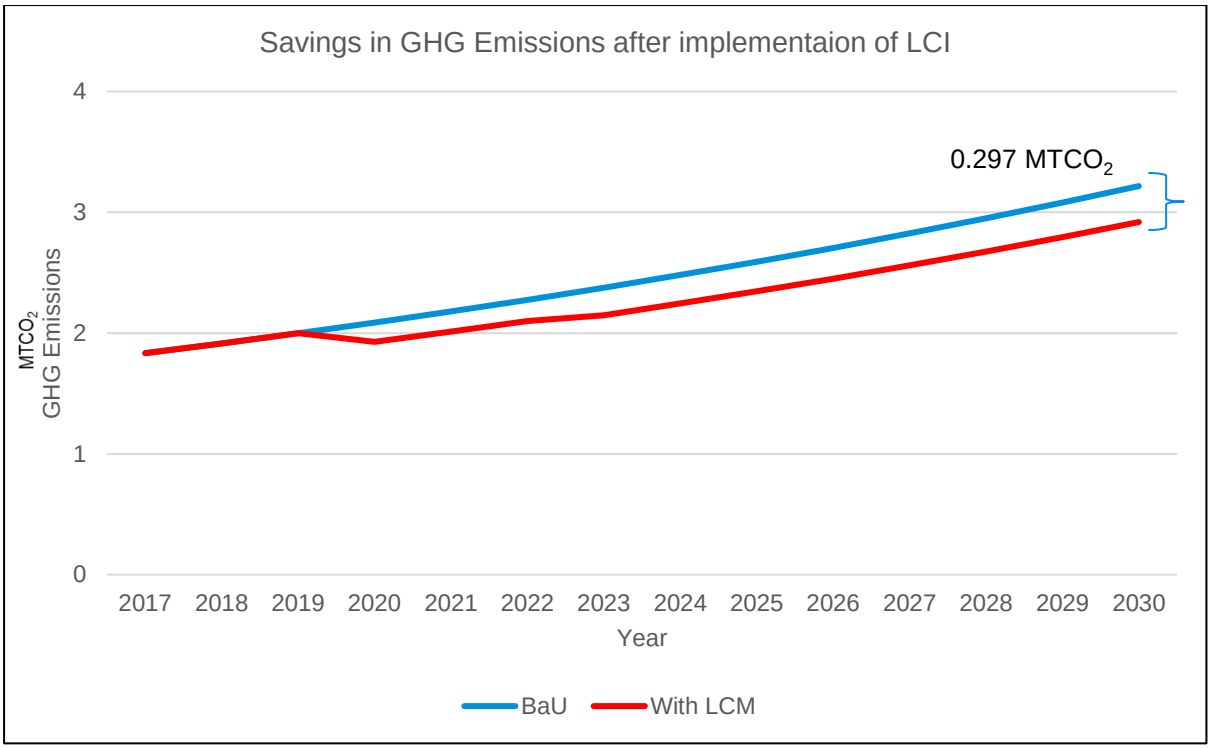


Figure 2: Saving in GHG emissions after implementation of Low Carbon Interventions

2 Project Background

2.1 About Project Dissemination

The APEC region[1] has been witnessing increasing urbanization in recent years and this trend is expected to continue in the near future as well – level of urbanization in all APEC economies was 68.5% in 2010, which will increase to 80.9% by 2050 (APEC, 2011). The growing rate of urbanization has had a cascading effect on the energy consumption – primary energy consumption in 2008 witnessed an 84.2% and 26.2% increase over 1990 and 2000 consumption levels respectively (APEC, 2011). With the expected growth in urbanization, the energy consumption levels are expected to carry on the upward trajectory in the future as well. Such increase in energy consumption will directly impact CO_2 emission in the atmosphere. Hence, if current trend of consumption continues unabated, level of CO_2 emission will reach harmful levels as well as lead to other detrimental effects like increase traffic congestion, overpopulation that will lead to decreased Quality of Life for the citizens.

In the background of these facts, Ministers attending the 9th APEC Energy Ministers Meeting (EMM9) in 2010 observed that "*Introduction of low-carbon technologies in city planning to boost energy efficiency and reduce fossil energy use is vital to manage rapidly growing energy consumption in urban areas of APEC".* Responding to this observation, they called for the APEC Energy Working Group (EWG) to implement an APEC Low-Carbon Model Town (LCMT) Project *to encourage creation of low-carbon communities in urban development plans and share best practices for making such communities a reality*".

The concept of LCMT is to provide a basic principle and framework to assist central and local government officials to plan policies and implementing measures ensuring CO_2 emission reduction taking in to account prevalent socio-economic conditions and city-specific characteristics. The LCMT Project previous phases consists of two activities:

1. Development of "Concept of the Low-Carbon Town in the APEC Region"
2. "Feasibility Study" and "Policy Review" of planned development projects as examples of real-life applications of the concept.

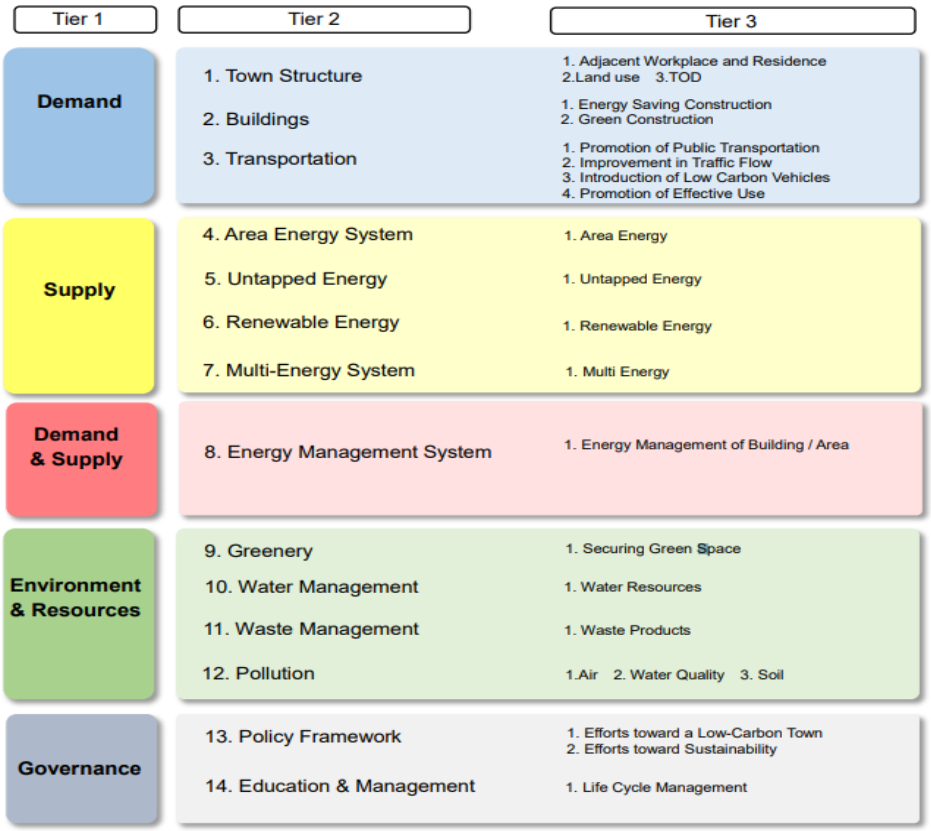
As an outcome of the project, Low-Carbon Model Town concept for 7 cities have been prepared and refined in 7 phases[2]. Through the process of developing the outputs of these studies, a self-assessment tool for providing assistance to local governments in evaluating and monitoring various low-carbon measures was conceived. After a basic survey in 2013, this tool - APEC Low-Carbon Town Indicator (LCT-I) System underwent trial evaluations in 2015 with the help of previous LCMT-case towns and endorsed in 50th APEC EWG Meeting in December 2015.

2.2 About the tool: LCT – 1 system

The tool, LCT-I System consists of 5 major items (Tier 1), 14 mid-level items (Tier 2) and 23 terminal level items (Tier 3) as given in the diagram below:

[1] Note: Asia-Pacific Economic Cooperation (APEC) region constitutes of 21 member economies located in the Asia-Pacific region

[2] Note: The 7 cities for which LCMT concept had been prepared are as follows: Krasnoyarsk City, Russia (October 2018); Mandaue, Cebu, The Philippines (May 2017); Bitung, North Sulawesi, Indonesia (June 2016); San Borja, Lima, Peru (January 2016); Da Nang, Viet Nam (May 2014); Koh Samui, Thailand (June 2013); Yujiapu CBD, Tianjin, China (September 2011)



Source: APEC LCMT Document

Figure 3: Structure of LCT-1 System

Tier-1 contains areas directly and indirectly related to energy usage – directly related areas are concerning technologies, design measures related to energy demand and supply, while indirectly related areas are the enablers that help ensure the directly related measures can be implemented successfully. Tier-2 further segregates the Tier-1 items into more definitive action areas. The Tier-2 items are further segregated to Tier-3 items which gives the development objective.

A 5-point marking scheme[3] is provided for each of the 23 Tier-3 items, along with the marking criteria to be followed. Marking criteria is based on the extent to which the proposed measure is expected to help achieve the specific objective for the Tier-3 item is concerned. To further aid evaluation an Excel worksheet[4] has also been prepared to capture the marking for each intervention/item.

2.3 Rationale

The LCMT Concept was developed and refined through the 7 phases of LCMT Project and it culminated in the development of LCT-1 system. This was succeeded by the APEC Low Carbon Model Town (LCMT) Project Dissemination Phase 1 (APEC, 2019) to accelerate the dissemination of low-carbon town for managing rapidly growing energy consumption in the APEC region and reduce corresponding CO_2 emission.

As part of Phase 1 of LCMT Project Dissemination, feasibility studies of low-carbon town developments in Banda Aceh City of Indonesia, Shah Alam City Center Section 14, Selangor of Malaysia and the City of Hang Tuah Jaya, Melaka of Malaysia were conducted to provide implementable advice towards low carbon urban development.

[3] Note: Depending on the indicator and instruction for evaluation under the system, a 3-point or 4-point scale may be applied. In cases without plans, efforts, systems or criteria, or in cases where the numerical value
cannot be measured, an evaluation is not given i.e. no point is given.
[4] For reference: Evaluation sheet for LCT-I System (APEC website, 2016)

In the Phase 2, the Concept and LCT-1 will be utilized to provide advisory on low carbon urban development for two volunteer cities in the APEC region - Da Lat (Viet Nam) and Davao (Philippines). The key objectives of the LCMT Dissemination Phase 2 are as follows:

1. To provide feasibility studies of low carbon development projects on the two volunteer towns; checking CO_2 emissions reduction goals; verifying how to develop attractive and innovative development plans through the feasibility study.
2. To share best practices and real-world experiences of low-carbon town design with planners and policymakers throughout the APEC region.

2.4 Objective and Scope of Work

Under the current project, which forms a part of LCMT Dissemination Phase 2, feasibility studies will be conducted to examine CO_2 reduction goals in pre-decided sections for the two volunteer cities and verify how to develop an attractive and innovative low-carbon development plan.

Accordingly, the objective of the project is as follows:

1. Identify specific selection of mitigation measures in the pre-selected APEC LCT-I Assessment Areas based on the analysis on CO_2 reductions and investment costs for potential measures. This is expected to provide valuable advice on how to design an attractive and innovative low-carbon development plan for the respective cities.
2. Develop implementation methodology and action plans of proposed mitigation measures including potential implementing bodies and funding sources.

In order to achieve the objectives, the following activities need to be undertaken:

1. Prepare Low-Carbon Development (LCD) Strategy for the two volunteer towns' low-carbon town development projects which will contain the following elements:

    a. A high-level vision in low-carbon town design
    b. CO_2 emissions baseline in Business As Usual (BAU) scenario
    c. CO_2 emissions reduction and environmental targets
    d. Low-carbon guideline for the categories of low-carbon town design challenges
    e. Select CO_2 emissions reduction measures in each design category

2. Analyze CO_2 emissions reduction and costs for the selected design measures
3. Study the implementation methodology and action plans of the proposed CO_2 reduction measures along with possible funding sources
4. Prepare two Feasibility Study reports for each of the two volunteer towns in the pre-selected LCT-I Assessment areas will improve their low-carbon development projects.

The pre-selected LCT-I Assessment Areas for Davao city is given below:

Table 4: Pre- Selected LCT-1 Assessment Areas

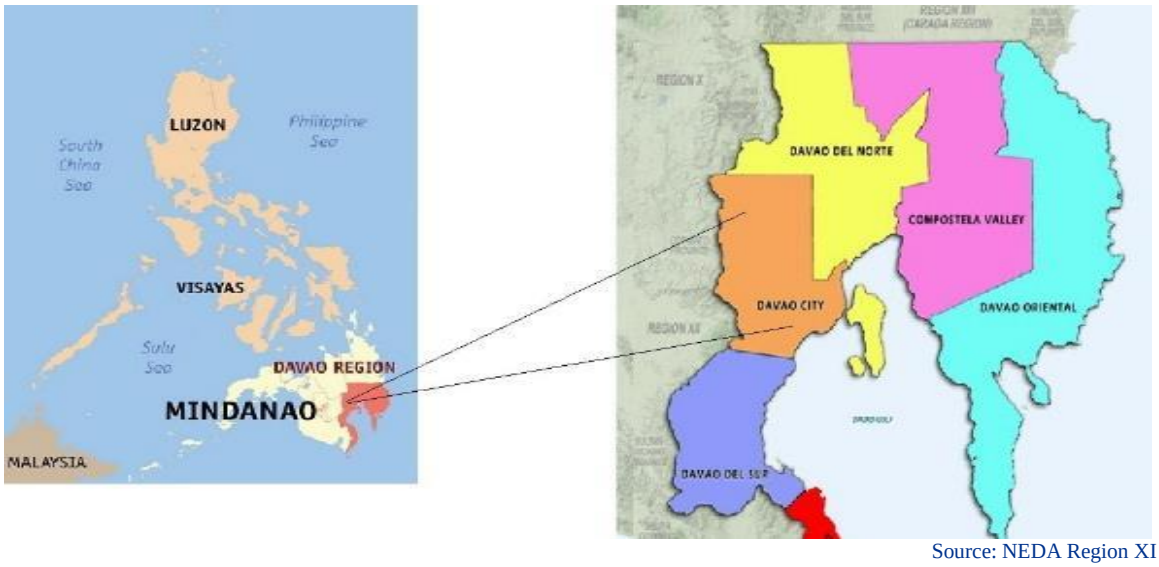
Davao City (Philippines)	
Tier -1	**Tier-2**
Demand	Transportation
Supply	Untapped Energy
Demand & Supply	Energy Management System
Environment & Resources	Waste Management
Governance	Policy Framework
	Education & Management

The report presented below deals with the low carbon interventions suggested for Davao city to reduce their GHG emissions.

3 Overview of Volunteer Town – Davao (Philippines)

3.1 Geographic Data

Davao City is located in the southeastern part of Mindanao, lying in the grid squares of 6 58' to 7 34' N latitude, and 125 14' to 125 40' E longitude (Comprehensive Land Use Plan (2013-2022)). It is bounded on the north by Davao Province; on the east partly by Davao Province and Davao Gulf; on the south by Davao del Sur; and on the west by North Cotabato. Davao City is approximately 946 aerial km or 588 statute miles, southeast of Manila. Davao City has an area of 244,000 hectares (Socio- Economic Indicators SEI 2018). The topography of the area is majorly mountainous, characterized by extensive mountain ranges with uneven distribution of plateaus and lowlands, only the southeast quarter is plain and slightly hilly, with slopes generally below four to five degrees.



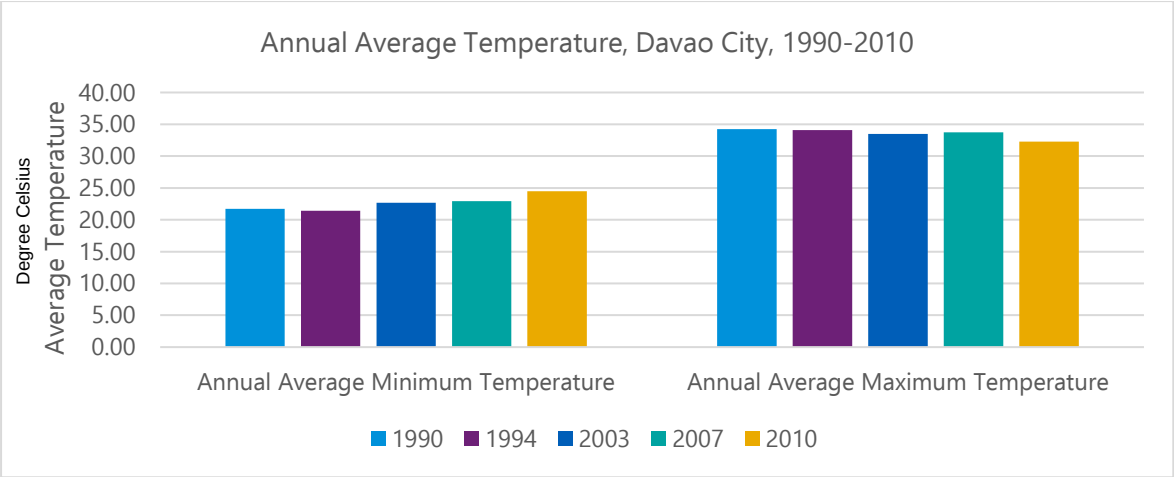
Source: NEDA Region XI

Figure 4: Davao City Map

Davao City has a mild tropical climate. Compared with other parts of the Philippines in which there is a distinct hot and wet season. It has the privilege of a climate where the days are always sunshiny and mild followed by nights of rain. The city is outside the typhoon belt and lacks major seasonal variations.

The annual average minimum and maximum temperature in 2010 is 24.5 and 32.3 degrees Celsius respectively. However, during the period 1990-2010 (Comprehensive Land Use Plan (2013-2022))[5] Figure 5, reveals that the annual average minimum temperature increased by almost 3 degrees while the annual average maximum temperature decreased by 2 degrees as compared to that of year 1990.

[5] Comprehensive Land Use Plan: The **CLUP** is a planning document prepared by LGUs to rationalize the allocation and proper use of land resources. It projects public and private land uses in accordance with the future spatial organization of economic and social activities. Under the LGC of 1991 and other pertinent laws, all LGUs are mandated to continue to prepare/revise/update their comprehensive land use plan which shall be enacted through a zoning ordinance.

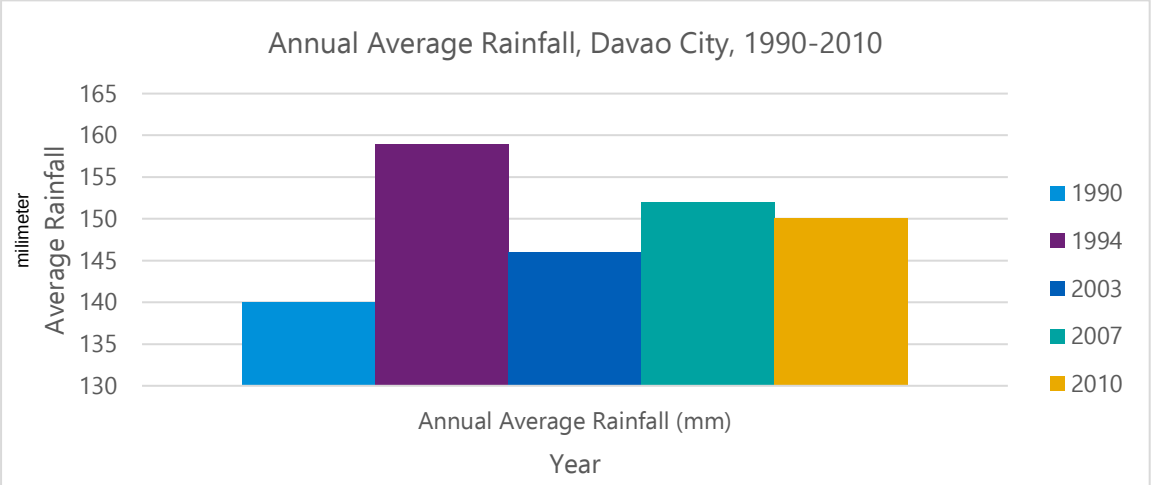


	1990	1994	2003	2007	2010
Annual Average Minimum Temperature	21.73	21.43	22.66	22.93	24.5
Annual Average Maximum Temperature	34.24	34.08	33.50	33.72	32.29

Source: Comprehensive Land Use Plan (2013-2022)

Figure 5: Annual Average Temperature

The average annual rainfall has a recorded increase by 10mm for the time period 1990 to 2010 (Figure 6). Although, a remarkable increase was observed in 1994, when average rainfall was 159 mm. However, it has remained in the 150mm level till 2010.



	1990	1994	2003	2007	2010
Annual Average Rainfall (mm)	140	159	146	152	150

Source: Comprehensive Land Use Plan (2013-2022)

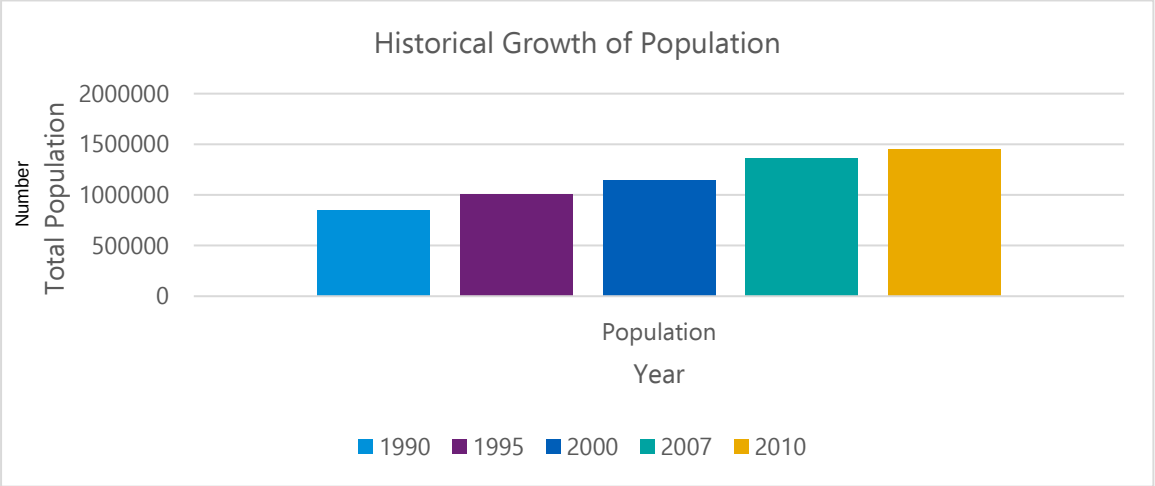
Figure 6: Annual Average Rainfall

3.1.1 Demographic Data

Based on the 2010 Census, Davao City accounted for 1.57 % of the total Philippine population of 92.34 million. Davao City has the largest population in the Southern Mindanao Region cornering 32.43 per cent of the 4.46 million people in in 2010. It also shared 5.71 % of the total population of 25.375 million in Mindanao (Comprehensive Land Use Plan (2013-2022)).

As seen in Figure 7, from the 2000 Census of Population and Housing, Davao City's total population was 1,147,116 populations which translated to 2.36 per cent growth from 2000 to 2010. For 2007, the population count reached 1,366,153 further translated to a 2.17 per cent growth up to 2010. Although, population growth slowed down from 2007 to 2010, if the 2.36 % increase continues, the

population of Davao City is expected to double in 32 years (Comprehensive Land Use Plan (2013-2022)).

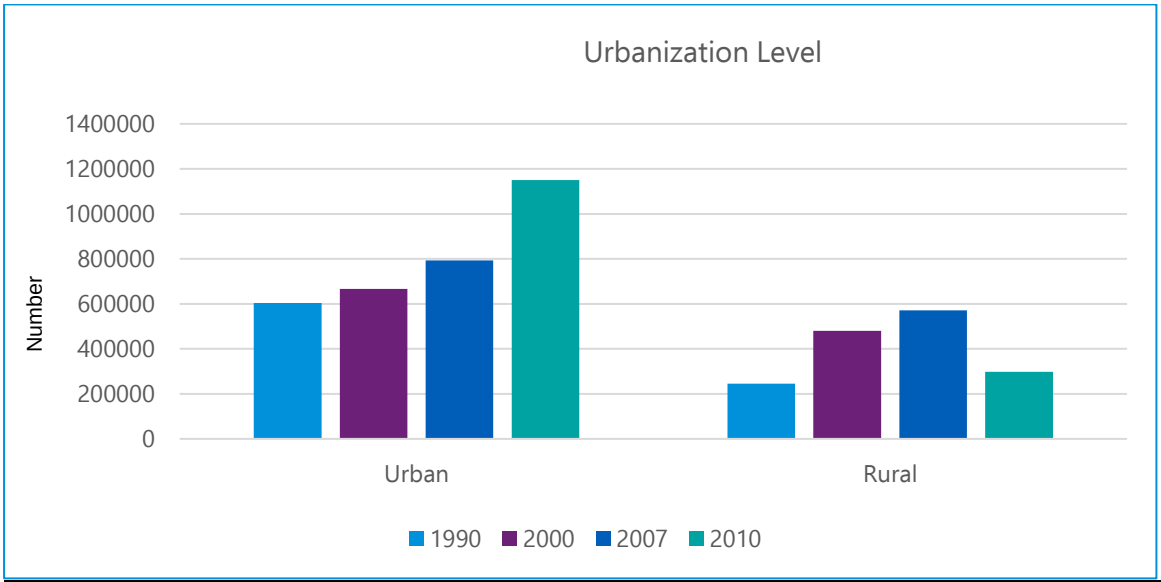


	1990	1995	2000	2007	2010
Population Growth	849947	1006840	1147116	1363337	1449296

Source: Comprehensive Land Use Plan (2013-2022)

Figure 7: Historical Population Growth

As per Figure 8, approximately four-fifths of the household population is located in the urban barangays in Davao City. Between 2000 and 2010, the 21.25 % age (Comprehensive Land Use Plan (2013-2022)) point's increase is significant as 80 % of the total population have resided in urban areas in the city.



	1990	2000	2007	2010
Urban	604508	666846	792540	1150504
Rural	245439	480270	570797	298792

Source: Comprehensive Land Use Plan (2013-2022)

Figure 8: Urbanization Level

3.1.2 Administrative structure

The administrative structure (see Figure 9) of the Philippines is as given below:

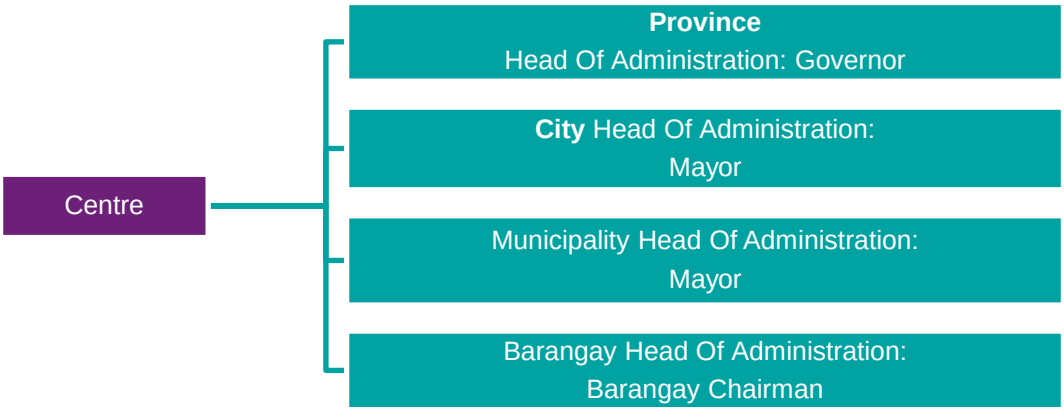
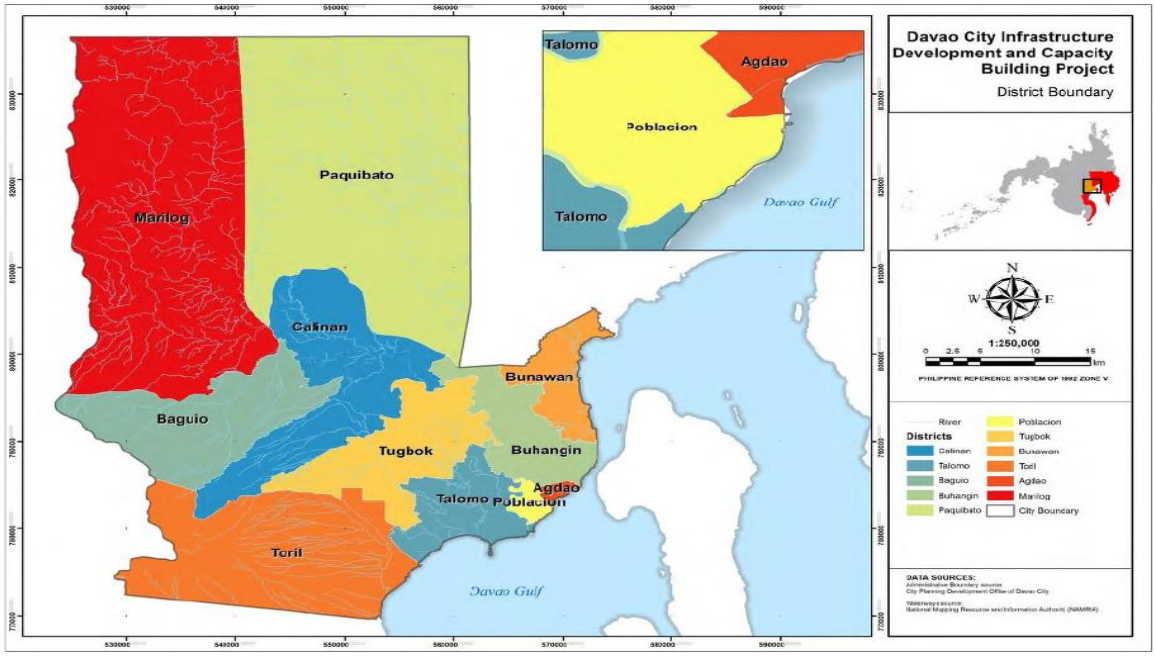


Figure 9: Administrative Structure

The barangay is the smallest local government unit in the Philippines. Each barangay is headed by a Barangay Captain. Its local legislative body is the Sangguniang Barangay.

The Davao city is comprised of 182 barangays grouped into 11 administrative districts and 3 political (or congressional) districts (Davao City Infrastructure Development Plan and Capacity Building Project), as shown below:



Source: A6 IM4Davao GIS database development.

Figure 10: Administrative Districts

The population growth in all 11 districts has been fairly consistent; their population shares have remained almost the same from one year to the next from 2000 to 2015. However, among the districts, it is Talomo, Buhangin, and Poblacion that have the greatest number of residents.

3.1.3 Local Economy

Davao City operates on a flexible market-oriented economy where the private investments are encouraged by the government to address the current needs of the population. The resilience of the government continually opens doors of opportunities to investors from micro to large-scale enterprises.

Davao City has a steadily growing economy due to various factors that contribute to the influx of investments such as the provision of infrastructure support and utilities, investment incentives, land area commensurate to the needs of investors, and human resource to serve the employment requirements of establishments and sound peace and order situation.

Revenue sources of Davao City are from establishments and activities ranging from micro to large-scale enterprises covering agriculture, commerce and trade, industry and tourism. These major sectors of the economy operate by pouring investments that continue to grow annually in number and capitalization. Having an annual growth rate of 15.98% from 2006 to 2010 in terms of capitalization of micro, small, medium and large-scale establishments or a total of P 182 billion in 2010 from P 109.0 billion in 2006, revenues also proved to increase annually. Commerce and trade posted an annual growth rate of 3.81% in revenues for the same period while industries registered 6.12% (Comprehensive Land Use Plan (2013-2022)).

Under the land use plan, the actual land cultivated for agriculture production is 29.95% (73,086 hectares). The major crops and fruits which are produced in Davao city are banana, durian, mango, rubber, abaca and cacao. The average employment rate for 2015 of 94.2% remained constant compared to its rate a year ago, the services sector had the highest share among the Region's total employed persons with 53%, followed by agriculture with 34%, and industry with 13%. In services, most of the employed engaged in wholesale and retail trade, repair of motor vehicles, and transportation (Annual Regional Economic Situationer).

3.1.4 Basic Infrastructure, Energy & Resources

1. **Road Infrastructure** (Davao Regional Development Plan (2017-2022))

   Davao Region's road network substantially connects it intra-regionally, and externally to other regions in Mindanao and the rest of the economy. In 2010, the total road network of Davao Region was 16,937.44 km with a road density of 0.83 km per square km. This network expanded by 653.69 km from 2010 to 2014, bringing the total to 17,591.13 km which translated to a road density of 0.86 km per square km. Additional road projects are still needed to meet the standard road density in Davao Oriental at 3,307.13 km; Compostela Valley at 817.86 km; and, Davao City at 92.83 km.

2. **Rail Infrastructure** (Davao Regional Development Plan (2017-2022))

   In Davao City, the Mindanao Railway project initiative is ongoing and is intended to provide inter-city rail service. Likewise, the Davao City Mass Transit Line project, a new intra-urban railway is proposed to provide fast and scheduled urban transport service within the city. Both rail systems will be combined as an integrated city railway network.

3. **Airport Infrastructure** (Comprehensive Land Use Plan (2013-2022))

   Air traffic in Davao city is operating from Francisco Bangoy International airport. Currently, the FBIA has only 5 local connections and 1 international connection. There is a need to expand air linkages to further enhance the competitiveness of Davao Region and Mindanao Island.

4. **Buildings**

   Davao City is currently drafting its local environmental code and the Davao City Council is scheduling a deliberation on the Green Building Ordinance.

   The population of the Philippines has been steadily growing for many years. As the population started to increase in the city, the requirement of residential and non-residential space started to increase. The residential and commercial buildings are further divided into following sectors:

   Residential: Single houses, Apartments, Duplex/Quadruplex, Residential Condominium

   Non- Residential: Commercial, Institutional, Agricultural

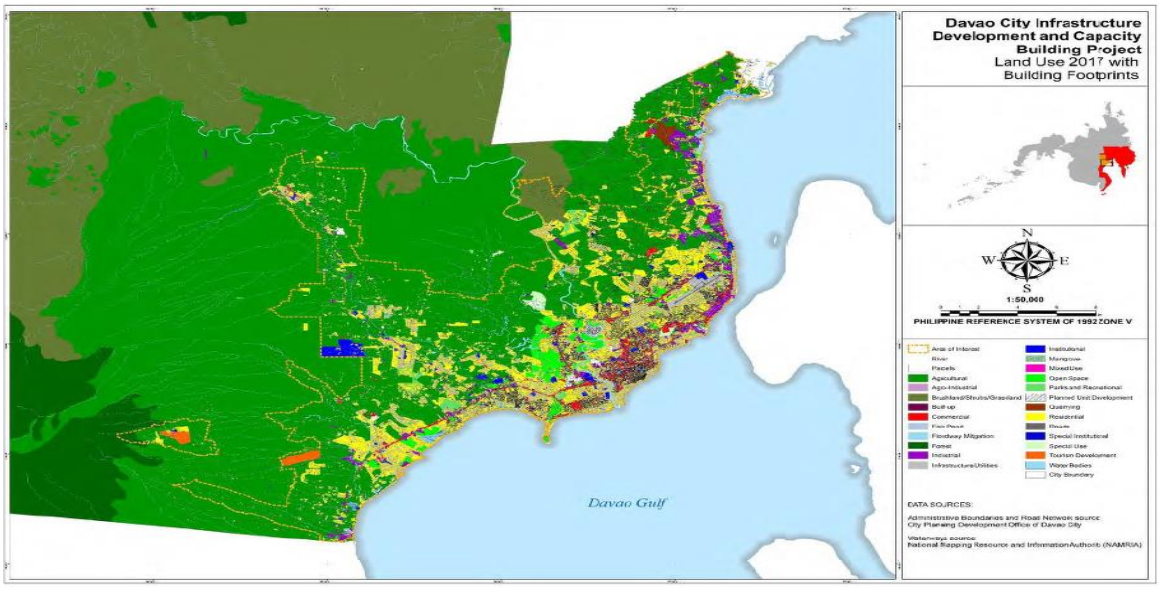
5. **Energy**

a. **Buildings (Commercial and Residential)**: Electricity is the primary source of energy for buildings sector and the level of electrification in residential buildings in nearly 100%. For the year 2017, electricity consumption in these two categories has been 4738 (Philippine Energy Plan 2016-2030) thousand units (KWh).

b. **Transportation** (Davao Sustainable Urban Transport Project): This sector comprises majorly motorized passenger transport which run on petrol or diesel for jeepneys and L-300 vans the fuel type is generally diesel, while the Filcabs (multi-cabs) are generally powered by petrol (gas) engines. Motorised tricycles have two-stroke petrol engines, which are noticeably polluting in areas where they congregate in significant numbers.

c. **Power Supply** (Comprehensive Land Use Plan (2013-2022))**:** Energy sufficiency and reliability remain to be challenging despite the significant developments of private sector led power generation. Efforts in harnessing alternative and renewable energy sources must be further explored to meet the current and potential power demands. The power supply of Davao City is distributed by the Davao Light and Power Company (DLPC) which is a major provider in Davao Region and tagged as the 3rd largest privately-owned electric utility in the Philippines, with 23 substations and 19 of which are located in Davao City.

3.1.5 Land-use structure



Source: A6 IM4Davao GIS database development

Figure 11: Land use plan of Davao

As given in the Land Use Plan, a major area of Davao is under agricultural cover. As per the Comprehensive Land use plan figures, nearly 30% of the total land of Davao is composed of agriculture land (73,086 hectares) and 16.36% is covered by forest. The remaining area is used for residential purpose and special-use purpose i.e. construction land for offices, construction of non-business works; land used for defense and security purposes; non-agricultural production and business land and land use for other public purposes.

3.1.6 Policies and targets related to Low carbon strategies

In the Philippines, policies are developed at domestic level and gets implemented at local levels. The Central government has come up with several policies related to energy efficiency and low carbon. There is domestic level, province level and local level policies. As Davao city does not come under any province, the domestic and city policies are included for the same. The overall structure applicability of all the policies for each sector is presented next.

Table 5: Policy structure for low carbon city (Davao, Philippines)

Name of the Policy		Applicability within Sectors											
		Energy Demand Side Sector								Energy Supply Side Sector			
		Buildings		Transport	Industry	Municipality	Agriculture	Tourism	Others (Forestry, Fish)	Conventional Power Supply	Solar	Wind	Geothermal
		Commercial	Residential										
Domestic	Comprehensive Land Use Policy (2013-2022)	NA	NA	NA	Yes	Yes	Yes	Yes	NA	NA	NA	NA	NA
	Philippine Energy Efficiency Action Plan for 2016–2020	Yes	Yes	Yes	Yes	NA	NA	NA	NA	NA	NA	NA	NA
	Power Development Plan 2016-2040	NA	NA	NA	NA	NA	NA	NA	NA	Yes	NA	NA	NA
	Philippine Energy Plan 2016-2030	NA	NA	NA	NA	NA	NA	NA	NA	Yes	NA	NA	Yes
	Renewable Energy Roadmap 2017-2040	NA	NA	NA	NA	NA	NA	NA	NA	NA	Yes	Yes	Yes
Regional	Davao city Transport Roadmap	NA	NA	Yes	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Davao Regional Development Plan 2017-2022	NA	NA	NA	Yes	NA	Yes	NA	Yes	NA	NA	NA	NA

Each policy is explained in detail in subsequent sections. The explanation is divided into 2 parts, viz. (i) about the policy, and (ii) overview of the policy (attached as annexures).

Domestic Level Policies and Strategies related Low Carbon Development:

a) **Comprehensive Land Use Policy (CLUP)** (Comprehensive Land Use Plan (2013-2022)):

About CLUP:

The comprehensive land use plan is an attempt to shape the future physical development of the economy by the adoption of certain goals, principles and policies. It presents a vision, with long range goals and objectives that affect the local government. This plan helps in making decisions on public and private land development, the expenditure of public funds, availability of tax policy (tax incentives), cooperative efforts and issues of pressing concern, such as farmland preservation or the rehabilitation of older neighborhood areas.

Comprehensive Land Use Plan seeks to accomplish the following:

1. Contribute to the realization of city's vision of becoming the premier socio-economic and investment in Mindanao.
2. Construct the overall development strategies in attaining economic growth of the economy.
3. Sustainable and balanced development of the land use sector of the city for the next 10 years
4. Plan and implement the major infrastructure such as road network, communications services, power supplies, support facilities and utilities
5. Provide development strategies and framework policies that would enhance current efforts to restore damaged natural resources, ensure optimum utilization of the city's natural resources

b) Philippine Energy Efficiency Action Plan for 2016–2020 (Compendium of Energy Efficiency Policies of APEC Economies, 2016)**:**

About the Policy:

Domestic energy efficiency action plans are intended to estimate the total energy consumption, planned energy efficiency measures, and the improvements each economy expect to achieve in order to minimize their present energy consumption. The Energy Efficiency action plan shall guide the Philippines in building an energy efficient economy, and in making energy efficiency and conservation a way of life for all. Energy efficiency will advance economic development and help ensure energy security, protection of the environment, optimal energy usage and sustainable energy systems.

c) Davao city Transport Roadmap (Davao city Transport Roadmap)**:**

About the Roadmap:

The transport roadmaps help city authorities develop urban transport roadmaps that address the most pressing environmental, social and economic issues faced by their transportation systems. The purpose of the Roadmap is to support the improvement of transportation so that it prioritizes modes according to their economic, environmental and community sustainability. The Roadmap sets the framework, over the next 20 years with a focus on the first 10 years, for transport networks and systems to be integrated and be more efficient.

Sectors it caters:

- Different modes of transport

d) Power Development Plan 2016-2040 (Power Development Plan 2016-2040)**:**

About the Policy:
Government imposes power development plan (PDP) to develop the domestic energy security and to promote the renewable energy and energy conservation programs. The 2016-2040 Power Development Plan (PDP) provides the long-term outlook on the demand and supply requirements in the three major Grids, namely: Luzon, Visayas and Mindanao. The PDP also presents the holistic power sector roadmaps for the short-, medium- and long-term planning horizons. The DOE, in coordination with its attached agencies, the Energy Regulatory Commission (ERC) and electric power industry participants, has undertaken the following initiatives, policy issuances and programs to ensure supply security, foster competition, and increase energy access.

Sectors Covered:

- Power Sector

e) Philippine Energy Plan 2016-2030 (Philippine Energy Plan 2016-2030)**:**

About the Policy:
As energy is vital to quality human life and the domestic economic growth, the DOE initiated the formulation of the 2016-2030 sectoral energy roadmaps that will set out specific actions and directions to drive the sector forward. Development of these roadmaps took into consideration the economy's long-term economic growth forecast, wealth of indigenous and natural resources, energy security and reliability goals, as well as measured respond to impacts of climate change.

Sectors Covered:
- Fuel Supply
- Renewables
- Oil and Gas

f) Davao Regional Development Plan 2017-2022 (Davao Regional Development Plan (2017-2022))**:**

About the Plan:
Regional development plan can be seen as a general effort to reduce regional disparities by supporting (employment and wealth-generating) economic activities in region. The Davao Regional Development Plan, 2017–2022 was formulated through a series of consultations to ensure that the Region's development issues and concerns were identified and considered in the formulation of policies, strategies, targets and programs. This Plan serves as a guide for all Davao Region's stakeholders, to sustain the Region's inclusive growth, achieve a high trust and resilient society, and transform into a globally-competitive knowledge economy.

Sectors Covered:
- Agriculture
- Industry

g) Renewable Energy Roadmap 2017-2040: Strategies to increase the overall installed capacity of renewable energy to at least 20,000 MW. To achieve the objectives of RE roadmap, the DOE with its stakeholders headed by the Domestic Renewable Energy Board (NREB) formulated the NREP which summarizes the 20-year aspirational targets from biomass, solar, wind, hydropower, geothermal and ocean energy.

Paving the way in the fulfillment of NREP targets are policy mechanisms promulgated by the DOE. Among the ones are in place are the Feed in Tariff (FIT) and the Net Metering Mechanism. The remaining policy mechanism that needs to be implemented includes the Renewable Portfolio Standard (RPS) and Green Energy Option which are expected to further boost the share of renewables in the economy.

4 International Best Practices for Model Green Cities

This section discusses the best practices that several cities have adopted to become green cities/low carbon cities. In order to account for regional socio-economic considerations, several cities across South East Asia and other regions have been considered. The shortlisted list of cities for consideration of best practices were as follows:

1. Hue, Viet Nam
2. Jakarta, Indonesia
3. Samui Island, Thailand
4. Ngu Hanh Son, Viet Nam
5. Ho Chi Minh, Viet Nam
6. Ha Noi, Viet Nam
7. Cape Town, South Africa
8. Stockholm, Sweden

Further, four parameters were considered to assess the suitability of shortlisted cities with the context to the volunteer city i.e. Davao. These four parameters along with their description are given as follows:

a. Climate and Topography
b. Economic Situation (GDP per capita)
c. Economic Activities
d. Previous LCT study

The table below provides the comparative values of shortlisted cities with volunteer cities for points (a) to (c) as well as applicability of (d) for the shortlisted cities:

Table 6: Parameters of shortlisted cities for best practice consideration

Parameters	Davao, Philippines	Da Lat, Viet Nam	Hue, Viet Nam	Samui Island, Thailand	Ngu Hanh Son, Viet Nam	Ho Chi Minh, Viet Nam	Ha Noi, Viet Nam	Jakarta, Indonesia	Cape Town, South Africa	Stockholm, Sweden
Climate	Mild tropical	Temperate	Monsoon	Tropical monsoon	Tropical	Tropical	Warm humid	Tropical monsoon	Mediterranean	Humid Continental
Topography	Mountainous[6]	Combination of lowland and mountainous[7]	Mountainous[8]	Coastal	Mountainous	Coastal	Combination of delta area, the midland area and mountainous zone[9]	Hilly and coastal plains[10]	Mountainous, Coastal	Coastal
Economic Scenario (GDP/capita)	US$1300 (2016)[11]	US$ 2900[12] (2016)	US$2100[13] (2016)	US$ 5979[14] (2016)	US$ 2170[15] (2016)	US$5,428[16] (2016)	US$3,425[17] (2016)	US$14,570[18] (2015)	US$ 6,500[19] (2017)	US$ 61,000[20] (2015)
Major economic activities	Agriculture, commerce and trade, industry and tourism	Agriculture and tourism	Tourism hub	Tourism	Tourism	Industry, agriculture, tourism	Industry, trade, tourism, agriculture	Industry, banking and trading, tourism	Agriculture, Fishing, Shipping Companies, Industry, Tourism	Agriculture, Industry, Tourism

As is evident from the table above the shortlisted cities share similarities with Davao with respect to the climatic situation while topography for almost cities are similar to both Davao and Da Lat. Similarity in major economic activities is observed across all cities, with tourism being a common economic activity. In terms of economic scenario, Da Lat exhibits considerable similarity with the other shortlisted cities, while in case of Davao it is slightly on the lower side.
Of particular interest is Da Nang (Viet Nam) and Samui Island (Thailand) which have been part of APEC LCMT Phase I – a study of these cities can help provide measures which are aligned to the LCMT framework and hence, can be possibly be undertaken in the volunteer towns.

A brief of the best practices considered in the shortlisted cities are given below:

[6] Source: Comprehensive Land Use Plan (2013-22)
[7] Source: Description of topographic and climatic details of Da Lat (Alotrip website)
[8] Source: Sustainable urban tourism through low-carbon initiatives: Experiences from Hue and Chiang Mai
[9] Source: Topography of Ha Noi (Alotrip website)
[10] Source: APN LCI PROJECT; Project Reference Number: LCI2013-05CMY(R)-Jupesta
[11] Source: rsso11.psa.gov.ph/grdp
[12] Source: Da Lat Green Growth Plan
[13] Source: emerhub.com/Vietnam/business-location-in-Vietnam/
[14] Note: GDP per capita of Thailand considered, as for Samui Island data not available
[15] Note: GDP per capita of Viet Nam considered, as for Ngu Hanh Son data not available
[16] Source: emerhub.com/Vietnam/business-location-in-Vietnam/
[17] Source: emerhub.com/Vietnam/business-location-in-Vietnam/
[18] Source: en.tempo.co/read/742672/jakarta-economy-slows-down-in-2015
[19] Source: https://www.investcapetown.com/wp-content/uploads/2019/04/EPIC-2018Q3-FINAL.pdf
[20] Source: https://www.scb.se/en/finding-statistics/statistics-by-subject-area/national-accounts/national-accounts/regional-accounts/pong/statistical-news/regional-accounts-2015/

Case Study 1 – Hue, Viet Nam

Hue, Viet Nam (Advancing green growth in the tourism sector: The case of Hue, Viet Nam, 2014)**:**

About the City: Hue is a medium-sized city of 340,000 people, covering an area of some 71 square km in central Viet Nam. A cultural and tourism hub, Hue is famous for its ancient capital area, pagodas, cuisine, gardens and overall cityscapes. Hue is also regarded as the "Festival City of Viet Nam". It has successfully hosted seven domestically and internationally renowned festivals, attracting millions of tourists. The tourism sector alone contributed approximately 48% of GDP; revenues from the service sector were worth around US$250 million in the same year. The city now welcomes around 2.5 million tourists annually, of whom 1.5 million are international tourists.

Current Scenario:

Impacts of tourism

The Hue Centre for International Cooperation, together with the municipality of Chiang Mai, Thailand, and Asian Institute of Technology undertook research on 'Sustainable Urban Tourism through Low Carbon Initiatives: Experiences from Hue and Chiang Mai'. The study was funded by the Sustainable Mekong Research Network (SUMERNET) and CDKN.

Table given summarizes the greenhouse gas emissions produced by Hue's tourism sector:

Table 7: GHG emissions by tourism sector

Sources	Emissions (tons of CO_2e)	Share (%)
Travel	377,617	76
-within city	6,683	1
- by visitors from other cities within the economy and abroad	370,934	75
Freight	58,571	12
Industrial	19,423	4
Residential & Commercial	17,805	4
Direct waste (food, waste and waste water)	12,889	3
Others	5,895	1
Total	**492,200**	**100**

Source: Kumar et al. (2014)

City initiatives and support mechanisms:

At the domestic level, Viet Nam has acknowledged the adverse impacts of tourism on the environment. Sustainable tourism is a key component of the United Nations Strategic Orientation for Sustainable Development in Viet Nam. The first Vietnamese domestic conference on sustainable tourism development was held in Hue in 1997 and at this the Vietnamese Government adopted the principle of sustainable tourism development. The concept recognized the importance of conserving tourism resources, the natural environment, biodiversity and cultural values, as well as the need for increased involvement of, and benefits to, local communities.

The promotion of Hue's garden houses was identified as the most viable mitigation option to address the twin goals of emissions reduction and job creation, noting that garden houses could increase the locals' income and offer unique recreational and cultural experiences to the tourists.

Solution:

Garden houses – local people's choice for green growth

Garden houses form part of Hue's cultural heritage and number around 2,000 in total. They offer a kind of microcosm of nature within a house: house, garden, people, plants and water co-exist in a small urban space.

Most importantly, garden houses can help reduce greenhouse gas emissions in situ,

in various ways. First, they offer a carbon sink function in contrast to denser, conventionally modern forms of urban housing.

Second, garden houses can manage household waste through composting and/or using garden waste as animal feed, thereby reducing the amount of waste going to landfill. At the city level, since garden houses produce fruits and vegetables, they help reduce emissions from freight that would otherwise transport these products.

Thua Thien Hue Provincial Department of Culture, Sports and Tourism estimated that if the city authority promotes garden houses, it could attract 20 to 40% more visitors. At the same time, if the city authority and garden house association encourage these visitors to use bicycle to travel to garden houses, it could replace 127,950–255,900 km per year travelled by local petrol vehicles; this would translate to a reduction of 100–200 tons of CO_2e per year even with the estimated increase in visitors. This would constitute a reduction of 4–9% of greenhouse emissions from land-based transport within the city, while there will be higher tourism related economic activities.

Case Study 2 – Jakarta, Indonesia

Jakarta, Indonesia (Low Carbon Development in DKI Jakarta, 2018)**:**

About the city:

Jakarta, the capital city of Indonesia, is one of megacities in the world with 10 million population living in 662 square km of land area and 6,977 square km of sea area. The city is a coastal city (± 40% of land area is below sea level), located in a tropic region with dry and rainy seasons. Several rivers flowed across the city, combined with low topography make Jakarta prone to flooding from swollen rivers in the wet season and high sea tides. In addition, lack of water level control infrastructure, deforestation in surrounding area of Jakarta, and complex socio-economic problems indirectly contribute to triggering a flood event. This situation makes the city vulnerable to the impact of climate change, especially the rise of sea level and rainfall intensity.

The population of this city grew 1%/year and the GDP grew 6.5%/year during 2005-2010. The main contributor of the city's GDP is tertiary industry/commercial (73%) and secondary industry or manufacturing (15%).

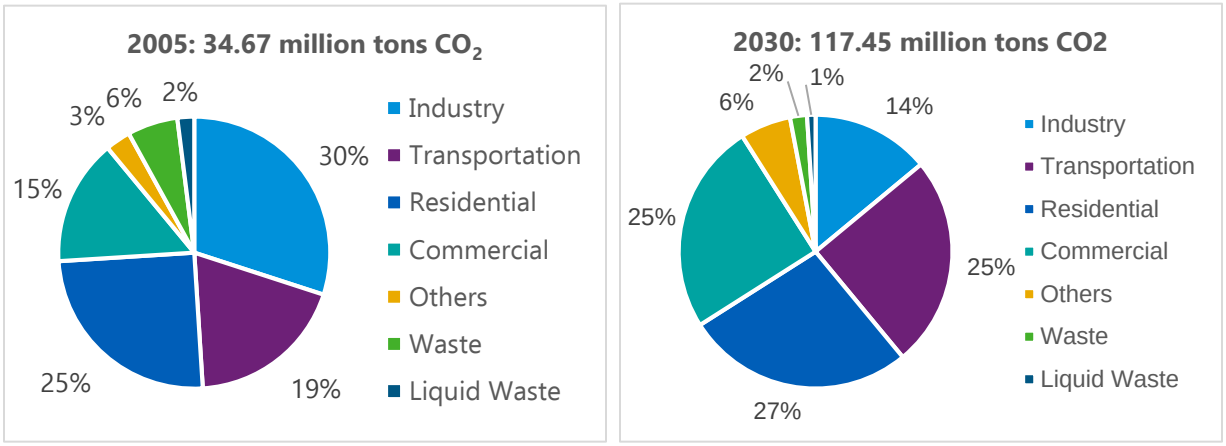
Current Scenario:

The city is characterized as having high motorized vehicle (cars and motorcycles) density, limited public transport infrastructure. Population growth, economic characteristics, and transportation condition lead to the high GHG emission level, i.e. 3.84 ton CO_2e per capita (2005), of which energy sector accounted for 89% of total GHG emission. As comparison, at the same year, domestic GHG emission is 3.01 ton CO_2e per capita.

This study presents results of a modelling study concerning Low Carbon City Scenario for Jakarta towards 2030. The study aims to identify development paths that will bring Jakarta becomes Low Carbon City in 2030.

Methodology:

The tool used in this research is non-linear programming model ExSS (Extended Snap Shot) using GAMS (General Algebraic Modelling System) v 23.3 supported by various technical, economic and social parameters (Dewi et al., 2010 and Dewi, 2012). The method based on back casting approach is developed with sets of desirable goal first and then seek the way to achieve it.

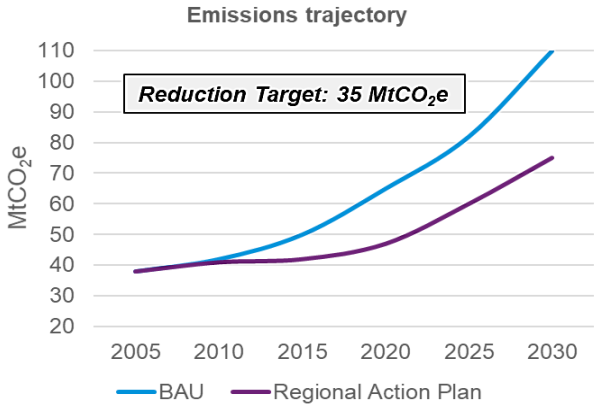


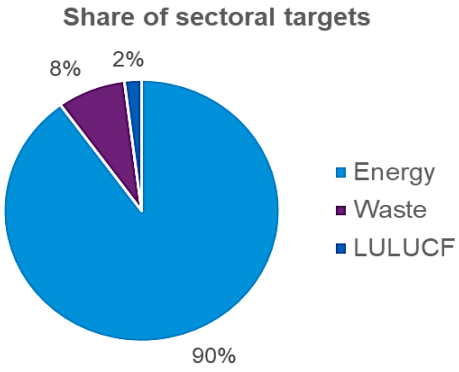
Source: Jakarta Planning Development Board

Figure 12: Sector Wise CO_2 emissions

Solution:

1. COP15 Denmark, Jakarta commits to reduce GHG emissions by 30% in the year 2030
2. Released Governor Regulation 38/2012 on Green Building and Governor Regulation 131/2012: Regional Action Plan for reduction of GHG emissions
3. Released Grand Design unveiling commitment to reduce water and energy consumption





ENERGY SECTOR TARGET	
Industry	10.8 $MtCO_2e$
Transportation	9.8 $MtCO_2e$
Commercial	5.7 $MtCO_2e$
Residential	5.2 $MtCO_2e$
Others	0.07 $MtCO_2e$

WASTE SECTOR TARGET	
Solid	2.6 $MtCO_2e$
Liquid	0.3 $MtCO_2e$

LLUCF TARGET	
Forest	0.6 $MtCO_2e$

Source: Jakarta Planning Development Board

Figure 13: GHG reduction target for 2030

Till 2016, Jakarta has achieved 13.58% of its target and would require an emission reduction of 95

Mitigation Action	Mitigation Monitoring Evaluation Report (ton CO_2e)					Emission Reduction Target Regional Action Plan-GHG (ton CO_2e)	
	2012	2013	2014	2015	2016	2020	2030
Public Street Lighting using energy-saving lamps	50	1.293	11.556	20.314	28.519	65.147	67.110
Public Street Lighting using solar cell	26	54	10	10	111	-	-
Solar cell in schools and government buildings	1	24	80	88	85	-	-
Solar cell in Sebira Island	4	69	62	60	59	-	-
Busway / Bus Rapid Transit	83.933	207.166	333.835	162.943	32.214	182.064	309.917
Feeder Busway	n.a	n.a	n.a	10.265	48.562	100.932	367.306
Intelligent Transport System (ITS)	34.405	34.405	27.424	5.940	-	62.437	65.848
Electric train	n.a	n.a	n.a	241.059	148.107	169.500	171.300
Energy efficiency in government buildings	n.a	n.a	32.446	35.831	4.601	49.430	129.458
Green building	6.809	8.090	11.913	13.789	14.388	1.479.086	5.522.972
Gas engine utilization in commercial buildings	n.a	n.a	n.a	21.504	19.262	-	-
Reducte of own use power plant	n.a	n.a	n.a	n.a	49	-	-
Power Plant Effieciency Escalation	n.a	n.a	n.a	n.a	3.711.837	-	-
Landfill Gas	276.690	197.557	117.348	67.785	48.195	838.937	838.937
Green Open Area	8.456	1.494	653.05	741.3	671.34	445	445
Biodiesel	114.975	179.645	n.a	n.a	n.A	1.396.600	4.145.200
LPG	1.845.185	1.894.197	n.a	n.a	n.A	91.633	101.581
Composting	n.a	n.a	7.698	18.890	27.377	138.174	138.174
3R Center	n.a	n.a	96.096	22.830	29.155		
Sewage treatment plant (Duri Kosambi & Pulo Gebang)	n.a	n.a	n.a	n.a	606	214.306	214.306
Wastewater treatment / Setiabudi Reservoir	n.a	n.a	n.a	n.a	1.849	100.511	150.766
TOTAL	2.370.534	2.523.994	1.291.518	1.362.608	4.786.327	14.612.205	35.240.080

$MTCO_2e$ by 2030 to comply with the set targets as given in Figure 14 given below:

Source: Low Carbon Development in DKI Jakarta, Jakarta Planning Board

Figure 14: GHG Reduction Achievement till 2016

The selected mitigation actions result in emission reduction of 35 million tCO_2 in 2030 compared to emission in BaU.

Green Zone (Climate Kampong) Development Acceleration Through New Building Standards, Jakarta (Case Study, 2018)

About the city:

Jakarta is the capital and largest city of Indonesia. Located on the northwest coast of the world's most populous island of Java, it is the centre of economy, culture and politics of Indonesia with a population of more than ten million as of 2014.The Jakarta metropolitan area has an area of 6,392 square km, and is the world's second most populous urban area after Tokyo, with a population of 30 million as of 2010

Current Scenario:

In 2004, in Indonesia, energy demand from the building sector accounted for around 27% of the total energy consumption, and this figure is expected to increase to up to 40% by 2030, with the majority of new buildings expected to rise in Jakarta. The International Finance Corporation (IFC) noted that up to one-third of the energy and water consumed by buildings in Indonesia, including those in its capital city, can be reduced through better building design and management.

Solution:

Supported by the IFC and assisted by the Clinton Climate Initiative and since 2009 by C40, Jakarta's local government has identified low to middle-income high-rise housing in Daan Mogot as the pilot area for the Green Zone project. The built area will cover 176,098 Ha and will consist of 7 sixteen-storey high-rise buildings, the Jakarta Grand Mosque - in process of completion - schools and hospitals.

Innovation:

To accelerate the implementation and development of the Green Zone project, the Governor established a Green Building Forum composed of a group of various stakeholders, aiming to mainstream the concept of Green Building as it has been defined by the Governor Regulation of DKI Jakarta No.38/2012 on Green Building and the Governor Instruction No. 30/2017. This Green Zone Project is part of the pilot implementation of "30:30 Commitment", which is Jakarta's commitment to reduce water and energy consumption, as well as GHG emissions by 30% by 2030.

Energy Savings	•853,914 MWh/year
Cost Savings	•68,313,105 US$/year
CO_2 Reduction	•605,425 Metric Tonne/year

Figure 15: Total amount of savings & CO_2 reduction

Case Study 3 – Samui Island (Thailand)

Samui Island (Thailand) (Energy Smart Communities Initiative)

The Samui Green Island Project aims to reduce CO_2 emissions as well as reduce and reuse solid waste and treated waste water for non-sanitary purposes. The project has developed a comprehensive strategy to meet these goals that includes reducing CO_2 emissions in the transportation and building (both residential and commercial) sectors through public awareness campaigns, planning and engineering techniques, and advances in technology.

It was estimated during a previous feasibility study conducted in the year 2006 that energy supply/demand side management alone could avoid the release of more than 80,000 CO_2 per year. However, that target must be re-evaluated in light of current trends, such as increased private transportation, and the construction of additional tourist facilities.

New estimates for potential CO_2 reduction have been estimated at 20 – 30 % in the year 2030 (over 2010) for a savings of between 120,000 – 180,000 tones CO_2 per year. Potential projects for CO_2 reduction are:

- reduction in energy use in homes and commercial buildings by installing energy efficient equipment and installing solar PV for generating clean energy;
- reduction from fuel switching either to bio-diesel or CNG in ferry transportation;
- reduction from the implementation of public transport, including EV buses;
- reduction from the implementation of district cooling;
- reduction from the implementation of renewable energy, along with recovery of waste heat;
- reduction from the introduction of LED street light;
- reduction from the reduced amount in landfill and methane (CH_4) fermentation

In addition to reducing CO_2 emissions, the plan for the Samui Green Island Project to be a "Clean and Green Development" calls for sorting solid waste to avoid sending it to the landfill, reusing treated waste water for non-sanitary purposes, and promoting the development of open, green spaces in an effort to attract tourist activity. Furthermore, the introduction of sidewalks and bicycle lanes along the beach will increase the island's attractiveness to tourists, while improving quality of life for the island's residents.

Case Study 4 – Ngu Hanh Son District, Viet Nam

Ngu Hanh Son District in Danang City, Viet Nam (Energy Smart Communities Initiative)

Danang City has proposed a LCT model for its Ngu Hanh Son District. The proposal incorporates new technologies and a "policy of an effective dissemination" to accomplish the ambitious goal of incorporating the use of biomass energy, effective transportation systems, and energy efficient buildings to achieve model LCMT status.
The Ngu Hanh Son District in Danang City intends to implement the following strategies:

1. Methane recovery and effective utilization of biomass energy
    - Utilize methane generated from a sewage disposal and a kitchen waste for a fuel material of Bus Rapid Transit (BRT).
    - Utilize bio-diesel produced from seed oil of plant for a fuel material of BRT.
2. Low carbon-emission transportation system
    - Promote electric motorcycle: Establishing a restricted area for engine motorcycles in Ngu Hanh Son District, and building free plug-in stations.
    - Establish a low-carbon transportation system using BRT along trunk road which runs from the airport and urban area to Ngh Hanh Son District.
3. Introduction of technologies of energy saving and CO_2 saving into buildings
    - Encourage employing the technologies into public facilities
        i. Air conditioning system with heat pump using river water or sea water,
        ii. BEMS, HEMS and CEMS,
        iii. Photovoltaic power plants,
        iv. Eco-friendly landscape design
    - Promotion policy introducing the technologies into the facilities of private sector
        i. Comprehensive assessment system for built environment efficiency,
        ii. Environment-consideration guideline for buildings.
4. Encouragement of dissemination of LCMT
    - Visualization of eco-friendly actions for urban residents,
    - Encouraging people's participation to eco-friendly action.

Table 8: Amount of CO_2 savings by implementing these strategies

Methods		Savings t-CO_2/yr
Sewage/Sludge	Methane generation emission 2116.1 m^3/day	**18,571,070**
Use of EVs	80% motorbike is replaced by EV	**152,338**
	BRT in the city	**22,532**

	Energy Management at Hotels	**49,292**

Source: LCMT scheme for Ngu Hanh Son District

Case Study 5 – Ho Chi Minh, Viet Nam

Ho Chi Minh, Viet Nam (Case Studies, 2015)

Current Scenario:

The city's current road system is congested and dangerous, experiencing an average of 4,700 accidents each year. Many of these crashes involve motorbikes, of which there are eight for every 10 people. The Saigon BRT line, which will expand to six corridors upon completion, will help ease this congestion and prepare Ho Chi Minh City for a safer and more sustainable future.

Solution:
In cooperation with the World Bank, Ho Chi Minh City launched the Green Transport Development Project in 2013, with the aim of catalyzing a cultural shift around transportation in the region and getting more people onto mass transit and off of the congested roadways. The cornerstone of the project is Saigon BRT, a 23 km bus rapid transit system that will accommodate up to 28,300 passengers daily when fully operational.

In addition to the bus infrastructure, the BRT corridor will also provide space for cycling and walking, as well as bike parking facilities. With Saigon BRT, the city seeks to transform how citizens view public transport and lay the ground-work for a more sustainable future based on transit-oriented development.

Social Benefits: By ensuring safer, faster, and more comfortable transportation, the Green Transport Development Project aims to change commuting habits and improve the public's attitude towards mass transit.

Economic Benefits: The city anticipates a substantial decline in traffic accidents and their associated costs due to the introduction of the BRT system.

Health Benefits: Ho Chi Minh City foresees improvements in air quality that will reduce cases of bronchial and asthmatic diseases among residents.

Key Impact
23,000 metric tons of CO_2 will be reduced by 2020

Case Study 6 – Ha Noi, Viet Nam

Ha Noi, Viet Nam (Case Studies, 2019)

About the city:
Ha Noi is the capital and one of the five municipalities of Viet Nam. It covers an area of 3,328.9 square km (1,285 square mile). With an estimated population of 7.7 million as of 2018, it is the second largest city in Viet Nam. The metropolitan area, encompassing nine additional neighboring provinces, has an estimated population of 16 million. Located in the central area of the Red River Delta, Ha Noi is the commercial, cultural, and educational centre of Northern Viet Nam.
Current Scenario: With a population of 93 million people, Viet Nam generates daily nearly 35,000 tons of urban domestic waste and 34,000 tons of rural domestic waste. In the capital city of Ha Noi alone, 10,000 tons of solid waste are generated every day. Without a sustainable recovery process, waste resources are not being optimised.

Such resources could be for example utilised to generate electricity. Effective waste treatment for energy generation will help ensure energy security, reduce environmental pollution, and contribute to effective land use and green sustainable economic development.

Solution:

The Ha Noi Urban Environment Company (URENCO) and its partners (T&T Group and 3 leading Korean companies) agreed in September 2017 to jointly design, build, finance and operate a facility that will gather, process, and treat methane gas emitted from decomposing garbage to produce electricity, aiming to reduce methane emissions, environmental pollution and dependence on fossil fuels.
The landfill gas utilization plant will be developed at the Nam Son landfill in the Soc Son District, just outside Ha Noi. The waste treatment complex at Nam Son landfill is the largest of its kind in Ha Noi, treating around 4,000 metric tons of garbage per day and stretching across 83.5 hectares.
Following the completion of a feasibility study, the facility is expected to have a total capacity of 5MW.

Outcome:
It is estimated that the project will achieve emissions reductions of about **128,304 tCO_2e/year.**

Ha Noi Bus Rapid Transit System (Case Study, 2019)

About the city:
Ha Noi is the capital and one of the five municipalities of Viet Nam. It covers an area of 3,328.9 square km (1,285 square mile). With an estimated population of 7.7 million as of 2018, it is the second largest city in Viet Nam. The metropolitan area, encompassing nine additional neighboring provinces, has an estimated population of 16 million. Located in the central area of the Red River Delta, Ha Noi is the commercial, cultural, and educational center of Northern Viet Nam.

Current Scenario:
Ha Noi's transportation has been characterized by the dominance of motorcycles, a symbol of high personal mobility associated with rapidly rising incomes. Over 5 million motorcycles and 585,000 private cars are occupying 85.8% of the city's road networks. Congestion was already becoming a critical problem in the city. Traffic was in general unorderly and sometimes chaotic at intersections, posing safety concerns and exacerbating air pollution

Solution:
The City of Ha Noi, backed by the World Bank, approved the construction of a critical road infrastructure (a Bus Rapid Transit system) to improve access to cities less developed areas and to facilitate an environmentally sustainable urbanization of Ha Noi.

This BRT project has been designed as a Specific Investment Loan, with the Global Environmental Facility (GEF) co-financing a set of initiatives that either would reduce barriers to project implementation or maximize its global environmental benefits. The project is consistent with the GEF Operational Program 11th objective of 'Promoting Environmentally Sustainable Transport' and the GEF climate change strategic priority related to sustainable transport. The Ha Noi Bus Rapid Transit (BRT) system proposed in this project has also been the first such system financed by the World Bank in Asia, with the potential to be a high-profile demonstration for bus-based mass rapid transit in the region.

Key Achievements:
14,000 people use the service each day, 80% of whom are students and office workers. According to the Ha Noi Department of Transport, 23% of riders have switched to using BRT from their private

vehicles. The BRT system has helped to increase urban mobility in targeted areas of the city, promoting more environmentally sustainable transport modes. It increased the use of public transport in selected traffic corridors and reduced travel time between the center and the west and northwest sections of Ha Noi.

The principal GHG emissions reduction comes from reduced car and motorcycle trips. The total GHG emissions reduction estimated until 2025 is **122,177 tons of CO_2e**.

Key Impact	Emission Reduction
• The introduction of a Bus Rapid Transit (BRT) system in Hanoi reduced motor vehicle access pressure on the inner city and private vehicles-driven GHG emissions, while improving urban mobility in targeted areas	• 20,000 tons CO_2e/year

Figure 16: Key Impacts of BRT system

Case Study 7: Cape Town - Transformative Land Use Plan Supports Transit

(Case Study, 2016)

About the city:

Cape Town is a legislative capital of South Africa, colloquially named the Mother City. It is the legislative capital of South Africa and primate city of the Western Cape province. It forms part of the City of Cape Town metropolitan municipality. The city is known for its harbour, for its natural setting in the Cape Floristic Region, and for landmarks such as Table Mountain and Cape Point. Cape Town is home to 64% of the Western Cape's population.

Current Scenario:

The Transport sector of Cape Town consumes a great deal of diesel, and transport, as a whole, is responsible for 34% of the city's CO_2 emissions.

Solution:

With its Transit Oriented Development Strategic Framework (TODSF), Cape Town is using transport as the foundation of its long-term land use management and growth development, marking a paradigm shift for the city, which wants to become more compact and connected. The TODSF's priorities include a modal shift towards public transport, the reduction of travel distances and costs, and the alleviation of urban sprawl through the optimization of land use. Concrete measures include a 12% improvement in access to transit and a 23% reduction in passenger km travelled by 2032. To embark on this new vision, Cape Town developed an optimized transport scenario that will direct the organization of different land uses, including transport zones, public utilities, and businesses, and identify the actors necessary to deliver the new developments. To facilitate the uptake of the new directives, this focus on transit- oriented development will be embedded within all strategic and built environment plans of the city and will be used as a sustainable growth management tool.

Environmental Benefits- The TODSF aims to have 20% fewer cars circulating in the city by 2032, which will improve the air quality of Cape Town. 1.6 million tons of CO_2 will be reduced from 2012 levels by 2032 under TODSF

Economic Benefits- By prioritizing transit-oriented development, the TODSF will decrease km traveled and transportation costs, particularly for low-income groups who currently spend 43% of their income on transport.

Health Benefits- By reshaping the city to allow for greater use of non-motorized transport such as walking and cycling, the TODSF will help residents lead healthier lifestyles

Case study 8: Stockholm - Becoming Fossil Fuel-free by 2040 (Case Study, 2015)

About the city:

Stockholm is the capital of Sweden and the most populous urban area in the Nordic countries. The city stretches across fourteen islands where Lake Malaren flows into the Baltic Sea. Stockholm is the cultural, media, political, and economic centre of Sweden. The Stockholm region alone accounts for over a third of the economy's GDP, and is among the top 10 regions in Europe by capital. It is an important global city, and the main centre for corporate headquarters in the Nordic region.

The Challenge:

Stockholm aims to be a true world leader as the largest city to become fossil-fuel free. In the past few years it has surpassed many of its climate change goals, proving it has the political will and technical experience necessary to achieve its ambitious target of a renewably-fueled future.

Solution:

In 2012, the City of Stockholm set the goal of becoming fossil fuel-free by 2050. Driven by ambitious leadership and actionable goals, in 2015, the city pushed the target date up by a decade, and now plans to run exclusively on renewable energy by 2040. The comprehensive plan relies on overall energy reduction and an increase in renewable energy use. For instance, energy standards for new buildings built on city-owned land are 55 kWh/m^2 compared with domestic standards of 80 kWh/m^2. Similarly, the city aims to reduce energy use in the building sector by 50% between 1995 and 2050.

By 2040, natural gas will be entirely phased out of the city's energy grid and heating system, replaced primarily by biogas. The energy company that provides district heating is particularly ambitious and has decided to phase out fossil fuels by 2030; starting in 2016, renewable energy will be able to fuel 90% of the city's district heating system, up from 80% today. Increasing the use of renewable energy in transportation from 16% to 100% by 2040 will likely be the city's most significant challenge, as this will entail removing all conventional fuel-powered vehicles from the city's streets. To achieve this goal, the city plans to double the capacity of the public transport system, while improving walking and biking infrastructure.

Key Benefits: 57% reduction in CO_2 emissions by 2020 based on 1990 levels

Comparative of best practices across shortlisted cities:

Table 9: Comparative table showcasing different interventions implemented in cities

Sectors	Hue, Viet Nam	Jakarta, Indonesia	Samui Island, Thailand	Ngu Hanh Son, Viet Nam	Ho Chi Minh, Viet Nam	Ha Noi, Viet Nam	Wuhan's Baibuting Community	Ha Noi, Viet Nam	Jakarta, Indonesia	Cape Town, South Africa	Stockholm, Sweden
Transport	Green houses for emission reduction.	Intelligent Transport System, Electric Train	Fuel switching to bio diesel or CNG, use of EVs	Utilized bio diesel and methane generated from sewage disposal as fuel for BRT, use of EVs	Use of bus rapid transit system		Use of bio fuels, intelligent transportation system	Use of bus rapid transit (BRT) instead of motorbikes		Optimization of land use and efficient vehicles	Use of EVs in public and private transportation
Residential buildings		Green Buildings	Energy efficient equipment				Use of LED lightings, use of solar energy		Green Building Implementation		Use of Solar PV, Solar heaters and use of biogas
Commercial buildings			Energy efficient equipment	Air conditioning system with heat pump, photovoltaic power plants, green buildings							Use of Solar PV, Solar heaters
Waste		Landfill gas, sewage treatment plant, wastewater treatment	Reduced amount of landfill and methane fermentation				Wastewater treatment				
Energy supply		Solar PV in schools and government buildings	Use of renewable energy and waste heat recovery			Waste to electricity generation					
Municipal Street Lighting		Public street lighting using energy saving lamps, solar cells	Use of LED street light								
Total tCO_2 Reduction	**100-200 tCO_2/year**	**4.78 Million tCO_2/year (achieved till 2016)**	**120 -180 kilo-tCO_2/year (estimated for the year 2030)**	**18795 kilo-tCO_2/year (proposed)**	**23,000 tCO_2/year (reduction by 2020)**	**128,304 tCO_2/year (estimated)**	**30,000 tCO_2/year (achieved so far)**	**20,000 tCO_2/year**	**605,425 tCO_2/year (estimated reduction by 2030)**	**1.6 Million tCO_2 till 2032**	**25 $MtCO_2$ by 2020**

5 Business as Usual Scenario

This section of the report discusses the Business as Usual (BAU) scenario of following sectors for Davao City of the Philippines.

Table 10: Sectors considered to study BAU scenario for Davao city

Davao City - the Specific Area for LCT - I				
NO.	**Location**	**Demand/Supply**	**Sector**	**Sub areas considered for BAU section**
1	Whole city of Davao	Demand	Transportation	1. Cars 2. Utility Vehicles (UV) 3. Sport Utility Vehicles (SUV) 4. Taxis 5. Motorcycle 6. Tricycle
			Building	1. Residential a) Bungalow/Single house b) Apartment c) Duplex d) Condominium e) Other types 2. Commercial a) Banks b) Hotel c) Office Buildings d) Store e) Other types
			Agriculture	1. Fishery 2. Agri Crop production
		Supply	Conventional Sources of Energy	1. Coal 2. Natural Gas 3. LPG 4. Petrol 5. Diesel 6. Kerosene 7. Fuel oil
			Renewable sources of energy	1. Solar 2. Wind 3. Geothermal 4. Hydro 5. Biofuel 6. Biomass

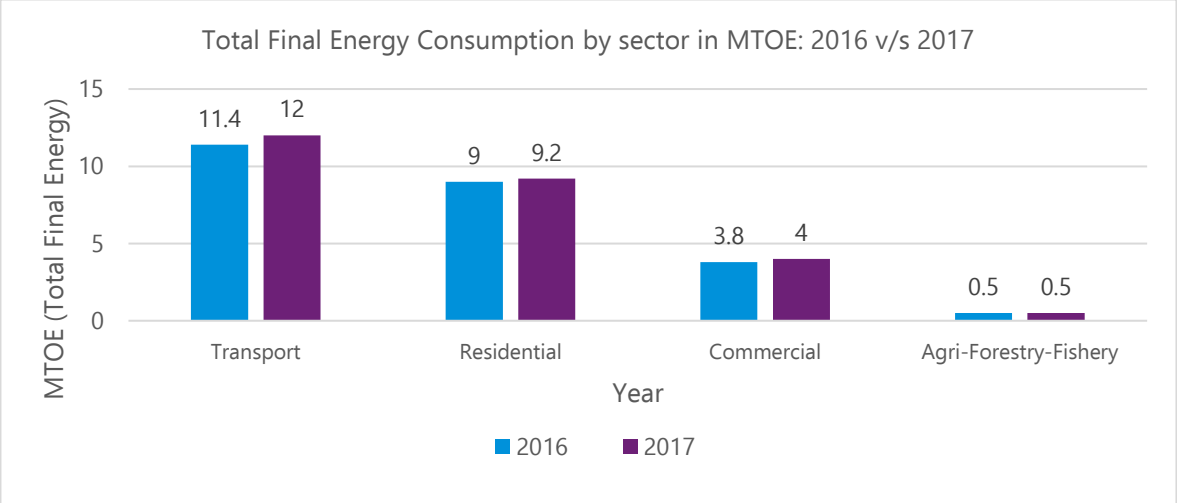
This chapter is divided into three sub sections viz. Sector wise total energy consumption, total primary energy supply, and environmental impact. Due to limitation in the availability of city level data, the information provided in these sub-sections are derived from domestic data available in the public domain of respective economies. Following steps were adopted to derive city level information:

Table 11: Steps to determine City Level information from an Economy Level Information

STEPS TO DETERMINE CITY LEVEL INFORMATION FROM AN ECONOMY LEVEL INFORMATION	
Step 1	The project team has considered base year as FY 2017-18
Step 2	Energy Supply and Energy Demand (sector wise) of the entire economy in FY 2017-18 is considered
Step 3	Domestic Level Population for FY 2017-18 was obtained via secondary research
Step 4	City level Population for FY 2017-18 was obtained via secondary research
Step 5	Domestic Energy Supply and Demand (Sector wise) was divided by Domestic Level population and the result was multiplied by City level population to get city level data.

5.1 Davao City, Philippines

In 2017, the economy's total final energy consumption[21] (TEFC) reached 25.7 million tons of oil equivalent (MTOE), up by 4 % from its 2016 level of 24.7 MTOE (Figure 26). It can be observed from the figure below, that the energy consumption of all economic sectors increased during the period.

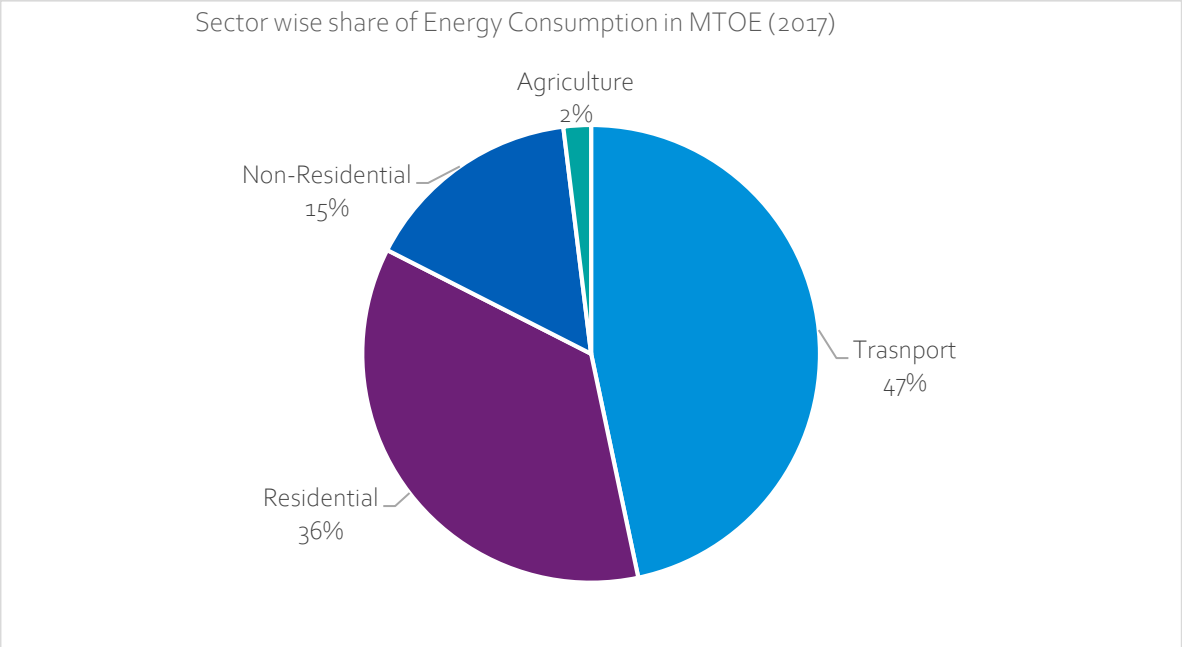


Source: Philippine Statistics Authority

Figure 17: Philippine total Final Energy Consumption by sector in MTOE: 2016 v/s 2017

As depicted in the Figure 19Transport retained its position as the most energy-intensive sector, accounting for more than one-thirds of total energy consumption. Its aggregate energy demand reached 12 MTOE, due to increase utilization of petrol, electricity and fuel oil for land transport (road and rail). Energy Use in the residential sector contributed around 27% share to the demand mix, albeit a sluggish increase to 9.2 MTOR during the period. Meanwhile, the robust economic performance of the services sector, which includes banks, retails, IT, consulting, telecommunication and the like, translated to a double-digit hike of 14% as its energy consumption reached 4 MTOE from its 2016 level of 3.8 MTOE. Likewise, the agriculture, fishery and forestry (AFF) sector registered energy consumption level of 0.5 MTOE in 2017.

[21] Note: As Industry sector is excluded from the analysis of Davao City, therefore, its details are also not considered in this section.



Source: Compendium of Philippine Energy Statistics and Information

Figure 18: Sector wise share of total energy consumption in the Philippines (2017)

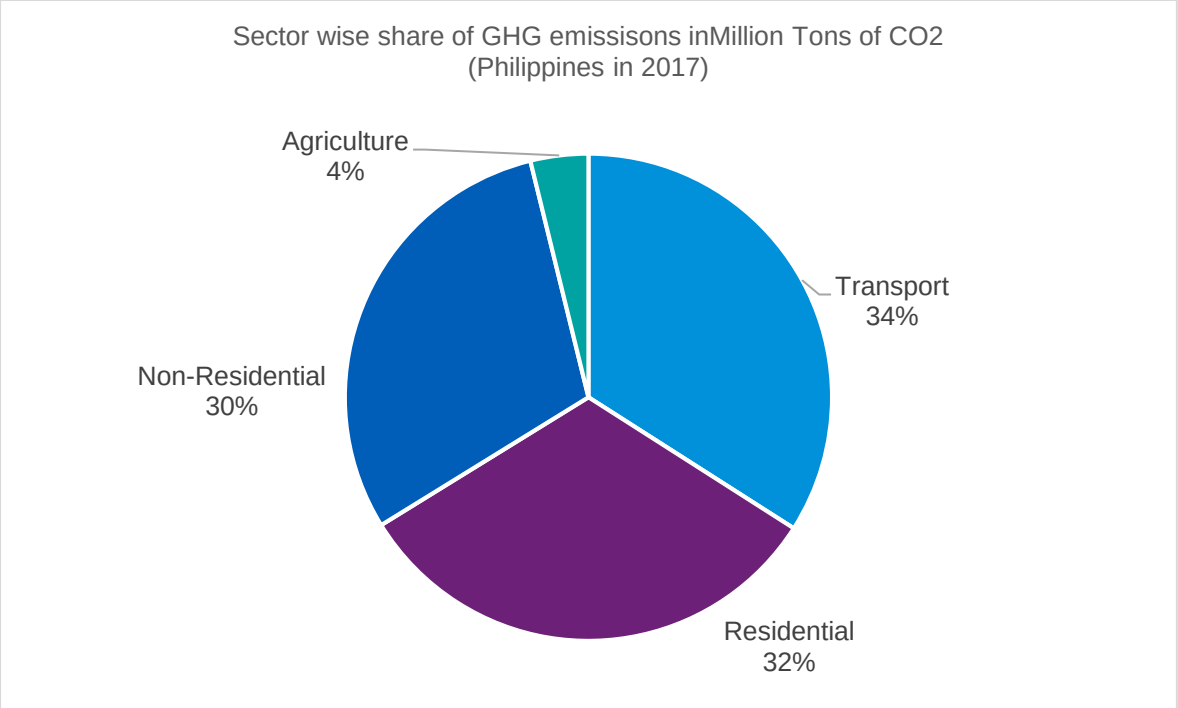
Table 12: Philippines - Economy Level: total final energy consumption, by sector in KTOE

PHILIPPINES	Total Final Energy Consumption, by Sector in KTOE							
Sector	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017 (Est.)**
Transport	8035	7983	8364	8785	9134	10556	11425	**12014**
Residential	7878	7991	8171	8386	8489	8731	9035	**9213**
Commercial	2663	2739	2830	3038	3397	3370	3865	**4076**
Agriculture	347	302	318	352	354	401	450	**467**
Total	**18923**	**19015**	**19683**	**20561**	**21374**	**23058**	**24775**	**25747**

Source: DOE Govt. of Philippines website

The energy consumption by each sector as depicted in table above, had led to GHG emissions. As per Source: Philippine Statistics Authority

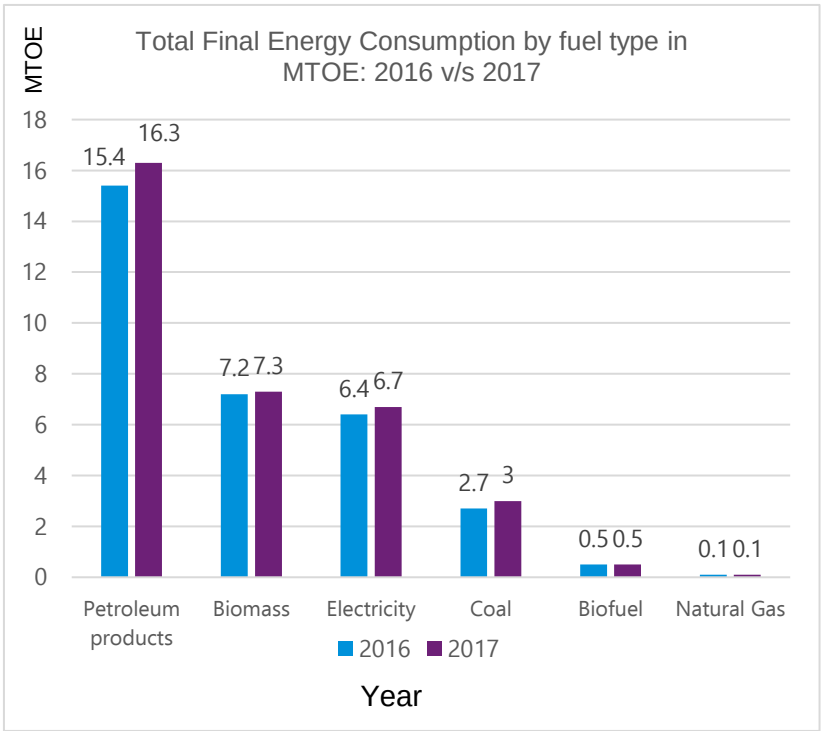
Table 18, the emission in 2017 from Transport sector was 5% more than 2016. Similarly, for residential and commercial sector, the emission in 2017 is 3% and 7% more than 2016.However, the emission from agriculture sector remained the same in both the years 2016 and 2017.



Source: Compendium of Philippine Energy Statistics and Information

Figure 19: Sector wise GHG emissions of the Philippines in 2017

As per Figure 19,Petroleum products accounted for a hefty share in the economy's TFEC, as its consumption went up by 6%, from 2016 level to 2017. The trends of domestic oil prices in 2017 encouraged consumption of petrol and diesel, as levels went up by 8.8% and 6.5% respectively, bringing in a combined share of 79.5 % to the total petroleum consumption. Biomass was the second most consumed fuel in 2017. Biomass utilization of households, accounting for more than 3/4th of the total demand for biomass. Electricity came in third after oil and biomass and contributed 19.8% share to TFEC in 2017. Its consumption increased by 4.9%. Meanwhile, consumption of coal registered an upsurge of 12.4 % in 2017, from 2016.



Source: Philippine Statistics Authority

Figure 20: Total final energy consumption by fuel type in MTOE: 2016 v/s 2017

However, the consumption of biofuels and natural gas has remained constant during the period 2016 and 2017.

Like the domestic situation, relevant data (as per Table 13) for the Davao city has been derived using population for FY 2017-18.

5.1.1 Total final energy consumption, by sector

Population of the Philippines in FY 2017-18 was 104.9 million[22], and for Davao city was approximately 1.7 million[23]. Using this information, sector wise energy consumption for the city is calculated and presented in table below.

Table 13: Davao City Level: total final energy consumption, by sector in KTOE

DAVAO	in KTOE							
Sector	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017 (Est.)**
Transport	130	130	136	143	148	171	185	**195**
Residential	128	130	133	136	138	142	147	**149**
Commercial	43	44	46	49	55	55	63	**66**
Agriculture	6	5	5	6	6	7	7	**8**
Total	**307**	**308**	**319**	**334**	**347**	**374**	**402**	**418**

Source: DOE Govt. of Philippines website

Further, details of each sector are discussed in the next sub section.

5.1.1.1 Transport sector

As Davao city has limited number of air and train connections, only roadways transportation has been studied for this assignment. So, it was discussed not to include both the modes in our study.

The City has a total of 1,856 km (Comprehensive Land Use Plan (2013-2022)) of roads and highways, 7% are domestic roads, 39% are city roads and 54% are barangay roads (Comprehensive Land Use Plan (2013-2022)).Road density on the other hand is below the domestic standard of 1 km per square km of land. Davao City has a density of 0.83. As of 2011, there are 65 bridges in Davao City, 34 of which or 54% of the total need replacement (Comprehensive Land Use Plan (2013-2022)).

Davao City's main road network consists of:
- Domestic Arterial roads
- Domestic Secondary roads
- City roads
- Barangay roads.

Domestic roads connect the city to surrounding areas via three main exit points:
- Davao - Cotabato Road/McArthur Highway (south-west)
- Davao - Bukidnon Road (north-west)
- Davao - Carmen Road/Pan-Philippine Highway (north-east).

Types of Transport: Transport services in the Davao city consist mainly of jeepneys (public utility vehicles), cars, taxis, tricycles, and motorcycles that are privately owned and operated. In 2012, utility

[22] Source: World Bank, StatCan
[23] Source: http://population.city/philippines/davao-city/

vehicles in Davao city comprised 29,714 (59%) of the 49,857 utility vehicles in entire Davao Region. The annual growth rate of motorcycle is 9.1%, highest among all the types of vehicles available in Davao.

Vehicle Registrations and their growth: Registration of vehicles is carried out by several LTO[24] offices in the Davao Region. Table below (See Table 14) indicates the numbers registered from the year 2010 -2012. Based on Compound Annual Growth Rate (CAGR), these numbers are extrapolated further till year 2017. The growth pattern (2010-2017) of all the vehicle types are seen in Figure 21, followed by overall growth in GHG emissions by transport sector for the period 2010 - 2017 in Figure 22.

Table 14: Registration of Vehicles

Vehicle Type	2010	2011	2012	2013 (Est.)	2014 (Est.)	2015 (Est.)	2016 (Est.)	2017 (Est.)	CAGR
Private									
Cars	13,888	12,459	11,473	11,242	10,370	9,498	8,626	**7,754**	**-6%**
Utility Vehicles	33,429	31,605	29,714	30,875	30,613	30,351	30,090	**29,828**	**-3%**
Motor Cycles	55,387	57,851	73,643	93,797	109,201	124,605	140,009	**155,413**	**10%**
Public									
Taxis	2,858	1,932	2,275	2,066	1,911	1,755	1,600	**1,445**	**-7%**
Utility Vehicles	6,890	6,364	7,197	6,877	6,893	6,909	6,925	**6,941**	**1%**
Buses	206	222	289	278	296	315	333	**352**	**12%**
Tricycles	1,398	1,597	2,788	2,757	3,145	3,533	3,921	**4,309**	**26%**
Trucks & Trailers	9,609	8,887	8,621	8,515	8,321	8,127	7,933	**7,739**	**-4%**

Source: Project Number: 45296 December 2013, Republic of the Philippines: Davao Sustainable Urban Transport Project by Asian Development bank (ADB)

Note: the number of private 4-wheeled motor vehicles registered has remained remarkably stable over that period, and the only very strong growth has been in motorcycles and tricycles.

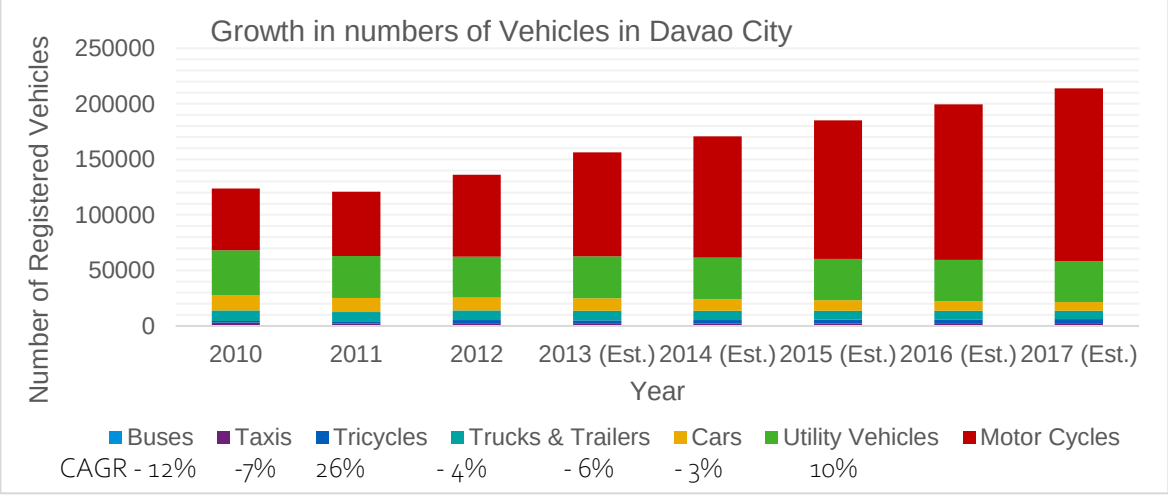
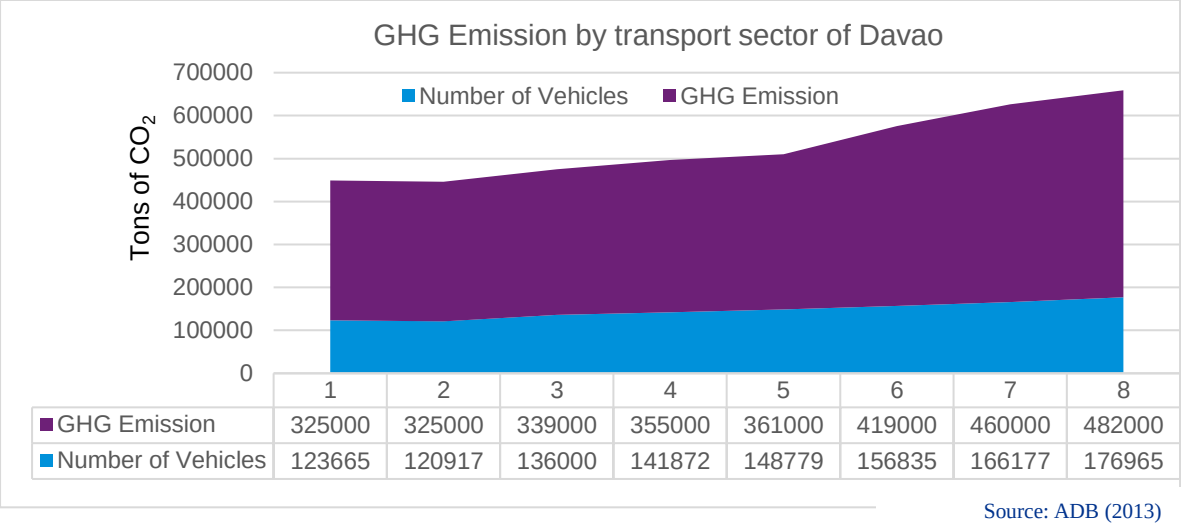


Figure 21: Growth in numbers of vehicles in Davao city (2010-2017)

[24] **Land Transportation Office (LTO)** is an agency of the Philippine government under the Department of Transportation and is responsible for all land transportation in the Philippines, which includes the inspection and registration of motor vehicles.



Source: ADB (2013)

Figure 22: GHG emission growth in transport sector between 2010 and 2017

During 2010-2017, Davao city has added around 53,000 vehicles on its road. This has led to addition of 0.16 Million Tons of CO_2 in the atmosphere. Overall, growth of 4.58% in vehicle registration has led to 5.05% growth in GHG emission in the past 8 years[25] (2010 to 2017). As the growth in GHG emission is slightly more than the growth of registered vehicles, it is therefore recommended that relevant low carbon interventions should be proposed so that the GHG emission becomes inversely proportional to the number of vehicles registered. This would help Davao's economy grow without corresponding increases in environmental pressure.

Energy consumption by fuel type: Road transportation accounts for major consumption of fuels. Based on economy level information, the project team has derived energy consumption by fuel type for Davao City.

Table 15: Energy consumption by fuel type in Transport sector (Roadways) for the Philippines and Davao City (FY 2016-17)

in KTOE							
PHILIPPINES	ROADWAYS ONLY						
FY	**Petrol**	**Diesel**	**LPG**	**Natural Gas**	**Bioethanol**	**Biodiesel**	**Electricity**
2010	2866	3966	74	-	98	82	-
2011	2831	3917	46	1	108	92	-
2012	2921	4127	39	1	172	85	-
2013	3086	4244	57	1	222	87	-
2014	3026	4452	42	-	246	92	-
2015	3498	5165	30	-	281	107	-
2016	3863	5673	13	-	309	116	-
2017 (Est.)	4031	5971	10	-	364	122	-

[25] Source: LTO Region XI annual report

DAVAO	ROADWAYS ONLY						
FY	**Petrol**	**Diesel**	**LPG**	**Natural Gas**	**Bioethanol**	**Biodiesel**	**Electricity**
2010	46.49	64.34	1.20	-	1.59	1.33	-
2011	45.92	63.54	0.75	0.02	1.75	1.49	-
2012	47.38	66.95	0.63	0.02	2.79	1.38	-
2013	50.06	68.85	0.92	0.02	3.60	1.41	-
2014	49.09	72.22	0.68	-	3.99	1.49	-
2015	56.74	83.79	0.49	-	4.56	1.74	-
2016	62.67	92.03	0.21	-	5.01	1.88	-
2017 (Est.)	**65.40**	**96.86**	**0.16**	**-**	**5.91**	**1.98**	**-**

Source: Compendium of Philippines energy statistics

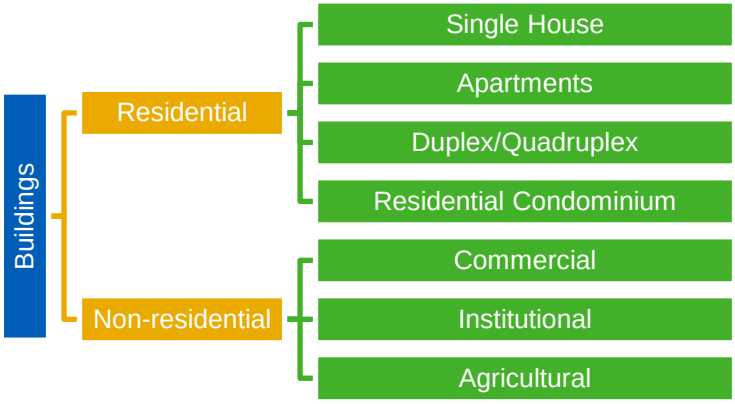
As till 2017, the usage of EV's is very low, so the electricity consumption in transport sector has not been considered. Similarly, for the building sector, information related to Residential and Commercial establishment was derived for the city and discussed in this sub-section.

5.1.1.2 Building sector – Residential & Commercial

The population of the Philippines has been steadily growing for many years. It is the 13th most populated economy in the world, and its population grew at a rate of 1.622% (Philippines Population, 2019). As the population started to increase in the city, the requirement of residential and non-residential space started to increase.

There are following types of residential and non-residential building types of Davao city.

Types of Buildings[26]:



Number of Construction: As Davao city is geographically situated in the province of ***Davao del Sur*** and grouped under the province by ***the Philippine Statistics Authority***, the project team reviewed construction data available with Philippine Statistics Authority (Construction Statistics from Approved Building Permits for the year 2017) for Davao Region.

[26] Note: Industrial building type has been removed as this is not a part of this assignment's TOR.

Table 16: Number of residential building types in Davao Region, Philippines (2017)

Region/	Single	Duplex/ Quadruplex	Apartments	Condominium
	Number of Buildings			
PHILIPPINES	**95,366**	**1,757**	**13417**	**114**
XI - Davao Region	7,613	8	292	5
Davao Del Norte	2,316	1	19	-
Davao Del Sur	**3,406**	**2**	**270**	**5**
Davao Oriental	228	4	3	-
Compostela Valley	1,645	1	-	-
Davao Occidental	18		-	-

Source: Philippine Statistics Authority

Table 17: Number of commercial building types in Davao Region, Philippines (2017)

Region/	Banks	Hotel/Motel	Office Buildings	Stores
	Number of Buildings			
PHILIPPINES	**304**	**1648**	**1194**	**6821**
XI - Davao Region	22	161	341	307
Davao Del Norte	5	62	219	79
Davao Del Sur	**1**	**62**	**116**	**121**
Davao Oriental	4	3	3	43
Compostela Valley	10	31	3	56
Davao Occidental	2	3	-	8

Source: Philippine Statistics Authority

Table 18: Number of institutional building types in Davao Region, Philippines (2017)

Region/	School	Religion structure	Hospitals	Welfare/similar Charitable structure
	Number of Buildings			
PHILIPPINES	**1,823**	**911**	**357**	**52**
XI - Davao Region	150	66	20	1
Davao Del Norte	37	20	7	-
Davao Del Sur	**87**	**21**	**11**	**1**
Davao Oriental	6	5	-	-
Compostela Valley	19	12	2	-
Davao Occidental	1	8	-	-

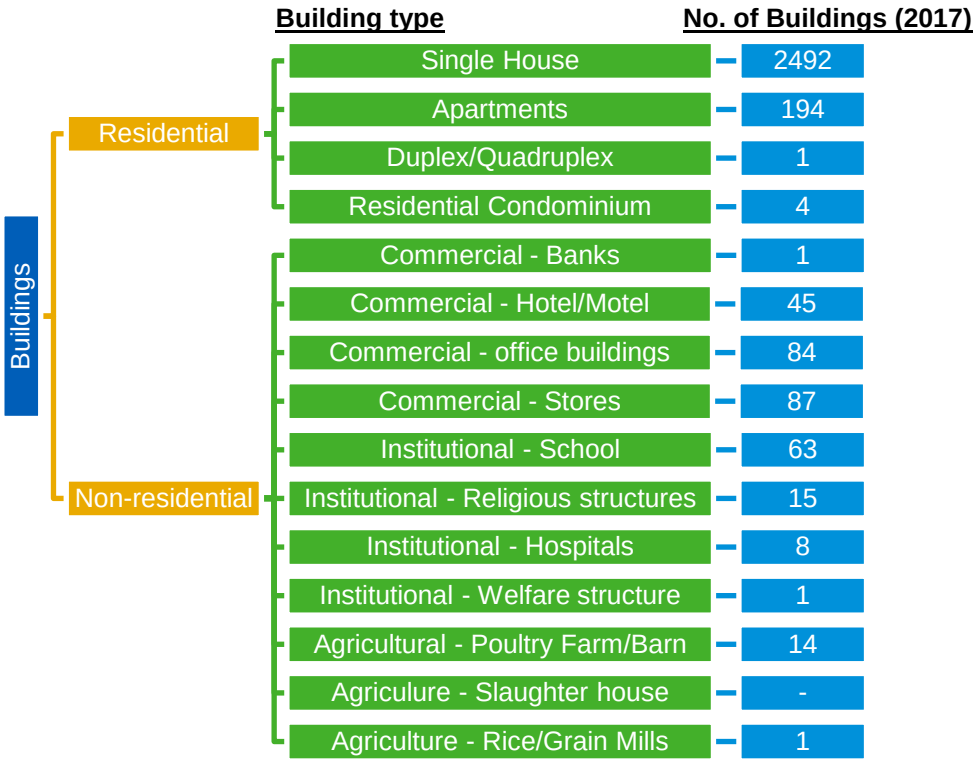
Source: Philippine Statistics Authority

Table 19: Number of agricultural building types in Davao Region, Philippines (2017)

Region/	Barn/Poultry House etc.	Rice/Grain Mill	Slaughter house
	Number of Buildings		
PHILIPPINES	**984**	**93**	**8**
XI - Davao Region	33	2	-
Davao Del Norte	3	1	-
Davao Del Sur	**20**	**1**	**-**
Davao Oriental	1	-	-
Compostela Valley	7	-	-
Davao Occidental	2	-	-

Source: Philippine Statistics Authority

Davao is the second most populous city after Manila in the Philippines. The population of Davao city is 72% of the total population Davao Del Sur, therefore is estimated that 72% of the residential and non-residential buildings will be available in the Davao city.



Energy consumption by fuel type: Residential & Non-Residential buildings accounts for major consumption of fuels. Based on economy level information, the project team has derived energy consumption by fuel type for Davao City.

Please note: *Building type wise energy consumption is not available*

Table 20: Energy consumption by fuel type in Residential sector for the Philippines and Davao City (FY 2017-18)

PHILIPPINES	in KTOE					
FY	Electricity	Charcoal	Fuelwood	others	LPG	Kerosene
2010	1619	765	4016	547	803	127
2011	1607	804	4099	565	804	112
2012	1693	848	4158	571	796	105
2013	1772	899	4246	589	776	104
2014	1803	946	4290	588	769	93
2015	1956	973	4259	570	888	85
2016	2204	1027	4131	551	1043	79
2017 (Est.)	2303	1071	4148	552	1083	74

Source: Compendium of Philippines energy statistics

DAVAO	in KTOE					
FY	Electricity	Charcoal	Fuelwood	others	LPG	Kerosene
2010	26	12	65	9	13	2
2011	26	13	66	9	13	2
2012	27	14	67	9	13	2

DAVAO	in KTOE					
FY	Electricity	Charcoal	Fuelwood	others	LPG	Kerosene
2013	29	15	69	10	13	2
2014	29	15	70	10	12	2
2015	32	16	69	9	14	1
2016	36	17	67	9	17	1
2017 (Est.)	37	17	67	9	18	1

Source: Project team analysis

Similarly, for non-residential building, energy consumption data is as in table below.

Table 21: Energy consumption by fuel type in Non-Residential sector for the Philippines and Davao City (FY 2017-18)

PHILIPPINES	in KTOE							
FY	Electricity	Charcoal	Fuelwood	others	LPG	Diesel	Fuel Oil	Biodiesel
2010	1398	152	153	8	215	549	177	11
2011	1429	154	156	8	208	626	145	13
2012	1529	157	159	8	204	632	129	13
2013	1574	159	161	7	228	776	116	15
2014	1613	162	164	7	266	1053	113	20
2015	1727	164	166	6	310	843	138	14
2016	1872	166	168	6	374	1058	201	21
2017 (Est.)	1952	168	168	6	405	1162	205	23

Source: Compendium of Philippines energy statistics

DAVAO	in KTOE							
FY	Electricity	Charcoal	Fuelwood	others	LPG	Diesel	Fuel Oil	Biodiesel
2010	23	2.47	2.48	0.13	3	9	3	0.18
2011	23	2.50	2.53	0.13	3	10	2	0.21
2012	25	2.55	2.58	0.13	3	10	2	0.21
2013	26	2.58	2.61	0.11	4	13	2	0.24
2014	26	2.63	2.66	0.11	4	17	2	0.32
2015	28	2.66	2.69	0.10	5	14	2	0.23
2016	30	2.69	2.72	0.10	6	17	3	0.34
2017 (Est.)	32	2.73	2.72	0.10	7	19	3	0.37

Source: Project team analysis

5.1.1.3 *Agriculture sector*

Similarly, for the agriculture sector, as per the economy level information the project team has derived energy consumption by fuel type for Davao City.

Table 22: Energy consumption by fuel type in agriculture sector (agri crop production and fishery) for the Philippines and Davao City (FY 2016-17)

PHILIPPINES	Agri Crop Production - in KTOE					
FY	Electricity	Gasoline	Diesel	Fuel Oil	Kerosene	Biodiesel
2010	23	-	18	-	-	-
2011	21	-	19	-	-	-
2012	24	-	24	-	-	-
2013	29	-	33	-	-	1
2014	32	1	30	-	-	1
2015	37	2	32	-	-	1
2016	39	2	32	-	-	1
2017 (Est)	42	2	35	-	-	1

Source: Compendium of Philippines energy statistics

DAVAO	Agri Crop Production - in KTOE					
FY	Electricity	Gasoline	Diesel	Fuel Oil	Kerosene	Biodiesel
2010	0.37	-	0.29	-	-	-
2011	0.34	-	0.31	-	-	-
2012	0.39	-	0.39	-	-	-
2013	0.47	-	0.54	-	-	0.02
2014	0.52	0.02	0.49	-	-	0.02
2015	0.60	0.03	0.52	-	-	0.02
2016	0.63	0.03	0.52	-	-	0.02
2017 (Est)	0.68	0.03	0.56	-	-	0.02

Source: Project team analysis

PHILIPPINES	Fishery in KTOE					
FY	Electricity	Gasoline	Diesel	Fuel Oil	Kerosene	Biodiesel
2010	15	7	179	5	1	4
2011	14	4	153	4	1	1
2012	16	7	142	3	1	3
2013	19	2	148	4	1	3
2014	21	4	135	2	0	3
2015	24	6	150	3	0	3
2016	26	5	179	3	1	3
2017 (Est)	28	5	179	3	1	3

Source: Compendium of Philippines energy statistics

DAVAO	Fishery in KTOE					
FY	Electricity	Gasoline	Diesel	Fuel Oil	Kerosene	Biodiesel
2010	0.24	0.11	2.90	0.08	0.02	0.06
2011	0.23	0.06	2.48	0.06	0.02	0.02
2012	0.26	0.11	2.30	0.05	0.02	0.05
2013	0.31	0.03	2.40	0.06	0.02	0.05
2014	0.34	0.06	2.19	0.03	0.00	0.05
2015	0.39	0.10	2.43	0.05	0.00	0.05
2016	0.42	0.08	2.90	0.05	0.02	0.05
2017(Est)	0.46	0.08	2.90	0.05	0.02	0.05

Source: Project team analysis

5.1.2 Total primary energy supply

The Philippines, as a county supplies following fuels to the economic sectors to generate energy and function.

Table 23: Total Primary energy supply, fuel type for the Philippines (2017)

Philippines								
In KTOE	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017 (Est)**
Oil	13609	12787	13605	13754	14420	17211	18547	19386
Coal	7031	7726	8085	10003	10642	11615	13086	14300
Natural Gas	3028	3269	3134	2887	3036	2854	3270	3306
Geothermal	8538	8549	8813	8258	8863	9496	9519	9668
Hydro	1943	2414	2554	2494	2275	2157	2019	2030
Solar	0.11	0.1	0.11	0.12	1.42	11.91	94.33	248
Wind	5	8	6	6	13	64	84	126
Biomass	6679	6874	7035	7237	7356	7431	7494	7618
Biofuels	214	224	293	350	382	434	477	535

Source: Compendium of Philippines energy statistics

As the city level data was not available, the project team determined total primary energy supply for Davao city using domestic and city level population data. As a result, the estimated values for Davao city are as mentioned in the table below.

Table 24: Total Primary energy supply, fuel type for Davao city, Philippines (2017)

Davao City, Philippines								
In KTOE	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Oil	221	207	221	223	234	279	301	314
Coal	114	125	131	162	173	188	212	232
Natural Gas	49	53	51	47	49	46	53	54
Geothermal	139	139	143	134	144	154	154	157
Hydro	32	39	41	40	37	35	33	33
Solar	-	-	-	-	-	-	2	4
Wind	-	-	-	-	-	1	1	2
Biomass	108	112	114	117	119	121	122	124
Biofuels	3	4	5	6	6	7	8	9

Source: Compendium of the Philippines energy statistics

5.1.3 Environmental Impact

Overall in the Philippines, the total greenhouse gas (GHG) emissions from energy related activities in 2016 has increased by 10.5% to reach 118.5 million ton of CO_2 ($MTCO_2$) in 2017 from 107.2 $MTCO_2$ in 2016. The growth is due to increased activities in all sectors (including power and industry sector). Considering this growth in GHG emissions, the government has devised certain policies for Transport and Building sector. These policies as discussed in first chapter are as follows:

Table 25: List of policies for transport and building sector to reduce GHG emissions (Davao City, Philippines)

Sector	Policy	Implementation
Transport	Alternative Fuels and Energy Technologies Roadmap 2017-2040	Implementation from 2023
	Electric Vehicles	Tricycle implementation already started from 2015. Few pilot projects with ADB. Other vehicles implementation from 2020
Buildings	Green building policy (BERDE - Building for Ecologically Responsive Design Excellence)	Philippine Green Building Code started implementation from 2015

Davao city, which is the second populous city after Manila has also seen significant growth in GHG emissions in the last decade. Considering FY 2017-18 as a base year, GHG emissions from both, supply and demand side are calculated as BAU scenario. The conversion factors from IPCC has been referred for the calculation purpose.

Table 26: Davao city GHG Emissions – Supply side (2017)

SUPPLY SIDE - Capacity and CO_2 Emissions		
PRIMARY ENERGY		SUPPLIED
STATE	FUEL	in KTOE (2017)
Liquid	Oil	314
Solid	Coal	232
Gas	Natural Gas	54
Renewable Energy (RE)	Geothermal	157
RE	Hydro	33
RE	Solar	4
RE	Wind	2
Solid	Biomass	124
Liquid	Biofuels	9
TOTAL (KTOE)		928

PRIMARY ENERGY		SUPPLIED
STATE	FUEL	MT CO_2 (2017)
Liquid	Oil - Petrol	0.309
Liquid	Oil - Diesel	0.582
Liquid	Oil - Fuel Oil	0.014
Liquid	Oil - Kerosene	0.009
Solid	Coal	0.991
Gas	Natural Gas	0.115
RE	Geothermal	-
RE	Hydro	-
RE	Solar	-
RE	Wind	-
Solid	Biomass - Charcoal	0.115
Liquid	Biofuels - Biodiesel	0.004
Liquid	Biofuels - Bioethanol	0.003
TOTAL (MT of CO_2 emission)		2.142

Source: Project team Analysis

Table 27: Davao city – Demand side (2017)

DEMAND SIDE - Consumption and CO_2 Emissions																	
DEMAND SIDE SECTOR	in KTOE (2017)																
	Electricity	Coal	Charcoal	OIL				GAS		RENEWABLE							
				Petrol	Diesel	Fuel Oil	Kerosene	Auto LPG	Natural Gas	Bioethanol	Biodiesel	Fuelwood	others	Geothermal	Hydro	Solar	Wind
Buildings - Residential	37	-	17	-	-	-	1	18	-	-	-	67	9	-	-	-	-
Buildings - Commercial	32	-	3	-	19	3	-	7	-	-	-	3	-	-	-	-	-
Transport - Roadways	-	-	-	65	97	-	-	-	-	6	2	-	-	-	-	-	-
Agriculture - Fishery	0.46	-	-	0.08	2.9	0.05	0.02	-	-	-	0.05	-	-	-	-	-	-
Agriculture - Crop production	0.68	-	-	0.03	0.56	-	-	-	-	-	0.02	-	-	-	-	-	-
TOTAL (kTOE)	**70.14**	**-**	**20**	**65.11**	**119.46**	**3.05**	**1.02**	**25**	**-**	**6**	**2.07**	**70**	**9**	**-**	**-**	**-**	**-**
390.85																	

DEMAND SIDE SECTOR	Million Tonne (MT) of CO_2 emission (2017)										
	Electricity	Coal	Charcoal	OIL				GAS		RENEWABLE	
				Petrol	Diesel	Fuel Oil	Kerosene	Auto LPG	Natural Gas	Bioethanol	Biodiesel
Buildings - Residential	0.353	-	0.079	-	-	-	0.003	0.049	-	-	-
Buildings - Commercial	0.305	-	0.014	-	0.056	0.006	-	0.019	-	-	-
Transport - Roadways	0.000	-	-	0.182	0.285	-	-	-	-	0.011	0.004
Agriculture - Fishery	0.004	-	-	-	0.009	-	-	-	-	-	-
Agriculture - Crop production	0.006	-	-	-	0.002	0	-	-	-	-	-
TOTAL (MT of CO_2 emission)	**0.669**	**-**	**0.093**	**0.183**	**0.351**	**0.007**	**0.003**	**0.068**	**0.000**	**0.011**	**0.004**
1.388											

TOTAL CO_2 Emission in 2017 (base year)	**3.530**	MT
	3529910.094	Tonne
	3529910094	kg

Source: Project team Analysis

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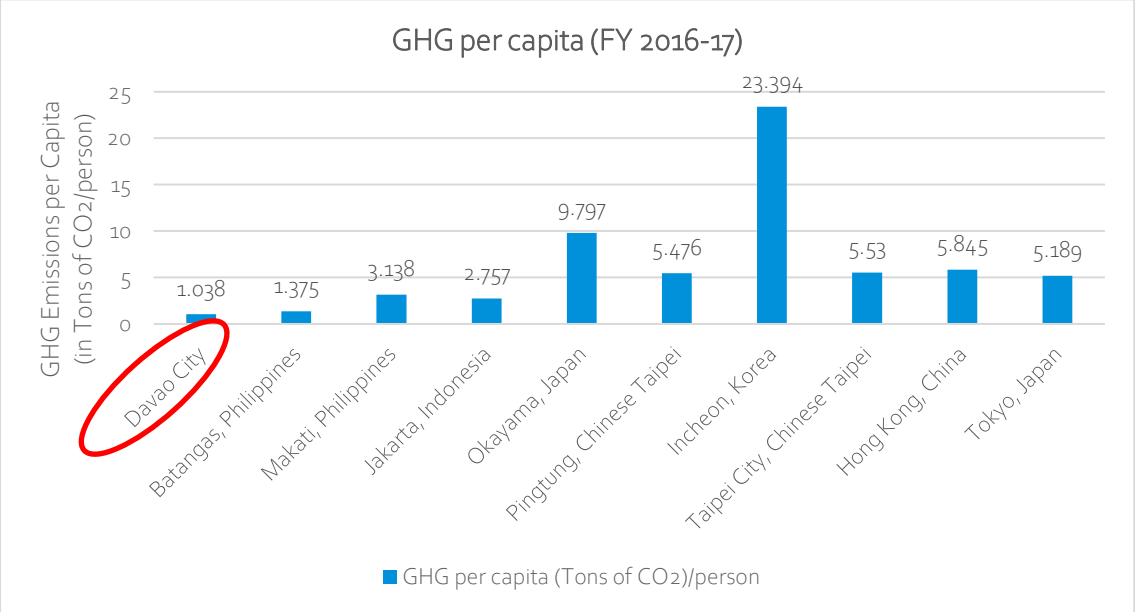
The total GHG emission for Davao city for the year 2017 is 3.53 Million Tons of CO_2. According to the Philippine Statistics Authority, GHG emission of the Philippines in the year 2017 was 118.5 Million tons of CO_2 (Compendium of Philippines Statistics and Information), which means Davao city contributes to approximately 3% of the total GHG emissions of the entire economy. Per capita GHG emission of Davao city is 1.038 Tons of CO_2. This is the lowest as compared to cities of similar nature for the financial year 2016-17. The comparison is seen as table below:

Table 28: GHG per capita of different cities (FY 2016-17)

City	GHG Emission (TCO_2)	Population in 2016	GHG per capita (Tons of CO_2)/person
Davao City	1,728,546	1665,660	1.038
Batangas, Philippines	457,288	332,458	1.375
Makati, Philippines	1,660,370	529,039	3.138
Jakarta, Indonesia	27,780,000	10,075,300	2.757
Okayama, Japan	6,916,000	705,917	9.797
Pingtung, Chinese Taipei	4,604,805	840,931	5.476
Incheon, Korea	69,794,140	2,983,484	23.394
Taipei City, Chinese Taipei	14,957,404	2,704,810	5.530
Hong Kong, China	42,700,000	7,305,700	5.845
Tokyo, Japan	70,125,000	13,513,734	5.189

Source: Data.cdp website



Source: Data.cdp website

Figure 23: Comparison of per capita GHG Emissions (tons of CO_2/person) of Davao city with other similar cities (2016)

With population of only approx. 1.7 Million (around 2% of the Philippines population) in 2017, if Davao city can contribute around 3% to the overall GHG emissions then a significant step needs to be taken towards the adoption of low carbon strategies for each sector.

Considering that the city has started to adopt all the policies as planned, total GHG emission (supply + demand side) by the city in the next 20 years (FY 2037) will equate to 53.44 MT of CO_2. The calculation of the same in Table 29 and 30.

To estimate the results, the project team has considered following assumptions:

1. As during 2017, Davao city contributed 3% of the overall GHG emissions, we have considered this as our base year and focused to reduce the emission from the base year value i.e. FY 2017-18
2. Energy Supply and Energy Demand (sector wise) of the entire economy in FY 2017-18 is considered
3. Domestic Level Population for FY 2017-18 was obtained via secondary research
4. City level Population for FY 2017-18 was obtained via secondary research
5. Domestic Energy Supply and Demand (Sector wise) for the period 2010- 2017 obtained through secondary research was divided by Domestic Level population and the result was multiplied by City level population to get city level data.
6. The population of Davao city is 72% of the total population of Davao Del Sur province, therefore to calculate the number of buildings in Davao City, it is estimated that 72% of the residential and non-residential buildings will be available in the Davao city.
7. The number of buildings for Davao Del Sur province was obtained through secondary research, then 72% of these number of buildings were calculated to get the number of buildings in Davao City.
8. **GHG Emissions:** The energy supply and demand data obtained for the city level in step 5, was utilized in calculating the city GHG emissions by using IPCC's value for CO_2 emission conversion for the period 2010- 2017.
9. The emissions for the period 2017-2040 was extrapolated based on the CAGR value obtained for the period 2010- 2017.
10. **Transport Sector:** The implementation of Electric Vehicles will be made mandatory from the year 2020 in different phases to reduce the emission by 5% every year
11. **Residential Building Sector:** The star labelled program to replace old appliances with new energy efficient appliances has started from the year 2017, which will reduce the GHG emission from electricity by 5% for every 5 years.
12. **Commercial Building Sector:** The Green building codes will be implemented in 10% of the newly constructed building from the year 2015, which will reduce the GHG emission by 25% (as Green building code states that by adoption of the code, the economy can reduce up-to 25% of total energy consumption).

Table 29: GHG Emission in 2037 (Davao City) – Supply Side

Type of Fuels	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
Oil - Petrol	0.32	0.34	0.35	0.37	0.39	0.40	0.42	0.44	0.46	0.48	0.50	0.53	0.55	0.57	0.60	0.63	0.65	0.68	0.72	0.75
Oil - Diesel	0.61	0.64	0.66	0.69	0.73	0.76	0.79	0.83	0.87	0.90	0.95	0.99	1.03	1.08	1.13	1.18	1.23	1.29	1.35	1.41
Oil - Fuel Oil	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Oil - Kerosene	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Coal	1.08	1.18	1.29	1.41	1.54	1.69	1.85	2.02	2.20	2.41	2.63	2.88	3.14	3.44	3.75	4.10	4.48	4.90	5.36	5.85
Natural Gas	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.14	0.14	0.14	0.14	0.14
Biomass - Charcoal	0.12	0.12	0.12	0.12	0.12	0.13	0.13	0.13	0.13	0.14	0.14	0.14	0.14	0.14	0.15	0.15	0.15	0.15	0.16	0.16
Biofuels - Biodiesel	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02
Biofuels - Bioethanol	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.04	0.04	0.05
Total (MT CO_2)	2.28	2.43	2.59	2.76	2.94	3.14	3.36	3.59	3.84	4.11	4.41	4.73	5.07	5.44	5.85	6.28	6.76	7.27	7.83	8.43

Source: Project team Analysis

Table 30: GHG Emission in 2037 (Davao City) – Demand Side

Fuels	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
Electricity	0.70	0.73	0.76	0.80	0.83	0.87	0.91	0.95	0.99	1.03	1.08	1.13	1.18	1.23	1.28	1.34	1.40	1.46	1.52	1.59
Charcoal	0.10	0.10	0.11	0.11	0.12	0.12	0.13	0.13	0.14	0.15	0.15	0.16	0.17	0.17	0.18	0.19	0.20	0.21	0.22	0.23
Petrol	0.19	0.20	0.21	0.22	0.23	0.24	0.25	0.26	0.27	0.28	0.30	0.31	0.32	0.34	0.35	0.37	0.38	0.40	0.42	0.44
Diesel	0.37	0.39	0.42	0.44	0.46	0.49	0.52	0.55	0.58	0.62	0.65	0.69	0.73	0.77	0.81	0.86	0.91	0.96	1.02	1.08
Fuel Oil	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Kerosene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LPG	0.07	0.07	0.08	0.08	0.09	0.09	0.10	0.10	0.11	0.11	0.12	0.12	0.13	0.13	0.14	0.15	0.16	0.16	0.17	0.18
Bioethanol	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.05	0.06	0.06	0.07	0.08	0.09	0.11	0.12	0.14
Biodiesel	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02
Total (MT CO_2)	1.46	1.53	1.60	1.68	1.76	1.85	1.94	2.04	2.14	2.24	2.36	2.47	2.60	2.73	2.87	3.01	3.17	3.33	3.50	3.69

Source: Project team Analysis

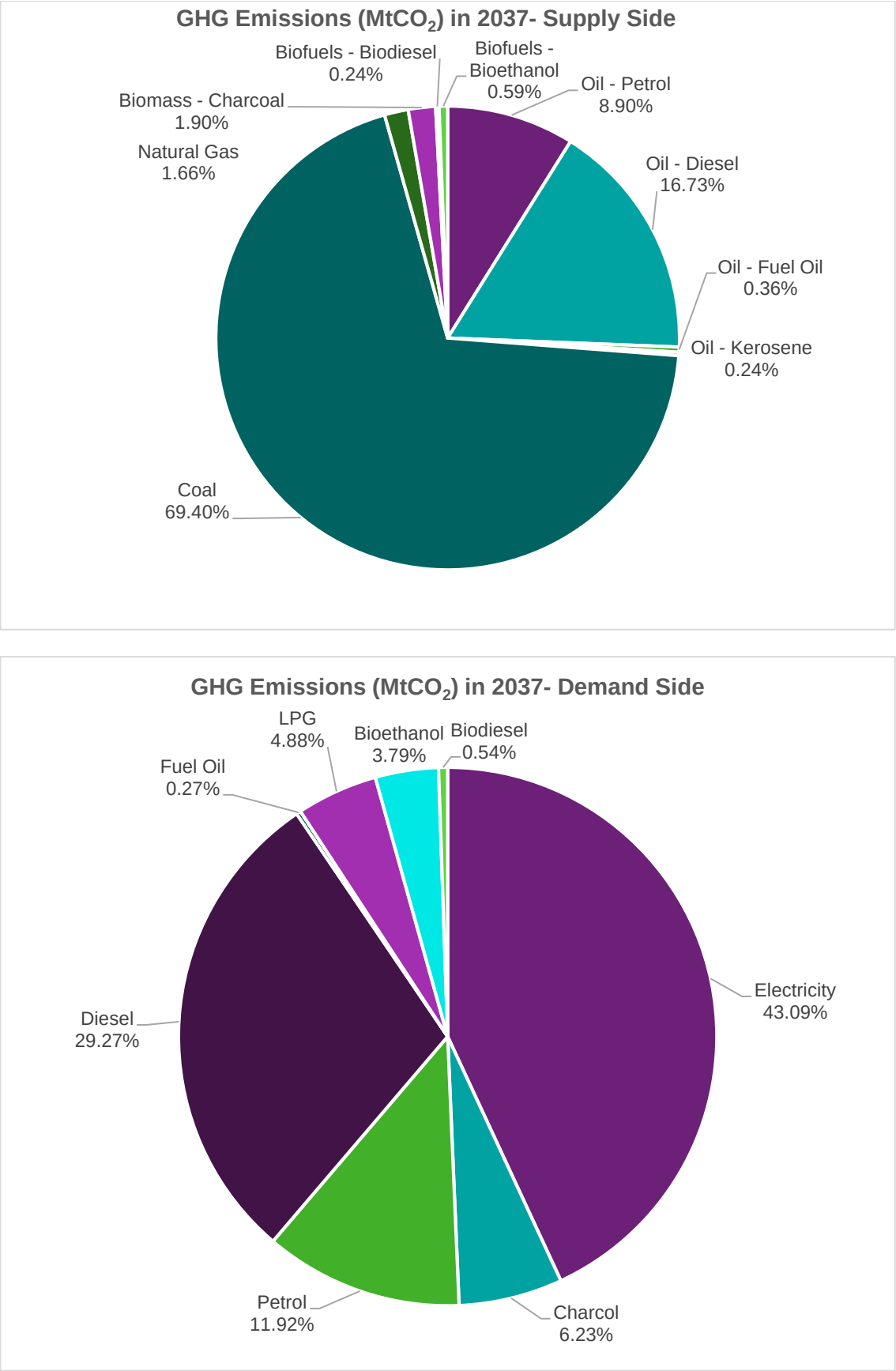


Figure 24: GHG Emissions from Supply and Demand side in 2037

6 Low carbon development strategy

As is observed from the baseline scenario, the sector wise emissions provide the areas where low carbon interventions can be undertaken. The best practice study provides the probable list of interventions which can be considered for the volunteer town. Based on the prevailing context of the city, the exhaustive list of interventions can be used to prepare a draft list of interventions. These interventions provide guidance to the low carbon development strategy for the respective cities in terms of the sectors and the corresponding sectoral focus areas that should be considered. The list of interventions contextualized to local conditions have been provided for Davao in the following section:

6.1 List of low carbon interventions for Davao City (Philippines)

Based on the baseline scenario, a number of interventions can be considered under each sector to ensure Davao grow on a low carbon trajectory, which are given as follows:

Table 31: List of low carbon interventions for Davao

Sector	Proposed Intervention	Brief Description	Context
Transport	Implementation of ODD-EVEN Road Rationing Scheme for private cars	• Mechanism to control pollution levels by restricting the number of on road vehicles per day • Reduces the number of on-road vehicles in a day by about half and thereby reducing the alarming levels of pollution. • Such scheme under the program named "**Unified Vehicular Volume Reduction Program**" has already been implemented in Manila in the year 1995	• Typically, a date of the month is "odd" or "even" • Hence, reduces the number of private cars on road
Untapped Energy	Installation of 12 MW Waste to Energy plant in the Davao city	• The city generates an average of 1,200 tons of solid waste daily. • Waste-to-energy technologies that can be introduced in Davao City are "incineration by grate stoker furnace" and "gasification".	Introduction of waste-to-energy technologies such as waste thermal treatment should be considered to reduce the amount of disposed wastes
Buildings	Adoption of Energy Management System in public buildings	• Identification of energy savings opportunities in public buildings. • Undertaking bulk purchase of Energy Management System to measure and reduce cost of energy usage	• Green Building codes (for commercial buildings) were made available in the economy • As Energy Efficiency is a part of green building code, the adoption of EMS in buildings will support in meeting Government's energy targets.

Sector	Proposed Intervention	Brief Description	Context

	Development of Energy Efficiency Building Code at economy level and then amending it for city Level. This code should be made valid for Residential Buildings (New Buildings)	• All new residential buildings with more than 10kW of connected demand should follow Energy Efficiency Building Codes for Residential buildings. To begin with, this code can be made with a focus on Building envelop then in the phase two HVAC and/or Lighting can be added.	• The city is the second most populated city in the Philippines and also has one of the largest land areas, the growth in the construction sector is expected in the next few years. More the construction, more the energy consumption. Therefore, it is importation to adopt Energy Efficiency Building Code
			• The implementation of Building codes will result into:
			  • Reduce energy consumption;
			  • Reduce CO_2 emissions;
			  • Lower costs through energy savings;
			  • Accelerate deployment of energy-efficient technologies.
			  • Use of Energy Efficient Equipment.
			  • Awareness and importance of Energy Conservation.
			  • Better use of Natural Resources

7 Project Assessment- Low Carbon Areas

7.1 Transportation

7.1.1 Current status analysis

Davao City is a highly-urbanized city located in the southern part of the Philippines. Davao City has been rapidly urbanizing in the past years. Population and vehicles in the city have been steadily increasing resulting to a negative impact in the city's transportation system. There are approximately 1.7 million people (Davao City Transport Roadmap, 2018) in the city. Out of these, 3.8% (Davao City Transport Roadmap, 2018) of households have private cars and 36.4% (Davao City Transport Roadmap, 2018) of the households have motorcycles.

7.1.1.1 Transport network

The city has 2,366 km of road, 24 pedestrian overpasses, 75 pedestrian crossings, 30 lay-bys along domestic roads, 1 bus terminal, 5 van terminals, 1 airport, 2 public ports, 18 private ports, and 72 bridges (Davao City Transport Roadmap, 2018).

7.1.1.2 Status of Public transport

The city has approximately 7,600 Public utility Jeepney, 5,600 Taxis, 2,400 Tricycles, 910 regional buses, and 1,100 regional vans (Davao City Transport Roadmap, 2018). Gasoline and Diesel being the major fuel consumed in transport sector.

7.1.1.3 Status of trip information

Due to lack of data of the total number of vehicles running (on road) in Davao city, the study from ADB was referred. This study had total number of yearly registered vehicles. The same number has been considered for our study.

Almost 80% (Davao City Transport Roadmap, 2018) of the trips are made by public transport[27] and remaining 20% by private transport. However, 80% (Davao City Transport Roadmap, 2018) of vehicles on road are private cars.

Table 32: Distribution of use of mode of transport to perform day to day activities

ACTIVITY	Public Transport (%)	Private Transport (%)	Walk (%)	Bike (%)
Work	70	19	10	1
School	73	18	9	1
Shopping/Grocery	73	20	7	0
Eat out	73	20	6	0
Recreational	71	21	7	1
Social	72	20	7	1
Accompany child to school	65	26	8	1
Medical	76	20	6	0

Source: Davao city Roadmap, 2018

[27] Includes Jeepney, Taxi, Tricycle, Bus and Van

It seems that very few people use bike and walk on road. Majority of them uses public transport and some uses private transport.

7.1.2 Government's vision

City government under Davao City Transport Roadmap aims Davao to become the model city for the Philippines. This model city should have safe and sustainable transport system which enhances livability and improves connectivity. The Government's vision for all transport users is showcased as below:

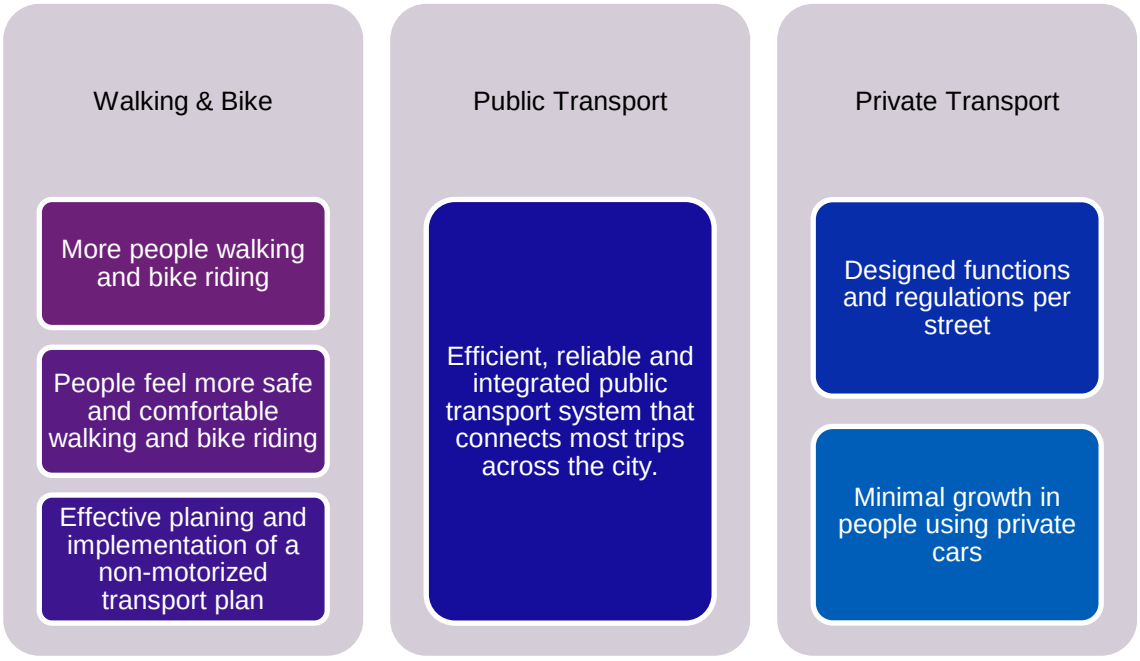


Figure 25: Government's Vision for transport

In order to achieve Government's vision, the project team has proposed following set of interventions in the subsequent sections.

7.1.3 Rationale for Proposed interventions[28]

In order to meet Government's vision by ensuring sustainability, the following low carbon interventions may be proposed:

7.1.3.1 Odd & Even Road Rationing Scheme for private cars

Heavy dependency on car use leads to traffic congestion, pollution, and physical inactivity, which impose high direct and indirect costs on society. The project team suggests starting Odd- Even scheme for private cars running in Davao city.

[28] Note: The government of the Philippines has already started the implementation of EV's under their Vehicle Energy Efficiency program from year 2020. So, implementation of EV's has not been considered.

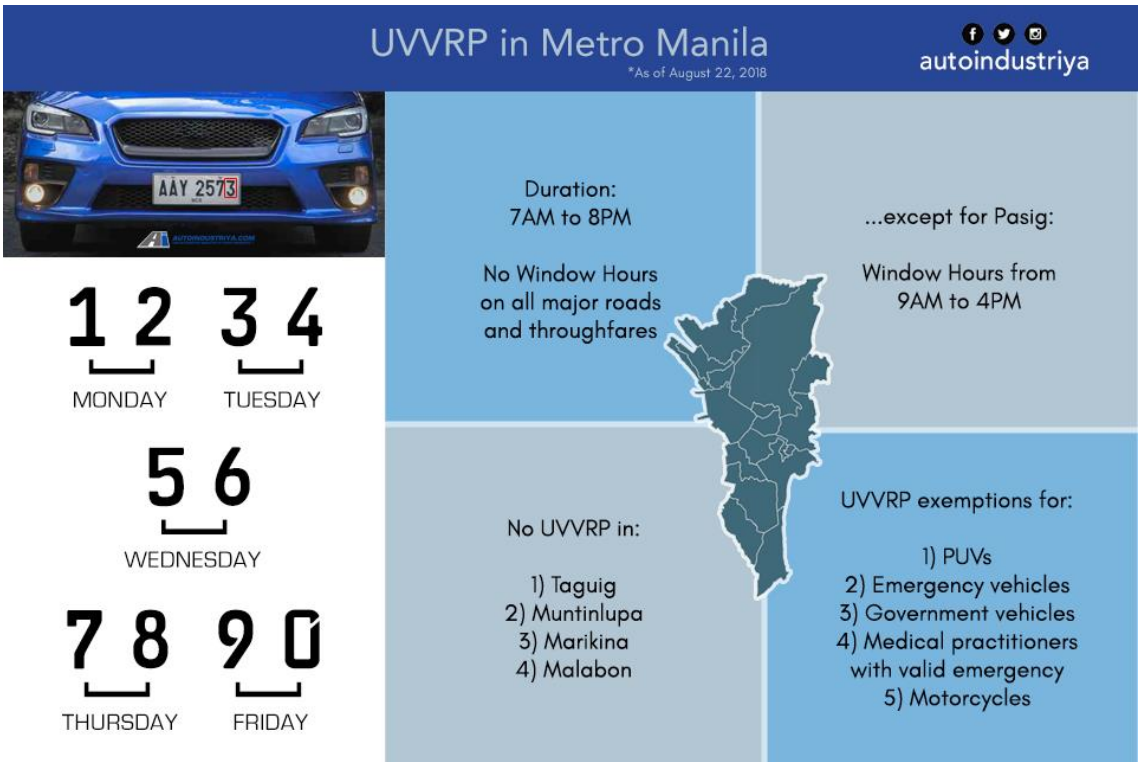
As the city is too congested with public and private vehicular traffic, the implementation of ODD-EVEN scheme will reduce the number of private cars in the city which will also curb the air pollution of the Davao city, overall reducing carbon emission of the city.

7.1.3.1.1 Description of the Intervention:

As the total number of vehicles and particularly private cars is not available, we have considered annual registered private cars as per ADB report, for our study.

The ODD-EVEN scheme is a transport rationing mechanism to control pollution levels by restricting the number of on road vehicles (private cars) per day. The aim of this scheme is to reduce the number of on-road vehicles (private cars) in a day by about half and thereby reducing the alarming levels of pollution and traffic congestion in the Davao city. The **Unified Vehicular Volume Reduction Program (UVVRP)**, commonly called number coding or color coding, working on similar concept has already been implemented in Manila, Philippines since 1995.

The most recent rules of the UVVRP or Number Coding are as follows:



Source: Autoindustriya.com

As the transport network has been predominantly road-based in Davao, there has been a considerable growth in the road length and the motor vehicles. Davao's roads are already under terrible strain. If action is not taken immediately, that strain would become unbearable.

Therefore, transport rationing mechanisms need to be effectively deployed in a strategic and holistic manner. The Odd-Even policy would be a measure to reduce the number of cars on Davao city roads and thereby cutting down on pollution levels in the city.

Following are the positive and negative aspects of the road rationing scheme:

Advantages:

- Pollution Control
- Less Traffic
- Increase in usage of public transports
- Carpooling

Disadvantages:

- Initial inconvenience to the people
- People with more than one car
- Monopoly of jeepney/cab driver owners

As per the ADB Urban Transport Report, the number of private cars in Davao city are around 75-80% of the total private cars in Davao Region, the team proposes to implement the ODD-EVEN road rationing scheme in Davao city first to curb the number of private cars on road and correspondingly GHG emissions.

Table 33: Number of Private cars in Region XI and Davao City

	2008	2009	2010	2011	2012
Region XI	15,999	22,761	18,166	16,597	16,275
Davao City	12,656	18,813	13,888	12,459	11,473
% of private cars in Davao city	79%	83%	76%	75%	70%

The team proposes the following characteristics of the scheme:

- The scheme to be applied only to four-wheeler private cars only
- The 2 wheelers, jeepneys, UVs are exempted from this project
- The scheme can be bound within a time limit i.e. from 8:00 AM to 8:00 PM between Monday to Saturday
- In the case of violation of a rule, a penalty to be charged by the government.

Overall, as the private car owners who are not able to use their cars on odd/even days, they could opt for e-buses which government is going to implement from year 2020 as per their Vehicle energy efficiency policy.

7.1.3.2 Impact of the Intervention

Environment: Reduction in CO_2 emission

To calculate the emission reduction due to ODD-EVEN Scheme implementation, following assumptions have been taken:

Assumption 1: Around 30%[29] of the total vehicles on road are private cars

Assumption 2: as total number of cars are 30%, the GHG emission caused by private cars is also 30% of the total GHG emissions from transport sector

The tables below illustrate the GHG emissions from private cars when ODD-EVEN scheme is implemented from the year 2020 in Davao city.

[29] Note: Car percentage calculated on basis of status of public transport in year 2018 and the number of registered cars in same year

Table 34: GHG reduction through ODD-EVEN Scheme

YEAR	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Total Number of private cars	7754	7289	6851	6440	6054	5691	5349	5028	4727	4443	4176	3926	3690	3469
Total GHG emissions from transport sector ($MTCO_2$)	0.482	0.506	0.532	0.559	0.587	0.617	0.648	0.680	0.715	0.751	0.789	0.829	0.871	0.915
Total GHG emission due to private cars ($MTCO_2$)	0.145	0.152	0.160	0.168	0.176	0.185	0.194	0.204	0.214	0.225	0.237	0.249	0.261	0.274
Assuming 50% reduction in private cars from 2020 due to ODD-EVEN Scheme														
Emissions from private cars ($MTCO_2$)	Not implemented			0.084	0.088	0.092	0.097	0.102	0.107	0.113	0.118	0.124	0.131	0.137
Total CO_2 emission (MT) reduction	0.482	0.506	0.532	0.475	0.499	0.524	0.551	0.578	0.608	0.638	0.671	0.704	0.740	0.777

Table 35: Comparison of GHG reduction

	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
CO_2 emission without ODD-EVEN Scheme (MT)	0.482	0.506	0.532	0.559	0.587	0.617	0.648	0.680	0.715	0.751	0.789	0.829	0.871	0.915
CO_2 emission with ODD-EVEN Scheme (MT)	0.482	0.506	0.532	0.475	0.499	0.524	0.551	0.578	0.608	0.638	0.671	0.704	0.740	0.777

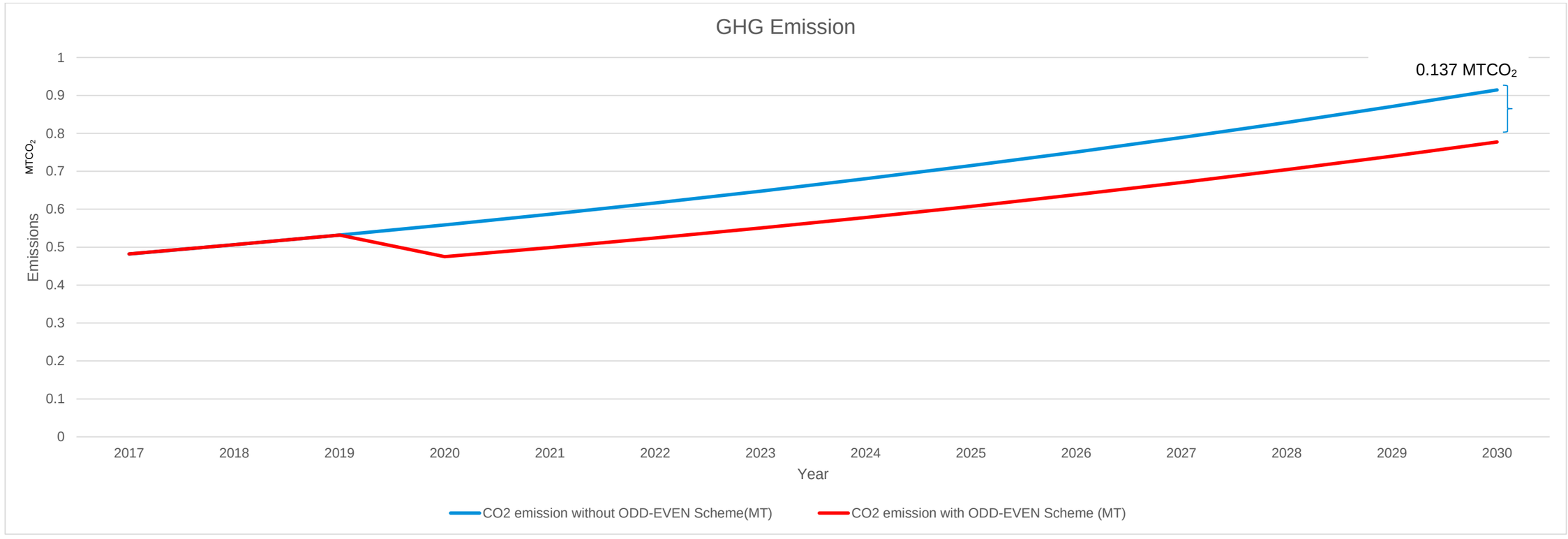


Figure 26: GHG Emissions with and without ODD-EVEN Scheme

7.1.3.2.1 Implementation Mechanism

The Government of the Philippines must direct Davao LTO or respective ministry to come up with some policy or regulation on Odd and even scheme for private cars which will surely support in curbing the air pollution and traffic congestion problems in Davao city.

Figure 27: ODD-EVEN scheme implementation

The Government is also required to develop a system that acts as series of incentives that urge people to act by consciously regulating private vehicular usage and reducing the latter's cost on society (by reducing private vehicular emissions).

In India, Delhi government came up with a policy to introduce Odd- Even scheme in New Delhi in the year 2016, to reduce the level of air pollution caused due to vehicular emission. The scheme aimed to reduce the number of cars on the road which would mechanically reduce vehicular exhaust emissions.

Source: autoportal.com

Figure 28: ODD-EVEN rule in New Delhi, India

This system was prior implemented in Beijing in 2008 just before the summer Olympics. While the rule was initially said to be temporary, it turned out to be so effective the government made it permanent.

Similar road-rationing rules are imposed in many places around the world like Paris, Mexico and Bogota to curb road jams and pollution.

The scheme as such requires no financial aid or support from the public or private sector. The success of this scheme depends upon the way, Davao city residents implement it.

7.1.4 Intervention for sustainable business model

Land transport infrastructures enable vehicles and people to move and travel from one place to another. At present, there is one overland transport terminal in the city located in Ecoland, Barangay Bucana. It has an area of 1.7 hectares and serves both the north and south bound routes. It caters more than 800 units of buses and is 24-hour in operation.

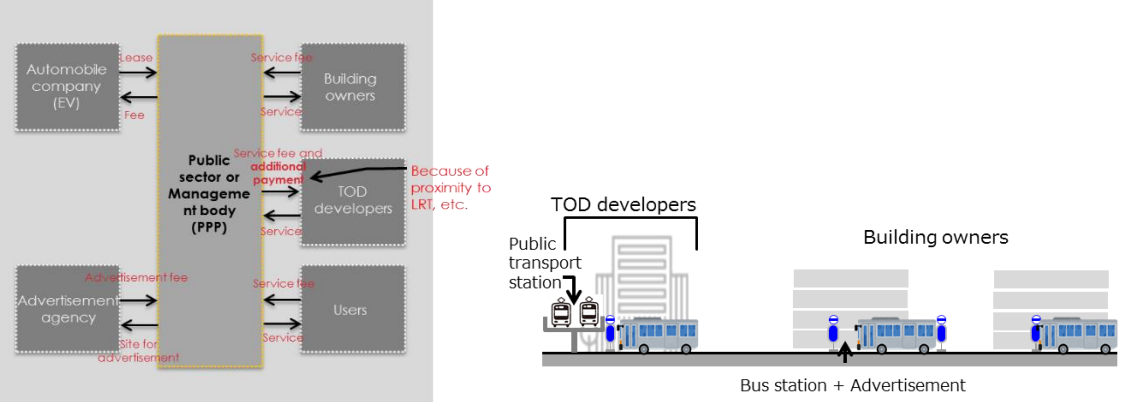
CO_2 in the traffic field is mainly emitted by private automobiles. In order to reduce CO_2, it is effective to control the traffic volume of automobiles, use forms of public transportation with less CO_2 emissions, reduce travel distance and reduce the amount of CO_2 emitted by each car. In addition, it is effective to change bus transportation, which is the main form of public transportation, to vehicles with low CO_2 emissions, and to reduce the amount of CO_2 emitted by each bus. In this regard, Davao city Government is already planning to introduce EV Jeepneys on Davao city road from the year 2020

Circular buses connect retail and residential facilities around business and commercial area in Davao city. The buses will utilize EV jeepney and will have advanced technology functions such as free Wi-Fi, smart card, CCTV, ensuring passenger security.

Source: www.wikipedia.org

Figure 29: Example of existing transportation in Davao

In the circular buses, the management organization can receive the basic service fee from the community that benefits from the service, as well as the advertising fee generated by the advertisement placed on the bus body and the bus station. In an effort to boost the non-ticket revenue, the city transport department may plan to sell advertisement space on its buses in the form of full bus wrap ads. The new financing mechanism will reduce the cost of maintaining a circular bus and lead to independent business operations.



Source: Project team generated image

Figure 30: Example of an advertisement scheme in Davao

Public sector and regional management agencies may lease electric buses from the company and manage circular bus services within designated areas. Electric bus services are considered to contribute to countermeasures in the event of natural disasters, regarding as excellent infrastructure for disaster prevention, such as being used as a backup power source in the event of a disaster. And also, it could reduce CO_2 emission by optimizing transportation routes.

In addition, it can be more effective to install a sensor monitoring human flow in each bus. The installation could optimize traffic volume and support the connection with other semi-public transportation such as jeepneys and vans.

7.2 Untapped Energy

Untapped energy is, despite the possibility of effective use such as waste heat from solid waste, factories, exhaust heat from subway or underground shopping centers, potential heat energy from rivers, sewage, snow, etc., which have large temperature difference between outside temperature, however, have not been effectively utilized yet.

7.2.1 Current status analysis

According to "10-Year Integrated Solid Waste Management Plan of Davao City 2007-2017" prepared by Davao City, the amount of solid waste generated and collected is shown in the table below:

Table 36: Waste Generated & Collection

Year	Waste Generated (daily, kg)	Waste Collection (daily, kg)
2011	833,921	387,022
2012	853,650	396,178
2013	873,845	405,551
2014	894,519	415,146
2015	915,682	424,968
2016	937,345	435,022
2017	959,521	445,313
2018	982,222	455,849
2019	1,005,459	466,633

Source: Collaboration Program with the Private Sector for Disseminating Japanese Technology for Waste-to-Energy system in Davao City

The city generates an average of 1,200 tons of solid waste daily, while at the final disposal site, the daily disposed municipal solid waste is estimated to be 500 - 600 ton/day.

Most of the municipal waste collected in Davao City is currently disposed at New Carmen Sanitary Landfill, which is approximately 15 km from the center of Davao City. Its land area is 3.8 hectare. New Carmen Landfill Site has been operating since 2010 and was initially designed to be used for 8 to 10 years. However, due to increase in population, economic development, and expansion of waste collection area, the amount of wastes to be disposed is exceeding the amount that was initially projected. The landfill area is already 80-90% full and there are wastes that have spilled over from the landfill area to the access road outside the landfill site.

Under this current condition, introduction of waste-to-energy technologies through measures such as waste thermal treatment (i.e. incineration) should be considered in order to drastically reduce the amount of disposed wastes.

7.2.2 Government's vision

The vision of the government of Davao City is to make the city Clean and Green. Every member is also mandated to protect, preserve, conserve and develop forest mining and other natural resources and renders assistance and services to beneficiaries of development project within the context of a balanced ecology.

The government has already started the implementation of solid waste management under the principle of 3 R's (Reduce, Reuse, Recycle) in cooperation with the Environment Bureau of Kitakyushu City.

7.2.3 Rationale for Proposed intervention

In order to meet Government's vision by ensuring sustainability, the project team proposes following low carbon interventions:

7.2.3.1 12 MW of Waste to Energy plant in the Davao city at Brgy Biao Escuela in Tugbok district

Waste to heat incinerator plant will help Davao city in:

- Diverting a portion of the waste that would otherwise be sent to landfill. This also, reduces the amount of GHG emissions released into the atmosphere
- Less waste in landfill lowers risks of soil contamination, which could further endanger wildlife and harm water sources
- Energy derived is partly renewable energy source, which contributes to renewable energy targets
- Reduces the need for additional fuel sources, as this form of energy can also be used alongside wind and solar for sustainable energy solutions
- Reduces the dependency on energy imports and the environmental cost of transporting that energy to the economy if they can generate their own from their own waste materials

The proposed intervention would abide by Section 20 of the Clean Air Act of 1999 (RA 8749). Further the intervention should install a furnace that directly combusts municipal solid waste

(MSW) and have a sustainable technology in place that avoids toxic ash, heavy metals and carcinogenic air pollutants as by-products to mix into the atmosphere.

7.2.3.1.1 Description of the technology

Waste-to-energy technologies that can be introduced in Davao City are "incineration by grate stoker furnace" and "gasification". Both of these technologies are being applied worldwide including in Japan and have proven to be highly effective in pollution control and volume reduction of municipal solid wastes (over 80 to 90% of reduction rate).

The 2 technologies that can be implemented in Davao city for WtE generation are discussed in brief below:

Gasification: It is a process that converts organic materials into carbon monoxide, hydrogen and carbon dioxide. This is achieved by reacting the material at high temperatures (>700 °C), without combustion, with a controlled amount of oxygen.

Incineration: It is a waste treatment process that involves the combustion of organic substances contained in waste materials. It converts the waste into ash, flue gas and heat. Incinerators reduce waste volume by approximately 95 % and reduce the solid mass of the original waste by 80 % to 85 %. Hence, low carbon incinerators are recommended for waste to energy generation.

Both the above-mentioned technologies have been successfully implemented in Japan, so the project team proposes to implement the incineration by grate stoker furnace and by gasification in Davao city.

7.2.3.2 Impact of the Intervention

Environmental:

The capacity of Waste to Energy plant is of 12 MW. This plant will generate 12 MW of electrical power per day. The electricity generated will then be utilized at demand side. Presently, Davao Light And Power Co. is catering demand of 421 MW (Philippine News Agency, 2019), providing electricity to people of Davao. The proposed WtE plant will feed 2.85% of the total demand of the city. To calculate total CO_2 emission saved, following information is taken into consideration:

1. Total installed capacity (2018) in the Philippines = 23,677 MW

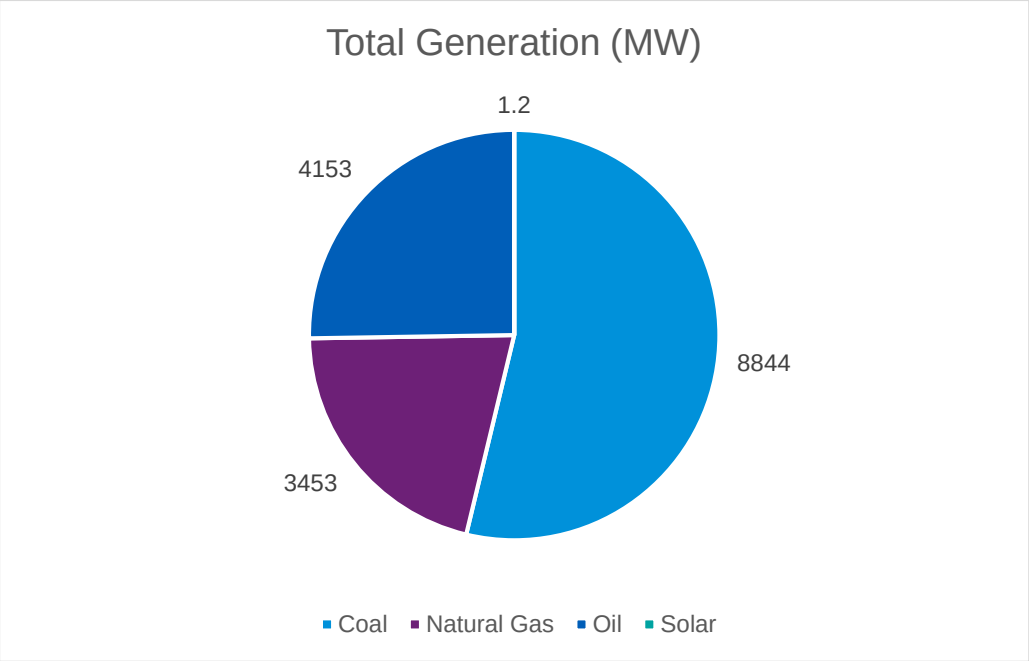


Figure 31: Share of total installed capacity

2. Total electrical energy generated (2018) in the Philippines = 99765 GWh (12 hrs operation/day)

3. Total waste used = 600 tons/day.

Therefore, total electrical energy generated by 12 MW Waste to Energy (electricity) = 12 MW x 12 hrs x 365 days = 53 GWh/year. To generate 1 kWh of electricity, 0.836 kg of CO_2 is emitted. Hence, total CO_2 emission reduction from the W2E plant equals to 0.044 Million Tons/year. The savings in CO_2 emissions will be obtained once the WtE plant becomes operational from year 2023.

Table 37: Electricity Generation and corresponding CO_2 Emission through WtE

Particulars	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electrical Energy generation using untapped energy (MWh)	815728	848357	882292	917583	954287	992458	1032156	1073443	1116380	1161036	1207477	1255776	1306007	1358247
Electrical Energy generation using fossil fuels (MWh)	815728	848357	882292	917583	954287	992458	979596	1020883	1063820	1108476	1154917	1203216	1253447	1305687
CO_2 emission without WtE	0.6819	0.7092	0.7376	0.7671	0.7978	0.8297	0.8629	0.8974	0.9333	0.9706	1.0095	1.0498	1.0918	1.1355
CO_2 emission with WtE	0.6819	0.7092	0.7376	0.7671	0.7978	0.8297	0.8189	0.8535	0.8894	0.9267	0.9655	1.0059	1.0479	1.0916

Source: Project team analysis

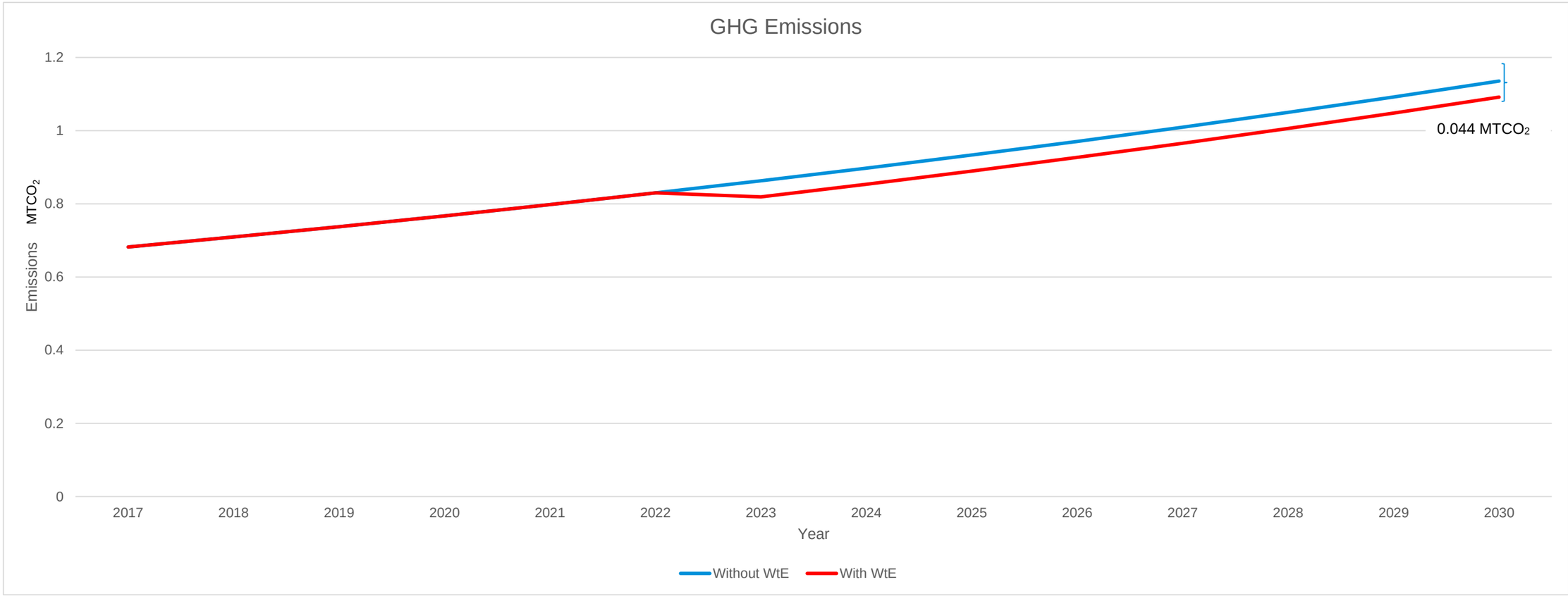


Figure 32: Comparison of GHG emission with and without WtE

7.2.3.3 *Implementation Mechanism:*

Earlier, waste incineration was recognized as one of the prohibited technologies under Clean Air Act (RA8749) in the Philippines, however, the guidelines for new policy were prepared by the Environmental Management Bureau (EMB) of the Department of Environment and Natural Resources (DENR) and the Domestic Solid Waste Management Commission (NSWMC) for promoting waste-to-energy technologies with proper incorporation of pollution control measures. The policy has been incorporated in the Republic Act (RA) 9003, otherwise known as the Ecological Solid Waste Management Act of 2000.

However, post policy making following steps must be taken to implement the technology:

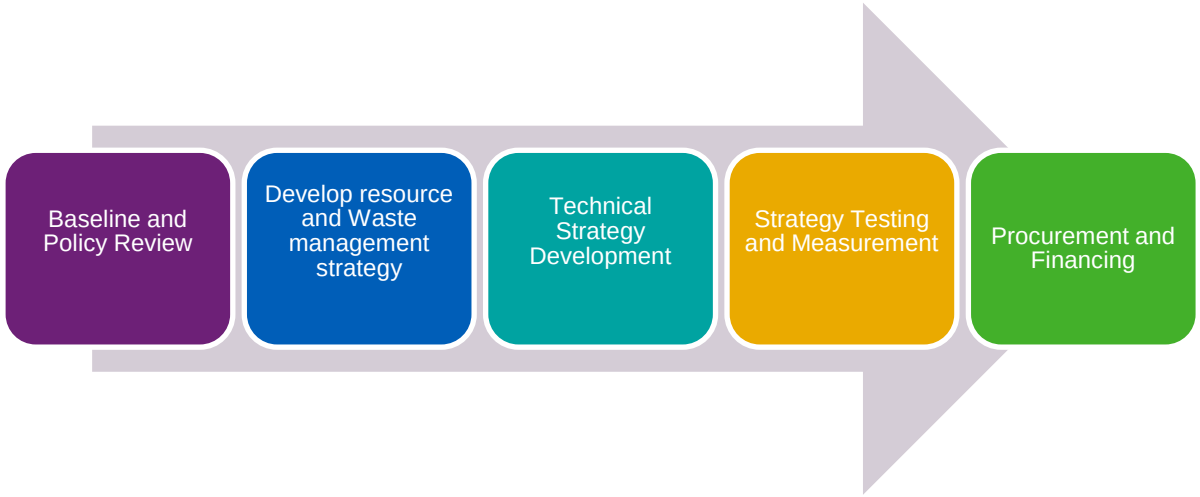


Figure 33: Steps taken for effective policy implementation

- **Baseline and Policy Review:** Its purpose is to obtain information that sets out the existing conditions with respect to resource and waste management
- **Resource and Waste Management Strategy:** The purpose of this stage is to establish a set of aims and objectives for the resource and waste management strategy.
- **Technical Strategy Development:** The technical strategy development should be based on the desired outcomes for sustainable resource and waste management as defined by the aims, objectives and targets described in resource and waste management strategy
- **Strategy Testing and Measurement:** The strategy should be tested throughout its development to ensure it is appropriate to proceed to the next stage of strategy development. Testing and measurement typically relates to overall viability, environmental performance, affordability and financial performance.
- **Procurement and Financing:** The purpose of procurement is to realise the preferred technical option on the best possible commercial terms regarding both risk transfer and cost.

Japan has successfully installed 3 WtE plants in Kitakyushu City, working on incineration by grate stoker furnace and gasification technology with waste capacity of approx. 2100 ton/day and generates power of 66 MW. As Japan is providing financial support to Davao for the installation of WtE plant in the city, the project team suggests to implement similar technology i.e. Incineration and Gasification that Japan has already implemented.

Source: City of Kitakyushu

Figure 34: Incineration plant in Kitakyushu city

7.2.3.4 Source of funding

The Government of Japan is providing grant of **2.5-billion PHP** to the Government of the Philippines to implement the proposed intervention. The intervention is expected to be completed by 2023.

7.3 Buildings

7.3.1 Current status analysis

The population of the Philippines has been steadily growing for many years. It is the 13th most populated economy in the world, and its population grew at a rate of 1.622% (Philippines Population, 2019). As the population started to increase in the city, the requirement of residential and non-residential space started to increase.

Residential & Non-Residential buildings accounts for major consumption of fuels. The table below shows the energy consumption by fuel type of residential and commercial buildings in Davao city:

Table 38: Energy consumption by residential buildings

DAVAO	in KTOE					
FY	Electricity	Charcoal	Fuelwood	others	LPG	Kerosene
2010	26	12	65	9	13	2
2011	26	13	66	9	13	2
2012	27	14	67	9	13	2
2013	29	15	69	10	13	2
2014	29	15	70	10	12	2
2015	32	16	69	9	14	1
2016	36	17	67	9	17	1
2017 (Est.)	37	17	67	9	18	1

Table 39: Energy consumption by commercial buildings

DAVAO	in KTOE							
FY	Electricity	Charcoal	Fuelwood	Others	LPG	Diesel	Fuel Oil	Biodiesel
2010	23	2.47	2.48	0.13	3	9	3	0.18
2011	23	2.50	2.53	0.13	3	10	2	0.21
2012	25	2.55	2.58	0.13	3	10	2	0.21
2013	26	2.58	2.61	0.11	4	13	2	0.24
2014	26	2.63	2.66	0.11	4	17	2	0.32
2015	28	2.66	2.69	0.10	5	14	2	0.23
2016	30	2.69	2.72	0.10	6	17	3	0.34
2017 (Est.)	32	2.73	2.72	0.10	7	19	3	0.37

7.3.2 Government's vision

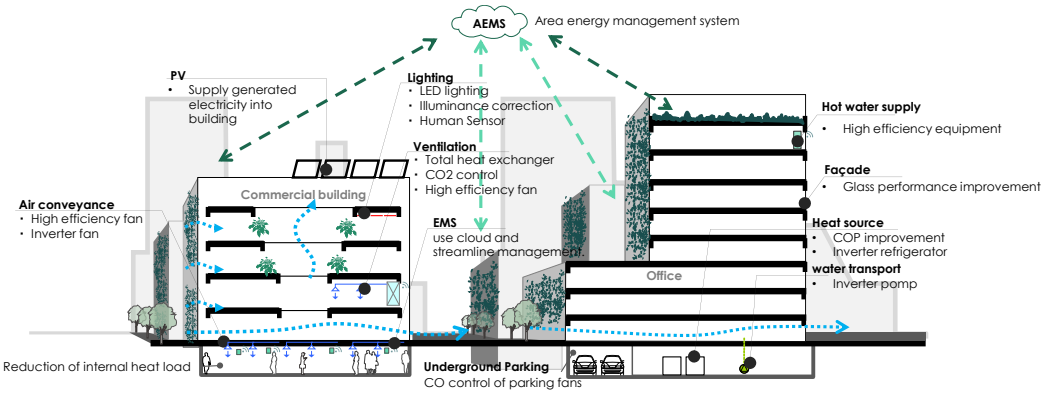
In order to reduce the energy consumption in building sector, the Government's vision is to implement the Green Building Codes in the Philippines. The implementation of Green building codes will certainly help to minimize the present energy consumption and correspondingly GHG emission from the major energy intensive building sector in Philippine.

7.3.3 Rationale for Proposed Intervention

7.3.3.1 Implementation of green building code

In order to reduce energy consumption and subsequently emissions from building sector, improving implementation of green building code is recommended. Improved implementation

would require policy level interventions, disbursal of financial incentives to end-users along with development of business opportunities around this aspect in case of green buildings (Figure 35).



Source: Image generated by project team

Figure 35: Green buildings images（high rise residential, commercial or office building images）

7.3.3.2 Description of Intervention

About Star Rating System:

There are a number of measures such as building codes, policy interventions, labelling/rating systems, appliance standards, etc. to streamline efforts to promote energy efficiency in the buildings sector. Building rating systems are a popular tool to add momentum in achieving energy efficiency. These help in assessing the level of performance of the building and provide opportunities in reducing the operation and maintenance (O&M) costs of the building besides creating a market pull towards environmentally sustainable buildings.

However, most green rating programs are based on design intent and do not rate energy performance of existing buildings through a systematic evaluation process. In order to enable rapid transformation towards energy efficiency in buildings, policies and measures that create a 'supply push', such as codes and standards need to be supplemented by policies and measures that simultaneously create a 'demand pull' as well.

The proposed Star Rating programme for buildings has been developed on the actual performance of a building in terms of its specific energy usage in kwh/square metre/year. This programme rates commercial & residential buildings on a 1-5 Star scale, with 5 Star labelled buildings being the most efficient. The scheme is propagated on a voluntary basis and the label provided under it is applicable for a period of 5 years from the date of issue. The Star Rating programme provides public recognition to energy efficient buildings and creates a 'demand side' pull for such buildings. Various categories of buildings have been identified under the scheme.

The rating normalizes for operational characteristics that define the building use, hours of operation, climatic zone and conditioned space. Further to provide a useful benchmark the rating also provides a meaningful comparison to the building's peer group representing those buildings that have the same primary business function, and operating characteristics. It is important that the rating be based on an analysis of city level data that accurately reflects the distribution of energy use for each building type.

This energy performance rating is a type of external benchmark that helps energy managers to assess how efficiently their buildings use energy, relative to similar buildings economy-wide. Additionally, building owners and managers can use the performance ratings to help identify buildings that offer the best opportunity for improvement and recognition.

The baseline model (BAU case) considered for the star rating system had the following assumptions considered for the box model simulation

- Ext wall U-value: **R1** (1 W/m^2-K (min requirement of the Philippines green building code)
- Roof U-value: **R2** (0.5 W/m^2-K) (min requirement of the Philippines green building code)
- Glazing specification
    - U- value- 5.7 W/m^2-K
    - VLT- 0.51
    - SHGC- 0.56
    - WWR: 60%
- No additional shading was considered for the case
- Cooling equipment efficiency of EER 8 (min requirement of the Philippines green building code)
- Lighting power density: as per ASHRAE standard case
- All the schedules and load profiles were kept constant across all the cases.

To derive a practical and implementable solution set, it is imperative to list down the major interventions that impact energy efficiency in a building and is easily implementable in the building design of all kinds. The list of interventions is studied further in detail below and its possibility of being implemented.

7.3.3.2.1 Window Wall Ratio

WWR has shown to be the most cost-effective solution in reducing the heat gain in the building. Hence, we tried incorporating that in the building design to achieve energy efficiency. For commercial establishments, the maximum threshold for WWR is 60% whereas for more efficient buildings it has been reduced to 40%. In case of residential buildings, the ratio is further reduced to 25% going down to 15% for more efficiency.

7.3.3.2.2 Envelope (Opaque)

It comprises the exterior wall and roof have a major impact on the heat transfer in a building. Essentially R-value is a measure of thermal resistance, or the ability to prevent the transfer of heat. The larger the number, the harder that insulation is working at preventing heat conduction. The less heat loss, the lower your energy consumption. As per the sensitivity analysis for walls and roof R-values, we could analyze that after a certain point there was no significant improvement in the cases despite increasing the R-value of walls and roof. This could possibly be because of the hot and humid climate that the location has. Hence, it is recommended that R-8 to R-12 is ideal for the location for both walls and roof.

7.3.3.2.3 Shading

Shading was another intervention that proved effective for both – reducing heat gains in the building as well as improving the quality of daylight available in the building. It even is a sensible alternate solution to providing High performing glass in the building. For optimum shading in the building it is recommended to have customized shading as per the orientation, glazing size, glazing material. However, for the solution set we have simplified the shading requirement to the ratio between **depth of shading, D/ height of glazing, H.** We have considered only horizontal shading in the solution set as it is more effective in terms of shading the building for the specified location.

7.3.3.2.4 Envelope (Glazed)

This is the major culprit when it comes to the heat gain in the building. Though glazing is essential for daylighting and view, it is recommended that the design, orientation and material selection and shading should be optimized to reap benefits rather than suffer owing to poor design and material choice. Apart from window wall ratio and shading that has been considered essential for optimized glazing, the glass selection is considered the most important aspect for achieving energy efficiency in the building envelope. There are three criteria that decide the glazing performance primarily.

7.3.3.2.5 Glass selectivity

SHGC

The **SHGC** is the fraction of incident solar radiation admitted through a window, both directly transmitted and absorbed and subsequently released inward. **SHGC** is expressed as a number between 0 and 1. The lower a window's solar heat gain coefficient, the less solar heat it transmits.

VLT (Visible light transmittance)

VLT is the amount of **light** in the **visible** portion of the spectrum that passes through a glazing material. A higher VT means there is more daylight in a space which, if designed properly, can offset electric lighting and its associated cooling loads.

U- value

It is a measure of air to air heat transmission (loss or gain) due to the thermal conductance of the material and difference of indoor and outdoor temperature?
As SHGC and VLT play a more pivotal role in determining the selectivity of glass compared to U-value the same has been considered for the solution sets. However, it is recommended to use glass of lower U-value as well. The previous analysis shows that how glass with better SHGC performed better in terms of heat transfer than U-value. VLT of glass will ensure that optimum daylight is available inside the building.
The optimization of the building envelope ensures that the cooling and lighting demand of the building is reduced along with the operational cost of the building. Hence, once that is achieved, we have made through the first phase of Energy efficiency in the building. The second phase involve determining the reduced demand in the building and selection of efficient electromagnetic and lighting systems.

7.3.3.2.6 Cooling equipment efficiency

This is a direct benefit. The more efficient the system the lesser the operational cost of the building. System sizing is something that needs to be carefully calculated for the building specially post the list of detailed interventions in envelope design that ensures reduction in cooling demand. An oversized system design will prove to be inefficient despite the impressive specification it may boast of. Minimum EER 8 has been considered for the cooling equipment. EER 8 is the minimum efficiency requirement of green building code in the economy.

7.3.3.2.7 Air Conditioners

Air conditioners (rating system as per DOE 10CR Part430) star rating system specification is considered for the solution sets. Even though the rating system is voluntary, the same has been used to determine the incremental levels for the ease of market.

7.3.3.2.8 Lighting Power Density, LPD

LPD is one area that can be substituted with latest technology in the field of LEDs and other efficient lighting solutions. The lighting power density can be substantially reduced compared to the ASHRAE requirement with these technologies. Task desk lighting can be added to achieve the higher lux levels

7.3.3.2.9 Daylight Integration

Daylight integration (optimum lux level without glare) in the building design is definitely a wise design solution. Automated stepped daylight controls can help ensure that artificial lighting is operational depending on the availability of daylight.

7.3.3.2.10 Domestic hot water system, DHW

DHW is another energy guzzler in the buildings. Rather than determining the efficiency of electric DHW it seems more sensible and practical solution to offset the requirement through heat pumps or solar DHW systems as per the building design possibility.

7.3.3.3 Impact of the Intervention

In order to assess the environmental benefit from implementing green building codes, energy simulation using eQUEST software had been used in case of the Philippines. The simulation results are in table 62-71 in Appendix section. In order to use the software, the following assumptions have been taken:

- A rectangular box model of dimension 75m x 30m constructed for preliminary analysis with longer axis facing N-S
- Weather file of Manila, the Philippines considered
- Green building code for the Philippine studied for mandatory requirements to be followed.
- BAU case based on most commonly followed market practice
- Multiple baseline analyses completed to derive appropriate building materials specification & passive strategies for Philippine specific climatic conditions

As a result of the simulation, the following energy saving results were obtained for various categories of buildings under different star-rating (levels of energy efficiency, where 5 star meaning the highest efficiency level and 1 star meaning the least Energy Efficiency level):

Table 40: Energy saving potential for different categories of buildings

BUILDING TYPE		CO_2 Emission Reduction (%)					
		Overall	1 ★	2 ★	3 ★	4 ★	5 ★
Commercial	Office	31% - 55%	31%	38%	44%	54%	55%
	School	35% - 60%	35%	41%	46%	57%	60%
	Hospital	22% - 43%	22%	28%	32%	39%	43%
	Hotel	17% - 53%	17%	25%	37%	48%	53%
	Shopping Mall	25% - 55%	25%	43%	49%	52%	55%
Average savings		20%-55%	20%	30%	40%	48%	55%
Residential	House 30C Set Point	16% - 52%	16%	26%	34%	49%	52%
	House 50% AC	29% - 60%	29%	34%	42%	48%	60%
	2 BHK	16% - 60%	16%	32%	41%	49%	60%

BUILDING TYPE		CO_2 Emission Reduction (%)					
		Overall	1 ★	2 ★	3 ★	4 ★	5 ★
	1 BHK	18% - 56%	18%	33%	40%	47%	56%
	Studio Apartment	20% - 55%	20%	33%	40%	48%	55%
Average savings		16%-55%	18%	30%	37%	47%	52%

Considering the current penetration of green buildings in Davao and the domestic targets for implementation of green buildings, the following targets can be adopted in case of Davao:

Period	2020-2025	2025-2030
Residential	5%	20%
Commercial	10%	30%

The relative lower targets for residential sector is due to the capital costs involved in undertaking energy efficiency initiatives in buildings and retail consumers do not usually have high electricity consumption which would prompt such investments. Residential segment would have greater propensity to undertake efficient lighting investment rather than investments which involve changes in building structure.

Commercial sector buildings on the other hand have relatively higher consumption and have a higher propensity to reduce costs. Also, buildings like hotels periodically (usually between 5-10 years or less) undertake building refurbishment. Integration of energy efficient solutions can be implemented during such refurbishment periods. Hence, the targets for this sector is higher.

In order to assess the environmental benefits of the initiative, the following assumptions have been considered:

1. Average savings in residential and commercial buildings by implementing energy efficient building guidelines is 25% and 35% respectively[30].
2. Electricity consumption in residential and commercial building in baseline year i.e. 2017 is 430 MWh and 370 MWh respectively.
3. CAGR increase in electricity consumption in residential and commercial building is 5% and 4% respectively[31].
4. Progression of target levels between 2020 and 2030[32]:

Table 41: Energy Efficiency Building Codes penetration target levels in residential and commercial buildings

Sector	Target levels of penetration (in %)										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Residential	0.5	1	2	3	4	5	7	10	13	16	20
Commercial	1	2	4	6	8	10	12	16	20	25	30

5. Emission factor for electricity is 0.82kgCO_2e/kWh

Accordingly, the following results on the environmental benefits have been obtained:

[30] Note: Most probable combination of savings achieved based on average savings for each building category, sub-category and star-rating.
[31] Source: Project team analysis based on baseline data
[32] Note: The progression of transformation has been taken after considering the S-curve of progress of any project – muted progress in the short term, exponential growth in the mid-term and limited growth in long term

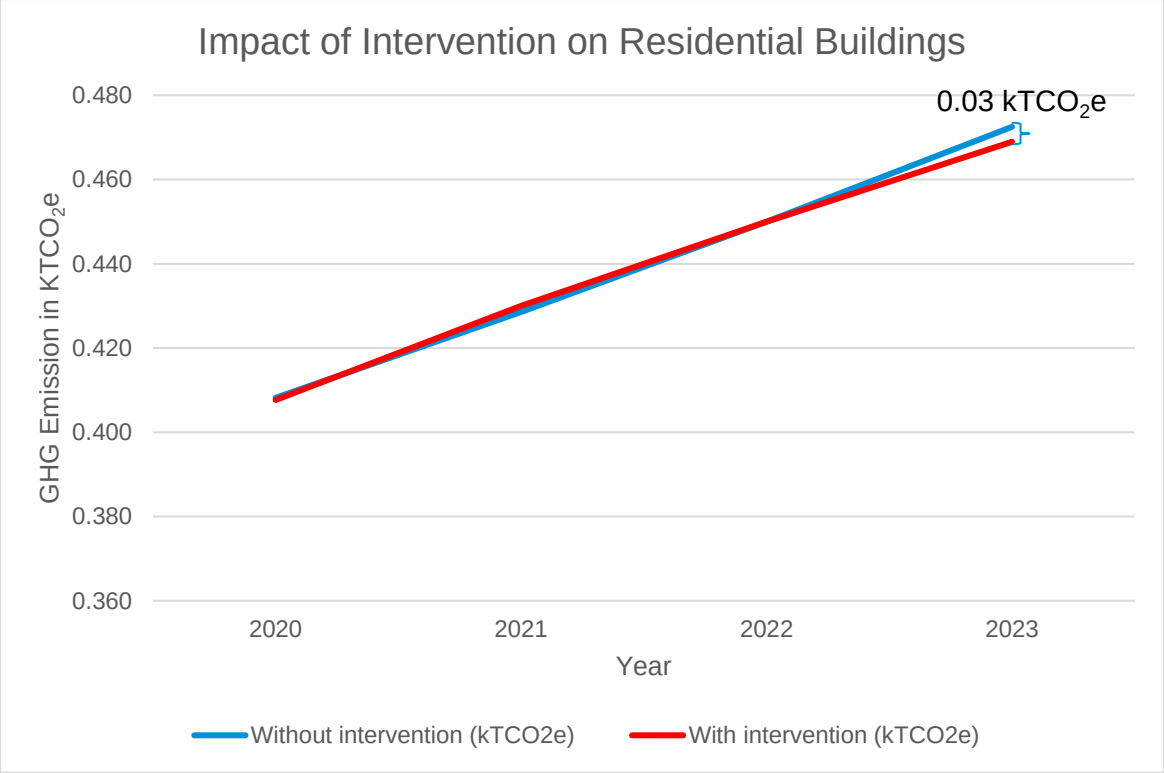


Figure 36: GHG emission reduction for residential buildings

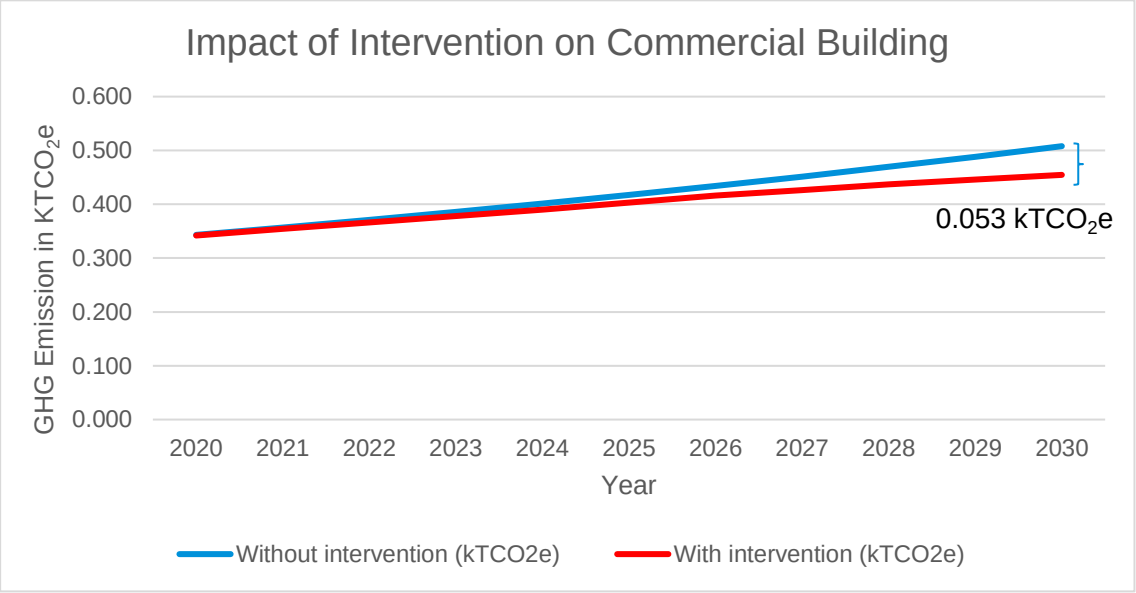


Figure 37: GHG emission reduction in commercial buildings

The targets can be achieved by implementing the green building codes in existing or new buildings. In case of existing buildings, retrofitting of interventions in the four areas given above can be undertaken, although changes in building envelope is limited to those interventions that do not interfere with structural integrity of the building. In case of new building, the entire set of interventions can be applied.

7.3.3.4 *Source of Funding*

The incremental capital required to construct a 1 star- 5 star rated buildings is discussed below:

Commercial Buildings:

Increment based on its comparison with Business as Usual (BAU) case

Table 42: Price increment of Commercial Buildings as compared to BAU scenario

Parameters	Rating Level	OFFICE	SCHOOL	HOSPITAL	HOTEL 3 STAR	SHOPPING MALL
Building Envelope	1	21%	21%	21%	21%	21%
	2	32%	32%	32%	32%	32%
	3	73%	73%	73%	73%	73%
	4	80%	80%	80%	80%	80%
	5	80%	80%	80%	80%	80%
Glazing and Shading	1	24.5%	24.5%	24.5%	24.5%	24.5%
	2	178%	178%	178%	178%	178%
	3	227%	227%	227%	227%	227%
	4	257%	257%	257%	257%	257%
	5	257%	257%	257%	257%	257%
HVAC/ Air Conditioning System	1	10%	10%	10%	10%	10%
	2	14%	14%	14%	14%	14%
	3	32%	32%	32%	32%	32%
	4	45%	45%	45%	45%	45%
	5	65%	65%	65%	65%	65%
Artificial Lighting & Controls	1	5%	5%	5%	5%	5%
	2	12%	12%	12%	12%	12%
	3	38%	38%	38%	38%	38%
	4	45%	45%	45%	45%	45%
	5	45%	45%	45%	45%	45%

Residential Buildings:

Increment based on its comparison with BAU case:

Table 43: Price increment of Residential Buildings as compared to BAU scenario

	Rating Level	Residential house (AC when set point is over 30°)	Residential house (~50% AC)	Residential: 2 BHK	Residential: 1 BHK	Residential: Studio apartment
Building Envelope	1	21%	21%	21%	21%	21%
	2	32%	32%	32%	32%	32%
	3	73%	73%	73%	73%	73%
	4	80%	80%	80%	80%	80%
	5	80%	80%	80%	80%	80%
Glazing and Shading	1	24.5%	24.5%	24.5%	24.5%	24.5%
	2	178%	178%	178%	178%	178%
	3	227%	227%	227%	227%	227%
	4	257%	257%	257%	257%	257%
	5	257%	257%	257%	257%	257%
HVAC/ Air Conditioning System	1	5%	5%	5%	5%	5%
	2	15%	15%	15%	15%	15%
	3	27%	27%	27%	27%	27%
	4	35%	35%	35%	35%	35%
	5	55%	55%	55%	55%	55%
Artificial Lighting & Controls	1	5%	5%	5%	5%	5%
	2	12%	12%	12%	12%	12%
	3	15%	15%	15%	15%	15%
	4	20%	20%	20%	20%	20%
	5	20%	20%	20%	20%	20%

Cost of implementation depends on the specific technical requirements of the intervention and method of implementation which makes any cost related calculations case specific. However, implementation of mandatory measures required to achieve any star-rating are generally cost intensive.

Based on the experience of driving green building codes in other parts of the globe, it is observed that policy push is key to driving changes. The Department of Energy and Department of Public Works and Highways (DPWH) should come up with some financing mechanisms which would support the implementation of Green building Codes in the Philippines, as the initial investment is too high to construct energy efficient buildings. The mechanism should be designed with an

objective to push the demand for EE technologies/materials by policy interventions of the Government.

The financing mechanisms developed by the Government, should empower the Central/ Domestic banks, Non- Banking Financial Institutions (NBFC) and International Funding Agencies to disburse loans for energy efficient buildings (both new and existing) on subsidized interest rates. The range for loan disbursement should be formulated in the financing scheme

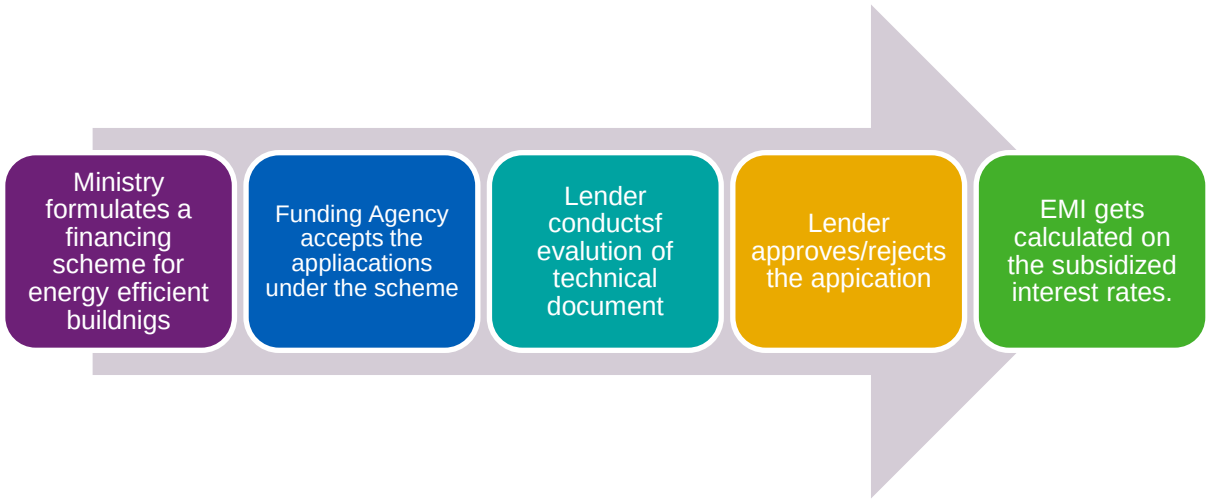


Figure 38: Funding for energy efficient buildings

Also, the electricity distribution companies may have collaboration with energy efficient equipment manufacturers, wherein the energy efficient equipment will be installed at the consumers building and the cost of the equipment shall be paid by the consumer in Equated Monthly Installment (EMI) which will be added in the monthly electricity bill of the customer. The equipment manufacturer can provide discount on bulk purchase of the equipment.

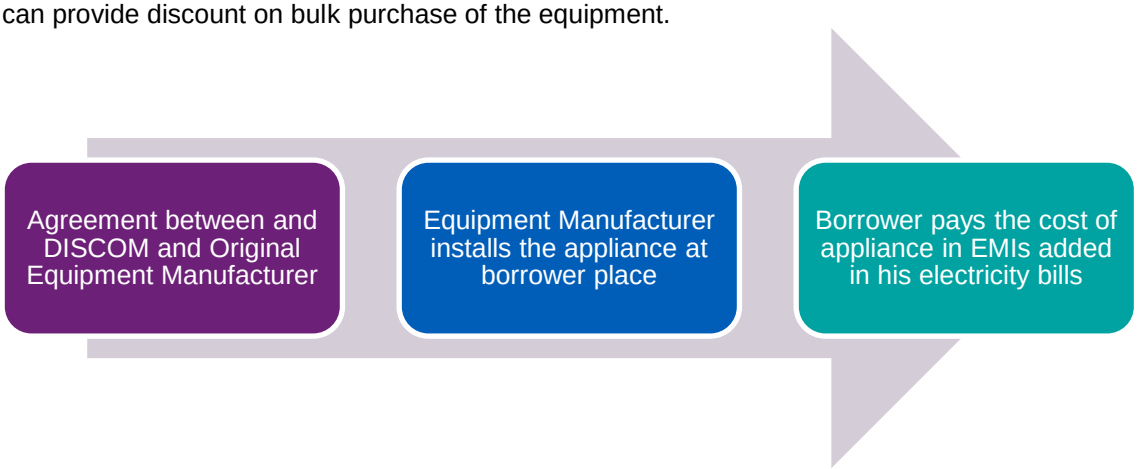


Figure 39: Funding for energy efficient appliances

7.3.4 Intervention for sustainable business model:

Based on the experience of driving green building codes in other parts of the globe, it is observed that policy push is key to driving changes, coupled with regulatory changes. While regulatory changes define the activities that need to be undertaken for transformation, policy measures help overcome the price barrier for implementation. Both these measures need to be supplemented by market promotion and awareness generation activities to stimulate citizen participation

Guidance on how to implement regulatory changes can be taken from the case of Building Environmental Plan System promulgated by the Tokyo Metropolitan Government (Tokyo Metropolitan Government, 2005). In Tokyo, it is required for the buildings that will be newly built or extended and whose total floor area exceeds 5,000 square meters to submit their building environment plans. Moreover, those buildings that will be newly built or extended and whose total floor area exceeds 2,000 square meters may submit their building environment plans on a voluntary basis. Details of plans and the results of evaluation of environment-friendly approaches are opened to the public on the official website of the Tokyo Metropolitan Government.

Details and methodology of the model is shown below:

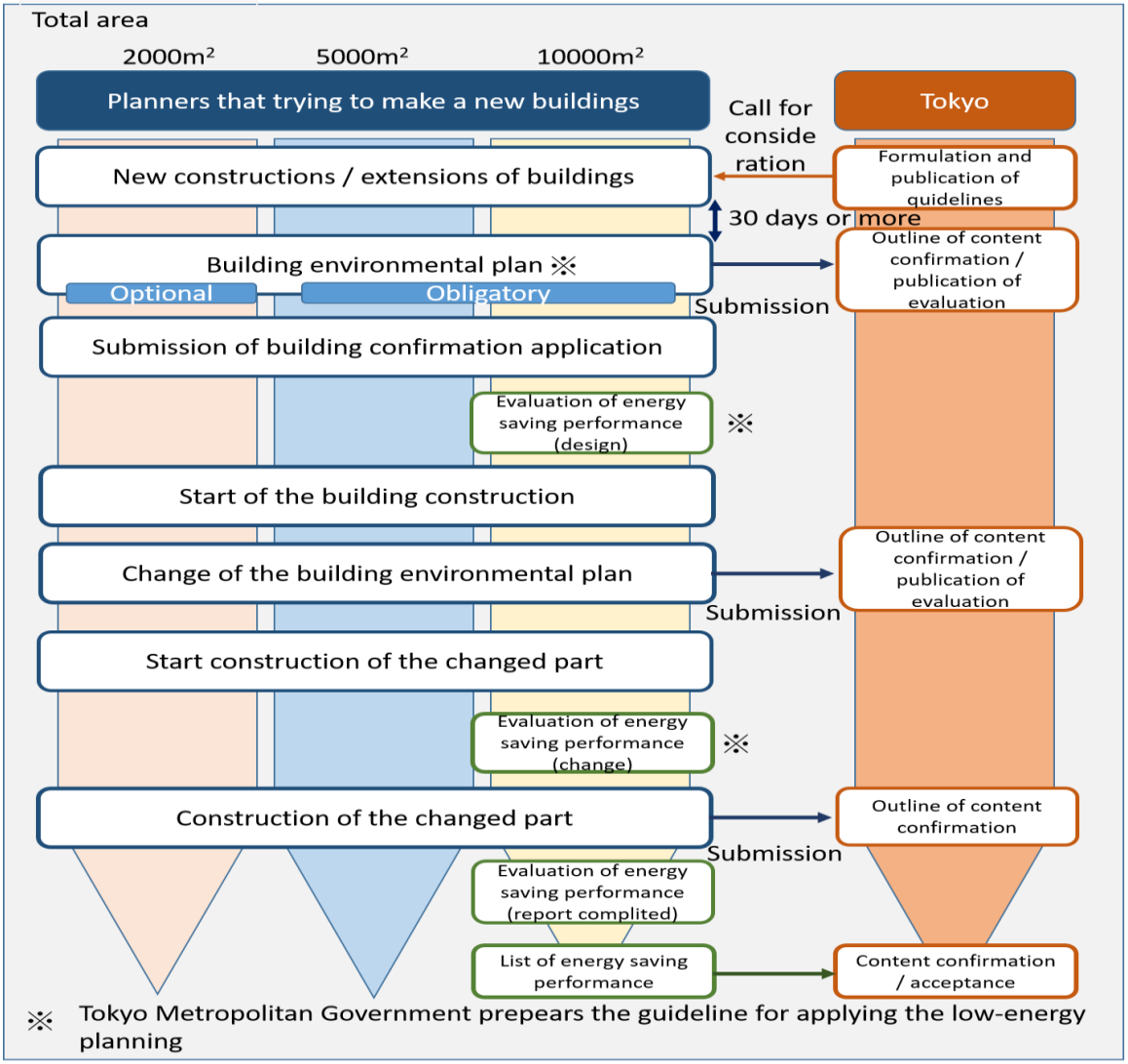


Figure 40: Methodology of Building Environmental Plan System in Tokyo

The submission system of building environment plan has four evaluation points, i.e., "streamlining of energy use," "appropriate utilization of resources," "protection of natural environment" and "mitigation of heat island phenomenon".

Table 44: Rating items under Building Environment Plan System

Fields	Items
Efficient energy use	Reducing building thermal load (insulation), use of natural energy, energy-conservation systems, efficient management systems
Appropriate use of resources	Usage of eco–friendly materials, protection of ozone layer, measures for longer building life.
Preservation of the natural environment	Hydrological recycling, greening
Mitigation of the heat-island effect	Measures to reduce effects of artificial heat emissions, measures to reduce heat accumulation in sites and buildings, consideration for the wind environment

Source: Tokyo Metropolitan Government website. C40 cities website

Under this program in Tokyo, which began in 2002, more than 1,300 buildings have been covered, at the rate of roughly 200 buildings per year.

Similar type of program is proposed in Davao city where, instead of the conventional regulatory method, the building owner evaluates the environmentally friendly efforts based on the guidelines, that encourages building owners to take voluntary initiatives using inductive methods. Such programs will surely benefit in reducing the energy consumption of the building sector.

7.4 Energy Management System

Energy management system (EMS) is an information-based management system that can collect information of both demand side and supply side, analyze and manage this information to realize optimal operation. It is an approach to environment and energy (low-carbon) as well as a support system for implementing, maintaining and improving the environment through cooperation between buildings. EMS can efficiently operate, monitor, and control energy across the entire region.

7.4.1 Current status analysis

Due to continued economic growth across the economy, the city's electricity distribution company, "Davao Light and Power Co." is expecting a 30-% increase in electricity demand in its franchise areas from 421 megawatts (MW) in 2018 to 546 MW by 2023. Davao Light serves Davao City, Panabo City, and the towns of Carmen, Dujali, and St. Tomas in Davao del Norte province.

Davao Light, the third largest privately-owned electric utility in the economy, is expecting the construction of more residential buildings, a hotel business park, a multipurpose indoor arena, a factory, and schools between 2019 and 2021. The electric utility anticipates an increase in its customer base to 504,911 from 404,574 (in 2018). It is also anticipating an increase in its sales from 2,468,191 MW per hour in 2018 to 3,137,336 MW per hour in next five years.

7.4.2 Government's vision

The government's vision is to design a mechanism that not only manages demand side but also supply side of energy.

7.4.3 Proposed intervention

In order to meet Government's vision by ensuring sustainability, the project team proposes following low carbon interventions:

7.4.3.1 Building Energy Management System (BEMS)

As the demand of power is going to increase due to rapid urbanization. Therefore, it is important to ensure that the limited resources that is used to produce energy is used efficiently. So, the efficient use of both electrical and thermal energy is important. The BEMS system will enable building sector to make controlled decision to use the incoming power effectively, without wasting it.

7.4.3.2 How will BEMS work:

BEMS is a sophisticated method to monitor and control the building's energy needs. Next to energy management, the system can control and monitor a large variety of other aspects of the building regardless of whether it is residential or commercial. Examples of these functions are heating, ventilation and air conditioning (HVAC), lighting or security measures. BEMS technology can be applied in both residential and commercial buildings. It combines both software and hardware for managing the behavior of the facilities of any building. Hardware system is set up by the sensor network, while software integrates the communication driver and business logic (control algorithms, database connection) establishing an "all in one solution".

7.4.3.3 Impact of BEMS

Environment: Reduction in CO_2 emission (Saving Energy using BEMS)

As the total energy reaction will vary up-to 20% (Saving Energy using BEMS), therefore similar estimate can be proposed for CO_2 emissions. However, presently we have considered that BEMS installation can help to reduce energy consumption by 10% in Davao city. In 2016, residential and commercial buildings consumed 4076 KTOE (Compendium of Philippine Energy Statistics and Information) of electrical energy, out of which Davao city's consumption was 66 KTOE (established). As, Building Energy Management System assists in energy reduction by 10%. So, by installing BEMS in commercial and residential buildings in Davao City, there can be 6.6 KTOE reduction in energy.

Table 45: Savings calculation through implementation of BEMS

Parameter	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Residential (KTOE)	32	36	38	40	41	43	45	48	50	52	55	57	60	63	66	69
Commercial (KTOE)	28	30	31	32	34	35	36	38	39	41	42	44	46	47	49	51
Total energy consumption (KTOE)	60	66	69	72	75	78	82	85	89	93	97	101	106	110	115	120
KTOE to MWh	697800	767580	801001	835893	872320	910351	950058	991514	1034797	1079990	1127176	1176445	1227889	1281606	1337697	1396268
Power consumption after BEMS implementation (10% reduction)						819317	855052	892363	931318	971991	1014459	1058801	1105101	1153446	1203928	1256641

Table 46: Energy consumption and CO_2 emissions

Parameter	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Energy Consumption in MWh Without BEMS	801001	835893	872320	910351	950058	991514	1034797	1079990	1127176	1176445	1227889	1281606	1337697	1396268
Energy Consumption in MWh with BEMS	801001	835893	872320	819317	855052	892363	931318	971991	1014459	1058801	1105101	1153446	1203928	1256641
CO_2 emission in MT without BEMS	0.67	0.70	0.73	0.76	0.79	0.83	0.87	0.90	0.94	0.98	1.03	1.07	1.12	1.17
CO_2 emission in MT with BEMS	0.67	0.70	0.73	0.68	0.71	0.75	0.78	0.81	0.85	0.89	0.92	0.96	1.01	1.05

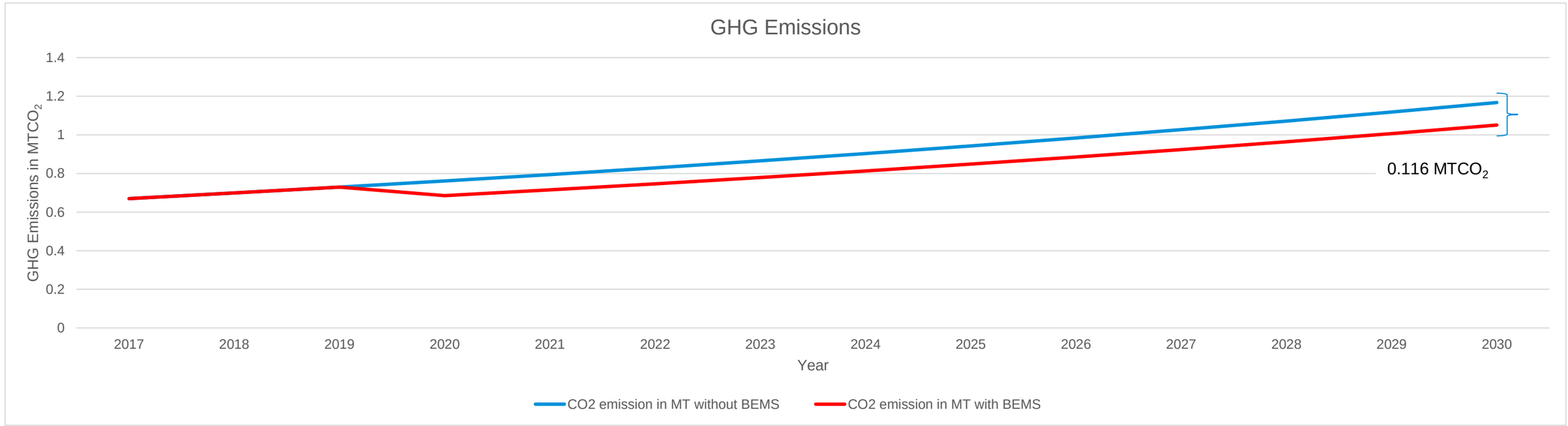


Figure 41: Comparison of GHG emissions with and without BEMS

7.4.3.4 *How BEMS will get implemented:*

Under Building Energy Efficiency initiative of Department of Energy of the Philippines, a policy must be framed where it should be made mandatory for every new residential and commercial building construction above certain sanctioned load to install BEMS in its premises. Also, in order to get a green building rating from any certification organization, the implementation of BEMS should also be mandatory.

7.4.3.5 *Source of funding*

BEMS system as and when installed helps in energy reduction by up to 20% (Saving Energy using BEMS). The design of EMS varies based on its usage. Therefore, estimation of financial requirement will vary from project to project. In case of Davao city, it is proposed to install EMS in demand side and in supply side.

As the energy consumption in building sector is very high, the Government or Public sector bodies should aim to accelerate their investment in energy efficiency technologies through invest to save schemes. The government should provide funds for proven technologies that are cost effective in saving CO_2 and that can maximize the potential of any further energy saving technologies.

Also, the energy efficiency service providers can come forward and invest in BEMS on ESCO (Energy Service Company) mode and can get returns on their investments when the building owner gets savings on their electricity bills.

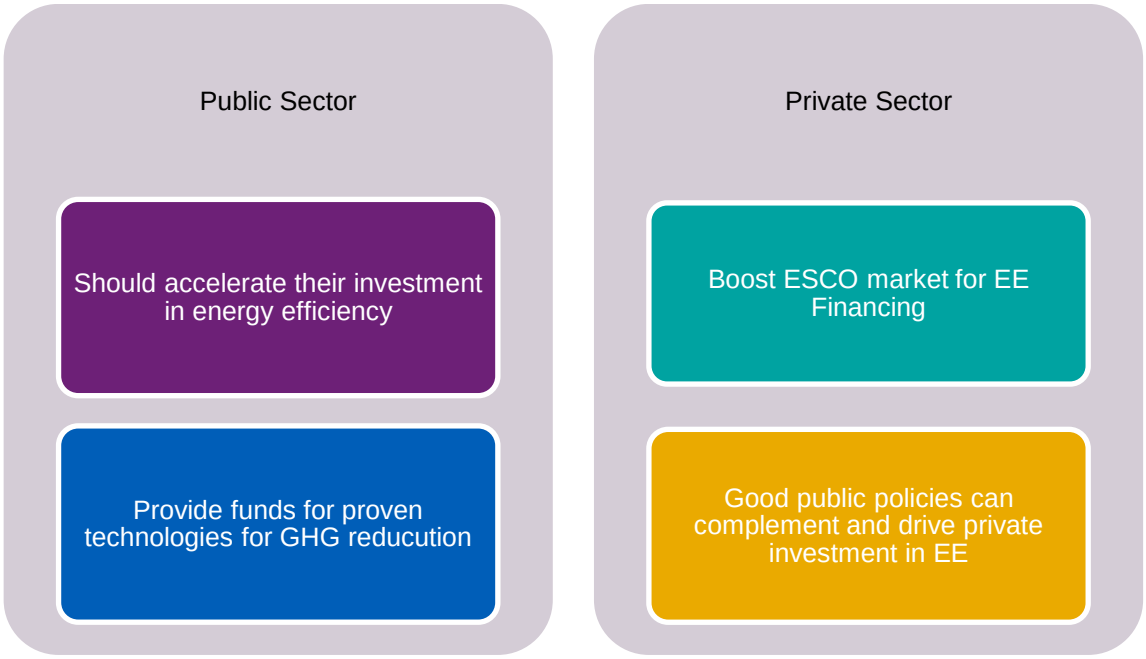


Figure 42: Source of funding for BEMS

7.5 Governance

7.5.1 Current status analysis

Presently, the people of Davao city lack the basic knowledge of energy efficiency and climate change. Without a basic understanding of energy, energy sources, generation, use, and conservation strategies, individuals and communities cannot make informed decisions on topics ranging from smart energy use at home and consumer choices to domestic and international energy policy. Current domestic and global issues such as the fossil fuel supply and climate change highlight the need for energy education.

7.5.2 Government's vision

The Governments vision is to impart basic knowledge of energy efficiency and climate change to the citizen of Davao city

7.5.3 Proposed intervention

In order to meet Government's vision by ensuring sustainability, the project team proposes following low carbon interventions:

7.5.3.1 Provide training/education on energy efficiency and climate change

Deficiencies in energy literacy have been found in many students as well as experience professionals. The aim of the intervention is to educate students and experienced people and provide training on climate change action and energy efficiency and the improved energy efficiency in major sectors of the economy. Attitude and behavior of the public can be affected through education.

7.5.3.1.1 Operating Mechanism:

The project team suggests 2 ways to impart basic energy knowledge to the students:

1. Collaborative planned program between school student/staff, and a sector expert who will provide the energy learning classes. The frequency of these classes may be twice or thrice in a week. Guardians should also be invited to attend these classes

2. The development of the e-learning resources on Energy and Climate Change that will help the students and other individuals to gain knowledge on energy related topics.

7.5.3.1.2 Impact of Training/Education on EE

The training of students will help them in

- Understand conceptual knowledge related to energy
- Understand how energy is used in everyday life
- Understand the relationship between energy production, consumption, environment, and society

- Recognize the impact on the environment of individual decisions and actions that are energy related
- Makes choices (or strives to make choices) that reflect energy conservation and energy resource development

7.5.3.1.3 Source of funding

The government will require support from all key stakeholders viz. NGOs, UN, Civil Society, and the Public and Private Corporate Sector to provide the basic knowledge/ training about energy efficiency and climate change to the school students.

As a part of Corporate Social Responsibilities (CSR) the corporate sector has taken several initiatives in improving the education standard of the children. Implementation is done either on its own or with a partner entity like an NGO

Probable funding sources for providing education/training to children can be the following:

Allocation from Government Education budget	Funding from Non Governmental funding agencies	Corporate Funding under CSR
• Basis of policy support can be utilized for allocation of funds from central education budget for intervention	• Individual private donors comprise a significant portion of NGO funding • These funds can be invested by the NGO's in imaprting training to the children.	• Govt. can partner with corporations for providing funds for training of children • Education is a key focus area for Corporations as part of their Corporate Social Responsibility.

Figure 43: Funding Sources for training/education

7.5.3.2 Introduction of Energy Efficiency and Climate Change in the School/College curriculum

Presently, in most schools you visit, the curriculum what is taught to students is too old and it has not been updated yet. There are no chapters to educate students on energy efficiency and climate change.

The project team proposes to inculcate energy related curriculum with entertaining and interesting books to educate students about energy issues and increase their awareness of energy opportunities, both in terms of their current behavior and their future interests.

7.5.3.2.1 Operating Mechanism:

The Department of Education of Davao city must change the present curriculum of students and should provide latest education on energy efficiency and climate change, which will support the teachers and students across the economy with the goal of increasing youth understanding of energy issues. The latest curriculum should aim to provide knowledge and awareness related to clean energy and energy efficiency.

7.5.3.2.2 Source of funding

Department of Education should notify all the publishers to change the curriculum in the textbooks and if in case required should provide some budget from the central government to support the implementation of the measure.

7.5.4 Policy Framework

The project team proposed following policies to be formulated in order to successfully implement the intervention suggested:

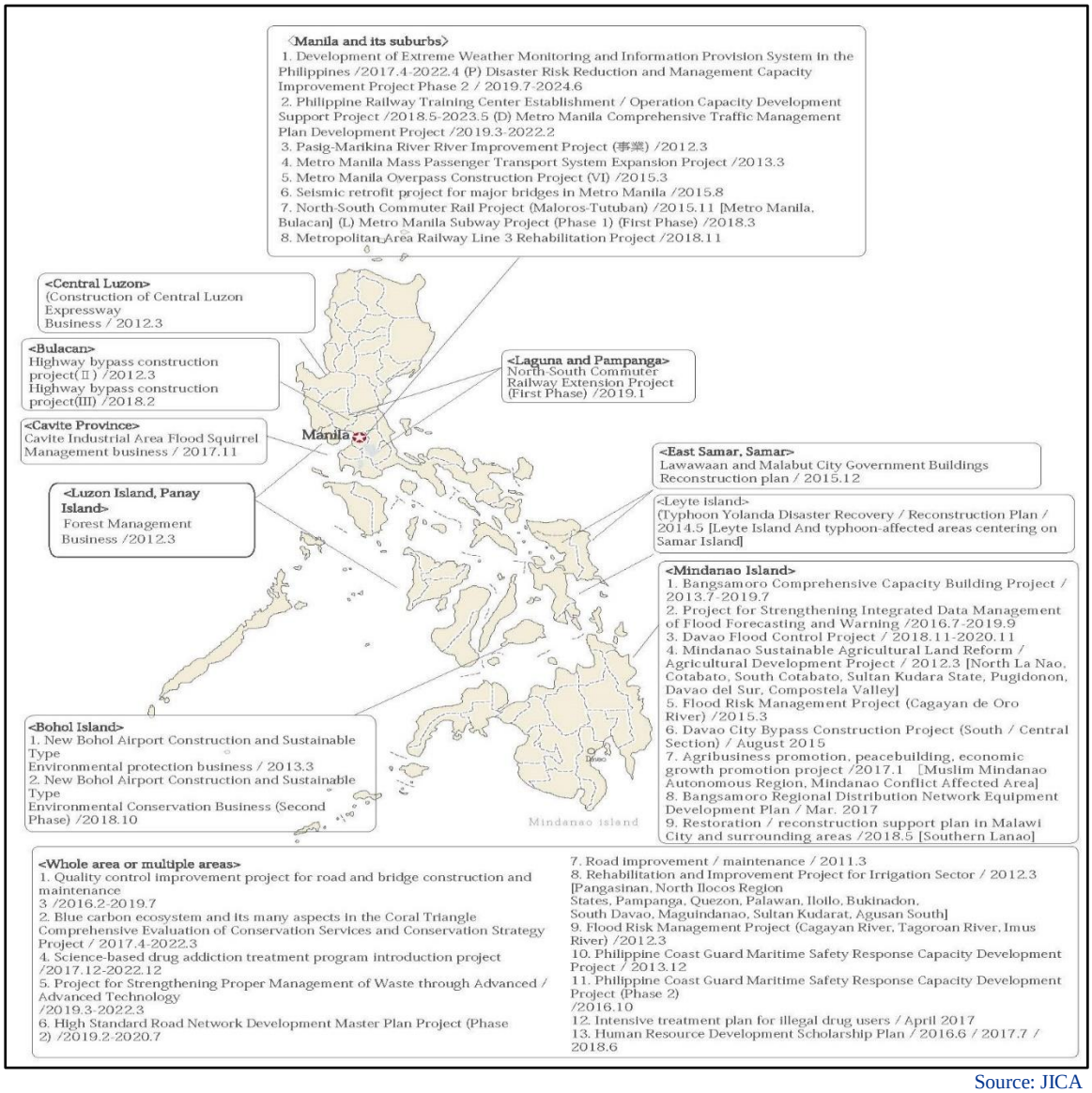
Table 47: Proposed list of sector specific policies that needs to be implemented

Sector	Intervention	Proposed Policy	Requirement to implement the policy
Transport	Implement of ODD-EVEN Scheme for private cars	The policy should aim to reduce the number of on-road vehicles in a day by about half and thereby reducing the alarming levels of pollution and traffic congestion in the Davao city.	**Education:** The citizens of Davao city should be made aware about the ODD-EVEN Scheme. Hence, promotion of the scheme should be done through advertisement, both printed and digital
Energy Supply	12 MW of Waste to Energy plant in Davao city	The new policy of promoting introduction of waste-to-energy technologies with proper incorporation of pollution control measure has already been incorporated in the Republic Act (RA) 9003,	**Financial:** To construct the WtE plant in Davao city, financial support of 2.5 billion PHP is required
Buildings	Implementation of Building Energy Management System in residential and commercial buildings	A policy must be framed where it should be made mandatory for every new residential and commercial building construction above certain sanctioned load to install BEMS in its premises.	**Technical:** The policy should follow all the ISO standards required to make an efficient building

8 Funding

The overall study seeks to improve the ability of Davao city to improve their infrastructure, reduce unnecessary energy waste and save scarce natural resources. The major barrier to implement the above discussed energy efficiency interventions in respective sector is the capital requirement. This section describes some of the potential institutions who can support the funding regarding the mentioned interventions in the current report.

- Figure 44 shows the project layout for all area in Philippines by JICA.
- Moreover, in Table 48 are shown some of the representative fund and project layout by each institution.



Source: JICA

Figure 44: The project layout regarding a funding shown by JICA in Philippines

Table 48: Potential institutions and projects layout regarding a funding in Philippines

Assessment Areas	Funding Agencies	Project Name
Transportation	Asian Development Bank	• Regional: Southeast Asia Transport Project Preparatory Facility Phase 2 • Philippines: Strengthening the Transition of Vulnerable Communities Affected by the Malolos-Clark Railway Project • Philippines: Malolos-Clark Railway Project
	World Bank	• Domestic Roads Improvement and Management Project II
	JICA	• Davao City Bypass Construction Project (South / Central Section) / August 2015 • Metro Manila Mass Passenger Transport System Expansion Project / 2013.3 • Metro Manila Comprehensive Traffic Management Plan Formulation Project / 2019.3-2022.2 • North-South Commuter Railway Project (Maloros-Tutuban) /2015.11 [Metro Manila, Bulacan]
Governance	Asian Development Bank	• Philippines: Local Governance Reform Program (Subprogram 1)
	United Nations Development Program	• Strengthening Domestic Systems to Improve Governance and Management of Indigenous Peoples and Local Communities Conserved Areas and Territories
Environment & Resources	JICA	• Project for Strengthening Integrated Data Management of Flood Forecasting and Warning /2016.7-2019.9 • Davao Flood Control Project / 2018.11-2020.11 • Cagayan de Oro River Basin Flood Forecasting and Warning System Improvement Project /2018.6 • New Bohol Airport Construction and Sustainable Environmental Protection Project /2013.3 • New Bohol Airport Construction and Sustainable Environmental Conservation Project (Second Phase) /2018.10
	United Nations Development Program	• Sustainable Land Management • Philippines: Low Emission Capacity Building Project • Reducing Pollution and Preserving Environmental Flows in the East Asian Seas • Scaling Up Implementation of the Sustainable Development • Wealth from Nature • Low Carbon Urban Transport System in the Philippines

Beyond the mentioned funding agencies in Table 48, there are various other bilateral and multilateral funding agencies which are operating in Davao City and are undertaking multiple projects in the assessment areas enumerated for low-carbon development of Davao. Along with government funds and possible alliance with private partners, such multilateral and bilateral funding agencies can also be explored to finance low-carbon measures presented in this project

9 Impact of Interventions

The business as usual scenario has been considered to represent the present GHG emission from major energy intensive sectors i.e. transport, residential and commercial buildings in Davao city. However, if the above-mentioned low carbon interventions are implemented in Davao city, the overall GHG emissions from these sectors will certainly reduce. The tables below depict the GHG emissions from these energy intensive sectors pre and post implementation of low carbon interventions. In the year 2030, there will be total reduction of 0.564 $MtCO_2$ as illustrated in the figure below, comparing both the GHG emission scenarios with and without LCI being implemented.

Table 49: GHG emissions without interventions

Scenario Description	Emissions (in $MTCO_2e$)													
	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Without WtE	0.681	0.709	0.737	0.767	0.798	0.830	0.863	0.897	0.933	0.971	1.009	1.050	1.092	1.135
Without BEMS	0.670	0.699	0.729	0.761	0.794	0.829	0.865	0.903	0.942	0.983	1.026	1.071	1.118	1.167
Without ODD-EVEN Scheme	0.482	0.506	0.532	0.559	0.587	0.617	0.648	0.680	0.715	0.751	0.789	0.829	0.871	0.915

Table 50: GHG emissions with interventions

Scenario Description	Emissions (in $MTCO_2e$)													
	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
With WtE	0.682	0.709	0.738	0.767	0.798	0.830	0.819	0.853	0.889	0.927	0.965	1.006	1.048	1.092
With BEMS	0.67	0.70	0.73	0.68	0.71	0.75	0.78	0.81	0.85	0.89	0.92	0.96	1.01	1.05
With ODD-EVEN Scheme	0.482	0.506	0.532	0.475	0.499	0.524	0.551	0.578	0.608	0.638	0.671	0.704	0.740	0.777

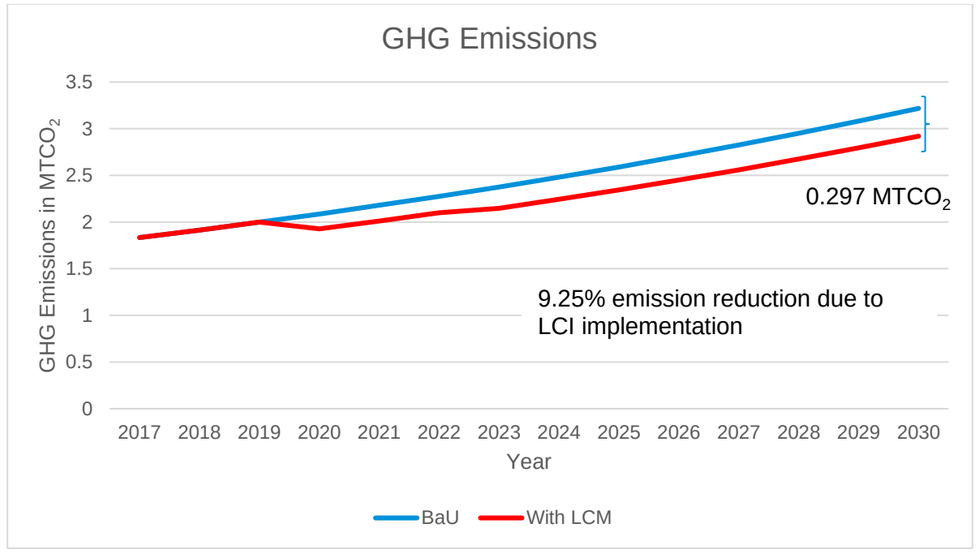


Figure 46: Davao City GHG emissions before and after LCI implementation

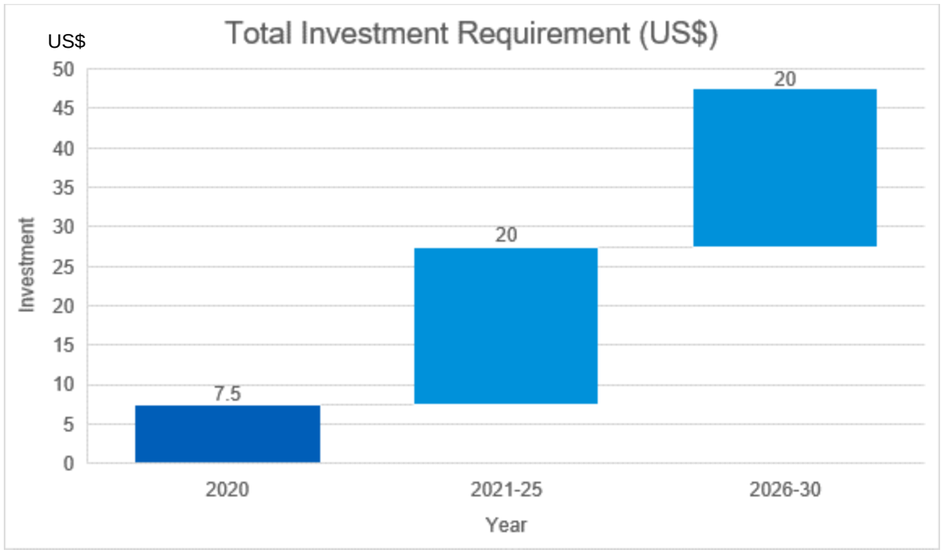


Figure 45: Investment requirement for proposed interventions in Davao

10 Summary of Interventions

Davao City in the Philippines has the potential to become a low carbon city. The table below showcases a list of interventions along with investments and CO_2 reduction that is proposed to make Davao as low carbon city.

Table 51: Overall summary of financial & CO_2 emission savings for Davao city

Assessment Area	Intervention Name	Implementation Targets		Financial Requirement (Million USD)	Abatement potential ($MTCO_2$)	Implementing Agency/ Department	Time period (Short/Medium Term)	Possible Funding Sources
		2020-25	2025-30					
Transport	Implementation of ODD-EVEN Scheme for private cars	50%	100%	Not required	0.287	LTO	Short	Funds not required
Untapped Energy	Waste to Energy – Power generation through incineration of solid waste	30%	70%	47.5	0.044	Department of Energy, Department of Environment and Natural Resources	Medium	Government of Japan
Energy Management System	Installation of EMS in existing and new building in Phased manner.	10%	35%	Finance varies from project to project	20% energy reduction	Department of Energy, Office of the city building officials	Medium	DOE
Buildings	Implementation of Energy Efficiency Building Codes in Residential and Commercial Buildings	10%	30%	Finance varies from project to project	10-30% energy reduction	Office of the city building officials, Department of Energy	Medium	Department of Environment and Natural Resources

11 Appendix

11.1 List of Stakeholders

The following stakeholders attended the workshop in Davao city:

Table 52: List of Stakeholders

S.No	Stakeholders
1.	Office of the Legislative District #1, #2, and #3
2.	Dept. of Economic Development
3.	Dept. of Fiscal Management
4.	Dept. of Infrastructure
5.	Dept. of Social Services
6.	City Planning & Development Office
7.	Davao city agriculture office
8.	Department of Transportation
9.	Office of the Building Official (OBO)
10.	Davao Light and Power Company (Davao Light)
11.	Davao Construction Association Center, Inc.
12.	Davao city environment & resources office
13.	Davao City Green Building Authority
14.	United Architects of the Philippines (UAP) - Davao Chapter
15.	Energy Saving Association (ESA) – Davao city
16.	Ateneo De Davao University –
a)	School of architecture,
b)	School of Urban planning
17.	Department of Energy, Central Level

11.2 Policies and targets related to Low Carbon Strategies - Davao City (Philippines)

1. Comprehensive Land Use Policy (2013-2022)

Table 53: Overview of CLUP Policy

Sector	Policies
Industry	• Protect and ensure a timely supply of well sited industrial land to meet projected demand • Assess, monitor and provide infrastructure to support industrial activities • Consolidate and strengthen key industrial areas to achieve operational advantages and the efficient provision of infrastructure. • Promote sustainable industrial practices, such as industrial ecology, and facilitate the co-location of businesses that can share their operations • Manage and prevent conflicts between industry and other uses
Agriculture	• Identify and protect areas of agriculture production • Facilitate the provision of necessary infrastructure and services. • Identify and plan for future viable and sustainable agriculture industry • Promote sustainable management of natural resources for agriculture production • Manage the boundary between agriculture industry and urban/rural residential areas • Enforce land productivity
Tourism	• Create visitor destinations that provide memorable experiences • Enforce pleasant and memorable visitor experiences • Facilitate the provision of appropriate support infrastructure for tourism • Boost tourism by promoting city as a “sustainable city". • Enhance the city to be accessible by people with disabilities.
Waste Management	• Strict implementation of Solid Waste Management Ordinance. • Ensure strict implementation on treatment and handling of medical, toxic and hazardous solid and liquid waste before its disposal in accordance with RA 6969. • An area for on-site collection and sorting of recyclable materials and garbage should be provided within all new development • A dedicated area for the collection and sorting of construction waste and the recycling of building materials during construction should be provided and screened from public view • Development should not result in emission of atmospheric, liquid or other pollutants.
Water Resource	• Water especially groundwater is a very valuable resource of Davao City and should be protected for the use of the present and future generations • Human activities over the area must be strictly managed to ensure that the aquifers will not be affected • Water-extractive activities will be strictly regulated to prevent over extraction

Sector	Policies
	• All structures built over the identified water resource area must have proper sanitation facilities to manage their wastes especially septage and wastewater • Activities that are highly polluting will be prohibited over the identified water resource area

2. Philippines Energy Efficiency Action Plan 2016-2020

Table 54: Overview of the Philippines Energy Efficiency Action Plan

Sector	Program	Proposed Action
INDUSTRIAL SECTOR: Industrial Sector Energy Efficiency Initiatives 2016–2020	Industry Energy Management and Opportunity Identification	Create a mechanism for the DOE to have direct energy efficiency input into the Investment Priority Plan development process for 2017–19. Assist the Department of Trade and Industry (DTI) in creating "green" industry roadmaps with energy efficiency measures.
		Scale up and broaden the sectors targeted by the Philippines Industrial Energy Efficiency Project (PIEEP) and Health Emergency Management Staff (HEMS) projects to the priority sectors of cement, steel, semiconductor manufacturing, and sugar.
		Provide technical assistance to the Philippine Economic Zone Authority (PEZA) on qualifying energy efficiency service providers and technologies.
		Link energy efficiency incentive provision by the DTI to the establishment of a compliant data collection regime.
	ESCO Development Program	Create coordinated platforms for the electric service company (ESCO) sector's capacity-building activities, and the consideration of guaranteed support.
		Develop standard ESCO contracts for bidding
		Develop project measurement and verification (M&V) guidelines in line with the International Performance Measurement and Verification Protocol (IPMVP).
		Overhaul the ESCO accreditation process
		Create an ESCO pilot site for the industry
	Demand Response and Demand-Side Management Program	Prepare an analytical paper setting out the framework and regulatory steps necessary to implement a comprehensive demand response strategy.
		Establish a Power Sector Energy Efficiency Strategy
TRANSPORT SECTOR: Transport Sector Energy Efficiency	**Vehicle Efficiency Improvement Program**	Complete baseline assessment for efficiency of new light duty vehicles
		Roll out new vehicle labeling for energy use.
		Vehicle inspection regimes • Include fuel efficiency ratings with emissions compliance testing.

Sector	Program	Proposed Action
Initiatives 2016–2020		• Investigate differentiated vehicle taxes for efficient vehicles
		Vehicle conversion programs • Extend the liquefied petroleum gas (LPG program) for the taxi fleet. • Support technical and vocational education and • training (TVET) for LPG-vehicle conversion • E-Trikes – focus on current delivery and consider further rollout in a mid-term review.
		Formulate a transport and urban energy efficiency Inter-Agency Committee
	Vehicle Efficiency and Driver Awareness Program	Re-launch the Fuel Economy Run initiative
		Driver training program rollout
	Freight Transport Energy Efficiency Partnership	Form a partnership to develop a Domestic Efficient Freight and Logistics Master Plan.
		Develop a Domestic Efficient Freight and Logistics Master Plan.
COMMERCIAL BUILDING SECTOR: Commercial Building Sector Energy Efficiency Initiatives 2016–2020	**Government Buildings Efficiency Program**	Strengthen and extend the Government Energy Management Program (GEMP).
		New guidelines released for government procurement of energy efficiency services.
		Complete a model ESCO procurement and implementation project at a high-profile government building site.
	Building Codes Program	Permanent coordination body established for energy efficiency input to Green Building Code Development
		Establish a building code training program for selected LGUs.
		Inclusion of energy efficiency in the three-year review process of Green Building Codes.
	Building Information and Ratings Program	Develop an annual performance information tool as a benchmark for government building energy efficiency.
		Incentive mechanism to link certification to eligibility for energy efficiency incentives
		Mandatory disclosure of performance ratings on the sale or lease of buildings
RESIDENTIAL SECTOR: Residential Sector Energy Efficiency Initiatives 2016–2020	**Appliance Standards and Labelling Program**	Reformulate the mechanism for energy efficiency input and cooperation on standards development.
		Increase post-market surveillance programs
	Large Employers Bulk Purchase and Staff	Undertake the design of a scheme: · Eligible organizations · Eligible products

Sector	Program	Proposed Action
	Incentive Program	· Scheme mechanics
		Roll out a scheme and establish the DOE support activities
	Behavioral Information Program for Low-Income Groups	Investigate greater utilization of billing information programs and prepaid billing models.
		Continue awareness-raising campaigns on energy efficiency, including those for housing design (e.g., insulation and cool roofs).

3. Davao Transport Roadmap

Table 55: Overview of Davao Transport Roadmap

Mode Of Transport	Strategy
Walking and bike riding	• Formulation of a clear Transport Master Plan, CLUP, and CDP that highlight investment opportunities and challenges and identify funding gaps • Hiring well-trained and knowledgeable staff dedicated to non-motorized transport planning management • Adoption of an ordinance which includes design standards and specifications supporting non-motorized transport
Public Transport	• Implementation of the High Priority Bus Project with enhanced commuter access, safety and commuting experience • Provision of improved and adequate transportation infrastructure and facilities • Harnessing strong stakeholder support, raise awareness of and concern for problems of current transport system, and build strong constituency for public transport modernization.
Private Transport	• Discouraging private vehicle usage by making public transport more efficient and reliable • Review existing policies on parking and their subsequent implementation
Freight	• Creation of an ordinance on freight operation and management • Establishment of logistic centers and support facilities

4. Power Development Plan 2016-2040

Table 56: Overview of Power Development Plan

Policy & Program	Description
Interruptible Load Program (ILP)	Under this program, Distribution Utilities (DU) and its Participating Customers (PCs) enter into an agreement for a voluntary full or partial de-loading of the PC during a mutually agreed period of time. PCs with standby generation capacities that are requested by the DU to

Policy & Program	Description
	participate in the ILP during instances of power supply deficits will be compensated should they use their own generating facilities.
Mindanao Modular Generator Set Program	Under the Program, a loan facility is extended to participating electric cooperatives (ECs) in Mindanao for the acquisition of the modular gensets as an immediate relief to supply the needed power in the franchise areas of ECs. The ECs have the option to eventually retain the generator sets or return the generator sets to the Government when the power supply in Mindanao has already stabilized after the entry of new power generation projects
Interim Mindanao Electricity Market (IMEM)	The IMEM was intended to augment supply by serving as a venue for transparent and efficient utilization of all the available capacities in the Mindanao Grid.
Competitive Selection Process (CSP)	To institutionalize a transparent system of power supply contracting that ensure provision of adequate and reliable supply of electricity to all end-users, the DOE issued on 11 June 2015, Department Circular No. DC2015-06-0008, “Mandating All Distribution Utilities to Undergo Competitive Selection Process in Securing Power Supply Agreements (PSAs).”
Privatization of Government’s Power Sector Assets	The privatization of the government’s power facilities is one of the key features of The Electric Power Industry Reform Act EPIRA and a prerequisite to the establishment of a level playing field in the power industry. The period 2010 to 2016 saw the turn-over of majority of the Domestic Power Corporation’s major generation assets, IPP contracts and transmission assets.
Wholesale Electricity Spot Market (WESM)	The establishment of WESM is part of the package of electric power industry reforms mandated by EPIRA where trading of electricity through a transparent and competitive process can be made.
Retail Competition and Open Access (RCOA)	The implementation of RCOA is pursuant to Section 31 of Republic Act No. 9136 or the EPIRA where Contestable Customers (CC) will be allowed to source their supply of electricity from a Retail Electricity Supplier (RES) by allowing the use of transmission and distribution systems and associated facilities, subject to the payment of transmission and distribution wheeling charges duly approved by the ERC.

6. Philippines Energy Plan 2016-2030

Table 57: Overview of the Philippine Energy Plan

Sector	Strategies
Fuel Supply	• Continuing conduct of the Philippine Energy Contracting Round (PECR) for coal to select the most qualified operators • Vigilant monitoring of coal mining operations to check compliance with the DOE approved work program • The DOE, with the assistance of law enforcement agencies and LGUs will continue its campaign against unauthorized coal mining and trading activities

Sector	Strategies
	• In a bid to reduce carbon footprint of coal generation, adoption of clean technologies will be promoted. • Continuous issuance of Certificate of Compliance for coal importation will be facilitated to meet the economy's coal demand • Continuous capacity building with the ASEAN Forum on Coal (AFOC).
Renewables	• The DOE will continuously pursue the conduct of **Open and Competitive Selection Process (**OCSP) where prospective geothermal areas will be offered and bid-out to private investors • Assessment on the utilization of Low-Enthalpy Geothermal areas will also be a continuing activity • DOE is also pushing to develop the small-scale power and non-power application to maximize full potential of the economy's geothermal resources. • DOE will also start conducting Research/ Feasibility Study on emerging technologies • IEC campaigns will be strengthened to address issues on environment and socio-cultural concerns • Optimization and Improvement of Geothermal Power Plant Efficiency and Energy Conversion • Continued exploration of identified underexplored/unexplored assessment of geothermal areas
Power Sector	• Advocate the passage of a legislative measure that will declare energy projects as projects of domestic significance to ensure timely implementation of power projects • Institutionalize an appropriate power portfolio (70-20-10 baseload, mid-merit and peaking categories) and reserve requirements • formulation of more stringent and sound policies • Continuous monitoring, inspection and conduct of technical performance audit of power facilities to ensure the security and reliability of supply • Continuous monitoring and implementation of EPIRA • Institutionalize performance standards to all energy regulatory and market related agencies of government • Continuous conduct of capacity building activities for the energy family and industry stakeholders to increase technical competency • Continuous conduct of research, development and deployment of emerging and innovative technologies
Oil and Gas	• Continuous Monitoring of the Downstream Oil Industry • Review and Possible Streamlining of Requirements for Entry and Operation of Players • Review of Existing Rules and Regulations and Recommendations of Amendments • Ensuring the Economy's Oil Supply Security through Oil Stockpiling • Fuel Quality Standard Development • Encourage investments in domestic natural gas supply and imported Liquified Natural Gas • Facilitate availability of delivery & storage infrastructure to meet demand of target markets • Maximize the potential of natural gas to fill future gap in power generation and increase share in power generation mix

Sector	Strategies
	• Expand the use of gas to transport, industrial, commercial, residential and agricultural sectors • Develop skills required for the natural gas industry • Formulate gas related policy and framework to support natural gas program implementation and industry development

7. Davao Regional Development Plan 2017-2022

Table 58: Overview of Davao Regional Development Plan

Goals	Strategies/Policies
High trust in public institutions	• Duty bearers' efficient delivery of entitlements to claim holders improved • Graft and corruption reduced • Citizens' participation strengthened
Swift and Fair Administration of Justice	• Capability, capacity, coordination, and efficiency of the courts and prosecution pillars of the justice system enhanced • Capacity and quality of the Region's correctional facilities, and rehabilitation and restoration services enhanced • Access to justice expanded, and community support for justice enhanced
Safeguard cultural diversity through culturally-sensitive and responsive governance.	• Access to culture-responsive education increased • Access to communication platforms increased • Genuine, participatory and dynamic culture-responsive governance promoted • Sustainable and culture-sensitive economic policies enforced • Appreciation for cultural diversity strengthened • Sensitivity on cultural heritage heightened • Enforcement of culture-sensitive gender and development programs strengthened
Significant growth of the agriculture, forestry and fisheries sector	• Strengthen research and development and extension services and pursue commercialization of R & D outputs • Pursue massive investments in logistics and infrastructure • Roll-out of the Domestic Color-Coded Agriculture and Fisheries Map • Provide simplified credit facility for farmers and fisher folks • Capacity building to strengthen farmers and farmers' organizations • Strengthen enforcement of agricultural and • Fisheries laws to ensure the sustainability of crop production and fisheries • Provision of weather index-based insurance and crop insurance for all product lines • Establishment and implementation of quality standards in agriculture and fishery products • Strengthen the capacities of the agriculture and fisheries sector on Disaster Risk Reduction and Mitigation and Climate Change Adaptation

Goals	Strategies/Policies
Globally competitive and innovative industry and services sectors	• Pursuit of agro-industrial development, particularly the strengthening of the Manufacturing Subsector through the implementation of the Industry Clustering Strategy • Pursue massive investments in logistics and infrastructure • Reduce the cost of doing business and improve the business support environment • Develop Competitive and Resilient MSMEs • Strengthen the Role of Cooperatives in Addressing Inequality and Foster Economic Development • Strengthen Research and Development (R&D) and technology adoption • Capacitate the Region's Human Resource Pool and Undertake Talent/skills mapping to match industry needs • Improve the business support environment by mandated agencies
Region shall build up socioeconomic resiliency of communities	• Addressing the housing needs and slum upgrading for informal settlers and urban poor • Fast-track inventory of idle lands for socialized housing • Intensify the formulation of local shelter plans • Restrict settlements in environmentally critical areas • Strengthen institutional arrangements in the housing sector • Promote disaster risk and climate proof housing and resettlement facilities
Promote technology adoption and encourage innovation	• R&D technology adoption and innovation in agriculture, industry and services sectors increased • S&T infrastructure and human capital investments strengthened and sustained • Appreciation and creative capacity for science, technology and innovation increased • Linkages and networking among R&D/S&T institutions locally and abroad strengthened

8. Renewable Energy Roadmap 2017-2040:

Table 59: Strategies for Renewable Energy Roadmap

Strategy	
Acceleration of RE positioning by:	• Review and update 2011-2030 NREP • Finalise rules and implement RPS and REM • Finalise rules and implement Green Energy Option • Conduct detailed RE technology and resource assessment • Intensify development in off-grid areas for wider populace access to energy • Continue and accelerate implementation of RE projects
Creation of conducive business environment	• Streamline administrative processes of RESC applications • To work on DOE energy projects to be declared as projects of domestic significance • Enhance EVOSS for RE projects • Provide technical assistance to lower investment cost • Promote and incentivize local technology producers
	• Strengthen resiliency of RE systems and facilities

Strategy	
Reliable and Efficient Infrastructure	• Harmonise transactions development plan with RE targets • Conduct R&D on the efficiency of RE technologies on the smart grid systems • Enhance local technical capabilities.

11.3 Building Energy Analysis

OBJECTIVE

The aim of this study is to derive a list of implementable solution sets for the building design that can be easily incorporated in the building design to make it energy efficient. Different building typologies have been studied for the set of defined parameters to achieve energy efficiency in the buildings in the Philippines.

METHODOLOGY: Achieving Energy Efficiency in Building Design

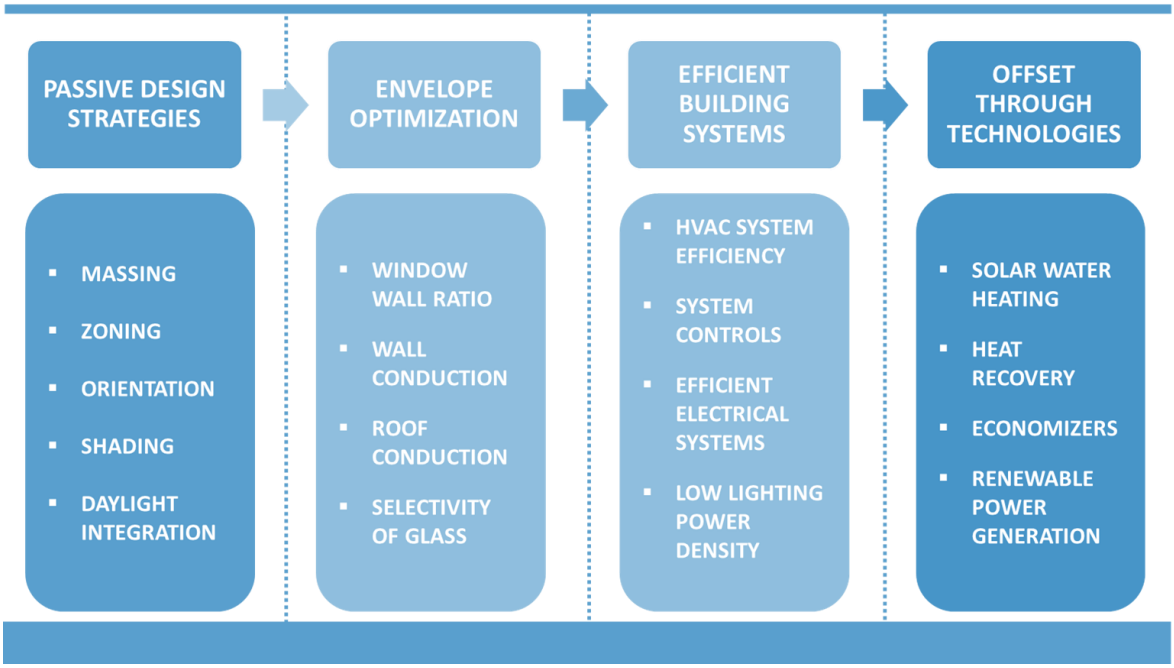


Figure 47 Flow process to achieve Energy Efficiency in buildings

When it comes to building design the key to energy efficiency in the building is by primarily reducing the operational load of the building. The first step to this approach is by reducing the heat load/ gain of the building by incorporating design strategies and thoughtful use of building materials and technologies keeping the energy saving and associated cost increment in mind. The conscience and intent to build better buildings for the future is a team effort and cannot be brought about by just one level of efficiency in a building. A quick run through of the methodology followed to derive at the solution set is as follows:

Passive Design Strategies

The first step in any building design understands the site, location climate type and associated requirements of building. Massing, site and space zoning, building orientation, shading play pivotal role in how efficient a building is. Daylight integration in the building further reduces the dependency on artificial lighting, promotes wellbeing, mental health and efficiency of building occupant. In simple words, a well-designed building reduces the magnitude of effort that is required to make a building energy efficient. The different parameter under this has been studied further and the impact assessment has been backed by a simulation study.

Envelope Optimization

Building envelope is the skin of the building that determines how the building behaves in a climate type and location. The materials used for the building construction further determine how energy

efficient a building can be. The heat ingress in a building can be significantly reduced by optimizing the building envelope, that reduces the cooling requirement of the building significantly. The same can be observed later in the preliminary analysis. A well optimized building envelope will reduce the system sizing of HVAC, lighting design and electrical backup which is often an overlooked benefit.

Efficient Building Systems

This is a direct saving that can be incorporated in the building design. The more efficient systems installed in the building, more the energy saving achieved. This comprises of HVAC, air conditioners, lighting system, hot water system and equipment.

Offset Through Renewable

After achieving an energy efficient building design, a part of the energy consumption can be offset through renewable energy generation both on and off site.

SIMULATION TOOLS DISCRIPTION

For the analysis, Design builder energy analysis software has been used. Design builder uses the DOE 2.2 Building energy simulation engine and TARP algorithm for surface convection. Design Builder comprises of a core 3-D modeller and 9 modules of which work together to provide in-depth analysis of energy use, consumption and commitment for any building. It has the ability to explicitly model all of the following:

- 8,760 hours per year
- Considers local direct solar obstructions, enables the simulation for modulating airflow openings, accounts for the characteristics of heat emitters.
- Hourly variations in occupancy, lighting power, miscellaneous equipment power, thermostat set points, and HVAC system operation, defined separately for each day of the week and holidays
- Thermal mass effects
- Part-load performance curves for mechanical equipment
- Capacity and efficiency correction curves for mechanical heating and cooling equipment.
- This simulation software utilises annual hourly climate data from ISHRAE's Energy plus Weather data (EPW format) downloaded from the Energy Plus website.

PRELIMINARY ANALYSIS

To achieve energy efficiency in buildings in the Philippines, the preliminary study analyzes the thermal performance of the building envelope. Sensitivity of different components like wall construction and window material, envelope design, WWR, building orientation, etc. was carried out to provide probable efficient building envelope options with minimal cost.

Assumptions

For the preliminary analysis, Box model for Office type building (9-6 occupancy) has been considered. Rectangular box model of dimension 75m x 30m has been constructed for preliminary analysis with longer axis facing N-S. Weather file of **Manila, Philippines** has been used as it was the closest to **Davao City**

- Ext wall U-value: 1.88 W/m^2-K
- Roof U-value: 1.57 W/m^2-K
- Glazing specification

  U- value- 5.7 W/m^2-K
  VLT- 0.51
  SHGC- 0.56
  WWR: 60%

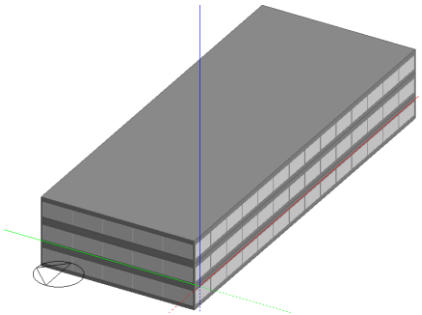


Figure 48 Snapshot of Box model

ORIENTATION

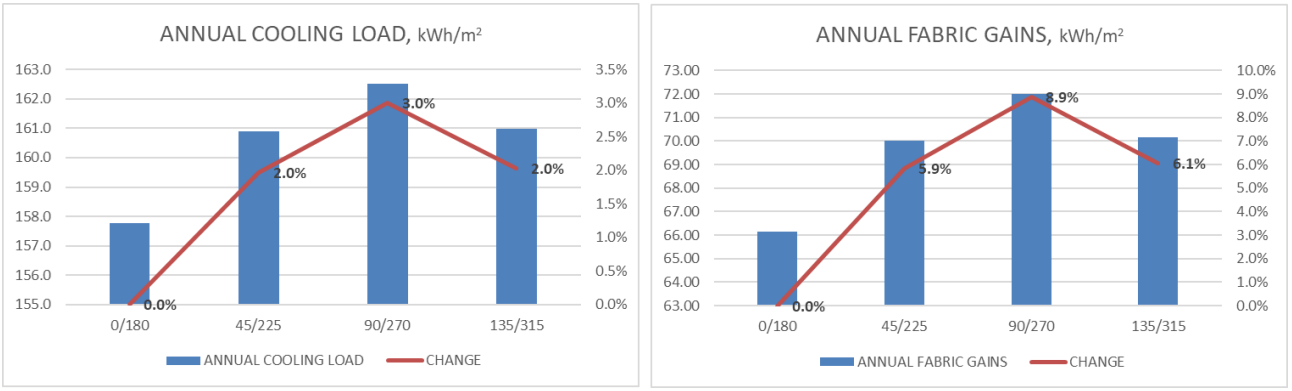


Figure 49: Annual Cooling and Fabric Gains corresponding to different Orientation

Orientation plays a major role in achieving energy efficiency in buildings. As the base case is Business as usual (BAU), Low e single glazed unit has been used in this analysis, hence the impact of rotating the building axis is not very significant. Changing the longer axis of the building from N-S to E-W does show an increase in Fabric gains by ~9% annually. In addition, if daylight has to be harnessed, N-S facades have better access than E-W, which might bring in glare despite any practical dimension local shading.

WINDOW WALL RATIO

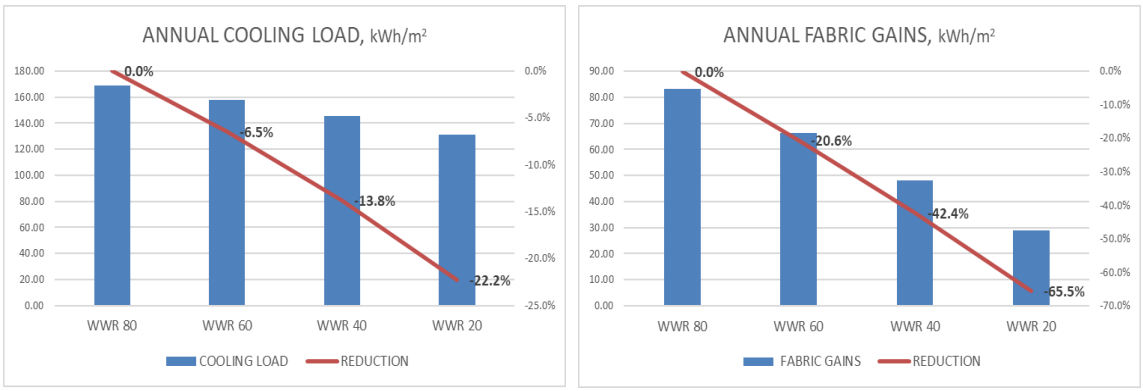


Figure 50: Annual Cooling Load and Annual Fabric Gains corresponding to WWR

Window area or window-to-wall ratio (WWR) is an important variable affecting energy performance in a building. Window area will have impacts on the building's heating, cooling, and lighting, as well as relating it to the natural environment in terms of access to **daylight**, **ventilation** and **views**. The window-to-wall ratio is the measure of the percentage area determined by dividing the building's total glazed area by its exterior envelope wall area. Facades can have optimized WWR in design to reduce the unwanted solar gain through the large window area, while still allowing natural daylight to enter spaces which results in reduced artificial lighting use along with reduced cooling load. In our study, significant impact of WWR reduction can be observed which was mainly due to the reduced solar gains through windows.

ENVELOPE SENSITIVITY: OPAQUE

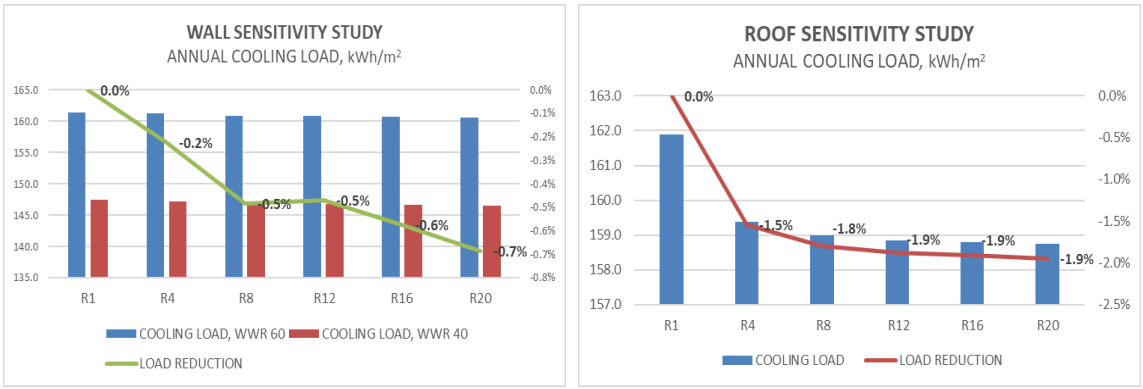


Figure 51: Wall and Roof Sensitivity Study

- Wall and Roof sensitivity study with variable R-value was carried out.
- An insulating material's resistance to conductive heat flow is measured or rated in terms of its thermal resistance or R-value -- the higher the R-value, the greater the insulating effectiveness.

Table 60: U Value for corresponding R values

R VALUE	U VALUE, W/m² K
R1	1
R4	0.25
R8	0.125
R12	0.083
R16	0.0625
R20	0.05

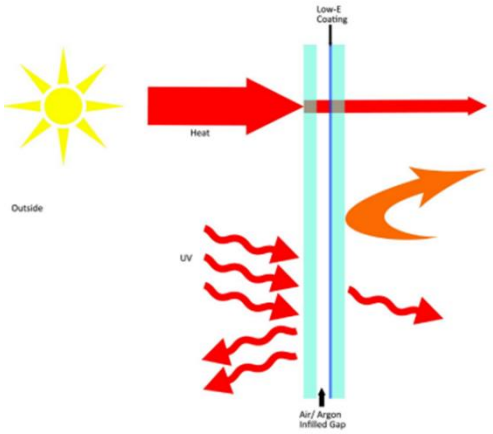
- As the outside temperature is ambient more than 50% of the total annual hours of simulation, very less impact of increasing insulation can be observed.
- Hence, considering revised WWR works better than adding extra insulation to BAU case.
- U value closer to 1 W/m² K seems to take care of wall efficiency.

ENVELOPE SENSITIVITY: GLAZED

GLASS SELECTION

LIGHT TRANSMISSION:

Percentage of visible light directly transmitted through the glass



REFLECTION OUTSIDE:

Percentage of visible light directly reflected from the exterior glass surface

SOLAR FACTOR:

Percentage of solar energy transmitted through the glass. It therefore measures the ability of a glazing to reduce the heating of the room. The lower the solar factor is, the better it helps to improve the comfort inside of the building

U-VALUE:

The U-value is a measure of the heat loss by penetrating the glass. The lower the U-value is, the better the insulating properties are. Expressed in W/M²k

SELECTIVITY:

The selectivity of glass is expressed as the ratio between its light transmission and solar factor. When the selectivity of glass is higher than 2, it gives you twice as much light versus heat.

GLAZING OPTIMIZATION

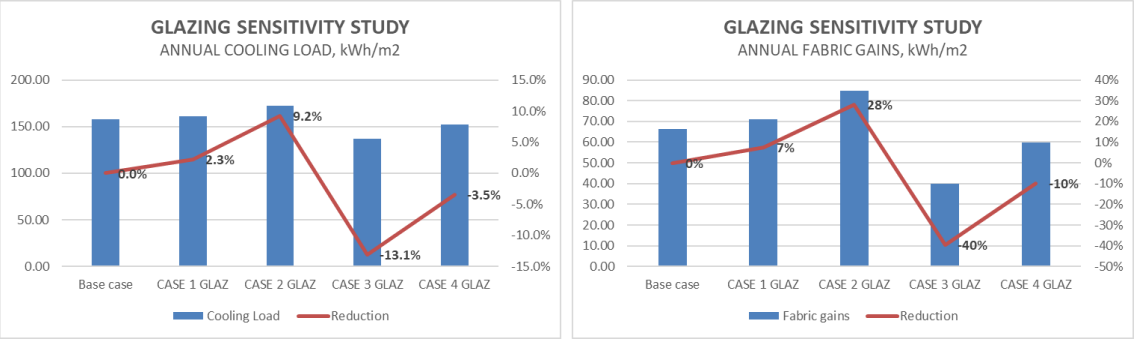


Figure 52: Annual Cooling Load And Annual Fabric Gains of Glazing Sensitivity

Table 61: Selection of glass based on SHGC, VLT, U Value

	SHGC	VLT	U value, W/m^2 K	Selectivity VLT/SHGC	Description
Case 1	**0.59**	**0.75**	**6.12**	**1.27**	Low e single glazed
Case 2	**0.65**	**0.8**	**1.44**	**1.23**	Low e DGU (16mm argon)
Case 3	**0.275**	**0.6**	**1.35**	**2.18**	Low e DGU(12mm air)
Case 4	**0.486**	**0.4**	**2.7**	**0.82**	Low e DGU(12mm air)
BASE CASE	**0.56**	**0.51**	**5.7**	**0.91**	Low e single glazed

The study shows how selectivity of glass has larger impact than U value of glass for its selection in building design Glass selectivity index takes into account the light transmittance and solar factor for better envelope optimization. If sufficient shading is provided for glass, U value plays a more important role in glass selection.

SHADING OF GLAZED FAÇADE

Shading the glazed façade can significantly reduce the direct solar gains of the building by cutting out the direct solar radiations entering the building. A well shaded glazing is any day better than having a high SHGC glazing installed in the building both in terms of energy and cost saving.

SHADING REQUIREMENT - Davao City

Davao city has a north latitude of 7.4º. As seen in the sun path chart below, the city receives a good amount of south sun in most of the months of the year. Summer months have sun coming in from the North direction which requires shading. Shading will be different for different facades of the building. Here, a simple study considering the building to be oriented true north and 45º to true north has been done. While North and south facades of the building can easily be shaded for most time of the year with shading, the east, west and angular orientation (closer to 45º to true north) is difficult to shade even despite increasing the shading.

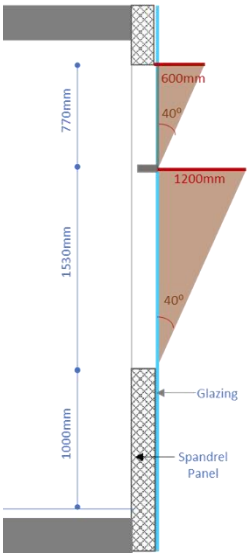


Figure 53: Sun path chart for Davao

FOR ORIENTATION CLOSER TO TRUE NORTH

- 30º horizontal shading for north facing façade
- 40º horizontal shading for south facing façade
- 50º horizontal shading for east/west facing façade

FOR ORIENTATIONS CLOSER TO 45º NORTH

- Min 50º horizontal shading for east/west facing façade

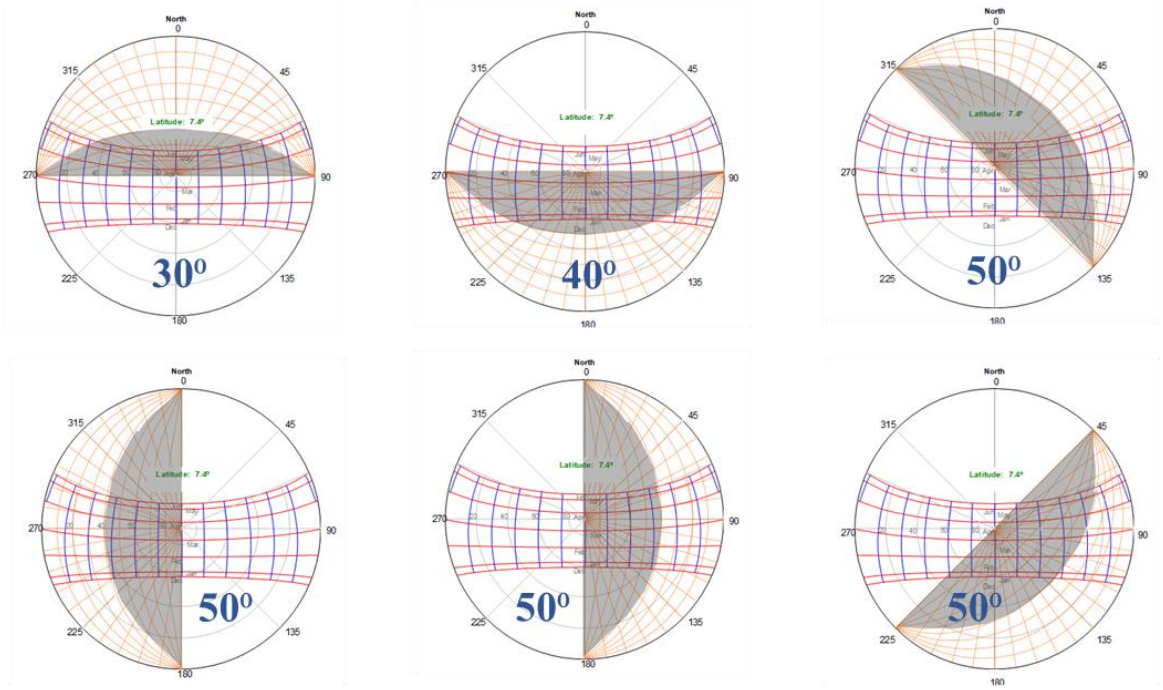


Figure 54: Building orientation types

SHADING IMPACT

CASE	SHADING DESCRIPTION
BASE CASE	No shading
SHADING OPTION 1	1000mm horizontal shading
SHADING OPTION 2	2000mm horizontal shading on N/S fenestration Horizontal fins on E/W fenestration

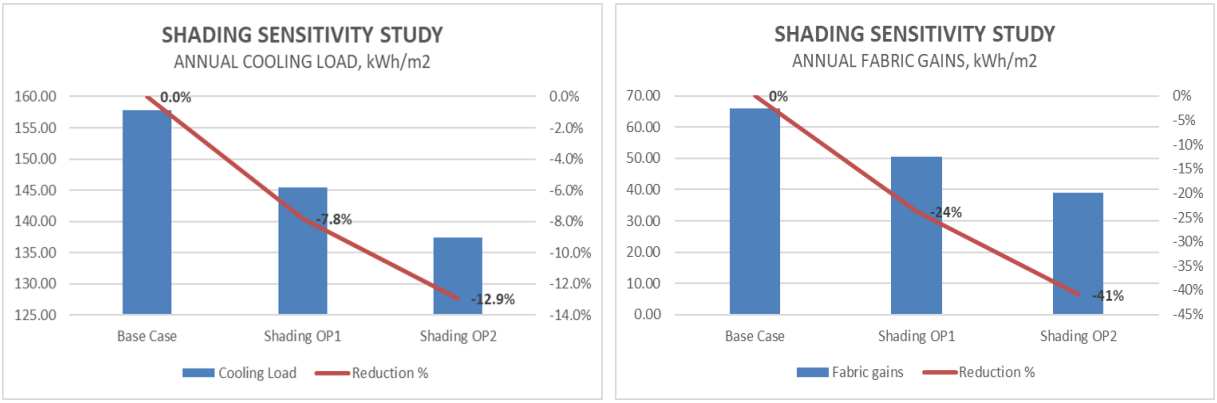


Figure 55: Shading Impact Options and corresponding sensitivity

Shading of fenestrations shows a considerable impact on envelope gains and cooling load of the building. The impact is clearly outstanding and emphasis the need for integration of shading in building design as a must for energy efficient & cost-effective intervention.

INCREMENTAL LEVELS FOR ENERGY EFFICIENCY

After analysing how the different building components perform in the given climatic conditions there was a definite clarity on the minimum interventions that would help achieve the incremental levels of performance in the building by the optimum incorporation of interventions in the building design.

ENERGY EFFICIENCY INTERVENTIONS

To derive a practical and implementable solution set, it is imperative to list down the major interventions that impact energy efficiency in a building and is easily implementable in the building design of all kinds. The list of interventions is studied further in detail below and its possibility of being implemented.

ORIENTATION

Preferred for the location is having the longer axis along the N-S. However, as there are site constraints, we may leave that from our final list of interventions to achieve Energy Efficiency. Preparing the solution sets this was taken into account that the solutions should have vast applicability and hence, location orientation and specific shading analysis was omitted here.
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SIMULATION DETAIL

Energy simulation for different building typologies were done for the 5 incremental levels of Energy Efficiency in the building design, namely:

- Office
- School
- Hotel
- Hospital
- Shopping Mall
- Residential House (~50 AC)
- Residential House (AC only when int. set point temp above 30^0 C)
- 2 BHK
- 1 BHK
- Studio Apartment

Assumptions:

All the schedules (occupancy, lighting, equipment, HVAC) have been kept constant for all the 5 incremental levels for each typology.
All incremental level incorporates all the mandatory requirements of the green building code of the economy and further improvements if specified in the table
The building energy performance is expressed in the form of EPI (Energy performance Index, kWh/square meter/annum)
For the study, Box model for each building typology has been considered
Weather file of **Manila, Philippines** has been used as it was the closest to **Davao City**
Design builder has been used for the following Energy simulation.
Deliberately, worst case scenario has not been presented as the baseline case to give a more realistic analysis. The present market analysis formed the basis to formulate the baseline.

INTERVENTIONS FOR ENERGY EFFICIENCY: Solution Sets

OFFICE

Table 62: Simulation results for Office

S.No	Building Component	BAU Case	1	2	3	4	5
1.	Window Wall Ratio	60	Less than 60	Less than 60	Less than 60	Less than 40	Less than 40
2.	Walls R Value	R1	R2	R4	R6	R8	R8
3.	Roof R Value	R2	R8	R8	R10	R10	R10
4.	Glass SHGC	0.67	0.37	0.37	0.37	0.45	0.45
5.	Glass VLT (Min)	0.5	0.5	0.5	0.5	0.6	0.6
6.	Glass Shading-Horizontal (D/H)	-	-	Min(0.1)	Min (0.5)	0.5	1
7.	Cooling Equipment Efficiency	EER 8	EER 12	EER 12.4	EER 12.8	EER 13.2	EER 14
8.	Air Conditioners (rating as per DOE 10CR Part 430)	Not Rated	1	2	3	4	5
9.	Lighting Power Density (Building)	14	10.8	8	6	4	4
10.	Lighting Controls	Manual Control	Manual Control	Manual Control	Manual and Motion Control	Daylight and Motion Control	Daylight and Motion Control
11.	Energy saving over BAU, KWh/m^2	211.5	145.7	130.8	119.4	99.06	95.56
12.	CO_2 emission mitigation		31.1%	38.15%	43.5%	53.16%	54.8%

School (70% conditioned)

Table 63: Simulation results for school

S.No	Building Component	BAU Case	1	2	3	4	5
1.	Window Wall Ratio	60	Less than 60	Less than 60	Less than 60	Less than 40	Less than 40
2.	Walls R Value	R1	R2	R4	R6	R8	R8
3.	Roof R Value	R2	R8	R8	R10	R10	R10
4.	Glass SHGC	0.67	0.37	0.37	0.37	0.45	0.45
5.	Glass VLT (Min)	0.5	0.5	0.5	0.5	0.6	0.6
6.	Glass Shading-Horizontal (D/H)	-	-	Min (0.1)	Min (0.5)	0.5	1
7.	Cooling Equipment Efficiency	EER 8	EER 12	EER 12.4	EER 12.8	EER 13.2	EER 14
8.	Air Conditioners (rating as per DOE 10CR Part 430)	Not Rated	1	2	3	4	5
9.	Lighting Power Density (Building)	14	12.9	10	8	6	4
10.	Lighting Controls	Manual Control	Manual Control	Manual Control	Manual and Motion Control	Daylight and Motion Control	Daylight and Motion Control
11.	Energy saving over BAU, KWh/m^2	200.3	129.6	117.4	108	86.8	81
12.	CO_2 emission mitigation		35.3%	41.4%	46%	56.6%	59.6%

Hospital

Table 64: Simulation results for hospital

S.No	Building Component	BAU Case	1	2	3	4	5
1.	Window Wall Ratio	60	Less than 60	Less than 60	Less than 60	Less than 40	Less than 40
2.	Walls R Value	R1	R2	R4	R6	R8	R8
3.	Roof R Value	R2	R8	R8	R10	R10	R10
4.	Glass SHGC	0.67	0.37	0.37	0.37	0.45	0.45
5.	Glass VLT (Min)	0.5	0.5	0.5	0.5	0.6	0.6
6.	Glass Shading-Horizontal (D/H)	-	-	Min (0.1)	Min (0.5)	0.5	1
7.	Cooling Equipment Efficiency	EER 8	EER 12	EER 12.4	EER 12.8	EER 13.2	EER 14
8.	Air Conditioners (rating as per DOE 10CR Part 430)	Not Rated	1	2	3	4	5
9.	Lighting Power Density (Building)	14	12.9	10	8	6	4
10.	Lighting Controls	Manual Control	Manual Control	Manual Control	Manual and Motion Control	Daylight and Motion Control	Daylight and Motion Control
11.	DHW	100% Electric	100% Electric	50% demand by solar/heat pump	50% demand by solar/heat pump	100% demand by solar/heat pump	100% demand by solar/heat pump
12.	Energy saving over BAU, KWh/m^2	639.6	500.1	459	433.6	388	363
13.	CO_2 emission mitigation		21.8%	28.2%	32.2%	39.3%	43.24%

Hotel

Table 65: Simulation results for hotels

S.No	Building Component	BAU Case	1	2	3	4	5
1.	Window Wall Ratio	60	Less than 60	Less than 60	Less than 60	Less than 40	Less than 40
2.	Walls R Value	R1	R2	R4	R6	R8	R8
3.	Roof R Value	R2	R8	R8	R10	R10	R10
4.	Glass SHGC	0.67	0.37	0.37	0.37	0.45	0.45
5.	Glass VLT (Min)	0.5	0.5	0.5	0.5	0.6	0.6
6.	Glass Shading-Horizontal (D/H)	-	-	Min (0.1)	Min (0.5)	0.5	1
7.	Cooling Equipment Efficiency	EER 8	EER 12	EER 12.4	EER 12.8	EER 13.2	EER 14
8.	Air Conditioners (rating as per DOE 10CR Part 430)	Not Rated	1	2	3	4	5
9.	Lighting Power Density (Building)	20	16	12	10	10	10
10.	Lighting Controls	Manual Control	Manual Control	Manual Control	Manual and Motion Control	Daylight and Motion Control	Daylight and Motion Control
11.	DHW	100% Electric	100% Electric	50% demand by solar/heat pump	50% demand by solar/heat pump	100% demand by solar/heat pump	100% demand by solar/heat pump
12.	Energy saving over BAU, KWh/m^2	486.5	405.32	366.5	309	261	232
13.	CO_2 emission mitigation	-	16.7%	24.6%	36.5%	47.8%	53.3%

Shopping Mall

Table 66: Simulation results for Shopping Mall

S.No	Building Component	BAU Case	1	2	3	4	5
1.	Window Wall Ratio	60	Less than 60	Less than 60	Less than 60	Less than 40	Less than 40
2.	Walls R Value	R1	R2	R4	R6	R8	R8
3.	Roof R Value	R2	R8	R8	R10	R10	R10
4.	Glass SHGC	0.67	0.37	0.37	0.37	0.45	0.45
5.	Glass VLT (Min)	0.5	0.5	0.5	0.5	0.6	0.6
6.	Glass Shading-Horizontal (D/H)	-	-	Min (0.1)	Min (0.5)	0.5	1
7.	Cooling Equipment Efficiency	EER 8	EER 12	EER 12.4	EER 12.8	EER 13.2	EER 14
8.	Air Conditioners (rating as per DOE 10CR Part 430)	Not Rated	1	2	3	4	5
9.	Lighting Power Density (Building)	20	16	12	10	8	8
10.	Lighting Controls	Manual Control	Manual Control	Manual Control	Manual and Motion Control	Manual and Motion Control	Manual and Motion Control
11.	Energy saving over BAU, KWh/m^2	343	256.8	194.6	176.5	162.8	155.7
12.	CO_2 emission mitigation	-	25.1%	43.2%	48.5%	52.5%	54.6%

RESIDENTIAL HOUSE: STANDALONE (AC when int. set point over 30^0 C)

Table 67: Simulation results for Residential house

S.No	Building Component	BAU Case	1 ★	2 ★	3 ★	4 ★	5 ★
1.	Window Wall Ratio	30	Less than 25	Less than 20	Less than 20	Less than 15	Less than 15
2.	Walls R Value	R1	R2	R4	R6	R8	R8
3.	Roof R Value	R2	R8	R8	R10	R10	R10
4.	Glass SHGC	0.67	0.37	0.37	0.37	0.45	0.45
5.	Glass VLT (Min)	0.5	0.5	0.5	0.5	0.6	0.6
6.	Glass Shading-Horizontal (D/H)	-	-	Min (0.1)	Min (0.5)	0.5	1
7.	Domestic Equipment Efficiency	Not Rated	1 ★	2 ★	3 ★	4 ★	5 ★
8.	Air Conditioners (rating as per DOE 10CR Part 430)	Not Rated	1 ★	2 ★	3 ★	4 ★	5 ★
9.	Lighting Power Density (Building)	11	10.8	8	6	4	4
10.	DHW	100% Electric	100% Electric	50% demand by solar	50% demand by solar	100% demand by solar	100% demand by solar
11.	Energy saving over BAU, KWh/m^2	72	60.7	53.1	47.6	41.2	35
12.	CO_2 emission mitigation	-	16%	26.25%	33.8%	42.8%	51.4%

RESIDENTIAL HOUSE: STANDALONE (~50% AC)

Table 68: Simulation result for Residential house (~50% AC)

S.No	Building Component	BAU Case	1	2	3	4	5
1.	Window Wall Ratio	30	Less than 25	Less than 20	Less than 20	Less than 15	Less than 15
2.	Walls R Value	R1	R2	R4	R6	R8	R8
3.	Roof R Value	R2	R8	R8	R10	R10	R10
4.	Glass SHGC	0.67	0.37	0.37	0.37	0.45	0.45
5.	Glass VLT (Min)	0.5	0.5	0.5	0.5	0.6	0.6
6.	Glass Shading-Horizontal (D/H)	-	-	Min (0.1)	Min (0.5)	0.5	1
7.	Domestic Equipment Efficiency	Not Rated	1	2	3	4	5
8.	Air Conditioners (rating as per DOE 10CR Part 430)	Not Rated	1	2	3	4	5
9.	Lighting Power Density (Building)	11	10.8	8	6	4	4
10.	DHW	100% Electric	100% Electric	50% demand by solar	50% demand by solar	100% demand by solar	100% demand by solar
11.	Energy saving over BAU, KWh/m^2	105	74.5	69	61	55	42
12.	CO_2 emission mitigation	-	29%	34.3%	41.9%	47.6%	60%

RESIDENTIAL: 2 BHK

Table 69: Simulation result for 2BHK Residential

S.No	Building Component	BAU Case	1	2	3	4	5
1.	Window Wall Ratio	30	Less than 25	Less than 20	Less than 20	Less than 15	Less than 15
2.	Walls R Value	R1	R2	R4	R6	R8	R8
3.	Roof R Value	R2	R8	R8	R10	R10	R10
4.	Glass SHGC	0.67	0.37	0.37	0.37	0.45	0.45
5.	Glass VLT (Min)	0.5	0.5	0.5	0.5	0.6	0.6
6.	Glass Shading-Horizontal (D/H)	-	-	Min (0.1)	Min (0.5)	0.5	1
7.	Domestic Equipment Efficiency	Not Rated	1	2	3	4	5
8.	Air Conditioners (rating as per DOE 10CR Part 430)	Not Rated	1	2	3	4	5
9.	Lighting Power Density (Building)	11	10.8	8	6	4	4
10.	DHW	100% Electric	100% Electric	50% demand by solar	50% demand by solar	100% demand by solar	100% demand by solar
11.	Energy saving over BAU, KWh/m^2	105.2	88	71.6	62	54	42.3

RESIDENTIAL: 1 BHK

Table 70: Simulation result for 1BHK Residential

S.No	Building Component	BAU Case	1 ★	2 ★	3 ★	4 ★	5 ★
1.	Window Wall Ratio	30	Less than 25	Less than 20	Less than 20	Less than 15	Less than 15
2.	Walls R Value	R1	R2	R4	R6	R8	R8
3.	Roof R Value	R2	R8	R8	R10	R10	R10
4.	Glass SHGC	0.67	0.37	0.37	0.37	0.45	0.45
5.	Glass VLT (Min)	0.5	0.5	0.5	0.5	0.6	0.6
6.	Glass Shading-Horizontal (D/H)	-	-	Min (0.1)	Min (0.5)	0.5	1
7.	Domestic Equipment Efficiency	Not Rated	1 ★	2 ★	3 ★	4 ★	5 ★
8.	Air Conditioners (rating as per DOE 10CR Part 430)	Not Rated	1 ★	2 ★	3 ★	4 ★	5 ★
9.	Lighting Power Density (Building)	11	10.8	8	6	4	4
10.	DHW	100% Electric	100% Electric	50% demand by solar	50% demand by solar	100% demand by solar	100% demand by solar
11.	Energy saving over BAU, KWh/m^2	109.1	90	73	65.4	58	48.3
12.	CO_2 emission mitigation	-	17.4%	33%	40%	46.8%	55.7%

RESIDENTIAL: Studio apartment

Table 71: Simulation results for studio apartment

S.No	Building Component	BAU Case	1	2	3	4	5
1.	Window Wall Ratio	30	Less than 25	Less than 20	Less than 20	Less than 15	Less than 15
2.	Walls R Value	R1	R2	R4	R6	R8	R8
3.	Roof R Value	R2	R8	R8	R10	R10	R10
4.	Glass SHGC	0.67	0.37	0.37	0.37	0.45	0.45
5.	Glass VLT (Min)	0.5	0.5	0.5	0.5	0.6	0.6
6.	Glass Shading-Horizontal (D/H)	-	-	Min (0.1)	Min (0.5)	0.5	1
7.	Domestic Equipment Efficiency	Not Rated	1	2	3	4	5
8.	Air Conditioners (rating as per DOE 10CR Part 430)	Not Rated	1	2	3	4	5
9.	Lighting Power Density (Building)	11	10.8	8	6	4	4
10.	DHW	100% Electric	100% Electric	50% demand by solar	50% demand by solar	100% demand by solar	100% demand by solar
11.	Energy saving over BAU, KWh/m^2	114	91	76	68	59.3	51
12.	CO_2 emission mitigation	-	20.2%	33.3%	40.3%	48%	55.3%

12 References

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