Asia-Pacific Economic Cooperation

Final Report:
Low Carbon Model Town (LCMT) Project Phase 4 Feasibility Study San Borja, Lima Province, Peru

Submitted to:

Asia-Pacific Economic Cooperation Forum

Submitted by:

Hitachi Consulting

in partnership with
Nikken Sekkei Research Institute and
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ACRONYMS

AFOLU - Agriculture, forestry, and land use

APEC – Asia-Pacific Economic Cooperation

AR5 - 5th Assessment Report (IPCC)

BAU – Business as usual

BBVA – Banco Bilbao Vizcaya Argentaria

BCP – Banco de Crédito del Perú

BDF - Biomass diesel fuel

BEMS – Building energy management system

BIF – Banco Interamericano de Finanzas

BINI – Building-integrated natural infrastructure

BNDES - Brazilian Development Bank

BOT – Build-Operate-Transfer

BRT - Bus rapid transit

CAF – Corporación Andina de Fomento

CASBEE – Comprehensive Assessment System for Built Environment Efficiency

CCAP – Center for Clean Air Policy

CDM – Clean development mechanism

CEMS – Community energy management system

CH4 – Methane

CO2 – Carbon dioxide

CO2e – Carbon dioxide equivalents

COFIDE – Corporación Financiera de Desarrollo, S.A.

CY - Calendar year

Defra – United Kingdom Department for Environmental Food and Rural Affairs

DOD – Department of Defense

DR – Demand response

EDGE - Excellence In Design for Greater Efficiencies

EMS – Energy management system

EVs - Electric vehicles

FAR – Floor-to-area-ratio

FEMP - U.S. Federal Energy Management Performance

FMO – Dutch Development Bank

GDP – Gross domestic product

GEF – Global Environmental Facility

GHG – Greenhouse gas

GPC – Global Protocol for Community Greenhouse Gas Emissions

GWP – Global warming potential

ha - Hectare

HEMS – Home energy management system

HEVs - Hybrid electric vehicles

HOV – High occupant vehicle

HVAC – Heating, ventilating, and air conditioning

ACRONYMS (continued)

IC – Integrated circuit

ICLEI – International Council for Local Environmental Initiatives

ICT – Information communications technology

IDB – Inter-American Development Bank

IFC – International Finance Corporation

INDECOPI - National Institute for the Defense of Competition and the Protection of Intellectual Property

IPCC – Intergovernmental Panel on Climate Change

IPEN - Peruvian Institute of Nuclear Energy

IPPU - Industrial Process and Product Use

IRENA - International Renewable Energy Agency

ISO - International Standards Organization

ITDP - Institute for Transportation and Development Policy

ITS – Intelligent transportation systems

JICA – Japan International Cooperation Agency

Kg – Kilograms

KJ – Kilojoules

Km – Kilometer

Kw – Kilowatt

kWh – Kilowatt-hour

L - Location

LCM – Low carbon measure

LCMT - Low carbon model town

LCMT-CPC – Low Carbon Model Town Community Planning Council

LCP – Low carbon plan

LED - Light-emitting diode

LEED – Leadership in Energy and Environmental Design

LPG – Liquefied petroleum gas

M – Mode

m2 - meter squared

MAIN - Mitigation Action Implementation Network

MINEM – Ministry of Energy and Mines, Peru

MJ – Megajoules

MtCO2e – Metric ton of carbon dioxide equivalents

MW – Megawatts

N20 - nitrous oxide

NAMA – Nationally Appropriate Mitigation Action

NMT – Non-motorized transportation

OD - Origin/destination

ODA - Official development assistance

OLADE - Latin American Energy Organization

ACRONYMS (continued)

OTC – Over-the-counter

PCM – Phase change material

PFI - Private finance initiatives

PHEVs - Plug-in hybrid electric vehicles

PKT – Passenger kilometers traveled

PPP – Public private partnership

PV – Photovoltaic

R - Route

RER - Renewable energy resource

RIT - Rede Integrada de Transporte or Curitiba, Brazil Integrated Transit Network

ROI – Return on investment

SBRS - Sustainable Building Reporting System

SECO – Swiss State of Secretariat for Economic Affairs

SEDAPAL – Servicio de Agua Potable y Alcantarillado de Lima

SP – Strategic Planning

SPC – Special purpose company

SWH – Solar water heating

T - Time

Tc – Cold water temperature

TDM – Transportation demand management

Th – Hot water temperature

TOD – Transit-oriented development

UHI - Urban heat island

UNFCCC - United Nations Framework Convention on Climate Change

UNIDO - United Nations Industrial Development Organization

USAID – United States Agency for International Development

USD – U.S. Dollars

USEPA - U.S. Environmental Protection Agency

USGBC - U.S. Green Building Council

VKT – Vehicle kilometers traveled

WRI – World Resources Institute

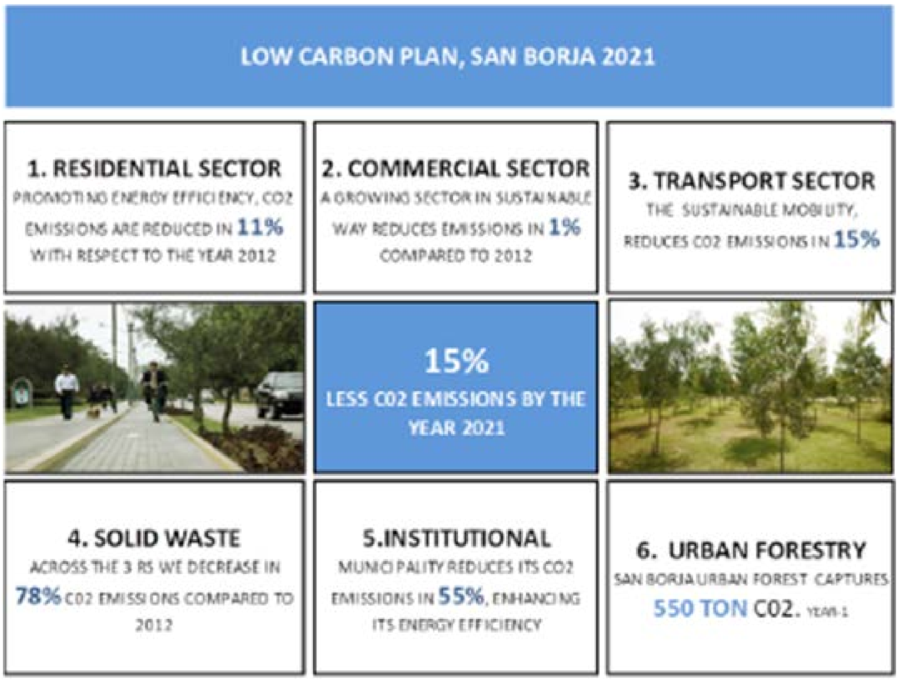
EXECUTIVE SUMMARY

This Feasibility Study (study) completes the fourth phase of the Asia-Pacific Economic Cooperation (APEC) Forum's Low Carbon Model Town (LCMT) Project. The focus is the District of San Borja, a predominantly residential municipality in Lima Province, Peru. The goal of this study is to provide government officials at the local, provincial, and national levels–and stakeholders in San Borja–with actionable advice to support their existing plans and initiatives to design, develop, and implement a low carbon development path that produces repeatable results and measurable outcomes for San Borja. The intent is for San Borja's LCMT approach to be scalable within Lima Province and other cities in Peru, and provide valuable lessons learned for cities within all APEC economies. The objectives of the study are to:

1) evaluate the 2012 baseline and sector inventories for best practices in quantification, accounting and reporting;
2) assess sufficiency of existing LCMs in the LCP to meet the 15% reduction target by 2021;
3) identify value-added LCMs that could help San Borja meet if not exceed the 15% reduction target; and
4) enable cooperation for complete, consistent and transparent GHG accounting and reporting across Lima Province.

This study builds on San Borja's *Low Carbon Plan 2021* (LCP) by evaluating the District's 2012 greenhouse gas (GHG) baseline, sector-specific inventories, and business-as-usual (BAU) emissions projections for calendar years (CY) 2018, 2021 and 2035. The study relies on the Global Protocol for Community-Scale GHG Emissions Inventories, version 2.0 (GPC, v. 2), as the normative standard for evaluating San Borja's GHG quantification, accounting, and reporting systems and for recommending enhancements to increase completeness, consistency, accuracy and transparency. The LCP focuses on six "Action Areas" that comprise San Borja's priorities for GHG reductions. Each Action Area has a specific reduction target, expressed as a percentage reduction by 2021 compared to the 2012 baseline. Figure ES-1 shows San Borja's six Action Areas, their individual reductions targets, and the municipality's overall 15% reduction target by 2021 compared to the 2012 baseline.

Figure ES-1: The Six Action Areas in San Borja's Low Carbon Plan 2021



The study team evaluated and confirmed quantification of the District's GHG emissions from the electric power, transportation, solid waste, and wastewater sectors by tailoring the U.S. Department of Energy's Federal Energy Management Program (FEMP) Workbook (an Excel spreadsheet) to reflect Lima-specific emissions factors (and San Borja-specific factors whenever possible) as well as activity data provided by San Borja. The study team developed a separate worksheet using the FEMP tool to evaluate and confirm the amount of CO2 sequestered in 2012 by San Borja's urban forest. The study team also used the FEMP tool to project GHG emissions reductions from the portfolio of low carbon measures (LCMs) recommended in this study. A key evaluation finding is that the 2012 GHG baseline in the revised version shows 207,805 metric tons of carbon dioxide-equivalent (MtCO2e) compared to 113,704 MtCO2e reported in the LCP 2021. Table ES-1 presents the results.

Table ES-1: San Borja 2012 GHG Emissions Profile: Baseline, Inventory, Reductions

San Borja GHG Emissions Baseline, Projected Reductions and Inventory: 2018 - 2035		2012 MtCO2e	2018 MtCO2e	2021 MtCO2e	2035 MtCO2e
Residential	*BAU GHG emissions/yr*	29,508	33,424	37,860	42,884
	Projected reductions/yr from LCMs	n/a	(5,382)	(9,834)	(18,677)
	Total GHG emissions/yr with LCMs	n/a	28,042	28,026	24,207
Commercial	*BAU GHG emissions/yr*	39,355	48,131	58,864	71,991
	Projected reductions/yr from LCMs	n/a	(9,256)	(16,667)	(33,691)
	Total GHG emissions/yr with LCMs	n/a	38,875	42,197	38,300
Transportation	*BAU GHG emissions/yr*	68,162	79,715	93,227	109,029
	Projected reductions/yr from LCMs	n/a	(3,189)	(11,187)	(23,986)
	Total GHG emissions/yr with LCMs	n/a	76,526	82,040	85,043
Solid Waste & Wastewater	*BAU GHG emissions/yr*	66,842	79,890	95,484	114,122
	Projected reductions/yr from LCMs	n/a	(4,843)	(10,057)	(74,920)
	Total GHG emissions/yr with LCMs	n/a	75,047	85,427	39,202
Municipal	*BAU GHG emissions/yr*	4,077	4,452	4,862	5,309
	Projected reductions/yr from LCMs	n/a	(910)	(1,470)	(2,757)
	Total GHG emissions/yr with LCMs	n/a	3,542	3,392	2,552
Urban Function	*BAU GHG emissions/yr*	0	0	0	0
	Projected reductions/yr from LCMs	n/a	(4,156)	(6,234)	(20,780)
	Total GHG emissions/yr with LCMs	n/a	(4,156)	(6,234)	(20,780)
Urban Greening & Forestry	*BAU GHG emissions/yr*	(139)	(41)	(32)	(14)
	Projected sequestration/yr from LCMs	n/a	(571)	(929)	(1727)
	Total GHG emissions/yr with LCMs	n/a	(612)	(961)	(1741)
2012 Baseline GHG Emissions		207,805	n/a	n/a	n/a
All BAU GHG emissions/yr		n/a	245,571	290,265	343,321
All reductions/yr from LCMs		n/a	(28,307)	(56,378)	(176,538)
Total GHG emissions/yr with LCMs		n/a	217,264	233,887	166,783
% GHG reductions compared to BAU with LCMs		n/a	-12%	-19%	-51%
% GHG reductions from 2012 baseline with LCMs		n/a	-14%	-27%	-85%

Source: Project Team

The study's recommendations for LCMs are organized in five "design categories" for low carbon development. Each category has its own chapter and includes a recommended set of LCMs, a GHG reduction analysis, and cost estimate. The recommended LCMs are additional and complementary measures to the strategies identified by San Borja in its LCP 2021. Table ES-1 above shows the total projected emissions reductions per year from the portfolio of LCMs by sector for CY 2018, 2021, and 2035. Table ES-2 lists and defines the focus of each design category.

Table ES-2: Design Category Definitions

Design Category	Definitions for this Feasibility Study
Urban Function Planning	Urban function is a city's ability to integrate complementary land use, town planning and structure, as well as urban development growth policies, system processes and procedures, to manage energy consumption trends and GHG emissions across multiple urban sectors.
Transportation Planning	Transportation planning minimizes reliance on private passenger cars as a default mode of travel while maximizing reliance on public mass transit, bicycling, and pedestrian access in order to reduce traffic congestion and GHG emissions from motor vehicles.
Buildings Design Planning	Building design planning means creating structures and using processes to support an environmentally responsible and resource-efficient built environment of residential, commercial and municipal buildings in San Borja. The focus is on the life cycle of a building, from siting to design, construction, operation and maintenance, renovation, and decommissioning. The intended result is a "green" building.
Energy Planning	Energy planning concerns electric power, including electricity generation, transmission, distribution, and balancing of supply and demand. The four electric power areas explored in the study are area energy planning, community-based energy management to increase efficiency and manage demand, converting landfill waste-to-energy, and renewables-based electricity generation.
Environmental Planning	Environmental planning has three aspects: (1) solid waste recycling program expansion through stakeholder education, awareness and economic incentives; (2) urban greening and forestry expansion to increase shade cover as a way to mitigate the urban heat island (UHI) effect combined with wastewater biofiltration system expansion for irrigation; and (3) the untapped energy potential of landfill waste-to-energy , and solid waste incineration.

Source: Project Team

The LCMs recommended within each design category will position San Borja to meet its 15% GHG reduction target by 2021. Table ES-3 lists the LCMs recommended to San Borja for further consideration.

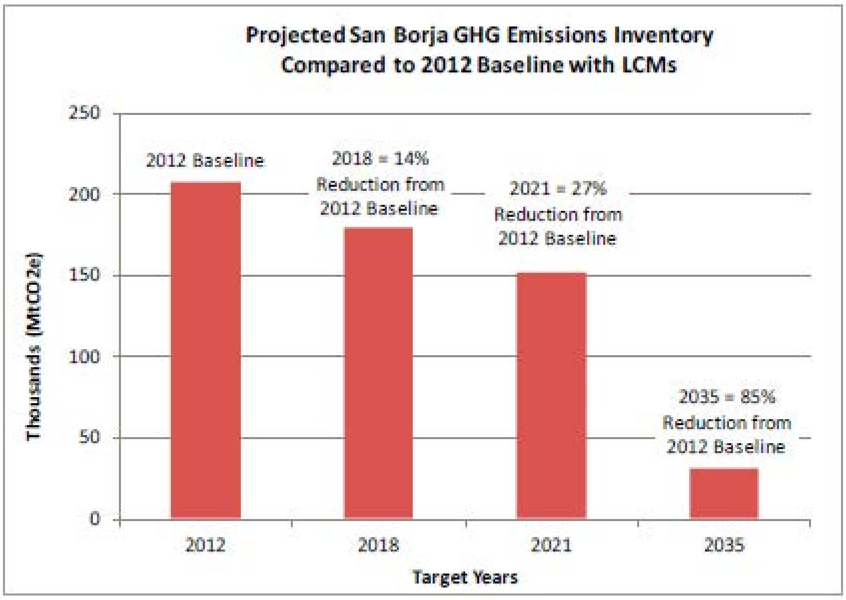
Table ES-3: Portfolio of LCMs Recommended to San Borja for Further Consideration

LCM Category	LCMs Recommended	Description
Urban Function Planning	Transit oriented development (TOD) planning for mixed-use land use development	Development that prioritizes use of public transit, non-motorized transport (e.g., bicycles), safe pedestrian access to public and mass transit, and land use development patterns so that communities have mobility to access services and places while being less dependent on motor vehicles.
	Market-based solutions and public-private partnerships for urban greening and forest preservation	Public policy and incentives to support land use decisions that balance urban development and growth with preservation of existing urban greening and forests.
	Information and communication technologies (ICT) for city management performance	ICT that transforms data into information and insight for performance management and predictive analytics. Includes indicators for city services, quality of life, and climate preparedness as a foundation for an integrated data management system to support human well-being in cities.
Transportation Planning	Modal switching and mixed-mobility solutions to reduce GHG-intensity per kilometer of travel	Transportation policies, infrastructure, incentives and services that encourage switching from more to less GHG-intensive modes and that support mixed-mobility solutions such as bicycles to access public transit nodes.
	Travel demand management (TDM) to reduce travel demand by private passenger car	Management system to help reduce travel demand, particularly single occupant private vehicles, or to redistribute mobility demand at peak commute hours instead of increasing roadway supply. Focus on system efficiencies across all modes.
	Intelligent transportation systems (ITS) to reduce traffic congestion and increase travel speeds	Systems to manage traffic congestion better and to enable people and businesses to make more informed mobility choices through real-time information. Focus on circulation plans, routes.

LCM Category	LCMs Recommended	Description
Buildings Design Planning	Low carbon building passive design	An architectural design method that harnesses natural phenomenon such as sunlight, solar heat, and direction of wind. Includes implementation of photovoltaic power systems or solar water heating systems. Applies to residential, commercial and municipal.
	Low carbon building active design	An architectural design method that utilizes mechanical systems for heating, cooling, dehumidification, and lighting to ensure efficient energy use that reduces GHG emissions and building operating costs, while improving comfort and quality of the interior environment. Applies to residential, commercial and municipal.
Energy Planning	Area-wide energy efficiency and management planning and micro grid implementation	Implementation of a multi-source energy network that increases energy resilience by balancing energy supply and demand and by decreasing dependence and strain on regional utility grids.
	Community energy management system and smart meter implementation	Implementation of a community management system, including smart metering, to help the community identify and implement improvements in energy efficiency and management.
	Renewable energy: solar energy	Implementation of photovoltaic power systems or solar water heating systems for low carbon power generation.
	Untapped energy: waste-to-energy	The process of converting biomass waste into usable energy, thereby providing municipalities/organizations with a new source of energy for electricity generation, heat production, and production of biofuel.
Environmental Planning	Solid waste recycling education and awareness for expansion	Implementation/enhancement of a recycling program to divert sorted waste from landfills, continue working with vendors to increase recycling and repurposing of waste, and increase participating households in diverting of waste from landfills.
	Solid waste untapped energy: incineration plant	Waste incineration to decrease volume going into landfills combined with waste heat recovery for electricity power generation.
	Urban greening and forest expansion with bio filtration system expansion for wastewater reuse in irrigation	Increase in tree planting to help sequester carbon and increase shade coverage. Expansion of wastewater capture and bio filtration systems to reuse or recycle wastewater for irrigation and other purposes.

Figure ES-2 depicts the projected emissions reductions for 2018, 2021 and 2035 compared to the baseline. Implementation of the LCMs could potentially allow the District to achieve a 27% GHG emissions reduction compared to its 2012 baseline by 2021 and an 85% reduction compared to 2035.

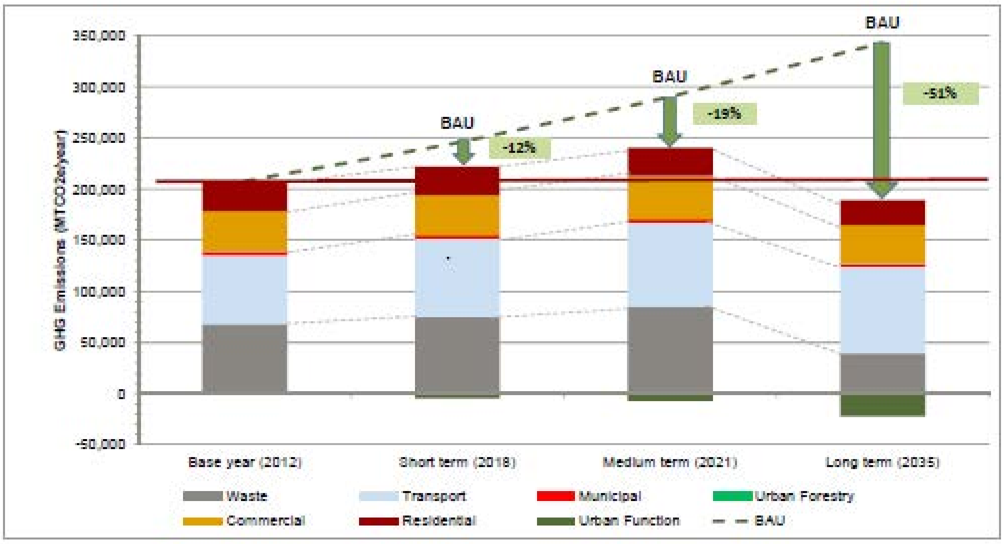
Figure ES-2: Projected GHG Emissions Reductions Compared to 2012 Baseline



Source: Project Team

In addition, this study concludes that the District could achieve the following emissions reductions compared to projected business as usual (BAU) development: a 19% reduction compared to BAU projections in 2021 and a 51% reduction compared to BAU projections by 2035. Figure ES-3 depicts projected reductions compared to the BAU scenarios for the same target years.

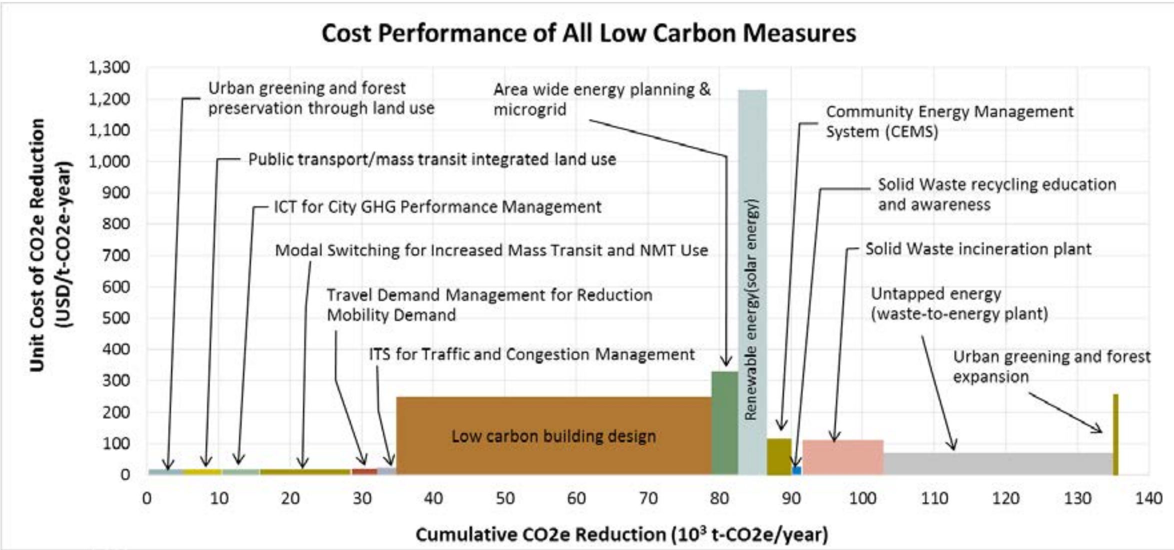
Figure ES-3: Projected GHG Emissions Reductions Compared to BAU



Source: Project Team

Implementation of the LCMs could bring additional, significant benefits to San Borja in the form of greater energy security, water security, cleaner air, more equitable access to urban services, and regional job creation. Implementation of LCMs with relatively low cost performance (e.g., “area wide energy planning and micro grid", "renewable energy (solar energy)" would require technology transfer and technical support from economies with experience in the relevant low carbon technologies. In Transportation Planning, "Intelligent Transport System (ITS)" enhances the effectiveness of "modal switching" and "Travel Demand Management" measures. Subsidies or financing support from the public sector or other entities would be essential in the preparation, procurement and operation of such low carbon projects. Figure ES-4 shows the comparative cost performance of all low carbon measures in all LCM categories.

Figure ES-4: Comparative Cost Performance of All Low Carbon Measures



Source: Project Team

This study recommends that San Borja consider the following to implement the LCMs and achieve projected GHG emissions reductions:

- Formation of an LCMT Community Planning Council (LCMT-CPC)
  - The LCMT-CPC should lead low carbon efforts by performing the overall planning and management for all carbon reduction measures.
  - The LCMT-CPC should consist of various stakeholder groups and departments within the San Borja Municipality.
- Project Implementation Business Schemes
  - The business scheme for each carbon reduction measure should be designed based on the characteristics of the measure.
  - There are a variety of project implementation schemes, such as public-based projects and public-private partnership (PPP) projects.
- Financing
  - LCMT-CPC projects could be funded by one of the following sources:
    - Municipal budget;
    - Provincial budget
    - National budget;
    - Other domestic source;
    - International sources:
      - Private financing

- Bilateral development funding
- Regional development bank financing
- International financial institutions
- Foundation grant funding

This study recommends San Borja include the following four considerations, (in addition to considering the per unit cost of MtCO2e reduced), when prioritizing LCM investment:

1) Does San Borja have director management control of over the emissions the LCM is to reduce (i.e., Scope 1 emissions);
2) Could San Borja reduce its Scope 2 emissions through procurement policies;
3) Could San Borja reduce Scope 3 emissions from greater employee and resident awareness and education; and
4) Would San Borja be using a multi-criteria investment analysis to identify LCMs with significant benefit to cost ratios.

Table ES-4 lists the next steps for San Borja to realize its LCMT vision further.

Table ES-4: Key Steps for Realization of LCMT

Step	Descriptions
1. Select LCMs	Select the LCMs with the greatest potential for sustainable implementation based on the outputs from this study.
2. Create technical outlines for LCMs	Prepare the technical outlines and the operating and maintenance criteria for the selected LCMs. Prepare business plan in concrete detail (e.g. location, scale, and project period).
3. Develop finance project scheme	Identify stakeholder groups, project implementing body, and investors. Assess financing options. Conduct risk assessment and prepare risk management plan.
4. Conduct meetings with enterprises interested in project participation	Conduct preliminary meetings with enterprises who are interested in bidding for the project.
5. Project assessment	Develop a project plan (e.g., cost and profit assessment, identification of potential project management issues).
6. Prepare for business operators selection	Decide on evaluation criteria for business operators (e.g., technical abilities and experience in construction, operation and management of advanced technologies in the related sector, company's financial status).

1. INTRODUCTION

1.1. Low Carbon Model Town (LCMT) Project

In 2010, the Asia-Pacific Economic Cooperation (APEC) Forum initiated the Low Carbon Model Town (LCMT) Project with the goal of integrating low carbon measures (LCMs) and best practices in city planning across the APEC region.

The San Borja study is the fourth phase of the APEC LCMT Feasibility Studies. The previous three APEC phases included:

- Phase 1 (2011): Yujiapu Central Business District, China - a new district where the central business district was being planned;
- Phase 2 (2012): SAMUI Island in Surat Thani Province, Thailand – a previously developed resort island; and
- Phase 3 (2013): Da Nang City, Vietnam – a brownfield redevelopment in an existing urban district.

Each phase of the LCMT Project incorporates the following elements: a low carbon town concept and vision for low carbon development, a Feasibility Study of LCMs to support the vision, a preliminary policy review of related initiatives, and a LCM GHG reduction analysis and cost estimate.

1.2. Feasibility Study Scope

The focus of this Feasibility Study is the District of San Borja, a mainly residential area within Lima Province. San Borja District was selected by APEC for the fourth phase of the LCMT project because it is a residential municipality within a large city. Figure 1-1 is the entrance to the municipality of San Borja.

Figure 1-1: Entrance to San Borja

Source: Hitachi Consulting

The primary objective of this Feasibility Study is to provide government officials and stakeholders in San Borja with valuable advice on how to design, develop and implement a low carbon development plan with measurable results and repeatable outcomes.

The scope of this Feasibility Study entailed:

- Creating a Low Carbon Development Strategy for San Borja including:
  - A high level vision;
  - Definition of the greenhouse gas (GHG) emissions baseline and business-as-usual (BAU) scenario;
  - Definition of the GHG reduction and environmental targets;
  - Guideline for categories of low carbon town design challenges; and
  - Selection of GHG reduction measures for each design category;
- Analyzing the GHG reductions and costs for the selected design measures assuming the strategy is implemented; and

- Developing a methodology and action plan for implementing the proposed GHG reduction measures, including identification of potential implementers and funding sources for the proposed measures.

Table 1-1 provides a location map detailing where the reader can find specific information by scope throughout the report. The report is organized as follows: Chapter 2 provides background information on the local conditions and characteristics of San Borja; Chapter 3 describes the LCMT vision and guidelines; Chapters 4 through 8 summarize the recommended LCMs by category (e.g., transportation planning); Chapter 9 presents the GHG emissions reductions analysis and cost estimates; and Chapters 10 and 11 summarize implementation and funding recommendations.

Table 1-1: Report Organization by Scope Element

Scope Element	Section
Develop a high-level vision	Chapter 3
Define GHG emission baseline and BAU scenarios	Introduced in Chapter 3 and described in more detail in Chapter 9
Define the GHG reduction and environmental targets of the low-carbon town	Introduced in Chapter 3 and described in more detail in Chapter 9
Prepare a Low-Carbon Guideline for categories of low-carbon town design challenges	Chapters 4 through 8
Select GHG reduction measures (i.e., LCMs) in each design category	Chapters 4 through 8 A summary of the LCMs is included in Chapter 11
Analyze GHG reductions and costs for the selected design measures	Chapter 9
Develop a methodology and action plan for implementing proposed GHG reduction measures	Chapters 10 & 11

1.3. Methodology for GHG Quantification Accounting and Reporting

This Feasibility Study confirms[1] San Borja's GHG baseline and inventory by using the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC) as the normative standard to evaluate San Borja's accounting and quantification results.[2] San Borja is one of the first urban communities in the world to use the GPC version 2.0 as a tool to guide its GHG quantification, accounting, and performance management. This Feasibility Study uses carbon dioxide equivalents (CO2e) as the unit of measure for GHGs per the request of San Borja and as endorsed by APEC.

Use of the GPC allows San Borja to demonstrate quantitatively the GHG reductions which result from LCM implementation. This data will in turn inform public and private policymaking, budgeting, and investment prioritization within San Borja. San Borja establishes itself as a leader in fostering collaboration with its neighboring municipalities by using the latest GPC framework to establish its GHG baseline and accounting procedures. These efforts support the LCMT approach on a wider scale within Lima Province.

1 Note: in this Feasibility Study confirmation refers to evaluating San Borja's existing inventory within the GPC standard protocol and revising the inventory when appropriate to align with the GPC. It does not refer to a formal third party review of the inventory.

2 The GPC version 2.0 was developed by the World Resources Institute (WRI) in coordination with the C40 Climate Leadership Group and ICLEI-Local Governments for Sustainability.

2. GEOGRAPHIC, DEMOGRAPHIC, AND ECONOMIC BACKGROUND

This chapter provides background on the local and regional geography, climate, and population community and economic structures. It also outlines energy production and consumption information for Peru, Lima, and San Borja. The purpose is to provide context to readers so that they may better understand the rationale for LCM recommendations made in this Feasibility Study.

2.1. Geography

Local geographic conditions, including natural resources, renewable resources, hydrology cycles, and airsheds are important context for selecting LCMs. The sections below summarize the geographic characteristics of Lima Province and San Borja.

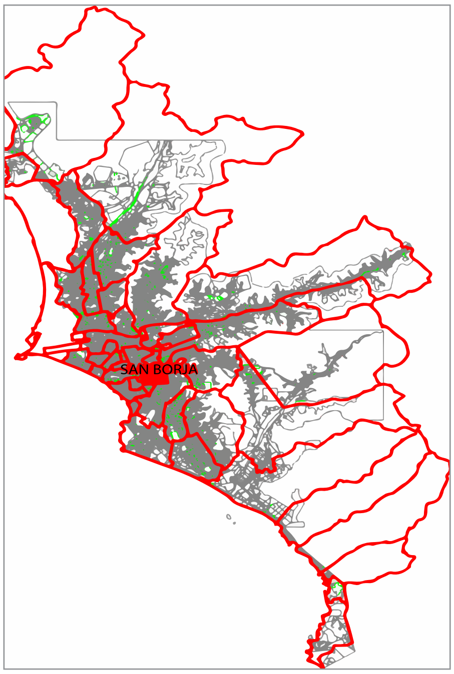
2.1.1. Regional Geography: Lima Province

Lima Province is located within west-central Peru, sitting in a long, narrow desert strip between the Pacific Ocean and the Andes mountains. The desert terrain is mostly flat and it spreads across the Chillon, Rimac, and Lurin River valleys. Lima Province stretches from north to south along the Pacific Ocean for almost 80 kilometers (km), and from west to east from the Pacific to the Andes for approximately 40 km covering a total area of 2,672.28 kilometers-squared (km^2). Figure 2-1 is a map of Peru showing the location of Lima.

Figure 2-1: Map of Peru

The capital of Lima Province is Lima, which is also the capital of Peru. Lima Province is comprised of 43 municipalities and has a total population of approximately 9.7 million people, making it one of South America's largest megacities. The historical city center of Lima sits alongside the Rimac River which has historically been a primary source of fresh water for the city. Figure 2-2 is a map of Lima showing the location of San Borja.

Figure 2-2: Map of Lima



Source: San Borja LCMT Forum Presentation

2.1.2. Local Geography: San Borja

San Borja, established as a unique district in 1983, covers 9.96 km^2 and is 170 km above sea level. Its geographic coordinates are 12° 6' 0" South, 77° 1' 0" West, and it sits within Lima's west-central section near the coast. San Borja shares a border with seven other municipalities: La Victoria and San Luis to the north, Santiago de Surco and Ate-Vitarte to the west. Surquillo and Santiago de Surco to the south, and San Isidro to the west. San Borja is the 23rd largest of the 43 municipalities in terms of population, and is within the top five municipalities in terms of educational levels and affluence.

2.2. Regional Climate and Local Weather

2.2.1. Regional Climate

The World Bank identifies Peru as one of the most vulnerable countries in the world to impacts of climate change on precipitation and water availability.[3] Lima Province is currently experiencing rising temperatures, extreme temperature fluctuations, changing rainfall patterns, and sea level rise due to variations in the hydrological cycle resulting from an increased rate of glacier melt in the Andes. Furthermore, Lima Province is also subject to the effects of the El Niňo Southern Oscillation phenomena, which in the past has resulted in increased temperatures.[4] For instance, during the 1997-1998 episode, the mean ambient temperature in Lima increased by as much as 5º C above normal.[5] As a result of these climate variations and a reduction in glacial runoff resulting in reduced river flows, the region is projected to suffer from water scarcity.[6] Figure 2-3 provides an overview of San Borja's planning to address water quality and security.

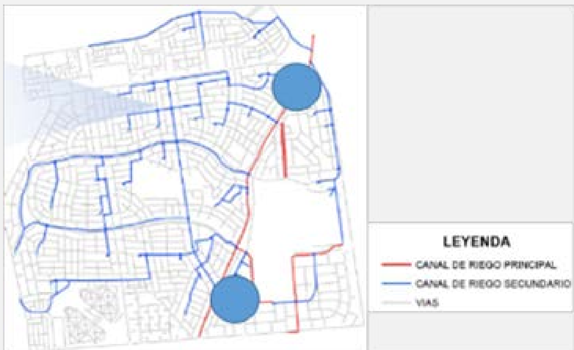
Figure 2-3: Potential Future Needs for a Water Treatment Plant

San Borja is planning to construct a new water treatment plant for the Surco River.

The municipality is working to establish strategic alliances with SEDAPAL, (Servicio de Agua Potable y Alcantarillado de Lima), the local water utility, to coordinate this effort. A primary purpose is to eliminate the use of potable water for non-drinking purposes among commercial and industrial users throughout the municipality.

Needed for a multi-functional, high efficiency system with fresh water reuse, and wastewater treatment capacity that is higher than the existing system. This study does not discuss estimated GHG emissions because this is an ongoing discussion already within San Borja. The map to the right shows the potential locations (the two circles) for a future water treatment plant. The strategy includes using reclaimed water for:

- Landscape irrigation on privately-owned lands;
- Toilet flushing for all commercial, residential and municipal buildings;
- Cleaning outdoor areas on privately-owned land; and
- Coolant for privately-owned machinery and equipment.



3 The World Bank, Lima Transport Project, ICR 0000 1373 (2012).

4 ibid.

5 Effect of El Niño and ambient temperature on hospital admissions for diarrheal diseases in Peruvian children. Checkley WI, Epstein LD, Gilman RH, Figueroa D, Cama RI, Patz JA, Black RE.

6 USAID, Peru Climate Change Vulnerability and Adaptation Desktop Study, December 22, 2011.

2.2.2. Local Weather

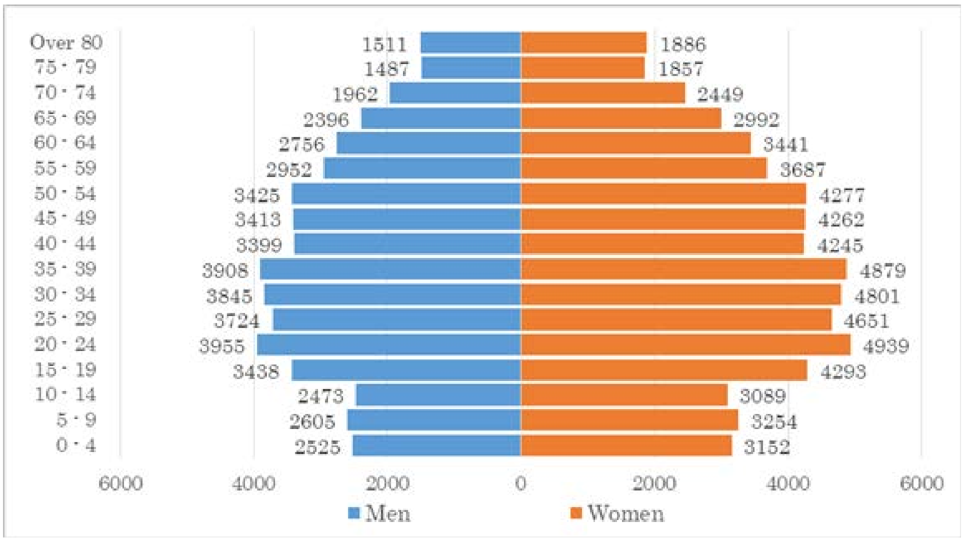
San Borja has a subtropical and desert climate, typical of the Peruvian coastal area. It rarely rains, although from June to October the streets dampen due to a fine drizzle called "garúa". The sky is usually overcast during this period. Despite being in the desert, the coastal influence results in an average annual humidity of 86%.[7] Average annual temperature ranges from 16-22 °C (62-72 °F). The summer season lasts from December to April. During this time, temperatures can reach highs of 28-30 °C (82-86 °F). Winter lasts from May to November, with temperatures as low as 12-15 °C (54-59 °F).

2.3. Population Structure

2.3.1. Demographics

In 2011, San Borja's population was 111,808 people comprising approximately 36,000 households.[8] In 2012 the population was 112,562 people. The majority of the population is between 20 and 50 years of age (52%), and is comprised of 55% female and 45% male. The projected growth rate for population is 1% per year. Figure 2-4 depicts the projected population by age distribution for 2015.

Figure 2-4: Estimated Populations Structure of San Borja (2015)



Source: Indicadores Demograficos spreadsheet, provided by the Municipality of San Borja.

The general population is among the most highly educated in Lima with 36.3% of the population having graduated college, and has among the highest per capita income rates with 43% of the population characterized as upper middle class (see Table 2-1).

Table 2-1: San Borja Population by Household Income Per Capita (2012)

Strata	Income Per Capital for Home (Current Dollars)	Population	Homes	%
High	590.01 +	135	34	0.12
Middle High	313.01 – 590.00	48,626	12,279	43.20
Middle	191.01 – 313.00	52,634	13,291	46.76

7 National Institute of Statistics and Information, Average Humidity by Department.

8 San Borja LCMT Project Nomination Sheet Part B (2011).

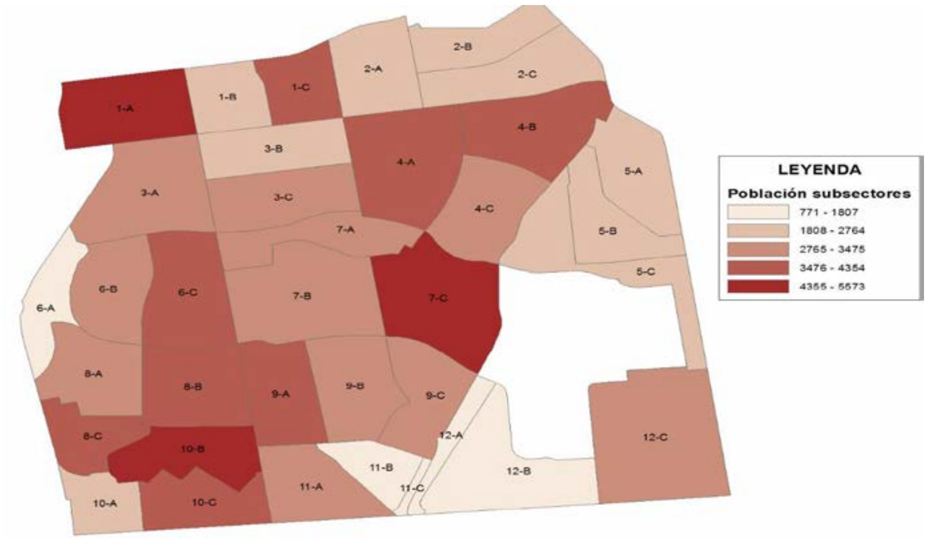
Strata	Income Per Capital for Home (Current Dollars)	Population	Homes	%
Middle Low	132.01 – 191.00	11,156	2,817	9.91
Low	132 -	12	3	0.01
	Total	**112,562**	**28,424**	**100**

Source: San Borja LCMT Nomination Sheet Part B, 2011

2.3.2. Community Structure

San Borja is one of the few districts in Lima developed on the basis of a Master Plan which requires ongoing systematic review, planning, and management. San Borja has 12 administrative areas each of which has a representative on the community council. Their role is to facilitate ongoing review, planning, and urban management. Their responsibilities include providing input on the policies, processes, programs, and systems for urban function planning and performance, parks and recreation planning and management, district administrative and fiscal management, waste collection and disposal, resident security, and transportation planning and performance.

Figure 2-5: San Borja Administrative Districts



Source: San Borja 2035 Sustainability Plan

Each administrative area is further divided into three sub-areas for zoning purposes. The least populated area is Sector 11 on the southern end of the district with 5,104 people; the most populated is Sector 7, located in the center of the district, with 12,164 people (see Figure 2-5). Of San Borja's approximately 36,000 households, 53% of the population lives in apartment buildings (17,450), 47% live in detached houses (13,278), and 0.1% live in housing estates (37).

The people of San Borja have a strong sense of community identity and commitment to community-based governance. Residents participate in municipal programs, including sustainability programs such as the municipal sponsored green roofs program. Another example of this trend is that residents have embraced the bicycle sharing program, San Borja en Bici (Bike San Borja)

Figure 2-6: Aerial view of San Borja's Cultural District

Source: Municipality of San Borja

Figure 2-7: San Borja's Commercial District

Source: Hitachi Consulting

San Borja is home to numerous national institutions, including the Ministry of Energy, Ministry of Environment, Ministry of Education, the National Institute for the Defense of Competition and the Protection of Intellectual Property (INDECOPI), and the Peruvian Institute of Nuclear Energy (IPEN). There are also several institutions of national significance such as the National Library of Peru and the National Grand Theater. Peru's Department of Defense (DOD) is located in San Borja. Figure 2-6 and 2-7 shows aerial views of San Borja's cultural and commercial districts..

2.4. Economic Structure

2.4.1. National Economy

Peru has one of the best performing economies in Latin America. The foundations of its economic growth rest on its most productive sectors: manufacturing, construction, agriculture, and mining. The economy has experienced strong growth; however that growth has begun to slow in the past 4 years. In 2010, gross domestic product (GDP) grew by 8.8%; in 2013 it slowed to 5.8%. During this time, Peru's per capita income increased by more than 50%.[9] This increase correlates with a growing middle class in Peru, which currently represents 50% of the population, and increased purchasing power in general.

2.4.2. Regional Economy

Lima Province is the financial center of Peru, producing more than two thirds of the Peruvian GDP, taxes, bank deposits, private investments, doctors, and university students. Almost all of Peru's major industries are located in Lima Province, including textile production, clothing and food, chemicals, fish, leather, and paper production. In addition, Lima is a center for retail and wholesale business, trade, finance, and tourism.[10]

2.4.3. Municipal Economy

San Borja is primarily a residential municipality with small commercial areas along the avenues San Luis, Aviacion, Civil Guard, Javier Prado, and San Borja Norte. In these areas there is limited mixed use development that includes housing, employment, commercial, and access to public transit. Figure 2-7 depicts one of San Borja's commercial areas.

9 Peru Overview, The World Bank; accessed at: http://www.worldbank.org/en/country/peru/overview

10 Lima Economy Profile, Lima Easy; accessed at: http://www.limaeasy.com/peru-info/peruvian-economy.

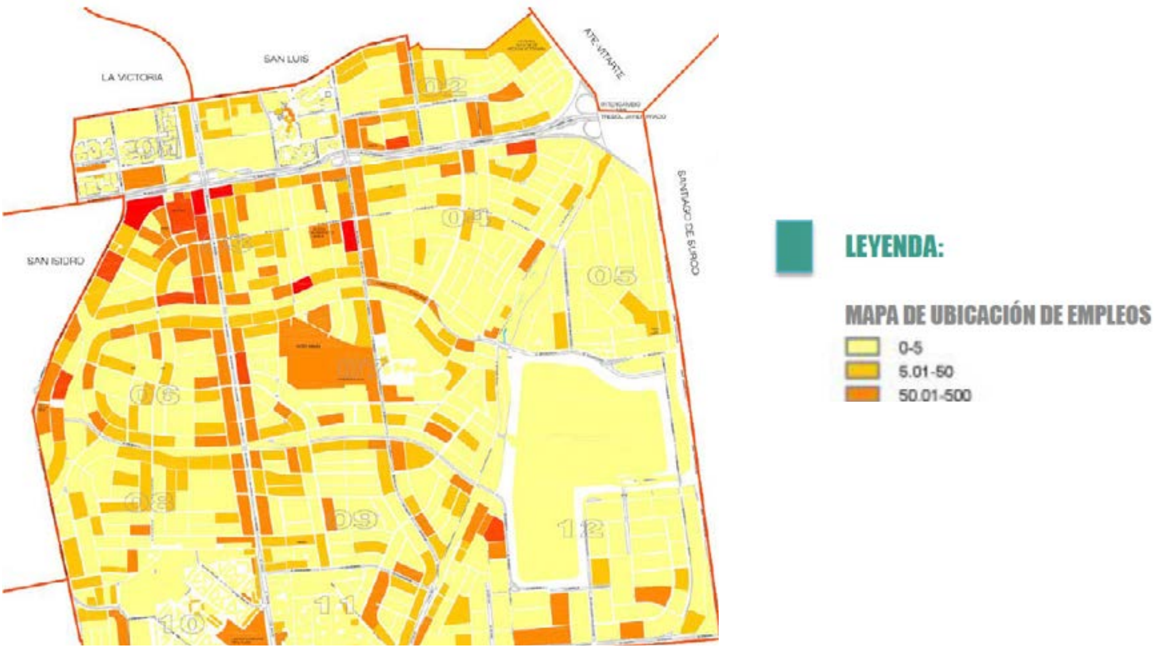
Table 2-2: Distribution of Economically Active Population by Sector (2011)

Type of Work	Number of People	%
Government	657	1.3
Professional, Scientific, and Intellectual	17,945	36.3
Mid-Level Technical	8,312	16.8
General Office	7,475	15.1
Hospitality and Service	5,009	10.1
Agriculture and Fisheries	114	0.2
Mines and Manufacturing	1,327	2.7
Construction, Clothing, and Paper Mills	1,365	2.8
Medical and Education	5,616	11.4
Other Occupations	1,596	3.2

Source: San Borja 2035 Sustainability Plan

Table 2-2 illustrates that in 2011 the majority of the population is “white collar” workers that have employment in government agencies, corporations and small businesses, scientific and academic institutes, the banking and trade industry, and the medical industry. Most white collar jobs in San Borja are located along the main streets of the district (Aviacion Avenue and Avenue San Luis). These jobs tend to be with national government, local government, research institutes, and education. The largest shopping centers, La Rambla and Plaza Real, also attract a high number of workers as does the Naval Center of Peru on Avenue San Luis (see Figure 2-8).

Figure 2-8: San Borja Map of Employment Areas



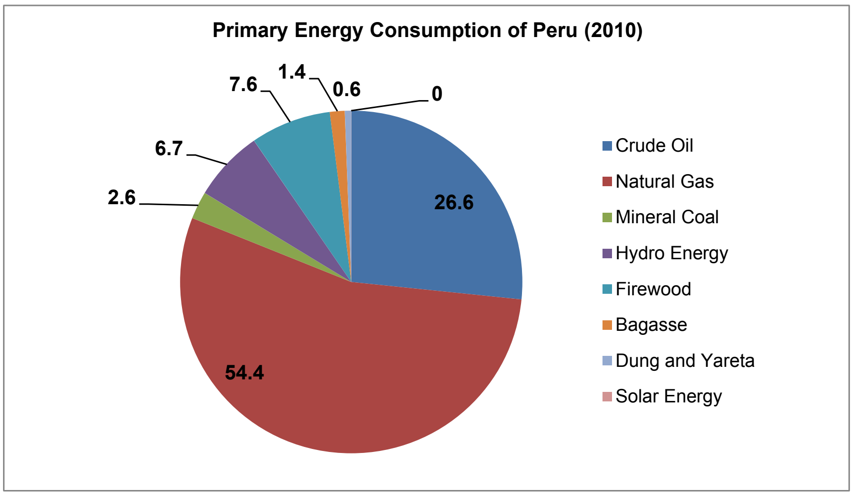
Source: San Borja 2035 Sustainability Plan

2.5. Energy Background

2.5.1. Primary Energy Sources

In recent years, energy development in Peru has focused primarily on the exploitation of natural gas reserves, which have replaced crude oil as the dominant primary energy source (Figure 2-9).

Figure 2-9: Primary Energy Consumption of Peru



Source: United Nations Statistics Division. "Energy Balance" database.

2.5.1.1. Electricity Production

Domestic hydroelectric and natural gas are the main electricity generation sources for Peru (Figure 2-10), allowing Peru to have low-carbon intensive electricity generation.

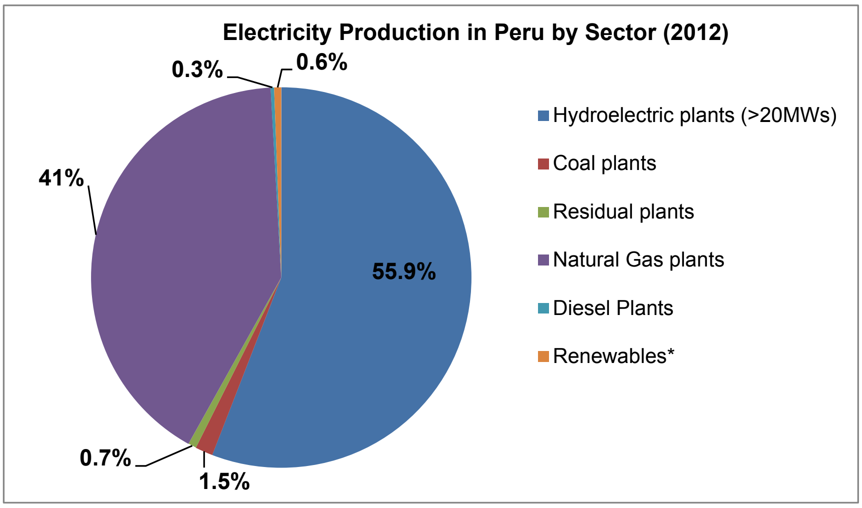


Figure 2-10: Energy Production in Peru

Source: U.S. Commercial Service (2012). "Peru: Renewable Energy Industry".

Peru has a universal energy grid with interconnected transmission lines. Its power sector underwent privatization and restructuring in the late 1990s. In 2012, 70 large companies were officially operating in the Peruvian energy sector, including 31 generation companies, 14 transmission companies, 22 distribution companies, and three public institutions.[11] The average tariff is $0.1046 per kWh for the residential sector, and $0.0146 for the commercial sector.

Despite continued growth in electricity production, Peru's electric power infrastructure is regularly strained to meet electricity demand. Specifically, Peru faces the following concerns:

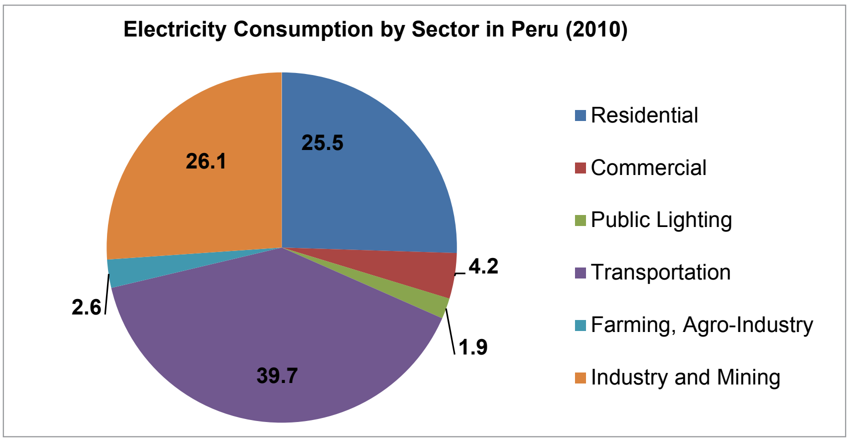
- Low expected annual demand growth rate (7% and 9% over the next few years);
- High transmission losses (about 4.7% annually);
- High distribution losses (about 5.03%); and
- Electric power interruptions (average occurrence: 14.5 times per year / average duration: 18.3 hours[12]).

According to the "SWH Market Assessment Regional Report" (2012) by the Organization of Energy of Latin American and the Caribbean, there has been considerable interest in solar water heating systems in some regions. The study also reported that the technical efficiency and technological advancement of solar water heaters is relatively high in Peru as a result of national energy saving projects that helped develop minimum technical standards for solar water heaters among other equipment and appliances. However, despite interest and promotion of renewable energy in Peru (e.g., the Law on the Promotion of Investment in Electricity Generation through the Use of Renewable Energies [Legislative Decree 1002 of 2008]), the artificially low price for electricity due to heavy government subsidies limits the incentives for consumers to invest in renewable energy generation in Peru.

2.5.2. Primary Energy Consumption

According to the United Nations Statistics Division's "Energy Balance" database, the transportation, industry and mining, and residential sectors are the main contributors to total primary energy consumption in Peru. Figure 2-11 provides a full breakdown of sector contributions to energy consumption.

Figure 2-11: Primary Energy Consumption in Peru (2010)



Source: United Nations Statistics Division. "Energy Balance" database.

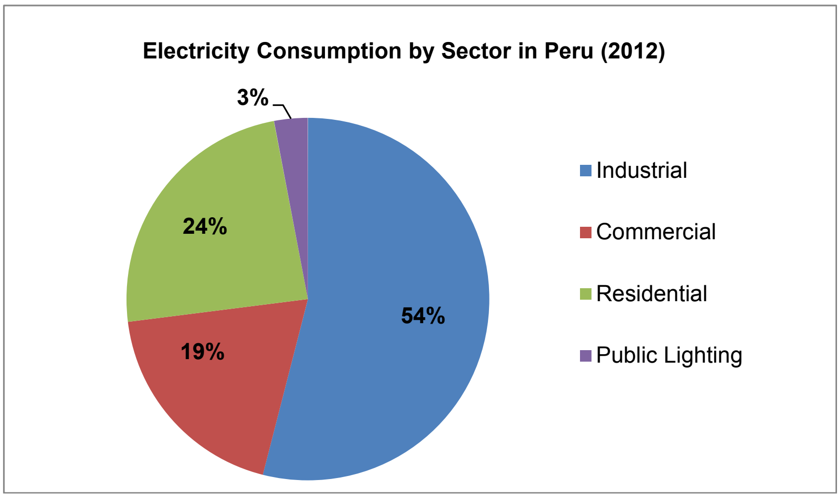
11 Information retrieved during site visit on July 30 – August 1, 2014.

12 Information retrieved during site visit on July 30 – August 1, 2014.

2.5.2.1. Electricity Consumption

At the national level, installed electricity generation capacity is divided evenly between thermal (48%) and hydroelectric (48%), with a negligible share of renewable resources such as wind, biomass, and solar photovoltaic.[13] The industrial sector is the largest electricity consumer, accounting for over half of the nation's electricity use. Figure 2-12 shows the breakdown of electricity consumption in Peru.

Figure 2-12: Electricity Consumption by Sector in Peru (2012)

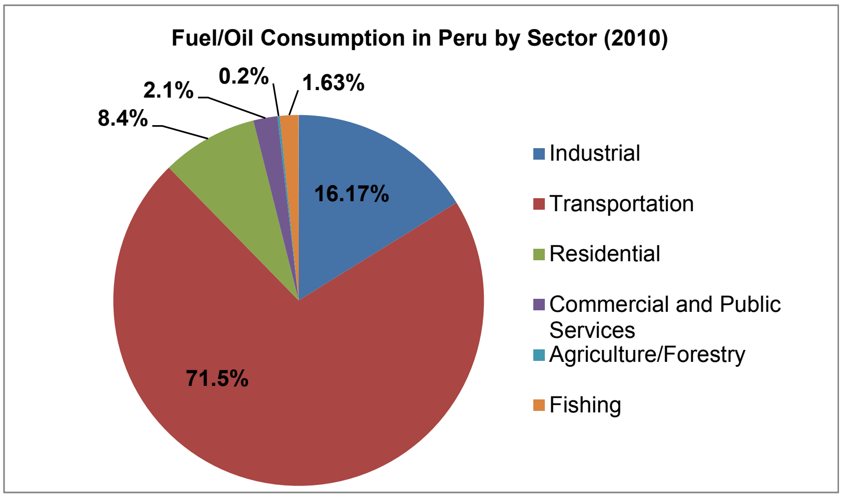


Source: U.S. Commercial Service (2012). "Peru: Renewable Energy Industry".

2.5.2.2. Fuel Consumption

According to the International Energy Agency's energy statistics database, the transportation sector is the main contributor to total fuel consumption in Peru. Figure 2-13 provides a full breakdown of sector contributions to fuel consumption.

Figure 2-13: Breakdown of 2010 Fuel Consumption in Peru by Sector



Source: International Energy Agency

13 U.S. Commercial Service (2012). "Peru: Renewable Energy Industry".

2.5.3. Energy-Related GHG Emissions

To date, Peru has shown active support for GHG mitigation initiatives involving energy. In September 2010, Peru submitted a voluntary communication entitled *Second National Communication to the United Nations Framework Convention on Climate Change,* in which it provided a breakdown of its energy consumption and a summary of its national policies, institutional framework, and GHG emissions among Peru's different sectors.[14]

14 Nationally Appropriate Mitigation Action of Developing Country Parties. United Nations Framework Convention on Climate Change (UNFCCC). (Accessed on 10/27/14). Retrieved from http://unfccc.int/meetings/cop_15/copenhagen_accord/items/5265.php

3. LCMT CONCEPT

This chapter outlines the high level vision of the APEC LCMT concept as it applies to San Borja. San Borja is unique among APEC's other LCMTs in that it had already established a low carbon community vision and plan before APEC selected it as the Phase 4 LCMT project. Therefore, this Feasibility Study builds on the strategies already identified in San Borja's Low Carbon Plan (LCP) 2021. It evaluates San Borja's existing GHG baseline, inventory, BAU scenarios and GHG reduction potential associated with San Borja's existing strategies. This study recommends for 2018 (short term), 2021 (mid term), and 2035 (long term).

Figure 3-1: Aerial view of San Borja

Source: San Borja Low Carbon Forum

3.1. LCMT Approach

3.1.1. San Borja's Low Carbon Town Vision: Low Carbon Plan 2021

In 2013, the San Borja Task Force prepared the district's first GHG emissions inventory for calendar year (CY) 2012. The Task Force chose a bottom-up approach for developing the inventory, meaning they estimated GHG emissions using activity data such as fuel consumption data, electricity use invoices from the utility, operation logs related to municipal operations, and survey data to estimate the district's baseline emissions. The results from San Borja's initial GHG emissions inventory are included in Appendix A. Figure 3-1 is an aerial view of the municipality.

One purpose of this Feasibility Study is to evaluate San Borja's initial GHG 2012 baseline and inventory following the GPC, (version 2.0) as the normative standard. Chapter 9 discusses the results of the evaluation. San Borja's initial GHG emissions as the normative standard inventory was the basis for the San Borja LCP 2021, including the goal to reduce total municipal emissions by 15% by 2021. The San Borja LCP 2021 sets forth six action areas with targets for reducing emissions within the following sectors: residential, commercial, transport, solid waste, institutional, and urban forestry. Figure 3-2 summarizes these action areas, their associated reduction targets, and the overall municipal target.

Figure 3-2: Low Carbon Plan 2021 Action Areas and GHG Reduction Targets

Source: San Borja Low Carbon Plan 2021

The LCP 2021 outlines for each action area various strategies for reducing emissions and pursuing a low-carbon development path.

3.1.2. APEC's LCMT Concept

This Feasibility Study builds upon San Borja's LCP 2021. It proposes additional and complementary strategies to the strategies identified in San Borja's plan. These strategies are referred to as LCMs throughout this study and are organized according to the five APEC LCMT "design categories." These are: 1) urban function planning; 2) transportation planning; 3) buildings sector planning; 4) energy planning; and 5) environmental planning.

Figure 3-3 describes the vision developed by the project team to guide the selection of the LCMs in this Feasibility Study.

Figure 3-3: LCMT Concept for San Borja

Sustainable and Comfortable Living in a "nZero Carbon Community"

Source: Feasibility Study Project Team

Figure 3-4 outlines the LCMs recommended by this feasibility study and how they relate to San Borja's LCP 2021 action areas and strategies. The LCMs include urban planning and design processes, people-oriented transportation systems, microgrid and smart energy systems, energy efficient building practices, waste management, trash repurposing that creates jobs, and efficient and strategic water use practices.

Figure 3-4: Relationship between San Borja LCP 2021 and LCMT Recommendations

San Borja Low Carbon Plan 2021		LCMT Phase 4: San Borja Feasibility Study		
Action Areas	Strategic Actions	LCMT Category		Recommended LCMs
Residential Sector	Increase natural gas use in residential buildings	Building Design Planning	Energy Planning	Passive design for buildings
	Promote energy efficiency in households			Active design for buildings
Commercial Sector	Increase natural gas use in commercial buildings			Area wide energy planning and management and microgrid implementation
	Promote energy efficiency in commercial buildings			Community energy management system and smart meter implementation
Institutional Sector (Municipal Operations and Buildings)	Promote energy efficiency in Municipal owned buildings			Renewable energy
	Replace municipal vehicles with LPG CNG vehicles			Untapped energy (waste-to-energy)
Transport Sector	Increase the number of NMT trips, specifically through bicycle use	Transportation Planning	Urban Function Planning	Land use and market based strategies for urban forest preservation
	Increase average occupancy rate in private cars			Transit oriented development and transit station planning for mixed-use development
	Improve the average traffic speed through intelligent traffic lights and traffic control			Information and communication technologies for city management
	Reduce the number of trips in smaller units by increasing van and bus trips			Modal switching and mixed mobility solutions
	Increase efficiency of freight transport through circulation plans, routes, and schedules for cargo transport in the district			Travel demand management techniques
				Intelligent transportation system
Urban Forestry	Plant 50,000 new trees to achieve shade cover over 25% of the district's total area, and sequester 550 MtCO2 annually of the total areas of the district	Environmental Planning		Solid waste recycling expansion
Solid Waste	Ensure proper treatment and disposal of waste from municipal Organic			Urban greening and forest expansion (Includes Biofiltration System)
	Improve segregation and collection and recycling of municipal solid waste			Untapped energy (Incineration Plant)

Source: Project Team

4. URBAN FUNCTION PLANNING

This chapter address the GHG emissions associated the urban design and land use decisions affecting town structure and driving energy consumption patterns and trends. The chapter outlines the recommended LCMs that build on the ideas listed in San Borja's 2035 Sustainability Plan and the emissions reductions targets outlines in San Borja's LCP 2021 (See Appendix B). This chapter concludes with a summary of the projected GHG emissions performance and costs of the recommended LCMs.

4.1. Background and Issues

4.1.1. Urban Function Planning Defined

The definition of urban function in this study is a city's ability to integrate complementary land use, town planning, and urban development policies, systems, processes, and procedures to reduce GHG emissions across its multiple urban sectors. This study focuses on three elements of urban function: 1) land use, 2) urban greening and forestry, and 3) information for decision support and city performance management. (e.g., integrated data for decision support).

Figure 4-1: Relaxed Height Restrictions for Apartment Buildings

Source: Hitachi Consulting.

4.1.2. Challenges and Responses

4.1.2.1. Land Use Drives Energy Consumption Petitions

San Borja is a primarily residential district, with commercial and residential land-uses separated per zoning requirements. San Borja is typical of many urban neighborhoods in cities around the world in that commercial uses are limited to small businesses, and development is oriented along a well-connected street grid. San Borja is one of the few districts in Lima that is experiencing population growth and zoning for increased density. Current (2014) average density is 11,344 residents / km^2.

In response to projected population increases, San Borja revised its zoning ordinance in favor of increased residential and commercial density. For instance, it has eased height restrictions on new construction. The intent is that multi-family residential units will begin displacing single-family residences. Figure 4-1 shows a new apartment under construction that is able to take advantage of the newly-eased height restrictions. In many cities around the world, separation of residential and commercial uses results in greater emissions due to greater reliance on motor vehicle trips to access goods and services in order to meet daily needs. In contrast, mixed use transit-oriented development (TOD) prioritizes in land use policies and urban design pedestrian, bicycle and transit trips, resulting in overall lower transport-related emissions. According to the Transit Cooperative Research Program, results from studies have shown that residents in neighborhoods with good transit access.[15] Uncertain is whether San Borja is sufficiently focused on TOD-driven, mixed-use development to support emissions reductions from urban town structure.

Figure 4-2 shows the current land use of the large area in grey at the lower right hand side is Peru's national DOD (referred to locally as *The Pentagonito*), and the national government owns and operates the buildings on the land. San Borja does not have jurisdiction over the land use in that area.

Figure 4-2: San Borja Land Use Map

Source: San Borja 2035 Sustainability Plan

Note: The red areas are commercial, yellow areas are residential, green areas are green space or forest, and grey areas are institutional uses.

4.1.2.2. Urban Growth vs. Urban Greening and Forest

A challenge for San Borja is to increase its shade cover while accommodating urban growth. Public open space comprises 13.5% of San Borja's land use, including parks, boulevards, and urban forest. Each of these are important contributors to San Borja's goal of 550 MtCO2e per year of sequestered CO_2 and 25% shade cover over the entire district by 2035. The current proportion of shade cover is 10%. In the process of new development, San Borja is beginning to experience a loss of shade cover in certain areas. Figure 4-3 shows a street corner in a residential neighborhood in San Borja prior to re-zoning for higher density (image on the left), and the same street corner after re-zoning and the construction of an apartment building (image on the right). Prior to re-zoning there were trees and shade cover; after construction no trees remained and all shade cover was eliminated on that street corner.

15 Portland City Council (2008): North Pearl District Plan; Federal Transit Administration, Transit Cooperative Research Program Legal Research Digest #36: Transit Oriented Joint Development and Legal Issues Case Studies (2011).

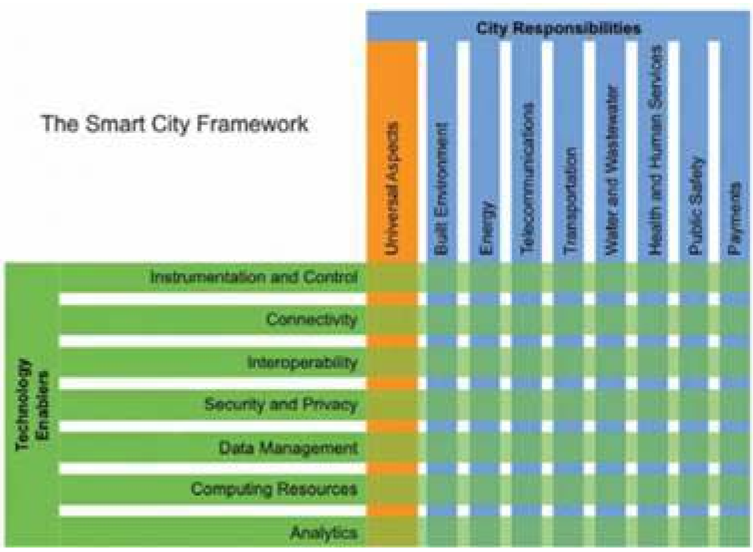
Figure 4-3: Redevelopment of single family residence to multifamily residence.

Source: 2035 Sustainable City Plan

This trend does not align with San Borja's urban forestry policy and program to stem a potential urban heat island effect by increasing urban shade cover to 25% by 2021. The loss of urban forest also does not align with San Borja's LCP 2021 target of sequestering 550 MtCO2e each year by 2021 from urban forest cover.

4.1.2.3. Information for LCMT Management

Figure 4-4: The ITC Smart City Framework



Source: Smart Cities Readiness Guide

Information communication technology (ICT) is an important enabler for San Borja to reach the full extent of its LCMT vision and its long term sustainability goals as outlined in its 2035 Sustainability Plan. A couple of challenges San Borja faces is sufficiently integrated data management, including performance metrics and progress indicators, to address it's six action areas. Uncertain is the degree to which San Borja has sufficient predictive analytics that could help drive its LCMT performance in its six action areas, and integrate with LCMT with it long term sustainability goals. Both its LCMT vision and sustainability goals, touch on energy, water, transportation, buildings and the built environment, climate, resilience, community, materials and food, finance and economic development, city business and measurement indicators. Some cities define this integration as being a "smart" city. Figure 4-4 depicts the intertwining of ICT enables across the typical city managers responsibility across sectors.

4.2. Proposed Low Carbon Measures

The following section describes three potential urban function LCMs that could help San Borja preserve its existing urban forest and shade cover. The LCMs include a mix of policies, land use planning strategies, incentives, and technologies.

4.2.1. Urban Greening and Forest Preservation

This study proposes the use of various market incentives for preserving urban greening and forest for shade cover. Urban forest serves as a “carbon sink”, (i.e., urban forests sequester CO_2) and is therefore an important element in San Borja’s plan to reduce its overall GHG emissions compared to its 2012 baseline. Shade cover by trees is also a way to cope with the impacts of climate change by helping to manage and reduce the urban heat island (UHI) effect. The term “heat island” describes built up areas (i.e., cities) that are hotter than nearby rural areas. The annual mean air temperature of a city with 1 million people or more can be 1.8-5.4 °F (1-3° C) warmer than its surroundings. In the evening, the difference can be as high as 22 °F (12 °C).[16] The UHI effect can affect communities by increasing peak energy demand for cooling.

San Borja will be more able to maintain its urban forest and shade cover in proportion to urban growth, by working in cooperation with private sector developers to avoid either cutting down trees during development or replacing them after construction. Revising land-use zoning classifications in favor of multi-family dwellings while simultaneously requiring developers to construct higher density buildings without reducing San Borja’s net shade cover and urban forest will support San Borja in meeting its 550 MtCO2e per year sequestration goal and its overall 15% GHG reduction target by 2021. Table 4-1 describes some of the LCMs to preserve urban greening, forest and shade cover tohelp address the UHI.

Table 4-1: Solutions to Preserve Urban Forest and Shade Cover

Overview
Recommended types of LCMs to preserve existing urban forest and shade cover include but are not limited to: **Impact fees:** Local governments require developers to pay a fee that will be applied to the city’s cost of providing new or expanded public capital facilities required to serve that development. Developers typically integrate the costs into property and rental prices. San Borja may benefit from exploring how to apply impact fees to the preservation of its urban forest and street-side shade cover either through purchase of additional land for conservation easement or tree replacement. **Conservation easements:** A conservation easement[17] is a restriction that San Borja could place on a piece of property to protect its associated resources, i.e., in this case shade cover and urban forest. The easement is either voluntarily donated or sold by the landowner and constitutes a legally binding agreement that limits certain types of uses or prevents development from taking place on the land in perpetuity while the land remains in private hands. An easement selectively targets only those rights necessary to protect specific conservation values, such as water quality, air quality, or migration routes.[2] Local government tailors the easement to meet a landowner’s needs so that an easement property continues to provide economic benefits for the area in the form of jobs, economic activity, and property taxes. **Transfer of development rights (TDR):** A market-based, “smart growth” technique that encourages the voluntary transfer of growth from places where a community would like to see less development (called sending areas) to places where a community would like to see more development (called receiving areas). The local government requires developers to pay a fee as a precondition for project approval and construction permitting. There are numerous standards and guidelines available to assist local governments on the planning processes that must be undertaken to develop solutions such as impact fees, conservation easements, and TDR. Important is to carefully design the approach, including a transparent plans for preserving developer’s economic needs to keep the property profitable, plans for the use and allocation of impacts fees, and transparent conduct of TDR programs.

16 U.S. Environmental Protection Agency. http://www.epa.gov/heatisland/

17 The Nature Conservancy, http://www.nature.org/about-us/private-lands-conservation/conservation-easements/what-are-conservation-easements.xml

Examples of Application
City of Livermore, California, USA: • Goals include preventing urban sprawl and preserving natural resources • Decision makers developed a comprehensive urban growth plan • Zoned in favor of higher density residential housing in receiving area and increased floor area ratio in central business district • Established a "Transferable Development Credits" program **Montgomery County, Maryland, USA (TDR)** • Stemmed from a community desire to preserve green space, agricultural lands, and forest • Decision makers adopted an open space preservation plan that rezoned as low-density growth in "sending area" and rezoned for higher density growth in "receiving areas". • Established a "Transferable Development Credits" program Adapted from: New Jersey Future (2010), "Smart Growth through the Transfer of Development Rights"

4.2.2. Land Use Based on TOD

In Portland, Oregon, approximately 58% of trips in mixed use neighborhoods with good transit were low occupancy car trips compared to 87% of trips in neighborhoods without mixed use and transit access.[18] Research in California has shown that people who live within a TOD neighborhood are five times more likely to use transit for everyday travel, and people who work within a TOD neighborhood are 3.5 times as likely to use transit.[19] TOD also concentrates development activity, and therefore helps consolidate the tax base in a way that allows for focused value capture strategies by the local government. Local government then has the option to reinvest that captured value in public services such as environmental education and awareness programs, affordable housing, or public parks. Table 4-2 provides two examples of TOD planning techniques designed to minimize demand for travel by motor vehicle and to maximize use of public transit infrastructure in San Borja.

Table 4-2: Transit Station Planning for Mixed Use Development

Overview
Mixed Use Development: Mixed-use development creates three-dimensional, pedestrian-oriented places that layer compatible land uses, public amenities, and utilities together at various scales and intensities. Mixed-use neighborhoods are places where people can live, work, play, and shop. Mixed-use development can be represented as vertical mixed-use buildings, horizontal mixed-use blocks, or mixed-use walkable neighborhoods. Mixed-use zoning is a tool for municipalities to create mixed-use neighborhoods by allowing new development to incorporate residential and commercial uses in one building. **Transit-oriented development (TOD):** The Center for Transit Oriented Development defines TOD as higher-density, mixed-use development within walking distance — or half mile — of transit stations. It is a type of community development that includes a mixture of housing, office, retail and/or other amenities integrated into a walkable neighborhood. TOD prioritizes non-motorized transport (i.e., bicycle and pedestrian infrastructure), safe pedestrian access, and use of public transit (e.g., the Metropolitano BRT, public buses) and mass transit (e.g., MetroLima). TOD incorporates mixed-use development while focusing development at transit nodes in order to facilitate transit use and increase access to transit.

18 Portland City Council (2008): North Pearl District Plan; Federal Transit Administration, Transit Cooperative Research Program Legal Research Digest #36: Transit Oriented Joint Development and Legal Issues Case Studies (2011).

19 Federal Transit Administration, Transit Cooperative Research Program #102: Transit-oriented Development in the United States: Experiences, Challenges, Prospects (2004).

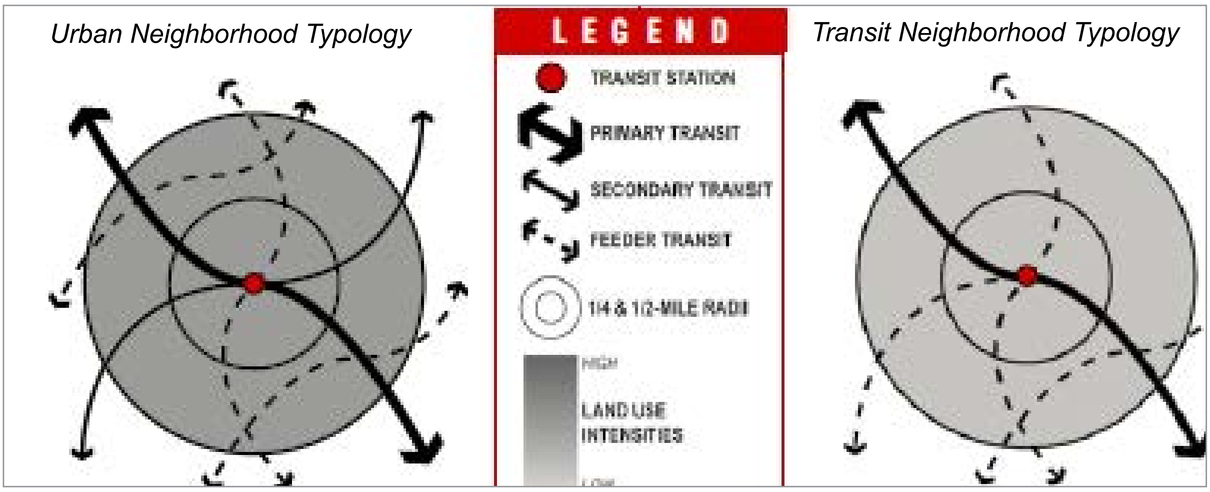
Examples of Application
Colombia Transit Oriented Development Nationally Appropriate Mitigation Action • An example of the application of planning for TOD implementation. • Proposal includes public private partnership funding. • Partners include: FINDETER (the national development bank) and the Colombia Ministries of Transportation, Environment, Housing, and Planning. • Focuses on urban development around transit stations and blending low-income and market-rate housing with commercial uses. • Estimates that implementation of the proposal will cut growth in driving by 25%. Source: http://ccap.org/colombia-transit-oriented-development-nama-gains-high-level-support/

4.2.2.1. Applying Mixed Use through TOD

San Borja appears from observation to be a hybrid technology with characteristics of both an "urban neighborhood" and a "transit neighborhood." An urban neighborhood typology refers to neighborhoods with moderate to high densities. Population densities are usually spread evenly throughout a half-mile radius with an increase near transit station. A transit neighborhood typology refers to neighborhoods that usually do not have enough density to support local retail.

Typology is what informs development strategies and helps the local government use market and physical characteristics to make sense of the types of investments needed to promote TOD at the neighborhood scale, and possibly avoid a more expensive, time-consuming and full-blown station area planning initiative. Transit neighborhoods are typically served by rail or multiple bus lines at once. Figure 4-5 below describes these distinctions schematically. San Borja has characteristics of both which is a strength.

Figure 4-5: Mixed Use Transit Station



Source: Reconnecting America, http://reconnectingamerica.org/assets/Uploads/tod202.pdf

This study recommends that San Borja consider policies and market-based solutions to entice private sector developers to invest and create mixed use development. In particular, mixed use development that is well-connected to neighboring municipalities such as San Isidro, which is the "financial capital" of Lima Province and the location of the Javier Prado Metropolitano station would be very attractive to developers. The arrows on the map shown in Figure 4-6 suggest the priority areas where San Borja could focus its efforts initially.

Figure 4-6: BRT and MetroLima Stations near San Borja

Source: Google Maps

San Borja should engage in a preliminary transit station area planning initiative, starting by defining its own implementation typology. The "urban neighborhood" typology appears to offer the greatest potential for San Borja to meet its GHG reduction targets. This typology would help satisfy existing mobility demand, manage future mobility demand, and foster modal switching by providing an attractive alternative to the private car. This study posits that San Borja should pursue the "urban neighborhood" typology in order to fully leverage the potential of the Metropolitano stations nearby, the MetroLima station located in the district, and its own non-mobile transit (NMT) infrastructure. This study recommends, however, that San Borja take a more in-depth look at its unique situation and expand its knowledge beyond this study by leveraging the existing analytical and planning tools and TOD best practice planning techniques of other cities.

This study also recommends that San Borja leverage the strength on opportunities of the "transit neighborhood" typology as well. San Borja should consider developing a transit station area planning manual for its own public sector and commercial sector, focused on maximizing the connections to the Metropolitano BRT and the MetroLima. The intent of the manual could be to leverage existing research and literature on TOD planning, and customize it for use in San Borja in order to simplify the complex policy and investment decisions that surround planning for TOD projects and station areas. For instance, the manual could include a discussion of the different TOD typologies, followed by a questionnaire to help San Borja residents, small businesses, and other commercial interests to identify needs and prioritize investment. Figure 4-7 provides an example of an analytical framework that policymakers and stakeholders can use to identify opportunities and constraints, identify and prioritize needs, and develop implementation plans.

Figure 4-7: Mixed-Use and Transit Oriented Development Technologies

A TOD Mixed Use/Employment Building Typology

		Net Density	Characteristics	Construction Type	Parking Configuration	
MIXED USE TYPES	Mid-Rise Residential Over Commercial	40-90 du/acre	3-6 stories with apartments, single- or double-loaded corridors with lobby entrance, off-street parking in structure or below grade	Type I/III (max 6 stories with building code modification/65 feet)	Groundfloor podium/ subgrade or elevated structure	
	High-Rise Residential Over Commercial	60+ du/acre	7+ stories, usually with base and point tower, single- or double-loaded corridors with lobby entrance, off-street parking in structure or below grade	Type I/II (max 12 stories/120 feet/no limits on Type 1)	Off-street parking in structure or below grade	
EMPLOYMENT TYPES	Low-Rise Office/Commercial	0.5-2.5 FAR	1-3 stories with lobby entrance to upper floors; retail, office or mixed-use with mix of tenant types, including limited large-footprint retail uses; parking in surface lots or structures	Type III/IV/V (max 4 stories/65 feet)	Off-street parking in groundfloor podium or surface	
	Mid-Rise Office/Commercial	2.0-5.0 FAR	3-7 stories, with lobby entrance to upper floors, office with potential groundfloor retail, parking in structure or below grade	Type I/II (max 12 stories/160 feet)	Off-street parking in structure or below grade	
	High-Rise Office/Commercial	4.0+ FAR	6+ stories with lobby entrance to upper floors sometimes with point tower over base, office with potential groundfloor retail, parking in structure or below grade	Type 1 (no limits)	Off-street parking in structure or below grade	
	Institutional/Other Employment	varies	schools, civic uses, stadiums, hospitals, other entertainment uses; range of densities and sizes; parking often in structures or below grade	Varies	Parking often in structures or below grade	

Source: Reconnecting America, http://reconnectingamerica.org/what-we-do/what-is-tod/

4.2.3. Low Carbon Towns through ICT

Every urban system comprises a supply side to provide the infrastructure for urban services (e.g., electric utility, water treatment plant, landfill sites, transportation infrastructure) and a demand side for the urban services provided by that infrastructure (e.g., lighting, drinking water, waste disposal, mobility). ICT can be employed in order to establish, maintain, and enhance urban function across multiple sectors and achieve desired quality of life outcomes. An integrated approach to city management, achieved in part through ICT, can provide the urban function upon which human wellbeing relies while simultaneously helping to reduce GHG emissions.

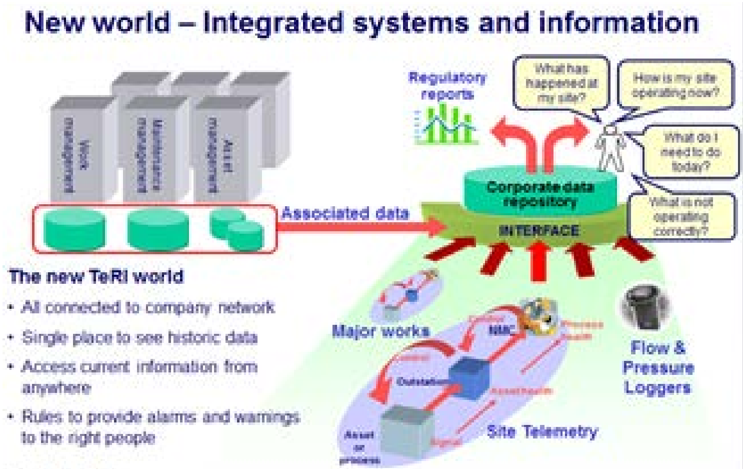
The following Table 4-3 LCM recommends using information and communications technology to more efficiently and effectively reduce GHG emissions.

Table 4-3: Information and Communication Technologies (ICT)

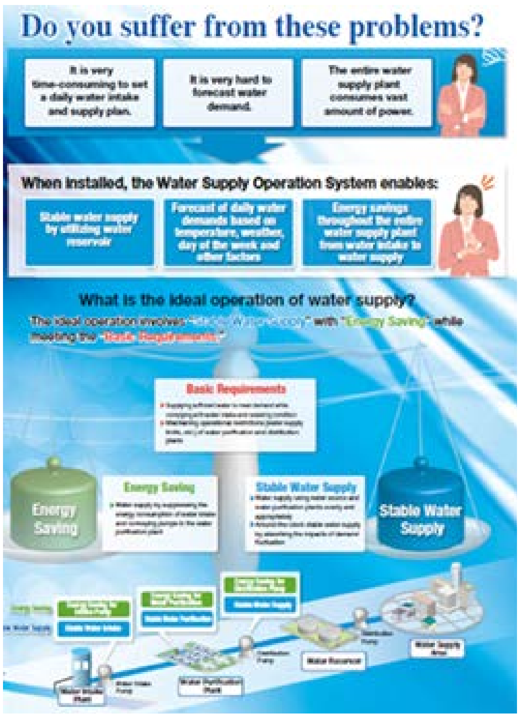
Overview
Cities can smooth demand and stabilize supply by using advanced information technology, which ultimately scales and optimizes an urban system's capacity to provide the level and quality of urban services people, business, governments, and communities want and need. The information and insight gained from data collection are essential tools for city managers and infrastructure operators to measure, monitor, benchmark, manage, and report performance across different interconnected systems. Data and technology management across multiple systems would provide San Borja with a more comprehensive picture of its overall GHG performance. Information and Communications Technologies can be applied to many different subject areas — especially energy, water, and transportation — to enable a city to monitor and then begin to reduce its GHG emissions. **Energy:** One way to understand overall GHG emissions is to collect the data that is used to calculate GHG emissions into a central data management system and then make this information available to the end customers that can use it to find ways to reduce their own energy use and GHG emissions. These data can also be used to compare their GHG performance with other entities within the city. This can be done by collecting data from the local energy utilities and applying the appropriate GHG calculations – and then making this data available (with appropriate security and privacy) to entities (businesses, citizens, city agencies) within the city. It is important that this data is available to all and about all actors in the city, not just city agencies, because most of the energy consumption and GHG emissions output is being driven by non-governmental activities. **Water:** In San Borja, the SEDEPAL water utility currently experiences about 20% water loss ("non-revenue water") due to factors such as leaks or theft. This is water that is being treated (which uses energy), being pumped (which uses energy) and then is lost or stolen. So, not only is it a waste of precious water, it is a waste of energy and therefore increases the GHG emissions of the city. In many cities, energy costs make up about 30% of the cost of operating the water utility – so not only is water loss affecting the city's GHG emissions it is also affecting the cost of the water. In Chapter 5, we will discuss our recommendations around Transportation, in the Intelligent Transportation Section (Table 5-3).

Examples of Application

- At Severn Trent Water Utility in the UK, Hitachi Consulting helped Severn Trent implement a Water Intelligence solution that enabled them to track water loss and energy consumption throughout the water network. This allowed them to more quickly identify small leaks before they became big leaks and to identify small problems with pumps before they became big problems. This enabled them to reduce water loss and energy and maintenance costs in the system.



- For multiple clients in Japan, Hitachi has implemented a Water Supply Operations System. This system enabled the water utility to better manage the sourcing of water from their various reservoirs and tanks in such a way as to use the least amount of energy and minimize cost.



4.2.3.1. Applying ICT

Data and technology management measures, including smart-grid energy systems and water quality data management systems, are recommended throughout the report as low carbon measures. To maximize the benefits of these measures and subsequently achieve the greatest efficiency in overall city function, these measures should be coordinated information technology systems can be used to inform planning for future development. Data and technology management across multiple systems would provide San Borja with a comprehensive picture of its performance.

San Borja can use data to support indicators outlined in international standards or performance, such as the International Standards Organization (ISO) 37120 – Sustainable development of communities. Moreover, advanced information technology systems can be used to inform planning for future development.

Figure 4-8: Possible Data and Management Applications

Source: Hitachi Ltd.

4.3. GHG Reduction Analysis and Cost Estimates

The projected GHG emission reductions from low carbon urban policy design and planning strategies are estimated and summarized in Table 4-4. The GHG emissions reductions are based on the Intergovernmental Panel on Climate Change (IPCC) emissions reductions estimates for policy and planning measures related to urban function. The GHG emissions reductions are based on a mix of possible outcomes; therefore, the IPCC data provides the best possible estimate for emissions reductions for the purposes of this Feasibility Study.

Table 4-4: Projections of GHG Reduction Percentages from Low Carbon Urban Function Policy Design and Planning Strategies

Urban Function LCMs	GHG Reduction Projections (% of Baseline)		
	Short term (2018)	Medium term (2021)	Long term (2035)
Transit oriented development (TOD) planning for mixed-use land use development	.05%	1%	4%
Transit oriented development (TOD) and transit station planning for mixed-use development	1%	1%	3%
Information and communication technologies (ICT) for city management performance	.05%	1%	3%
Total Emissions Reductions /Yr	4,156 MtCO2e	6,234 MtCO2e	20,780 MtCO2e

Source: Working Group III contribution to the IPCC 5th Assessment Report (AR5) "Climate Change 2014: Mitigation of Climate Change". Chapter 8: Transport of the IPCC's AR5 has reviewed scores of studies, and reviewed 1,200 scenarios involving dozens of LCMs related to urban function (e.g., mixed land use zoning, and information technology). in order to analyze and estimate relative GHG reduction potentials. These studies and scenarios have demonstrated CO2e emission reduction potential from LCM implementation ranging between .05% and 50%. Results depend on the comprehensiveness of the LCMs over time. The findings in AR5 constitute the percentages of reduction shown above, although this Feasibility Study is conservative in its estimates, i.e., choosing the low end of the scale in order to avoid overstating potential reductions.

Cost Estimate

The primary basis for the initial costs for implementing the urban function LCMs are the IPCC estimated costs for policy design and strategy initiatives, which range from $10-$20 per MtCO2e. This study chose the midpoint of the range to use $15 per MtCO2e for cost estimates. The Institute for Transport Engineers (ITE) and academic reports also helped to confirm this approximate range. The estimates for low carbon policy design and planning strategies are summarized in Table 4-5.

Table 4-5: Cost Estimates for Low Carbon Urban Function Policy Design and Planning Strategies

*Urban Function Planning	Carbon Emissions Reduction (MtCO2e/Year)			Life Cycle GHG Emissions Reductions (MtCO2e)[1]	% GHG Reductions Compared to Baseline 2012 (MtCO2e/Year)			Total Life Cycle Cost Savings[2]	Initial Investment Cost[3,4]	Marginal Cost[4]	Life Cycle Carbon Unit Cost[5]
	2018	2021	2035		2018	2021	2035	(USD)	(USD)	(USD)	(USD/ MtCO2e)
TOD Mixed-use Land use Strategies to Decrease CO2e-intensity of VKT	2,078	2,078	6,234	101,822	1.00%	1.00%	3.00%	$3,054,658	$1,527,329	$(1,527,329)	$(15)
Urban Forest and Shade Cover Preservation	1,039	2,078	8,312	126,758	0.50%	1.00%	4.00%	$3,802,738	$1,901,369	$(1,901,369)	$(15)
ICT for Urban Function Performance	1,039	2,078	6,234	97,666	0.50%	1.00%	3.00%	$2,929,978	$900,000	$(2,029,978)	$(21)
Total	**4,156**	**6,234**	**20,780**	**326,246**	**2.00%**	**3.00%**	**10.00%**	**$9,787,374**	**$4,328,698**	**$(5,458,676)**	**$(50.78)**
Average	**($16.93)**										

* The above urban function sector costs are for "soft" policy design and planning strategies, as opposed to "hard" infrastructure, hardware, construction, operation, and maintenance costs. Negative numbers indicate a USD savings per $MtCO_2$ reduced and sequestered. Assumptions: 1) life cycle from 2015 through 2035 is 20 years; life cycle from 2019 through 2021 is three years; 2035 is 20 years; 2) IPCC AR5 (2014) assumes the for every MtCO2e reduced there is a $30.00 cost of inaction; 3) IPCC AR5 (2014) estimates that the average cost for policy design and planning strategies ranges from $10-$20 per MtCO2e; and 4) definition of marginal cost is Initial Investment Cost minus Total Life Cycle Savings; 5) definition of life cycle carbon unit cost is marginal cost divided by life cycle GHG emissions reductions. Initial investment cost is based on the low end of the range from the US DOT for traffic light system ($900K), and Hitachi Consulting experiences with other solutions - Apps for Journey Planning, EV charge spot funding, car and bike sharing, On Demand Valet etc. (Free if you attract a company to come implement in San Borja), Smart Phone as Sensor App ($100K), Streetlight Sensor system ($250K). Initial investment cost based on Hitachi Consulting experience with similar Water ($600K) and Energy ($300K) ICT solutions.

5. TRANSPORTATION PLANNING

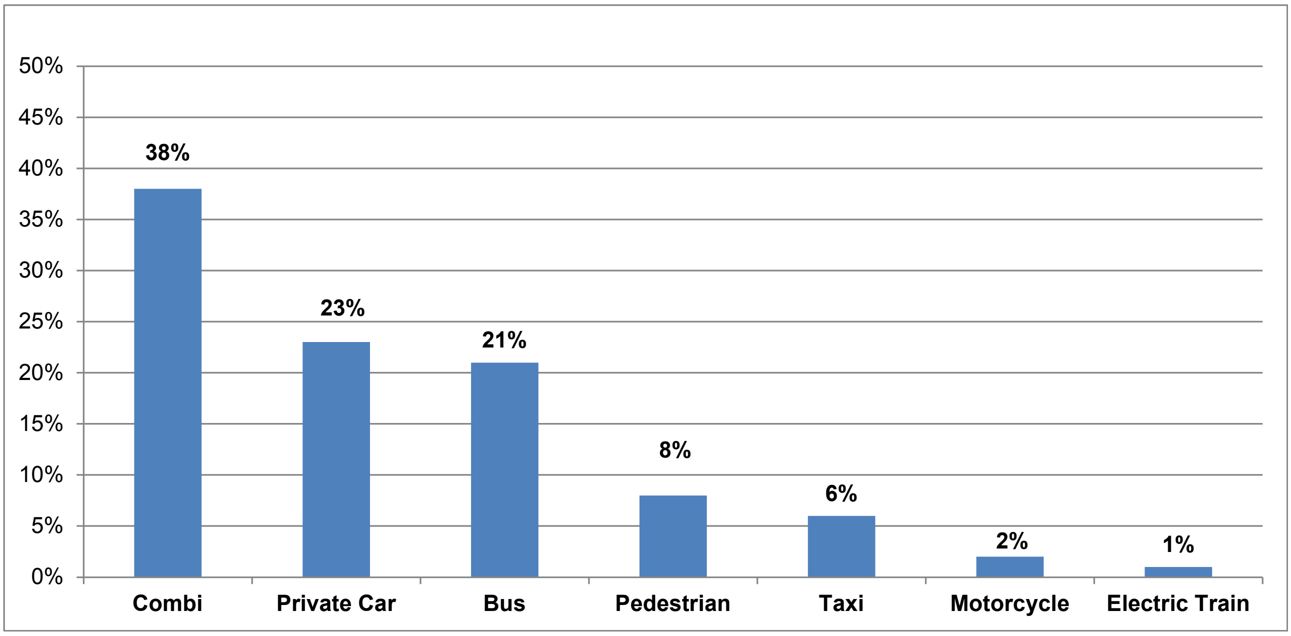
This chapter addresses the GHG emissions associated with transportation planning and the modes of transport ranging from pedestrians to private passengers cars. The chapter outlines the recommended LCMs that build on the ideas listed in San Borja's 2035 Sustainability Plan and the emissions reductions targets outlines in San Borja's LCP 2021 (See Appendix B). This chapter concludes with a summary of the project GHG emissions performance and costs of the recommended LCMs.

5.1. Background and Issues

5.1.1. Transportation Planning Defined

The definition of urban transportation planning in this study is about minimizing reliance on the private passenger car as the default mode of transport and maximizing reliance on NMT as important means to reducing GHG emissions and congestion. San Borja's goals for its transportation sector include: 1) managing mobility demand to reduce the number of vehicle-kilometers-traveled (VKT) by motor vehicles, particularly by private passenger car; and 2) increasing the passenger-kilometers-traveled (PKT) for all motor vehicles, including for public transport and non-motorized transport (NMT), specifically pedestrian access and bicycle transport. Figure 5-1 below describes San Borja's modal split as of 2012.

Figure 5-1: San Borja Modal Split Percentages (2012)



Source: 2035 Sustainable City Plan

Figure 5-2 below describes some of the causes and economic impacts of traffic congestion.

Figure 5-2: Traffic Congestion in San Borja

Source: San Borja 2035 Sustainability Plan

A typical cause of traffic congestion is either a surplus of demand for mobility, or a lack of supply in terms of NMT alternatives, public transit options, and lane capacity. Weather conditions, construction, and traffic accidents can reduce the carrying capacity of roadways. In Lima, the average amount of time that motor vehicles idle in traffic on Lima's streets is at least 30 minutes every day, which adds up to 2.5 hours each week. That means commuters, including San Borja residents who commute to and from work each day in Lima's other 42 districts, spend about 14.3 days annually sitting in traffic.

The amount of time sitting in traffic is more than just an annoyance for commuters; it is a loss of working hours, a waste of fuel, and source of significant air pollution. According to the Inter-American Development (IDB), each year Lima loses an estimated $500 million USD in person-hours and operating costs due to traffic congestion, blocked intersections and streets from illegal parking, traffic accidents, and traffic lights that are not synchronized.

The same IDB study estimated Lima commuters idling in traffic combust about 13.2 million liters of gasoline and emit approximately 1,000 MtCO2e emissions each year. Traffic and congestion management helps reduce congestion could help save fuel, reduce air pollution, and minimize GHG emissions.

5.1.2. Influence of National Transport Policies on San Borja

Over the last decade, Peru has undertaken a series of actions to reform the transportation sector across the area, including within Lima Province and its 43 municipalities. In 2009, transport policy in Lima changed toward creating a more multi-modal transport system when the Lima Municipal Council approved the Strategic Plan for Bicycle Transport 2008-2014. In 2010, Lima Province passed a national bicycle law, Bill 691-2830.[20] In response, San Borja launched it's San Borja en Bici (Bike San Borja) program in 2012. Figure 5-3 describes the program.

20 N. Tyler and C. Ramirez, "Developing Low-Carbon Policies in Peru with Capacity Building for Their Implementation." Embajada Britanica, Swiss Contact, ARUP (2012).

Figure 5-3: San Borja en Bici (Bike San Borja) Program

In March 2012, the Municipality of San Borja started its bicycle sharing program San Borja en Bici. The program is currently operated with staff bike stations and residents borrow the bikes at no cost. As of June 2014 the program had 6,466 registered users (6% of San Borja's population of 111,808) and 4,480 regular users. Between July 2013 and June 2014, the program loaned 127,332 bicycles and logged 802,275 vehicle-kilometers-traveled (VKT) by its users. For this period, San Borja estimates that user trips have avoided the combustion of 16,045 gallons of fuel and 128.3 MTCO2e emissions per year by displacing motor vehicle use within that same period with NMT trips. Given the success of the program so far, and its role in supporting San Borja's goal to reduce transportation related emission by 15% by 2021, the municipality is planning to expand the number of bikes available and the number of bike rental stations and automate bike rentals. Neighboring district San Isidro and other nearby municipalities are interested in participating in the program and San Borja is working with them to coordinate expansion of the program

Left: San Borja en Bici Bike Station, Source: Hitachi Consulting. Right: Mayor Marco Antonio Alvarez Vargas at the San Borja en Bici Launching Ceremony, Source: San Borja Carbon Town Forum Presentation, San Borja Municipality

User Survey Statistics

San Borja's survey of program participants showed the following:

- In the absence of the San Borja en Bici program, 34.83% of borrowers would have walked to their destinations, 38.2% would have driven a private passenger car, 22.47% would have taken public transport, and the rest would have taken either a taxicab or some other means of motorized transport.
- 25.33% of registered users borrowed a bicycle every day, 38.67% borrowed a bicycle 3-4 days per week, 22.67% borrowed a bicycle twice weekly, and the remainder borrowed a bicycle one time per week or less.
- The majority of users, 30.38%, borrowed a bicycle for recreational and exercise purposes, 22.78% used the bikes to get to work, and 17.72% used the bikes for shopping trips. The remainder of users (29.12%) did not specify the purpose of their use.

Sources: San Borja 2035 Sustainable City Plan

Lima has invested in public transport services and mass transit. Lima's new Bus Rapid Transit (BRT) system, called the Metropolitano, began operation in 2010. It connects the northern and southern areas of Lima with 38 stations spanning 33 kms. The Javier Prado station is the Metropolitano station nearest to San Borja. Figure 5-4 depicts the Metropolitano's state-of-the-art passenger loading platform.

The MetroLima system, a surface light rail line also known as the Tren Electrico, runs east to west along 9.2 kms of track with two operational stations through San Borja along Avenue Javier Prado Avenue. The MetroLima is an important point of access to public transit for San Borja commuters and shoppers.

Construction is underway to build another 12.28 kms and add 9 additional stations in 2015.[21]

Express bus service is another service Lima is evaluating. Lima also launched a pilot project in July 2014 called Corredor Azul. Corredor Azul is a semi-express public bus service whose goal is to routinize public transport services along Lima's most congested corridors by establishing official bus stops.[22] The system operates across multiple municipalities, including San Isidro, which borders San Borja to the west (Figure 5-5).

Figure 5-4: BRT Passenger Loading Platform

Source: Hitachi Consulting

Figure 5-5: Corridor Azul Map

Source: El Comercio; http://elcomercio.pe/visor/1766268/987257-corredor-azul-y-metropolitano-se-conectaran-estacion-balta-noticia

5.1.3. Challenges and Responses

In 2012, residents in San Borja averaged approximately 168,849 trips per day, traveling on average 337,697 miles per day. Table 5-1 provides more details on modal splits.

21 Data collection during site visit, July 2014.

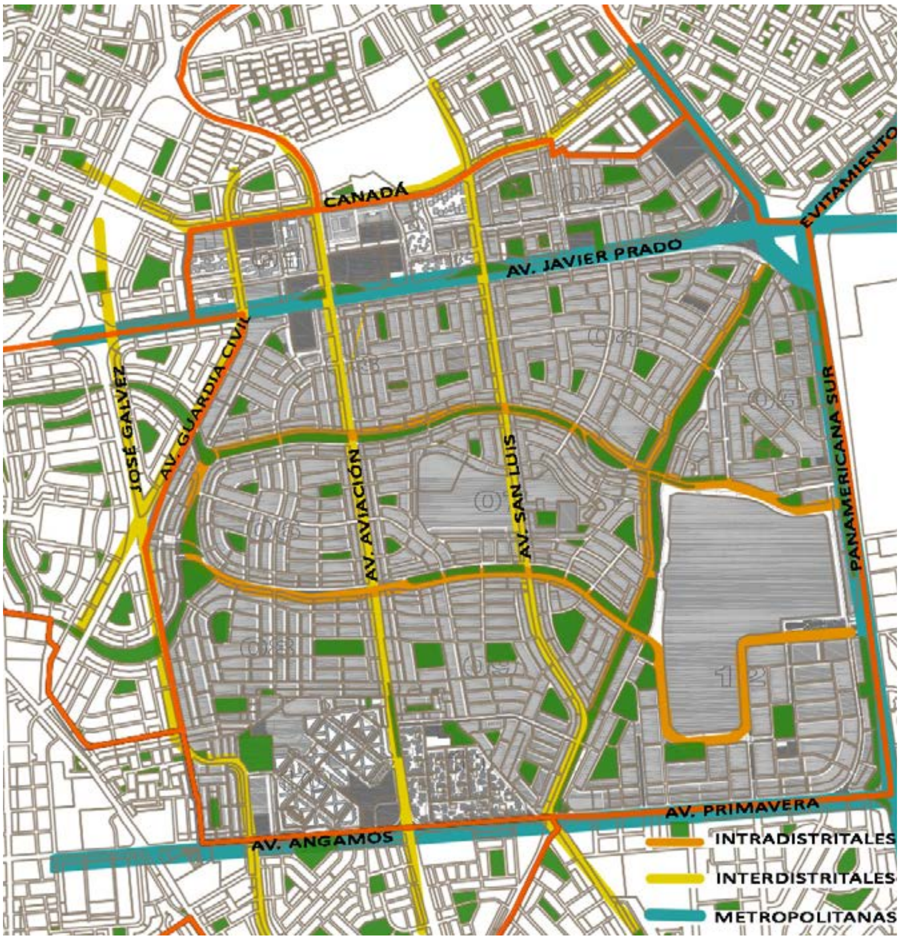
22 http://www.limaeasy.com/getting-around-lima/public-transport-in-lima

Table 5-1: San Borja Resident Daily Mobility Needs and Journeys by Mode

San Borja Population (2012)			112,562	
Residents with Daily Mobility Needs (2012)			87,942	
% of Population Making Mobility Choices			78%	
Travel Mode	**Modal Split (%)**	**Modal Split by No.**	**Estimated Miles Traveled / Day / Person**	**Total Miles Traveled / Day**
Combi	37%	32,099	3	128,395.32
City Bus	20%	17,676	3	70,705.37
Pedestrian	8%	7,035	1	14,070.72
Private Car	23%	19,875	3	79,499.57
Bus Rapid Transit	1%	1,231	3	4,924.75
Collectivo	1%	791	3	3,165.91
Mototaxi	1%	879	3	3,517.68
Taxi	5%	4,485	3	17,940.17
Motorcycle	2%	1,759	3	7,035.36
Metro Line 1	1%	1,231	3	4,924.75
Bicycle	1%	879	3	3,517.68

Source: Data collected during July 2014 Site Visit

Figure 5-6: San Borja's Major Roadways



Source: San Borja Municipality Staff, September 2014

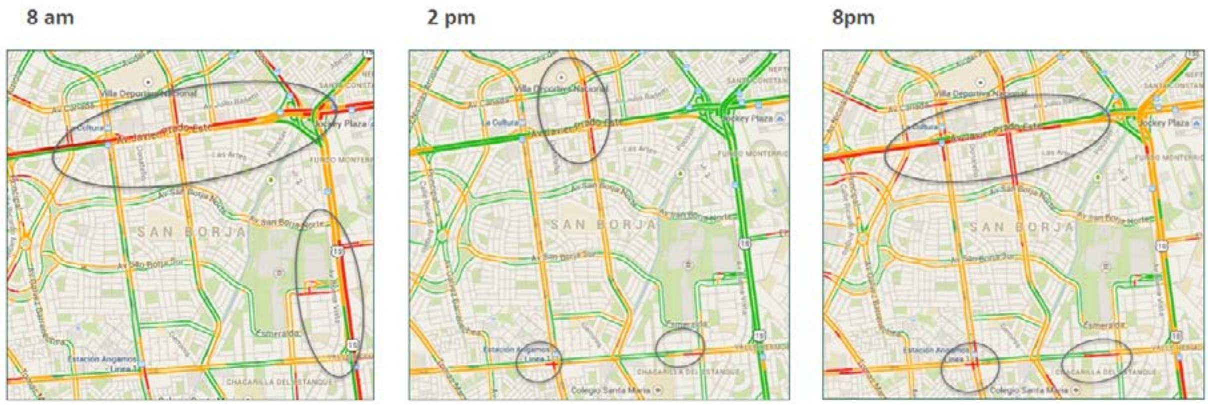
Figure 5-6 below is a map of San Borja, its geographic boundaries and its major roadways and thoroughfare highways. The area in gray is the interior of the District. The Panamericana Sur highway to the east, Avenue Angamos, and Avenue Primavera are the major highways surrounding San Borja. Avenue San Luis and Avenue Aviación are high mobility demand corridors serving all of Lima Province that operate within San Borja allowing for north/ south mobility.

Figure 5-7 reflects the peak hours of mobility demand in San Borja, including which roadways are subject to the heaviest demands. For instance, during the afternoon there is a high percentage of motor vehicle trips to the La Rambla and

Plaza Real commercial centers in the south. Most of the jobs in the district and the commercial activities are concentrated along the main streets within the district (Aviacion Avenue and Avenue San Luis) and they tend to be national government, local government, research institutes, and educational jobs.

In addition, many commuters pass through San Borja on Avenue Javier Prado on their way to work in San Isidro, Lima's financial center. The private and public sectors in San Borja do not currently rely on the use of staggered work hours and flex-time as options, although they have proven effective in other cities.

Figure 5-7: Peak Hours of Mobility Demand in San Borja



Source: 2035 Sustainable City Plan

Given the busy highways surrounding San Borja, the corridors of high mobility demand within the district, and its comparative high rate of private passenger car ownership, San Borja faces several challenges:

- Encouraging use of mass transit along corridors with high demand for mobility;
- Rationalizing and routinizing the provision of mobility services by the private sector;
- Maximizing the operational efficiency roadways and highways, and
- Providing residents access to existing bus and light rail options.

Another challenge expressed by San Borja municipal staff is how to connect the majority of the District to the cultural areas[23], in the northern section of the municipality. Currently, Avenue Javier Prado separates the cultural institutions (shown in dark grey) from the train and bus stops and residential neighborhoods. In addition a new convention center is planned for this area, which will likely generate additional vehicle, transit, and pedestrian trips. A dedicated pedestrian connection across Avenue Javier Prado that prioritizes both pedestrian and bicycle access would provide safe and viable access to one of the most popular destinations in San Borja.

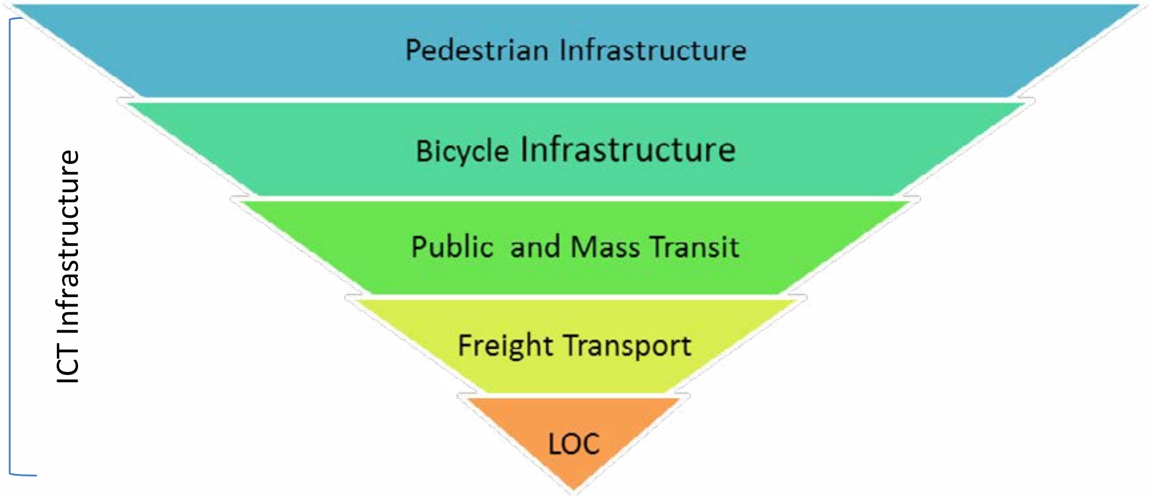
San Borja is already working to address these challenges through the transportation sector strategic actions identified in the LCP 2021 (see Appendix B). Their actions align with the hierarchy of mobility options (Figure 5-8) which includes the following four elements:

- Mass transit along corridors with high demand for mobility and access to urban services;
- Rationalizing and routinizing the provision of mobility services by the private sector;
- Maximizing the operational efficiency of vehicles, roadways, highways, mass transit; and
- NMT infrastructure to help meet demand for mobility and access.

23 Information collected during site visit, July 2014.

A version of this hierarchy was identified by UN sponsored research on appropriate mitigation actions for Lima's transport sector.

Figure 5-8: Hierarchy of Mobility



Source: Adapted from N. Tyler and C. Ramirez

5.2. Proposed Low Carbon Measures

The sections below describe policy-based and market-based LCMs intended to enhance reductions in transportation related GHG emissions.

5.2.1. Modal Switching and Mixed Mobility

In this study, modal switching refers to getting San Borja residents to use their private passenger cars less, and use more public transport or NMT options instead. Mixed mobility involves using two or more modes of transportation in a journey. An objective is to combine the strengths of different transport modes while offsetting the weaknesses. Location plays a large role in mixed mode mobility. Figure 5-9 depicts this concept. In the picture, a bus operating in the Westwood neighborhood in Los Angeles has a bike rack installed on its forward grille, allowing for a traveler to move from one mode to another to complete their journey.

Figure 5-9: Mixed Mobility in Los Angeles

Source: Los Angeles Metropolitan Transit Authority

Public transportation systems such as BRT and light rail tend to have the most efficient means and highest capacity to transport people around cities.[24] Therefore, mixed-mode mobility in the urban environment is largely dedicated to first getting people onto the train network and once off the train network to their final destination.[25] For example, many large cities link their railway network to their bus network. However, when the commuter considers the distance too far between the originating endpoint (e.g., home) and the destination (e.g., place of employment) to be practical, the single occupant, private passenger car, motorcycle, and taxi often remains the default mode. Table 5-1 provides an initial list of LCMs to support modal switching and mixed mobility.

Table 5-1: Modal Switching and Mixed Mobility

Overview	
Modal switching combined with mixed mobility can displace VKT with PKT and can support greater use of NMT infrastructure. An intended environmental outcome is to reduce dependence on private vehicles as the primary mode and increase the use of public transport (e.g., buses), mass transit (e.g., light rail and heavy rail systems), and NMT. The combination of modal switching and mixed mobility helps reduce GHG emissions, traffic congestion and air pollution, and promotes social inclusion because people have more options for access to people, places and services. Examples of modal switching and mixed mobility LCM policy design and planning strategies, and the key travel choices they influence (Route (R), Mode (M), Location (L), Time (T) or origin/destination (OD)), include:	
Modal Switching and Mixed Mobility Techniques	**Traveler Choices Affected**
Transit Management – Transit service available on-site, personal security, route and scheduling information, and coordination with traveler information services.	R, M, T, OD
Road Pricing and Electronic Payment – Payment services and systems associated with toll facility operations, variable road pricing, VKT fees, parking facilities, and transit services.	R,M,L,T, OD
Traveler Information – Pre-trip, Near pre-trip, and en_Route information provided to the traveler via roadside, in-vehicle or personal communication devices on the current travel conditions, trip planning services, tourism, special events, and parking information.	R,M,L,T, OD
Road Weather Management – Planning for and responding to weather events affecting traffic operations and roadway conditions, information distribution to travelers and response personnel, and operations or facility under inclement conditions.	R,M,L,T, OD
Arterial Management – the management of traffic signals, dynamic and fixed lane management along streets including speed management, pedestrian and bicycle interaction with vehicles, vehicle priority coordination, and coordination with other techniques such as traveler information, electronic payment, or incident management	R,M,L
Intermodal Freight – Integrated operations of freight transported by multiple modes both internationally and domestically.	R,M,L,T, OD
Quality Pedestrian Movement – Availability of pedestrian facilities that are integrated within the overall transportation network and accommodate or even promote non-motorized travel.	R,M,T, OD
Amenities On-site – Bicycle locks, showers, automated teller machines, carpool or vanpool parking, local shuttle service, infrastructure for teleworking	M,T, OD
Ridesharing Program – Carpools, vanpool programs, preferred parking, transit or parking subsidies	R,M,L,T, OD
Source: Colin Black and Eric Schreffer, "Understanding TDM and its Role in Delivery of Sustainable Urban Transport" Transportation Research Record 2163; from the Institute of Transport Engineers Handbook on traffic management.	

24 World Resources Institute. http://www.wri.org/blog/2013/12/4-ways-cities-benefit-bus-rapid-transit-brt
25 Institute for Transportation and Development Policy (ITDP) https://www.itdp.org/library/standards-and-guides/the-bus-rapid-transit-standard/

Examples of Application
Curitiba, Brazil Integrated Transit Network or Rede Integrada de Transporte (RIT): The Curitiba RIT refers to the complete network of buses working together to move Curitiba residents. It addition to the core BRT express buses, there are several other types of buses that support and enhance the system. Feeder buses run locally, collecting riders from a neighborhood and bringing them to a BRT terminal where they can transfer to express buses. In addition, inter-district buses connect outer neighborhoods directly, rather than traveling through the city center. A key innovation of Curitiba's system is allowing free transfers between these systems at terminals, making a seamless network for transit users. Several other types of buses also run in Curitiba, such as downtown shuttles and direct buses between key points, providing extra support. The Green Line, which opened in 2009 uses 100% bio-diesel articulated buses. Including all integrated buses, the RIT connects 14 municipalities with downtown Curitiba. Source: https://go.itdp.org/display/ADBdemo/Curitiba+BRT PreMetro E2 (Buenos Aires): A 7.4 kilometers (4.6 mi) tram line that connects with the Buenos Aires Underground line E, at the Plaza de los Virreyes station and runs to General Savio, with a short branch to Centro Cívico. It opened in 1987 and is operated by Metrovías. Source: http://www.lrta.org/mag/articles/art0104.html

5.2.1.1. Applying Strategies for Modal Switching and Mixed Mobility

This study recommends that San Borja consider developing a multimodal and mixed mobility transport plan, and within that plan, it consider a range of techniques. Figure 5-9 below shows the major thoroughfares (e.g., Avenue Javier Prado, Panamericana Sur, and Avenue Primavera) and primary roads within San Borja that could be prime locations for targeted experimentation to increase modal switching and mixed mobility options. These roads were selected because they are where people and business suffer the greatest amount of daily and peak-hours of mobility demand. A focus along Avenue Javier Prado in particular could help address regional traffic that cuts through San Borja, provided other districts begin to link to this system. Greater use of public buses and minivans operating along Avenues Aviación and San Luis would help meet mobility demand that originates with San Borja, and facilitate north-south travel.

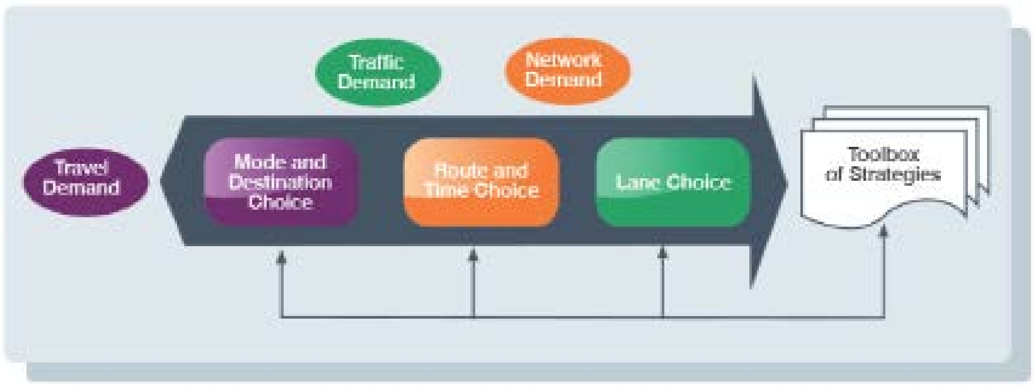
Figure 5-9: Key Roadways in San Borja for Daily Mobility

Source: 2035 Sustainable City Plan; Hitachi Consulting

5.2.2. Travel Demand Management

For purposes of this study travel demand management (TDM) is synonymous and used interchangeably with the terms “Transportation Demand Management” or simply “demand management,” and is defined as a set of strategies aimed at maximizing traveler choices. Transportation planners increasingly see TDM as a vital part of an approach to plan, design, and operate “smarter” and “more efficient” transportation systems in a region. As illustrated by Figure 5-10 below, TDM is less about certain management strategies and more of an operational philosophy that seeks a holistic approach to urban transportation, one that better balances supply and demand solutions, one that seeks to make better use of existing capacity, and one that seeks to do so in a more sustainable manner.

Figure 5-10: TDM: A Philosophy of Choices



Source: FHWA, Integrating Demand Management into the Transportation Planning Process: A Desk Reference (2012).

A rationale for recommending this LCM is San Borja’s own priorities and timing. San Borja is experiencing new construction now, and along with it, making fundamental urban growth choices related to housing development, NMT, and mixed use land use, all of which relate directly to developer credits. Table 5-2 provides an initial list of LCMs to support TDM.

Table 5-2: Overview of Travel Demand Management LCM and Applicability

Overview	
This LCM includes the integration of TDM as an element of transportation planning, focusing first on market-based solutions. These may include: • Expanding the supply and availability of alternatives to private passenger cars; • Integrating demand-side management strategies into operational efficiency initiatives; • Better controlling demand for the use of unsustainable modes; • Providing incentives and rewards for undertaking sustainable travel habits; and • Imposing pricing on the use of private passenger cars. TDM strategies and the key travel choices they influence (Route (R), Mode (M), Location (L), Time (T) or origin/ destination (OD)), include:	
TDM Technique	**Traveler Choices Affected**
Arterial Management – the management of traffic signals, dynamic and fixed lane management along streets including speed management, pedestrian and bicycle interaction with vehicles, vehicle priority coordination, and coordination with other techniques such as traveler information, electronic payment, or incident management	R,M,L
Highway Management – the management of lanes along highway and associated ramps interfacing with arterials including speed management, and coordination with other technical such as traveler information, electronic payment, or incident management.	R,M,L

Transit Management – Transit service available on-site, personal security, route and scheduling information, and coordination with traveler information services.	R, M, T, OD
Incident management – The detection, response, and recovery from events that non-recurring , providing information to response personnel and the public, minimizing the impacts on traffic flow, and optimizing the safety of the public and responders.	R, M, T, OD
Emergency Management – Hazardous material routing and securing management, routing, and coordination of emergency response service providers, and information and dissemination and coordination.	R, M
Road Pricing and Electronic Payment – Payment services and systems associated with toll facility operations, variable road pricing, VKT fees, parking facilities, and transit services.	R,M,L,T, OD
Traveler Information – Pre-trip, Near pre-trip, and en_Route information provided to the traveler via roadside, in-vehicle or personal communication devices on the current travel conditions, trip planning services, tourism, special events, and parking information.	R,M,L,T, OD
Roadway Operations and Maintenance – The management of work zones and route closures through the use of traveler information, lane and speed management systems, and enforcement and response service providers	R,L,T, OD
Road Weather Management – Planning for and responding to weather events affecting traffic operations and roadway conditions, information distribution to travelers and response personnel, and operations or facility under inclement conditions.	R,M,L,T, OD
Commercial Vehicle Operations – Clearance and screening of commercial carriers to optimize flow of goods and services while optimizing safety and efficiency with roadside and in-vehicle technology.	R,L,T
Intermodal Freight – Integrated operations of freight transported by multiple modes both internationally and domestically.	R,M,L,T, OD
Parking Management – Parking information, variable pricing, routing to available parking.	M,T, OD
Quality Pedestrian Movement – Availability of pedestrian facilities that are integrated within the overall transportation network and accommodate or even promote non-motorized travel.	R,M,T, OD
Amenities On-site – Bicycle locks, showers, automated teller machines, carpool or vanpool parking, local shuttle service, infrastructure for teleworking	M,T, OD
Ridesharing Program – Carpools, vanpool programs, preferred parking, transit or parking subsidies	R,M,L,T, OD
Alternative Work Schedules – Four 10-hour days per week, staggered hours, flexible hours	R,M,L,T, OD
Telecommuting Options – Work environment that support employer-employee relationship from remote site with consideration of accessibility, accountability and productivity	R,M,T, OD
Travel Plans – Worksite, school, or event plans that incorporate travel demand and traffic management strategies to reduce the negative impacts of car use to the site.	M,T,L, OD
On-Site Travel Coordinator – Staff and services focused on travel services and demand management strategies.	R,M,T, OD

Source: Colin Black and Eric Schreffer, "Understanding TDM and its Role in Delivery of Sustainable Urban Transport" Transportation Research Record 2163; from the Institute of Transport Engineers Handbook on traffic management,

Examples of Application

Denver, CO, USA RideArrangers Program

- A ride share program aimed at helping residents identify and establish carpooling opportunities with other residents based on location and daily commute.
- Improves traffic in area by decreasing car volume.
- Individual benefits – decreased commuting costs and emissions.

Source: Cherriots.org

5.2.2.1. Applying TDM in San Borja

The fact that San Borja has a strong and growing NMT culture, and because the district is entering a period of rapid growth and increased construction, the study recommends, as a starting point, a focus on market-based solutions to promote further use of NMT, public transport, and mass transit. A goal is no net increase in traffic within the municipality compared to its 2012 baseline. This study recommends that San Borja develop a desk reference as an analytical and decision support involving two fundamental aspects of planning: 1) policy objectives and 2) scope of the planning effort, including a focus on mixed use land use strategies.

A major output of the desktop reference would be summary of best practices for TDM related to key sustainability policy objectives, including GHG emissions, air quality, congestion management, and accessibility to mobility services. The other major output could be a discussion and best practice review on how TDM might be integrated into multiple levels of planning, including at the national level, Lima Province, among other districts, and at the corridor level. In addition, the desk reference could include information on evaluation tools to estimate and compare effectiveness in the context of San Borja, and prioritize budget allocation and financing for implementation. This tool would help San Borja to move along the capability continuum (from ad-hoc to defined and from defined to optimized) in the policymaking, planning and strategizing process. It would also help to identify the necessary policy actions and design strategies that will result in measurable GHG reductions.

5.2.3. Intelligent Transportation Systems

Intelligent Transportation Systems (ITS) enable people to make informed mobility choices that best suit their needs at the time of their need. ITS can also be used as a congestion management tool by implementing operational strategies such as incident management, commuter information systems, work zone management, ramp metering, parking strategies, and adaptive signal control. These operational measures and strategies can efficiently add supply or compensate for reduced supply. The result of greater efficiency in the system is reduced congestion and vehicle idling, which in turn reduces GHG emissions. ITS applications can also be extended to smartphones to enable communication of important information to and from travelers. Table 5-3 provides an initial list of LCMs to support traffic congestion management.

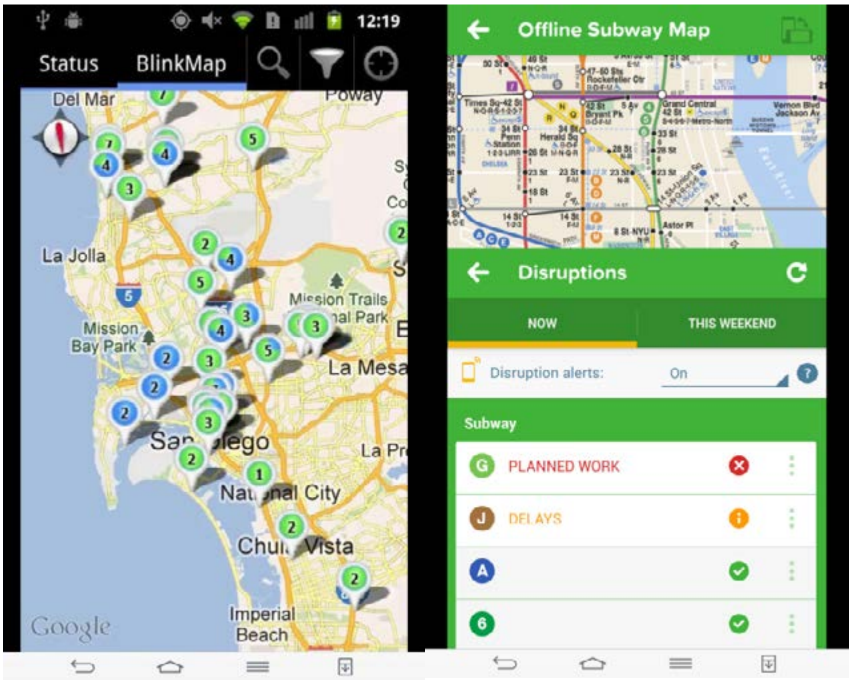
Table 5-3: Overview of Intelligent Transportation Systems

Overview
ITS vary based on the type of technologies applied. Basic management systems are more simplified and include car navigation, traffic signal control systems, container management systems, variable message signs, automatic number plate recognition or speed cameras, and monitor applications, such as security systems. More advanced applications integrate live data and feedback from a number of other sources, such as parking guidance and information systems, such as weather information.

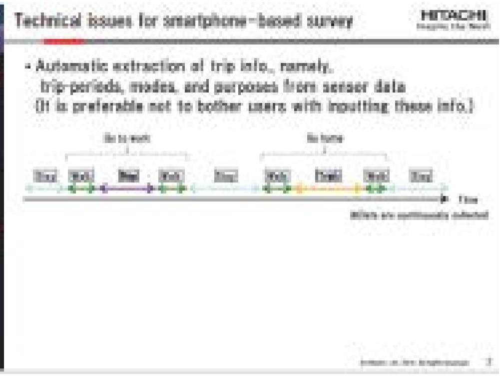
Technologies associated with this LCM include:

- Multi-modal, multi-agency journey planning via easy-to-use user platforms - such as smartphones, tablets and websites. These applications can:
  - Provide real-time transit display for buses, rail systems, and subways via smartphone applications. This makes the public transport options easier to use and takes some of the uncertainty out of use them – thereby enabling and encouraging more people to use the public transport.
  - Enable people to see where bike shares are available and reserve them. This will make it easier for people to include bike shares in their journey plans – thereby increasing adoption of the use of bikes and reducing traffic congestion and GHG emissions.
  - Incorporate data from transit sensors that can provide arterial and highway speed estimates – to digital signage and smartphone applications – once again enabling better decisions about what modes of transport to take and when and where.
  - Enable people to check availability of parking spots and EV charging spots before departure to a destination, and enabling reservations for these things. This will greatly reduce the time spent searching for parking spots and the associated traffic slowdowns and GHG emissions this causes. It will also allow citizens to more readily access EV charging spots – thereby helping to increase adoption of EVs
- Leveraging Smartphones as sensors to understand movement patterns of people within the city – whether in vehicles or on foot or on bikes or buses or trains etc.
  - This information can be used by individual citizens to help them understand their own patterns of movement and the application could recommend lower carbon options of transport
  - This information can also be used by city planners to plan roads, transport options (such as stops and schedules) or to anticipate volumes and locations of bikes for bike shares
  - This information would be collected in a non-identifying way so as to not invade people's privacy
- Implementing traffic lights on bike paths to give bikes a greater priority vs. autos and enabling bike "green waves".
  - "Green waves" are bicycle traffic lights that are timed with bike speeds and give the priority to bikes over cars – allowing bikes to move into the center of the city at a rapid pace. This encourages use of bikes for commuting – thereby reducing GHG footprint
- Implementing streetlight sensors – so that streetlights only turn on when there are people (walking, biking , driving) that need the light
  - This application can save energy and money and reduce GHG emissions.
- Other smartphone solutions to relieve traffic and parking congestion – such as car sharing, on demand valet parking, etc.
  - Car Sharing apps – such as Zipcar, Uber, Sidecar, Lyft, TaxiMagic – all take different approaches to "car sharing" but they all enable fewer people to a private vehicle – thereby reducing traffic congestion and GHG emissions
  - On Demand Valet Parking can enable people to nearly eliminate the time spent looking for parking spots – thereby reducing congestion and GHG emissions
- Automated tolls providing congestion pricing on crowded roadways

Blink Application for real time display of traffic data

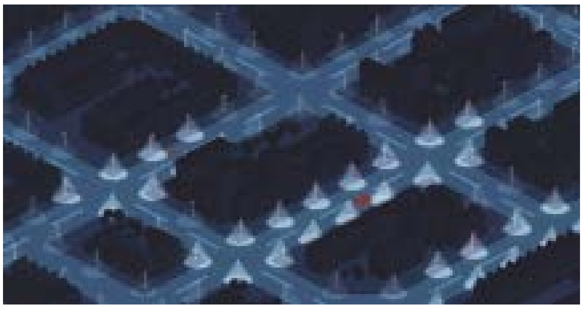


Smartphone data collection application, developed and implemented by Hitachi in Fukuoka Japan

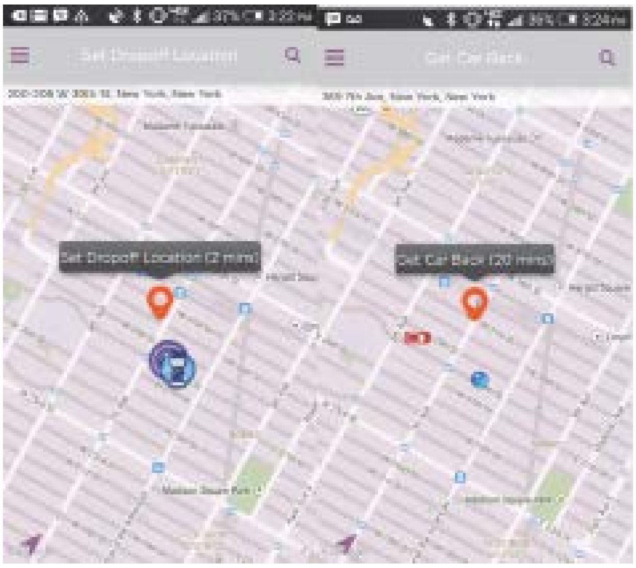


Bicycle Green Wave in Copenhagen, Denmark

TVILIGHT Intelligent Streetlight Solutions



ValetAnywhere: example of an on demand valet parking app



Source: ValetAnywhere

Congestion Pricing North Bridge Road, Singapore

- These solutions encourage driving at less congested times or use of alternative, lower carbon methods of transport.

5.2.3.1. Applying ITS in San Borja

There are an increasing array of low cost, digital solutions available to communities that enable dramatic improvements in transportation efficiency, environmental impacts and citizen experience. This study recommends that San Borja undertake a review of the ITS solutions currently available to address many of the transportation challenges that San Borja currently faces. As part of that review, we suggest the development of a decision support tool that helps municipal staff, government agencies, and private sector investors prioritize investment using a multi-criteria analysis that captures and makes transparent a full range of costs and benefits, in addition to return on investment.

5.3. GHG Reduction Analysis and Cost Estimates

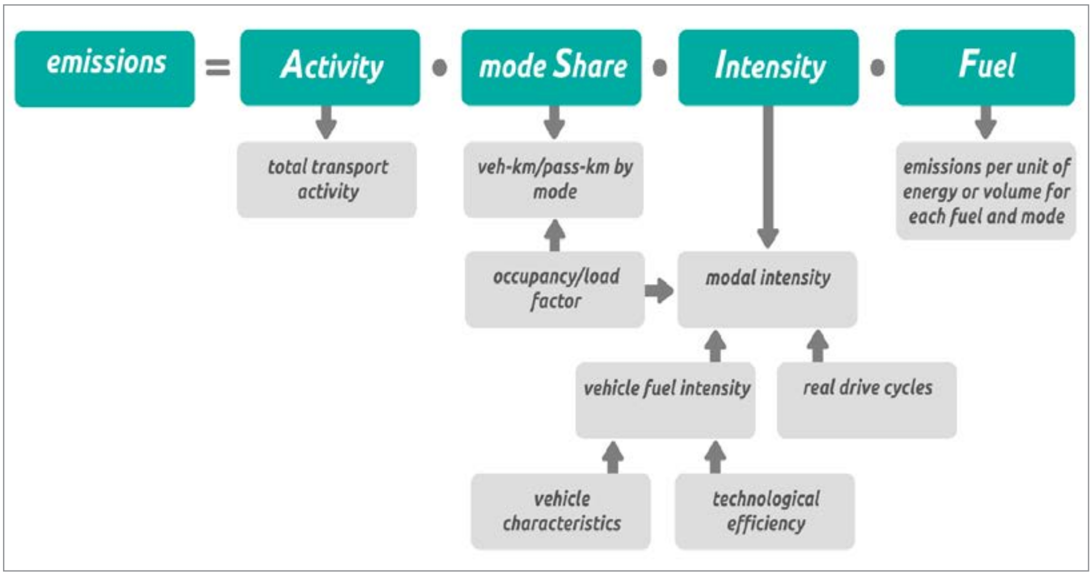
Reduction Analysis

This study used the calculation methodology described in Figure 5-12 adjusted according to the LCM by mode and technology to confirm San Borja's existing transport sector baseline and inventory and to estimate potential reductions from the proposed LCMs. The following section describes each of the four methodologies: fuel sales method, induced activity method, resident activity method, and commuter activity method. This study deployed all four methods to confirm San Borja's transport sector baseline, inventory of GHG sources, and accounting classification using activity data (with the exception of estimated miles traveled per day), for example the data shown in Figure 5-11.

Fuel Sales Method

This method calculates on-road transport emissions based on the total fuel sold within the city boundary. In theory, this approach treats sold fuel as a proxy for transport activity. Fuel dispensing facilities and/or distributors, or fuel sales tax receipts can provide the activity data on the volume of fuel sold within the city boundary. Sometimes the source of data is a survey. If a strictly in-boundary fuel sales figure is unavailable, data may still be available at the regional scale (through distributors). Calculating fuel sales emissions requires multiplying activity data (quantity of fuel sold) by the GHG-intensity of the fuel consumed. The fuel sales method accounted for some of San Borja's data sources. Per GPC guidance, in the absence of further information, all fuel sales from in-boundary fuel dispensaries account for Scope 1, even though fuel purchases may be for trans-boundary trips.

Figure 5-11: GHG Estimation Methodology for Transport



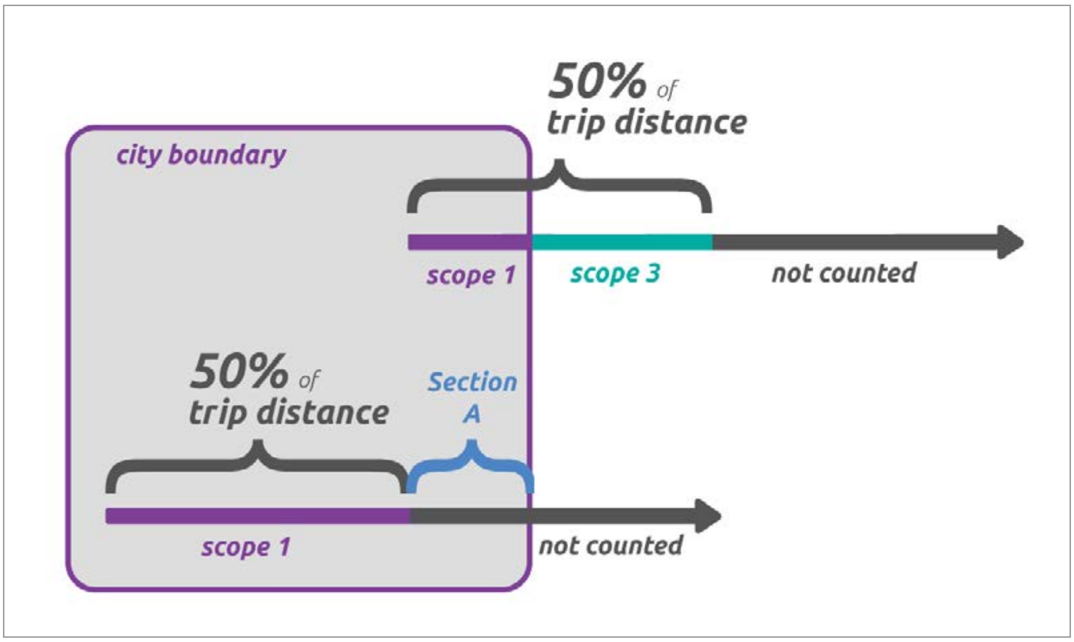
Source: GPC Version 2.0

Induced Activity Method

This bottom-up method seeks to quantify the emissions from transportation induced from within San Borja, including trips that begin, end, or are fully contained within San Borja (usually excluding pass-through trips such as on the Panamericana Sur highway). The method relies on models or surveys to assess the number and length of all on-road trips occurring – both trans-boundary and in-boundary only. This yields a VKT figure for each identified vehicle class. It also requires information on vehicle fuel intensity (or efficiency) and fuel emission factors. Another important indicator is PKT to convey how many passengers a vehicle contained. This indicator is useful in terms of measuring and monitoring the effectiveness of ridesharing programs and congestion pricing schemes using High Occupancy Vehicle (HOV) lanes.

To reflect the responsibility shared by other districts for inducing trans-boundary trips, such as commuters traveling through San Borja to reach San Isidro, the financial capital of Lima Province, the feasibility study used an origin-destination allocation that reports 50% of trans-boundary trips. Of that 50%, the portion that occurs within San Borja's boundary is considered Scope 1, while the remaining percent that occurs outside the boundary is a Scope 3. If 50% of the trip is entirely within the city boundary (e.g., a trip that just passes the city boundary), then the entire 50% should be in Scope 1. All of all in-boundary trips that begin and end within San Borja are included, but pass through trips are excluded from Scope 1 even though they represent "in-boundary" traffic (since they are not "induced" by the city). Figure 5-12 depicts this estimation approach.

Figure 5-12: Induced Activity Method



Source: GPC, version 2.0

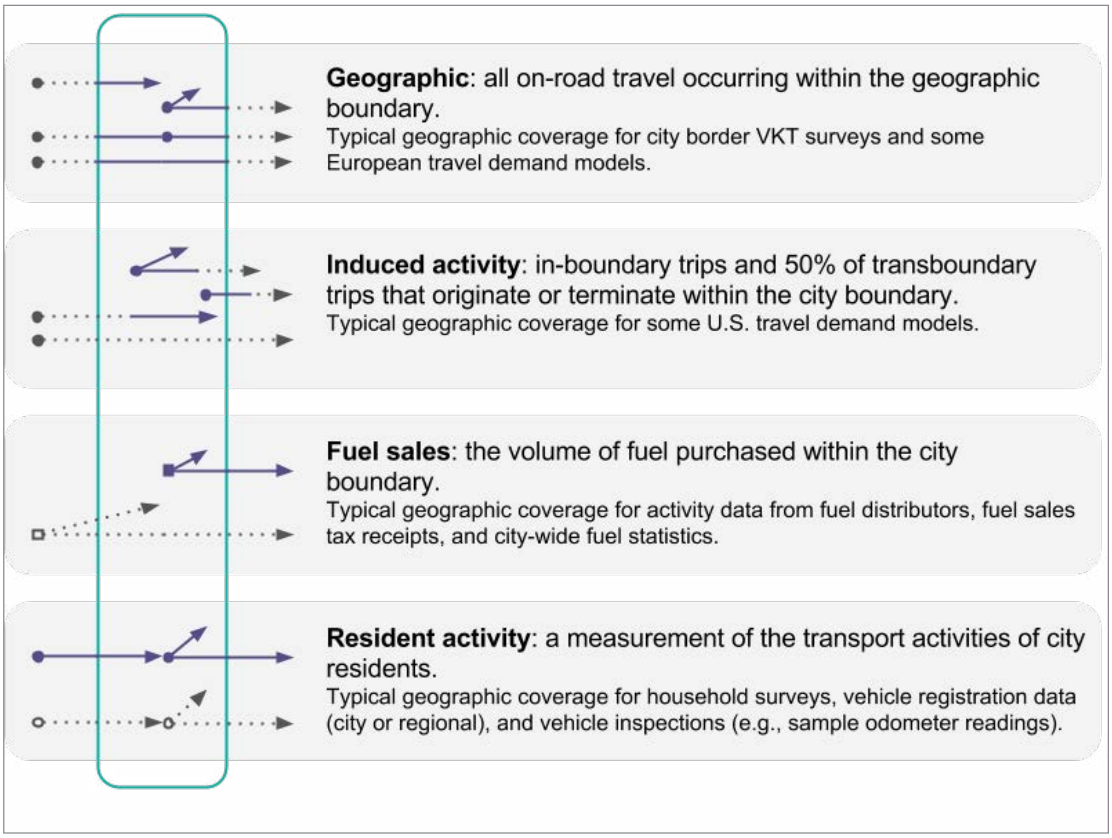
Resident Activity Method

This method quantifies emissions from transportation activity undertaken by San Borja residents only. It requires information on resident VKT, from vehicle registration records and surveys on resident travels. To collect this data San Borja relied upon resident travel surveys. While these kinds of surveys may be more manageable and cost-effective than traffic models, its limitation to resident activity overlooks the impact of non-city resident traffic by commuters, tourists, logistics providers, and other travelers. In this case, an inventory could apply the origin-destination allocation approach and report 50% of all resident trips.

Commuter Activity Method

For San Borja municipal workers, the Feasibility Study applied the same method by incorporating information on commuter VKT. San Borja provided modal split data for all residents, and the Feasibility Study extrapolated that model split percentage and applied it to San Borja's 1,200 municipal employees. The estimate assumed 230 working days each year and a conservative 2 km journey each way. Figure 5-13 depicts the four data types.

Figure 5-13: Types of Transport Data for Estimating Emissions and Reductions



Source: GPC, version 2.0

The projected GHG emission reductions from low carbon transportation policy design and planning strategies are estimated and summarized in Table 5-5. The GHG emissions reductions are based on IPCC emissions reductions estimates for policy and planning measures related to transportation. Since the GHG emissions reductions are based on a mix of possible outcomes, the IPCC data provides the best possible estimate for emissions reductions for the purposes of this Feasibility Study.

Table 5-5: Projections of GHG Reduction Percentages from "Low Carbon Transportation Policy Design and Planning Strategies"

Transportation Sector LCMs	GHG Reduction Projections (% of Baseline)		
	Short term (2018)	Medium term(2021)	Long term (2035)
Modal switching and mixed- mobility solutions	3%	7%	14%
Travel demand management (TDM)	1%	2%	4%
Intelligent transportation systems (ITS)	.05%	2%	4%
Total Reductions/Yr	3,189 MtCO2e	11,187 MtCO2e	23,896 MtCO2e

Source: Working Group III contribution to the IPCC 5th Assessment Report (AR5) "Climate Change 2014: Mitigation of Climate Change". Chapter 8: Transport of the IPCC's AR5 has reviewed scores of studies, and reviewed 1,200 scenarios involving dozens of LCMs related to transport low carbon policy design and strategies. These studies and scenarios have demonstrated CO2e emission reduction potential from LCM implementation ranging between 15% and 50%. Results depend on the comprehensiveness of the LCMs over time. The findings in AR5 constitute the percentages of reduction shown above, although this Feasibility Study is conservative in its estimates, i.e., choosing the low end of the scale in order to avoid overstating potential reductions.

Cost Estimates

The primary basis for the initial costs for implementing low carbon policy design and planning strategies are IPCC estimated costs for policy design and strategy initiatives, ranging from $7-$20 per MtCO2e. The Institute for Transport Engineers and academic reports also helped to confirm this approximate range. The estimates for low carbon policy design and planning strategies are summarized in Table 5-6.

Table 5-6: Cost Estimates for Low Carbon Transport Policy Design and Planning Strategies

*Transportation Planning LCMs	Carbon Emissions Reduction ($MtCO_2e$/Year)			Life Cycle GHG Emissions Reductions ($MtCO_2e$)[1]	% GHG Reductions Compared to Baseline 2012 ($MtCO_2e$/Year)			Total Life Cycle Cost Savings[2]	Initial Investment Cost[3,4]	Marginal Cost[4]	Life Cycle Carbon Unit Cost[5]
	2018	2021	2035		2018	2021	2035	(USD)	(USD)	(USD)	(USD/ $MtCO_2e$)
Modal Switching to Increase VKT of NMT and PKT of Public Transport	2,362	7,160	15,293	245,036	1.1%	3.4%	7.4%	$7,351,067	$3,675,534	$(3,675,534)	$(15)
Travel Demand Management to Reduce Mobility Demand	787	2,014	4,301	69,408	0.4%	1.0%	2.1%	$2,082,251	$1,041,125	$(1,041,125)	$(15)
ITS for Traffic Reduction and Congestion Management	39	2,014	4,301	66,416	0.0%	1.0%	2.1%	$1,992,474	$1,250,000	$(742,474)	$(11)
Total	**3,189**	**11,187**	**23,896**	**380,860**	**1.5%**	**5.4%**	**11.5%**	**$11,425,792**	**$5,966,659**	**$(5,459,133)**	**$(41.2)**
Average	**($13.7)**										

* The above transport sector costs are for "soft" policy design and planning strategies, as opposed to "hard" infrastructure, hardware, and construction, operation, and maintenance costs. Negative numbers indicate a USD savings. Assumptions: 1) life cycle from 2015 through 2035 is 20 years 2) IPCC AR5 (2014) assumes the for every $MtCO_2e$ reduced there is a $30.00 cost of inaction; 3) IPCC AR5 (2014) estimates that the average cost for policy design and planning strategies ranges from $10-$20 per $MtCO_2e$; and 4) definition of marginal cost is Initial Investment Cost minus Total Life Cycle Savings; 5) definition of life cycle carbon unit cost is marginal cost divided by life cycle GHG emissions reductions. Initial investment cost based on low end of a range from US DOT for traffic light system ($900K), and Hitachi Consulting experiences with other solutions - Apps for Journey Planning, EV charge spot finding, car and bike sharing, On Demand Valet etc. (Free if you attract a company to come implement in San Borja), Smartphone as Sensor App ($100K), Streetlight Sensor system ($250K).

6. BUILDINGS DESIGN PLANNING

This chapter addresses the GHG emissions associated with the energy use of residential, commercial and municipal buildings in San Borja[26]. Buildings represent almost 30% of San Borja's baseline (2012) GHG emissions. It provides an overview of green building practices and low-carbon design strategies currently implemented in San Borja. The chapter then outlines the recommended LCMs that build on the ideas listed in San Borja's 2035 Sustainability Plan and the emissions targets outlined in San Borja's LCP 2021 (see Appendix B). Finally, the chapter summarizes the projected GHG emissions performance and costs of these measures.

6.1. Background and Issues

6.1.1. Building Planning Defined

This study defines building design planning to be about the creation of "green buildings." It is the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life cycle from siting to design, construction, operation, maintenance, renovation, and deconstruction.[27] The result is a "green building." Leadership in Energy and Environmental Design (LEED) under the U.S. Green Building Council is the most widely used green building program, with certifications in 147 different countries and territories. It is a voluntary, consensus-based, market-driven program that provides third-party verification of green buildings.[28]

6.1.2. Sector Size: Floor Area Estimation

San Borja was created in 1983 and is the first planned community in Lima. The majority of its residential, commercial, and public buildings were constructed within the first 10 to 20 years of the municipality establishment.[29] The average age for residential buildings is 13 years old, and the average age for commercial buildings is 10 years. Since no precise data is available for the total building floor area in San Borja, the total building floor area for each sector or land use zone has been estimated based on the existing district zoning plan. The land plot areas for residential and commercial buildings were approximated from the San Borja Municipality's Land Use Zoning Plan dated March 2014 (*Municipalidad de San Borja. Plano de Zonificacion de Los Usos Del Suelo*). The total land plot areas for residential, commercial and institutional zones were calculated by measuring the outlines of individual blocks in the zoning plan (Figure 6-1) and summing up the individual block areas. All are applicable to residential and non-residential (commercial, educational, and municipality office) buildings.

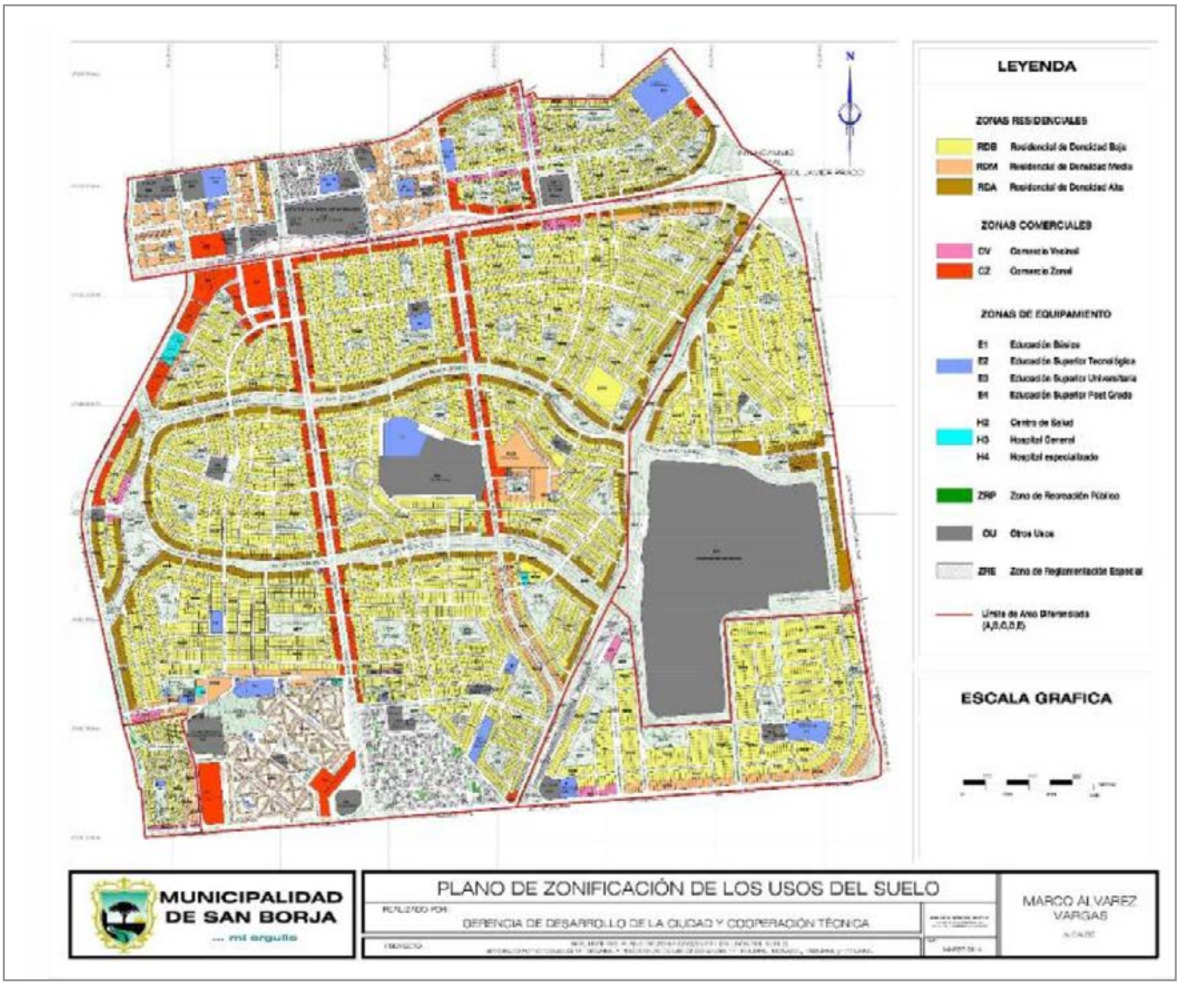
26 Municipal buildings refer to all government-owned public buildings. In this study "municipal" and "institutional" buildings are synonymous.

27 US EPA, Definition of Green Building, accessed at http://www.epa.gov/greenbuilding/pubs/about.htm.

28 USGBC Website, accessed at http://www.usgbc.org/international.

29 Information retrieved during site visit on July 30 – August 1, 2014.

Figure 6-1: San Borja Municipality's Land Use Zoning Plan



Source: San Borja Municipality homepage.

The building floor areas for each of these sectors and/or building types were estimated based on the following assumptions:

- The building footprint for residential buildings equals to 70% of land plot area[30].
- The building footprint for non-residential buildings equals to 80% of land plot area[31].
- For low-density residential buildings, a dwelling unit size is assumed to be 300m[32].
- For medium- and high-density residential buildings, a dwelling unit size is assumed to be 150m[33].

The estimated land plot areas, building footprint areas, building floor areas, and number of dwelling units are summarized in Table 6-1 below.

30 The ratio of building footprint area to land plot area was estimated according to San Borja Sustainability Plan 2035.

31 Nonresidential buildings generally have higher building footprint ratio than residential buildings.

32 The net floor area of a typical house in San Borja ranges between 250m^2 to 300m^2.

33 The net floor area of an apartment unit in San Borja generally ranges between 70m^2 and 200m^2.

Table 6-1: Building Floor Area by Building Type in San Borja

Building Type	Number of floors (average)	Total land plot area (m^2)	Total building footprint (m^2)	Total building floor area (m^2)	Estimated number of dwelling units
Low-density residential buildings	2	3,235,789	2,265,052	4,530,105	15,100
Medium-density residential buildings	4	393,082	275,157	1,100,629	7,338
High-density residential buildings	6	429,000	300,300	1,801,798	12,012
Residential Buildings Total				7,432,532	34,450
Neighborhood type commercial buildings	2	44,130	35,304	70,608	
Retail and office buildings	3	390,959	312,767	938,301	
Medical facilities (clinics, hospitals)	2	13,607	10,886	21,772	
Commercial Buildings Total				1,030,681	
Municipality Headquarters building	2	6,000	4,800	9,600	
Municipal Buildings Total				**9,600**	

Source: Estimated from San Borja Municipal Zoning Map

6.1.3. Challenges and Responses

Approximately 80% of the land is zoned and used for residential purposes, and the other 20% for commercial and public purposes.

There is currently little mixed-use development as the commercial and residential zones are physically separate. While two-story single-family homes are predominant, a densification process has started in recent years with the conversion of these buildings over five floors into multifamily housing. According to the current zoning plan, 80% of residential zones in San Borja are zoned for low density, 10% for medium density, and the remaining 10% is zoned for high density.

It has been difficult to promote "green buildings" in Peru, particularly in residential areas. The concept of a sustainable building or green building is still in an exploratory phase. Peru does not have a national Building Energy Code even though the National Building Regulations contain sections on building electrical and mechanical equipment. In addition, there are limited incentives available for this type of investment. Residents do not perceive "green buildings" to be of benefit to them, or as a way to increase their own property value. Instead, they perceive it as an additional cost.[34]

There are indicators, however, that suggest a change in policies, if not perceptions. The Ministry of Housing, Construction, and Sanitation of Peru has taken the initiative in addressing the needs for building energy efficiency and is currently developing Peru's sustainable building policies.

San Borja implemented the *Promotion of Green Buildings (Ordinance No. 496-MSB)* policy to promote new construction and rehabilitation of buildings by implementing sustainable design and construction methods,

34 Information collected during interviews with San Borja municipal staff, July 2014.

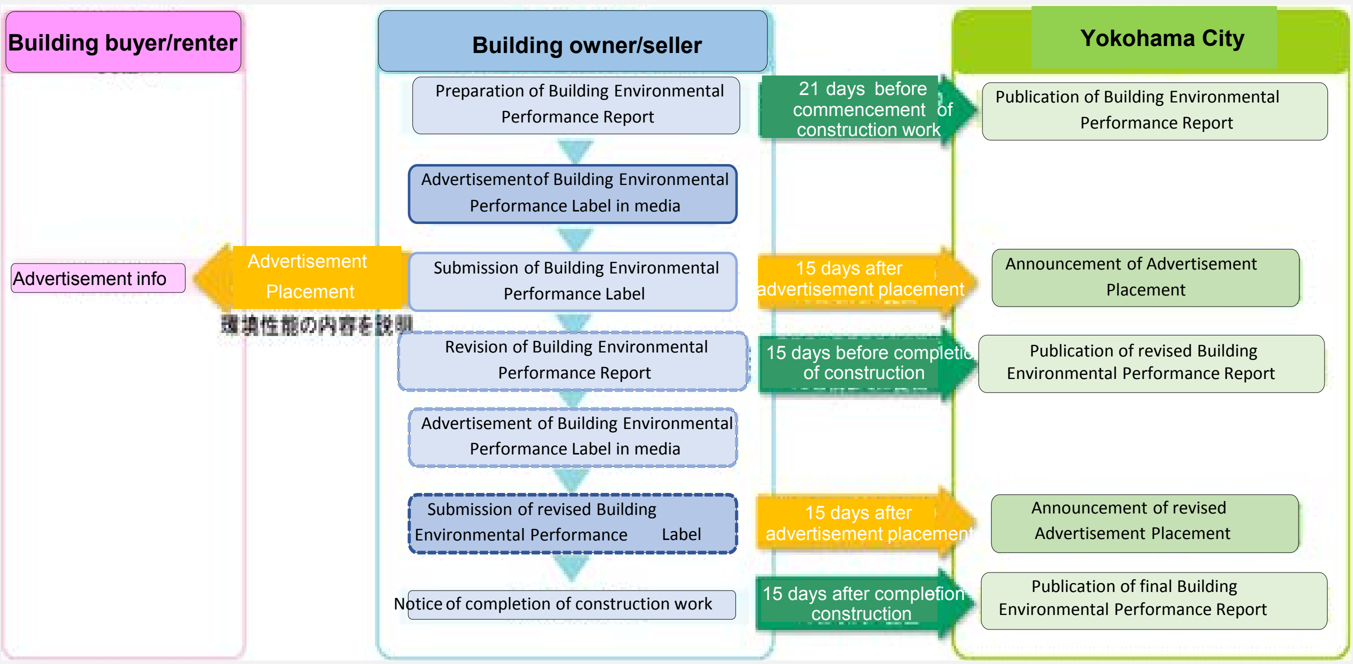
and San Borja has introduced a ‘density bonus’ for developers (e.g., allowing 12-floors instead of 8-floor construction) for green buildings. Four buildings recently achieved official LEED certification.

Furthermore, San Borja is developing its own “Green Seal” standard. The status of the development of this standard is unclear but it has demonstrated San Borja’s interest in a certification system for green buildings. This potential certification system could incorporate the low carbon design strategies described in section 6.2. San Borja may select to model their building certificate or labeling system after systems that have already been in place in other countries such as the *Energy Efficiency Certification Program* and *Condominium Environmental Performance Labeling System* of Tokyo Metropolitan Government or the CASBEE-based[35] *Sustainable Building Reporting Policy* currently implemented by many local governments throughout Japan. (See Figure 6-2)

Figure 6-2: “Sustainable Building Reporting Policy” based on CASBEE

Many local governments in Japan have employed a scheme called the Sustainable Building Reporting System (SBRS) that requires owners of large buildings to prepare and submit building performance plans to demonstrate their environmental efforts prior to construction. Currently, a total of 24 prefectural or city governments have adopted CASBEE (Japanese green building rating system) as the reference standard for their SBRS policy. The degree of reference or utilization of CASBEE varies widely among these governments; in most cases, they adopt specific CASBEE tool(s), tailor it to local conditions, and require owners of large buildings (typically over 5,000 m²) to submit assessment results based on this ‘localized’ version of CASBEE tool.

The City of Yokohama is currently the only government that offers an official CASBEE certification for local projects. The SBRS process flow chart of City of Yokohama is shown below.



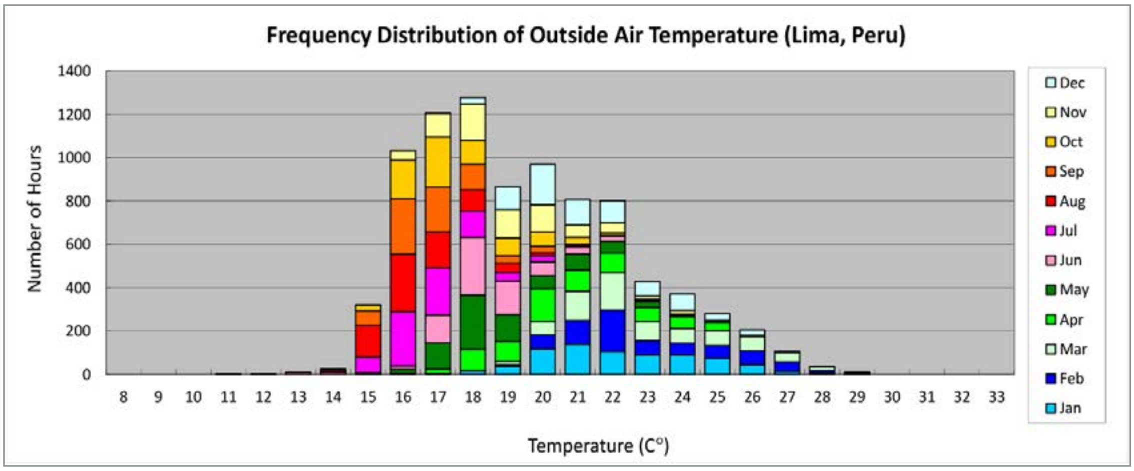
Source: City of Yokohoma Housing and Architecture Bureau homepage.

35 Comprehensive Assessment System for Built Environment Efficiency (CASBEE) is building environmental assessment system developed and mainly used in Japan; it is the “Japanese equivalent of LEED rating system”.

6.1.3.1. Building Energy Consumption

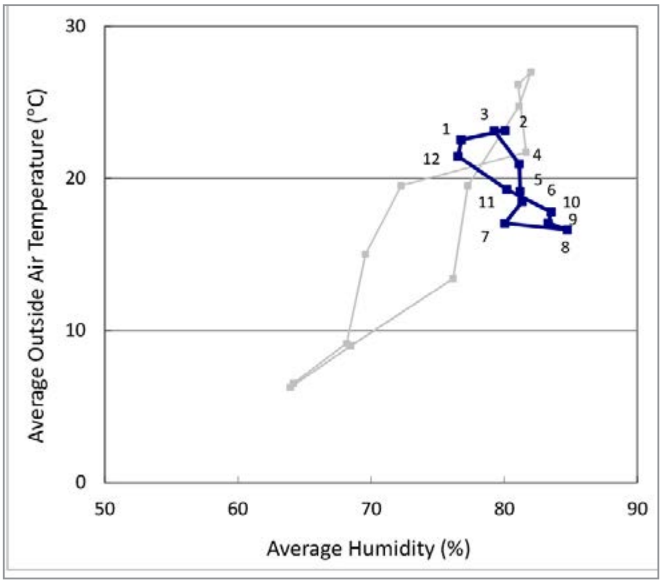
Lima (and therefore San Borja) has an average outside air temperature that ranges between 11 ºC and 30 ºC, with most days between 16 ºC and 22 ºC (Figures 6-3 and 6-4). There are very few cooling and heating degree-days (Figures 6-5). Air conditioning is seldom needed and heating is only needed a few days a year between July and September. Even though humidity is high, San Borja's year-round air temperature (16 °C ~ 22 °C) is close to ideal room temperature so passive design strategies could be easily applied to minimize building energy consumption without compromising thermal comfort.

Figure 6-3: Outside Air Temperature in Lima, Peru



Source: Nikken Sekkei Research Institute based on data from EnergyPlus energy simulation software

Figure 6-4: Average Temperature and Precipitation in Lima, Peru

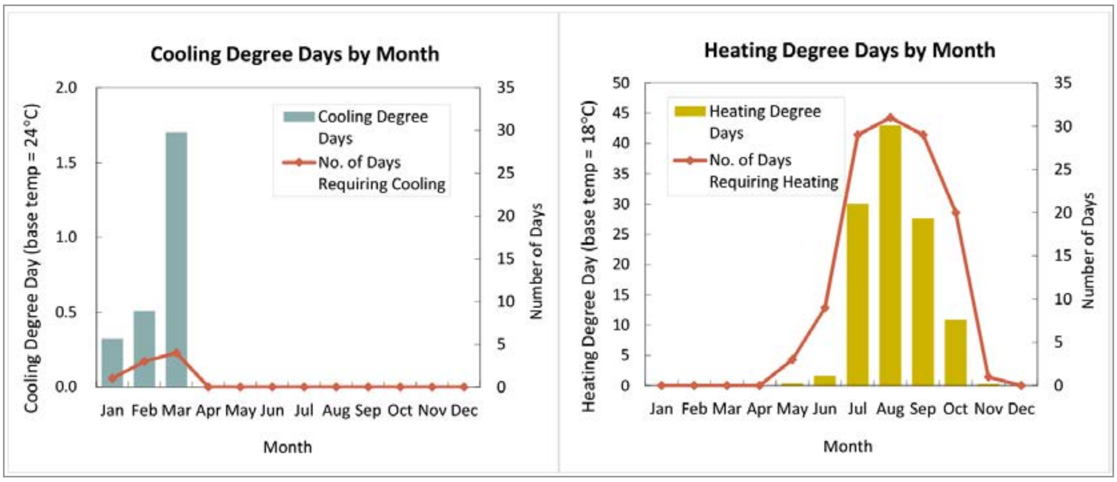


Source: Nikken Sekkei Research Institute based on data from EnergyPlus energy simulation software.

Heating and cooling needs may increase if indoor comfort becomes an issue as buildings are becoming vertically stacked and more densely-spaced. The cooling needs could also be amplified by changing climate conditions and urban heat island effect in the near future. According to the National Energy Balance 2010, residential, public and commercial buildings account for about 45% of the total electricity consumption and about 32% of the total energy consumption (See Appendix A).

Figure 6-5 shows the average number of heating and cooling days per month over a year in Lima. Without much need for artificial cooling or heating, the energy consumption in buildings (especially residential homes) has been generally low in Lima (and therefore San Borja). However, residential energy consumption, has been on the rise. Even though San Borja district is predominantly occupied by residences, the energy use intensity of the commercial sector (1,081 MJ/m^2)[36] is much higher than that of the residential sector (131 MJ/m^2). Prior to discussing options for reducing specific end-uses of energy in buildings, it is useful to understand the overview of energy end-uses in the residential and commercial buildings for San Borja or Lima.

Figure 6-5: Cooling Degree Days and Heating Degree Days of Lima, Peru



Source: Nikken Sekkei Research Institute based on data from EnergyPlus energy simulation software.

Unfortunately, precise data was not available on the energy end-use breakdown for San Borja or Lima. According to the energy consumption data provided by San Borja District for the residential sector, more than 70% of the energy consumed by households is provided by electricity followed by liquefied petroleum gas (LPG), primarily provided in the form of propane used for domestic cooking. After examining the heating and cooling needs and hot water demand of San Borja, it appears that more than half of the electricity consumption of the residential sector is for water heating.[37]

36 The 2012 energy consumption of the commercial and residential sector is 1,056,113.32 MMBtu and 816,278.6 MMBtu respectively according to the APEC's "Low Carbon Model Town – San Borja Nomination Sheet". The estimated building floor area of the commercial and residential sector is 1,030,681 m^2 and 6,556,775 m^2 respectively.

37 The estimated energy consumption of water heating system in one dwelling unit is 2,547 kWh/year (section 7.4). The average household electricity consumption estimated by San Borja Municipality is 4,685 kWh/year.

6.2. Proposed Low Carbon Measures

"The Concept of the Low-Carbon Town in the APEC Region - Third edition" by APEC Energy Working Group (EWG) outlined the following three steps for the proposal of design measures for low carbon buildings:

- Reduction of heat load in the building
  - The first step towards the reduction of carbon emissions from buildings is to consider design measures that could create a comfortable environment in the building with reduced amount of required energy.
- Adoption of passive energy design
  - "Passive forms of environmentally-friendly technology" that utilize natural light, solar heat, and wind energy are appropriate for San Borja to consider as a means of satisfying demand for energy, limiting GHG emissions, and other environmental benefits such as reduced air pollution.
- Improvement of equipment efficiency
  - Energy use in the building could be further reduced by improving the energy performance of active building systems such as air conditioning, lighting, and hot water systems.

These steps inform the selection of the LCMs below.

6.2.1. Passive Design Strategies

Passive design is an architectural design method that harnesses natural phenomenon such as sunlight, solar heat, and direction of the wind. The following passive and active design strategies and LCMs were selected according to the EWG steps. Table 6-2 describes the LCMs in more detail. All are applicable to residential, commercial and municipal buildings. In this study, we refer to institutional buildings as municipal buildings. In order to be more precise about a public or private entity in San Borja owns and operates the building.

Table 6-2: Passive System Design

Overview of Passive System Design LCM and Applicability
Passive design takes into account the local climate characteristics (temperature, wind, humidity, rainfall, solar radiation, and positioning) to maximize the thermal comfort of the indoor space. **Natural ventilation:** Buoyancy-driven natural ventilation: Buoyancy driven ventilation arises due to differences in air density, which mostly arises from differences in temperature. A 'solar chimney' could enhance the natural stack ventilation of a building by collecting solar energy near the top of a vertical shaft, thus creating an updraft of air in the shaft. Wind-driven natural ventilation: Wind-driven ventilation uses pressures generated on the building by the wind to drive air through openings in the building. However, wind speed and direction of the building site must be carefully studied during the design process especially if the surrounding buildings are densely-spaced. **Passive cooling:** Shading by building elements: Shading devices such as overhangs, exterior or interior blinds, and solar shading façade systems block solar radiation from entering a building. This reduces glare and demands on active cooling systems and improves thermal comfort. **Shading by trees or landscape**: Solar shading by placing shade trees or plants near windows provides the same benefits as shading by building elements but could also provide 'greens' to the site among other benefits. **Natural daylighting:** Daylighting design strategically places windows or openings and reflective surfaces so that natural light provides effective lighting for the internal space. Light shelves could be used to reflect daylight onto the ceiling and deeper into a building space.

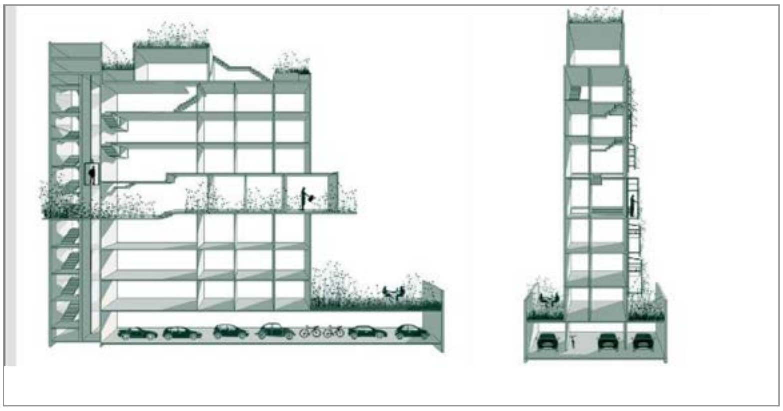
Building-integrated natural infrastructure: Rooftop or exterior wall with a vegetation covered surface could improve building energy efficiency by acting as added insulation. Vegetative cover can also reduce urban heat island effect and be visually attractive.

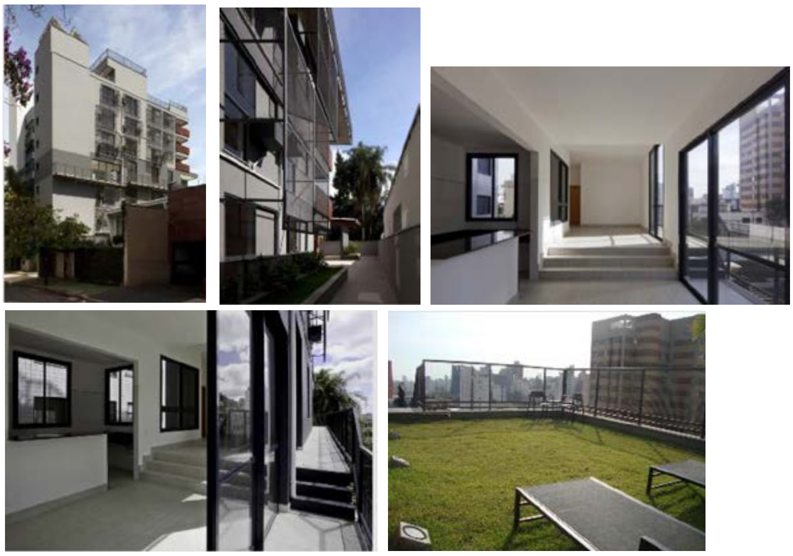
Humidity control: Although San Borja has near ideal temperature (16°C ~ 22°C) year round, its high humidity (60% ~ 80%) causes thermal discomfort and reduction in energy efficiency of the HVAC system. It is therefore necessary that indoor humidity be controlled by latent heat storage materials (passive strategy) or mechanical dehumidification systems (active strategy). Latent heat storage materials, also known as phase –change materials (PCM), are substances that store thermal energy by means of a phase change, typically from solid to liquid, PCM could be integrated into the wall finish or into building structure (wall, floor, etc.) to help absorb indoor humidity, thus improving comfort and increasing the efficiency of the HVAC system.

Example of Application

Residential Building with Passive Design (Belo Horizonte, Brazil)

Montevideo 285 is a multi-story apartment building built on a 480m^2 plot in Belo Horizonte City of Brazil. The building has incorporated solar heating, green roof, solar shading grilles facing the morning sun, and natural ventilation in the design.





Sources: http://www.vazio.com.br/projetos/ed-montevideu-285/?lang=en;
http://www10.aeccafe.com/blogs/arch-showcase/2011/09/09/montevideo-285-in-belo-horizonte-brazil-by-vazio-sa/

6.2.2. Active Design Strategies

Active design is an architectural design method that utilizes mechanical systems for heating, cooling, and lighting to ensure efficient energy use which will reduce GHG and building operating costs, and improve comfort and quality of the interior environment. Table 6-3 describes the LCMs in more detail. All are applicable to residential, commercial and municipal buildings.

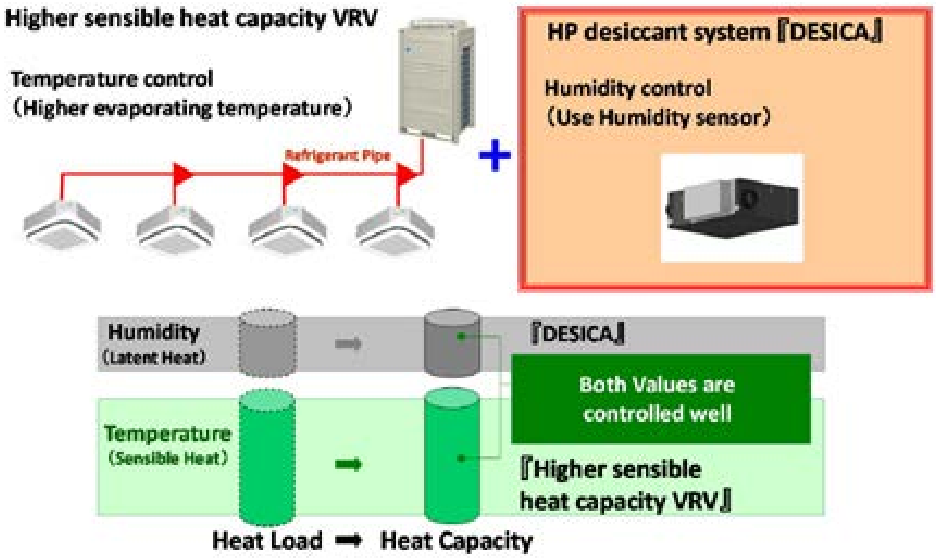
Table 6-3: Building Active System Design

Overview of Active System Design LCM and Applicability
Active design also takes into account the local climate characteristics (temperature, wind, humidity, rainfall, and solar radiation) and positioning of the building to maximize the thermal comfort of the indoor space and its lighting. Lighting system • LED lighting: LED lighting has lower energy consumption, longer service life and smaller size than incandescent light. The costs of LED lamps have dropped significantly as technologies have advanced and the global and domestic demand for LED lighting has grown rapidly. Many LED lighting products are available in the market now for both residential and commercial use. • Energy-saving lighting controls: Use lighting controls to automatically turn lights on and off as needed eliminates wasteful use of electricity. Common controls that could be easily integrated into new and retrofit buildings include motion sensors that control lights through motion detection, dimmer controls that provide variable lighting wattage and output, and daylighting control that automatically dims or switches electric lighting in response to changing daylight availability in the space. Wireless control system allow for easy and cost-effective solutions for retrofit projects. High efficiency HVAC system • High efficiency split system: Since most buildings in San Borja are small- to medium-sized with relatively low air conditioning load, decentralized HVAC systems such as split system are commonly used. The energy performance and type of the HVAC systems should be carefully considered before installation. For example, in commercial or office buildings with various temperature control zones, multi-split type air conditioning system that uses variable refrigerant flow control or heat recovery control may provide optimum energy efficiency and temperature control for individual zones. • High efficiency dehumidification system: The climate in San Borja is characterized by high humidity. Commonly used HVAC systems such as split systems generally tend to over-cool in order to remove the latent loads thus wasting energy. The need for sensible cooling could be greatly reduced with the use of high efficiency dehumidification systems such as new technologies that target latent loads (see example below). • Energy-saving operation and controls: Building energy management system (BEMS) could help manage, control and monitor building technical services (HVAC, lighting, elevator, etc.) and the associated energy consumption in a building. For medium- and large-sized commercial and office buildings, energy-saving operation should be integrated into HVAC controls, e.g., night purge ventilation control, zero energy band, outside air economizer, variable-air-volume control, demand-controlled ventilation with CO_2 sensors, etc. Water conservation • Water-saving plumbing fixture: High-efficiency, low-flow plumbing fixtures could help reduce the overall potable water demand. Motion sensing faucets installed in public facilities could help prevent water waste. • High efficiency irrigation system: Irrigation systems that are require less water demand or use recycled water could reduce on-site water demand. Natural energy • Photovoltaic (PV) power generation: PV panels could be integrated into the building envelope (roof or wall) design to simultaneously generate power and provide solar shading to the building to reduce solar gains. (See Chapter 7 for more details) Solar water heating • Solar-assisted water heating systems that use solar heat collectors could be used to supply hot water for residential buildings in San Borja, reducing electricity consumption. (See Chapter 7 for more details)

Example of Application

DESICA Commercial Humidity Controlling Heat Recovery Ventilation System

- DESICA uses outside air to control humidity through a Hybrid DESICA Element that contains a high efficient water absorption material and a heat exchanger. The energy consumed is only a fraction of the energy used by conventional humidity controlling devices. A combination of humidity control by DESICA and temperature control by split system could lead to considerable overall energy savings.



Source: International Energy Agency "State-of-the-Art Analysis of Nearly Zero Energy Buildings - Country report IEA HPP Annex 40 Task 1 Japan" (2013).

6.2.3. Applying Design Strategies

Active design can complement passive design given that the latter cannot always be relied on to meet the cooling or heating needs of a building. In fact, it is possible to achieve Net Zero Energy Buildings by applying a combination of passive design and active design strategies. A Net Zero Energy Building model example is shown in Figure 6-6. However, not all design strategies are applicable to all building types, nor they are equally applicable to new construction and retrofit projects. Table 6-4 shows the applicability of passive and active design strategies to residential, commercial, and municipal buildings in San Borja.

Figure 6-6: Net Zero Energy Building Model Example

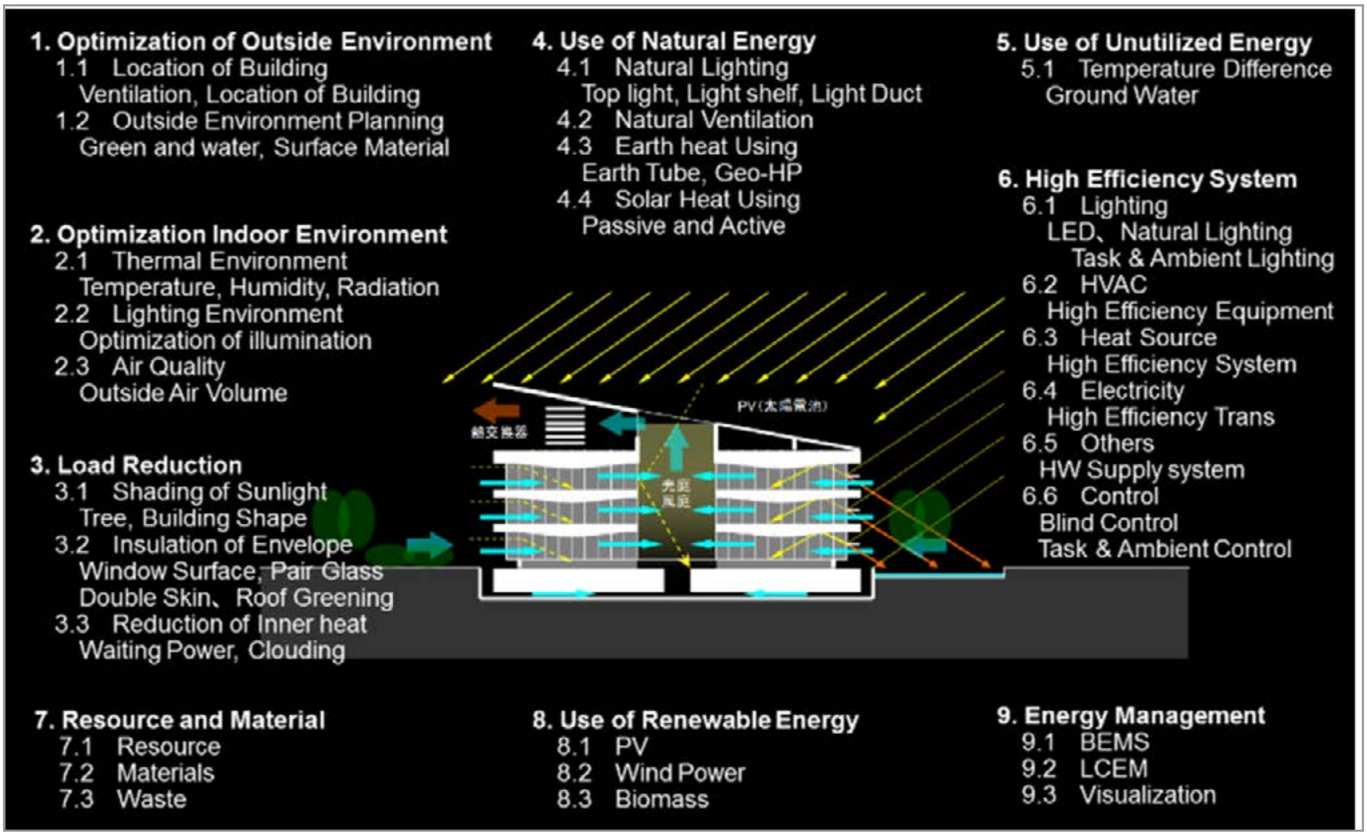


Table 6-4: Applying Design Strategies to Building Sector

Design Strategies		Existing Building Retrofits	New residential buildings (detached houses & multifamily apartment buildings)	New commercial / public buildings
Passive design strategies	Natural ventilation		◆◆	◆◆
	Passive cooling – shading by overhangs, eaves, etc.		◆◆	◆◆
	Passive cooling – shading by trees or landscape	◆	◆◆	◆◆
	Daylighting		◆◆	◆◆
	Green roof	◆	◆	◆◆
	Green wall	◆	◆	◆◆
	Humidity control		◆◆	◆◆

Design Strategies		Existing Building Retrofits	New residential buildings (detached houses & multifamily apartment buildings)	New commercial / public buildings
Active design strategies	LED lamps	◆◆	◆◆	◆◆
	Energy-saving lighting control	◆◆	◆◆	◆◆
	High efficiency split systems	◆◆	◆	◆◆
	High efficiency dehumidification system	◆	◆	◆◆
	Energy-saving operation and controls	◆	◆	◆◆
	Water-saving plumbing fixtures	◆	◆◆	◆◆
	High efficiency irrigation system	◆	◆	◆◆
	Solar water heating	◆◆	◆◆	◆◆
	PV panels	◆	◆	◆◆

Key:

	Unlikely to be applicable
◆	Possibly applicable
◆◆	Highly applicable

6.3. GHG Reduction Analysis and Cost Estimates

Low Carbon Design Strategies Reduction Analysis

The projected GHG emission reductions from "low carbon building design strategies" are estimated and summarized in Table 6-5.

Table 6-5: Projections of GHG Reduction Percentages from "Low Carbon Building Design Strategies"

Building Sector	GHG Reduction Projections from BAU (%)		
	Short term (2018)	Medium term (2021)	Long term (2035)
Residential	-5%	-15%	-30%
Commercial	-10%	-20%	-40%
Municipal	-10%	-20%	-40%

Note: Working Group III contribution to the IPCC 5th Assessment Report (AR5) "Climate Change 2014: Mitigation of Climate Change" Chapter 9: Buildings has reviewed 38 studies on GHG emissions reduction potentials for the residential and nonresidential buildings. These studies have demonstrated GHG emissions reduction potential ranging between 9.5% and 70% by implementing LCMs depending on the comprehensiveness of the measures. The range of GHG emission reduction potential for residential sector is generally lower than that for nonresidential sector. The findings of this report constitute the percentages of reduction shown above, which were also determined based on studies previously conducted by Nikken Sekkei Research Institute.

Cost Estimates

The initial costs for implementing low carbon building design strategies in Peru were estimated based on construction costs of Brazil and the US that are scaled according to the "house price to per capita GDP" (Table 6-6). The construction costs by building area for San Borja are shown in Table 6-6. Cost estimates are presented separately for new construction and retrofits. The estimates for low carbon construction cost premiums are summarized in Table 6-7. The cost estimates for low carbon building retrofit are summarized in Table 6-8.

The premiums for construction costs in San Borja were estimated based on the following assumptions:

- A total of 400 new construction projects in San Borja per year; 90% of the projects are residential (360 projects) and 10% are non-residential (40 projects).[38,39]
- Residential construction consists of 50% detached houses and 50% apartments[40].
- Building floor area of a detached house is 300m^2. Building floor area of an apartment building is 1,200m^2 (4 floors, two 150m^2 dwelling unit per floor).
- Building floor area of a non-residential building is 2,000 m^2.
- 50% of the new construction will be built to be "low carbon".
- The premium cost (increase in design and construction costs for low carbon construction) is 5%[41].

Table 6-6: House Price to Per Capita GDP

Economy	USD
Peru	23.3
Brazil	29.7
US	27.9

Source: Cubeddu, Tovar & Tsounta. 2012. "Latin America: Vulnerabilities Under Construction?" IMF Working Paper.

Low Carbon New Construction

Table 6-7: Construction Costs per Building Area (in USD per m^2)

	Brazil	Peru
Individual detached house	658	658 * 23.3 / 29.7 = 516.2
Apartments	1088	1088 * 23.3 / 29.7 = 853.5
Offices up to 20 floors	1127	1127 * 23.3 / 29.8 = 884.1

Source: Turner & Townsend. "A Brighter Outlook International Construction Cost Survey 2013"

38 According to San Borja's 2035 Sustainable City Plan, the number of construction certificates issued by the Municipality of San Borja in 2010, 2011 and 2012 was 305, 902 and 182 respectively. The drop in construction in 2012 was due to a new zoning ordinance. This study takes a conservative approach and assumes construction will rise again, and the number of construction certificates will average out to 400 per year in the long term.

39 Excluding green areas, special regulation zones and public zones, the land areas of residential zones made up about 90% of the land areas of San Borja. It is therefore assumed that 90% of the construction projects are in the residential sector. (See Table 6-4 for the land area estimate.)

40 According to San Borja's 2035 Sustainable City Plan, the San Borja district has been experiencing rapid vertical growth. This has resulted in the demolition of two-story single family homes and construction of multi-family buildings over 5 floors.

41 According to "The Business Case for Green Building" (2013) by the World Green Building Council, for the majority of certified green buildings the cost premium typically ranges from 0% to 4%. Only projects with a very high rating (e.g. LEED Platinum) have 10% higher costs.

Table 6-8: Estimates for Low Carbon Construction Cost Premiums

	Number of low carbon new constructions per year	Construction cost per building (USD)	Total construction cost (USD)	Annual cost premium for new constructions (USD/year)
Individual detached house	90	154,863	13,937,636	696,882
Apartment buildings	90	1,024,259	92,183,273	4,609,164
Nonresidential buildings	20	1,768,290	35,365,791	1,768,290

Low Carbon Retrofits

The low carbon retrofit costs in San Borja were estimated based on the following assumptions:

- Retrofit cost for residential buildings in the low-density zone is 200 USD per dwelling unit.[42]
- The retrofit cost for residential buildings in medium- and high-density zones is 100 USD per dwelling unit.
- The retrofit cost per building area for nonresidential buildings is 10 USD/m^2.[43]
- Costs of PV panels and solar water heating system are estimated in Chapter 7 and therefore excluded here.

Table 6-9: Estimates for Low Carbon Building Retrofit Cost

Building Type	Total building floor area (m^2)	Estimated number of dwelling units	Total retrofit cost (USD)
Low-density residential buildings	4,530,105	15,100	3,020,070
Medium-density residential buildings	1,100,629	7,338	733,752
High-density residential buildings	1,801,798	12,012	1,201,199
Residential Buildings Total			4,955,021
Neighborhood type commercial buildings	70,608		706,080
Retail and office buildings	938,301		9,383,010
Medical facilities (clinics, hospitals)	21,772		217,720
Municipality Headquarters building	9,600		96,000
Nonresidential Buildings Total			10,402,810

42 According to the “Introducing: The Edge” report by the Excellence In Design For Greater Efficiencies (EDGE), the total incremental capital costs of installing low-energy lights, solar collectors for hot water, low-flow taps for kitchen sinks, dual-flush toilets and hollow concrete blocks for external walls in an apartment in Latin America are 500 USD.

43 Retrofitting cost could vary widely depending on the comprehensiveness of the retrofitting measures, size and age of a building. According to various studies, the costs for green or energy efficient retrofits of commercial buildings in the US could range from $20 per square meter to $150 per square meter for large complex projects. The majority of the cost goes to HVAC- and energy-related retrofits. Taking into consideration that buildings in San Borja generally requires little space heating and cooling (thus HVAC-related retrofitting is not extensive), and the relatively lower construction costs in Peru, this study has chosen to use a retrofit cost of USD 10/m^2.

7. ENERGY PLANNING

This chapter addresses the GHG emissions associated with the generation, transmission and distribution of electric power in San Borja, as well as information on non-transport fuel combustion. The chapter then outlines the recommended LCMs that build on the idea listed in San Borja's 2035 Sustainability Plan and the emissions targets outlined in San Borja's LCP 2021 (see Appendix B). The chapter concludes with a summary of the projected GHG emissions performance and costs of the recommended LCMs.

7.1. Background and Issues

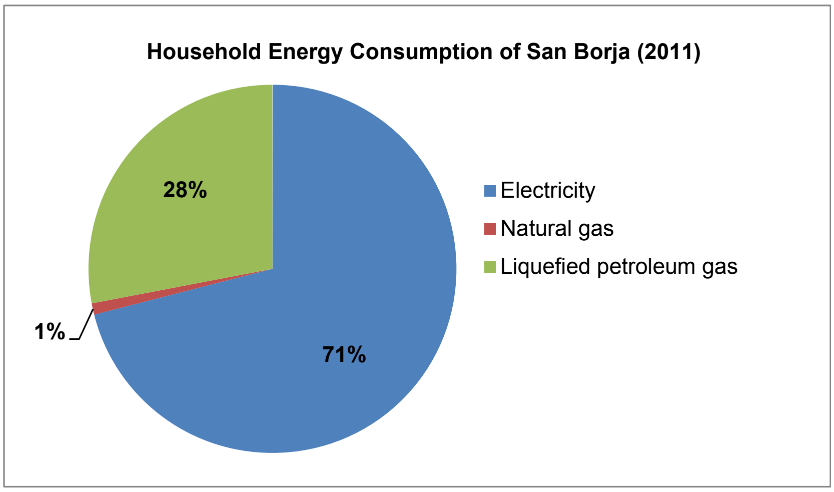
7.1.1. Energy Planning Defined

This study defines energy planning as promoting the use of energy resources (supply) while meeting energy needs (demand) of San Borja in ways that are environmentally responsible and sustainable. There are four areas this study explores: 1) area energy planning and the associated benefits of implementing a multi-source energy network; 2) the concept of a community-based energy management system to provide monitoring, reporting and management of overall electricity consumption, conservation and efficiency; 3) untapped energy and the potential for generating electricity or heat from municipal waste; and 4) the potential for electricity and heat from renewable resources.

7.1.2. Energy Consumption

According to the energy consumption data provided by the District of San Borja for the residential sector (Figure 7-1), the primary energy sources for San Borja's residents are electricity and liquefied petroleum gas (LPG), with electricity accounting for over 70% of energy use. LPG, most often provided in the form of propane, is the next major energy source, which is primarily used for domestic cooking.

Figure 7-1: Household Energy Consumption in San Borja

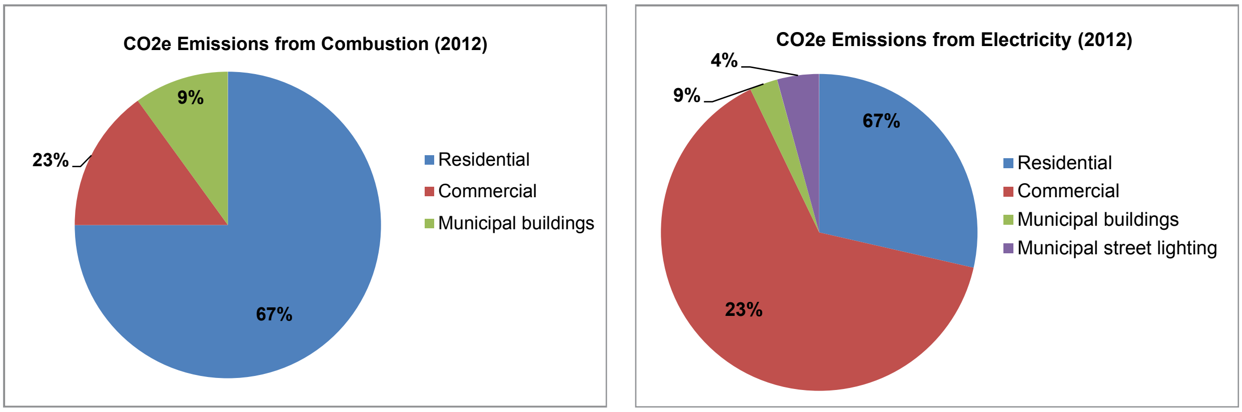


Source: Information retrieved during site visit on July 30 – August 1, 2014.

7.1.3. Electric Power

The GHG emissions associated with stationary fuel consumption, (e.g., diesel fuel and natural gas), and electricity use for residential, commercial, and municipal buildings are shown in Figure 7-2. The commercial building sector generates the highest percentage of emissions from fuel combustion energy sources, while the residential building sector generates the highest percentage of emissions from electricity. Electricity consumption in San Borja is almost evenly divided between the residential and commercial sectors with slightly more electricity being consumed by residential buildings.

Figure 7-2: GHG Emissions of San Borja (2012)

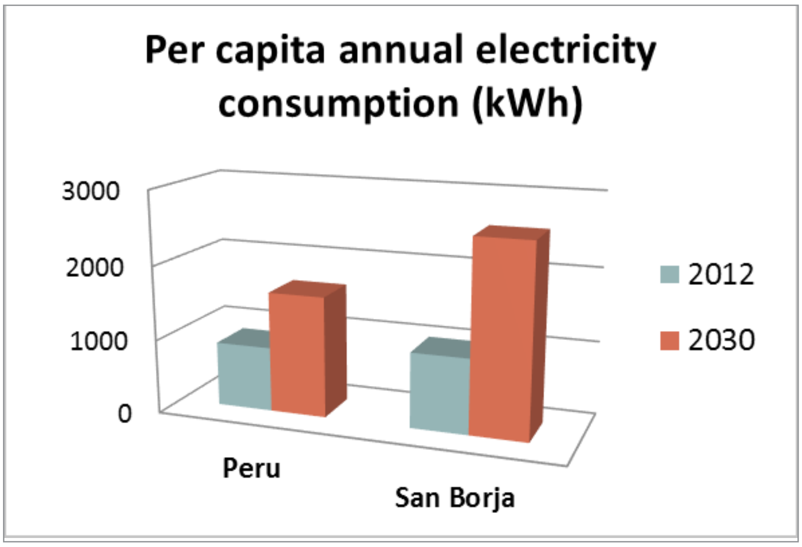


Source: Created from data from July 2014 Site Visit.

A description electricity consumption in San Borja includes higher per-capita electricity consumption than the average in Peru. Projections suggest that per capita electricity consumption in San Borja and Peru will double by 2030 (Figure 7-3). If low carbon electricity sources are not implemented, the increase in demand will result in higher GHG emissions.

The power transmission lines in San Borja are publicly owned and electric power is distributed by Luz Del Sur, a private electric power distribution company serving the southeast area of Lima.

Figure 7-3: Per Capita Electricity Consumption in San Borja and Peru



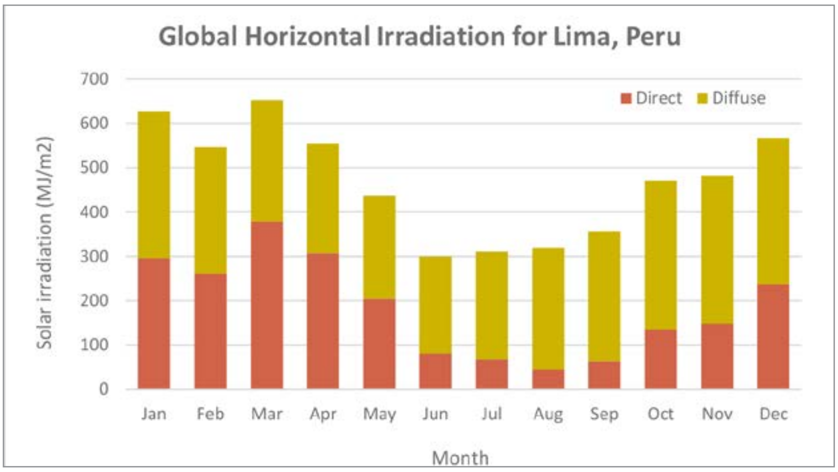
Source: Peru electricity consumption: UK Trade & Investment (2030); San Borja electricity consumption: Reported by San Borja Municipality during July 2014 site visit.

7.1.4. Renewable Energy Potentials

7.1.4.1. Solar Energy Potential

San Borja receives a moderate amount of annual solar radiation (approximately 5,619 MJ/m2 or 1,561 kWh/m2), making solar energy a technically viable low carbon technology despite a high portion of irradiation being made up of diffuse radiation (Figure 7-4).

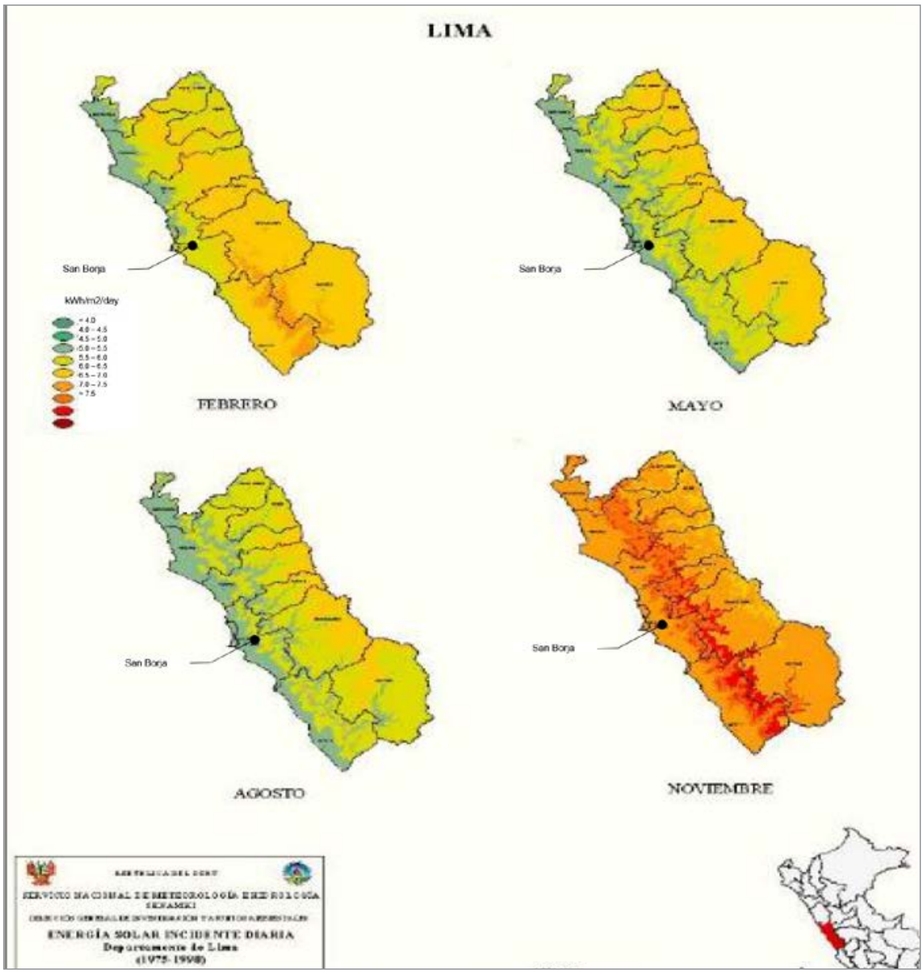
Figure 7-4: Global Horizontal Irradiation for Lima, Peru



Source: Peruvian National Service for Meteorology and Hydrology

According to Peruvian National Service for Meteorology and Hydrology data, solar radiation in San Borja has high seasonal variation, especially during the winter months (Figure 7-5). San Borja's daily solar radiation levels (typically 5-6 kWh/m^2) drop significantly in winter months to an average daily solar radiation level of about 2.8 kWh/m2.

Figure 7-5: Solar Radiation Map of Lima, Peru



Source: Peruvian National Service for Meteorology and Hydrology

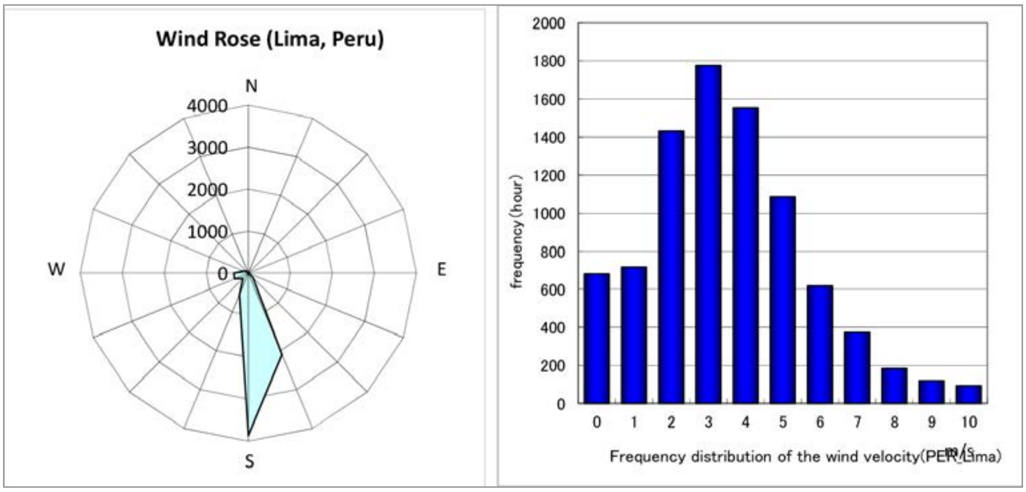
Nonetheless, studies have shown that PV system installations could be successful in economies with such characteristics (e.g., United Kingdom and Ireland) where diffuse radiation component is high – about 60% of the total annual irradiation and the solar radiation is moderate (2.5 to 3 kWh/m2/day for the United Kingdom and about 2.5 kWh/m2/day for Ireland).[44] Therefore, this study recommends that San Borja further research and consider solar energy harvesting as a potential LCM.

7.1.4.2. Wind Energy Potential

According to the wind energy map from the Peruvian Ministry of Energy and Mines, the potential for wind energy capture in San Borja is very limited (approximately 17 kWh/m²/year). Lima experiences southerly winds throughout the year, but the wind speed is generally lower than 5m/s (Figure 7-6). Given that 3.5m/s is the typical cut-in speed (speed at which a turbine starts to rotate and generate power) for most commercial wind turbines, the wind speed in San Borja would be too low to make wind energy economically viable.

44 Sustainable Energy Authority of Ireland. "Best Practice Guide – Photovoltaics (PV)"

Figure 7-6: Wind Direction and Wind Speed in Lima, Peru

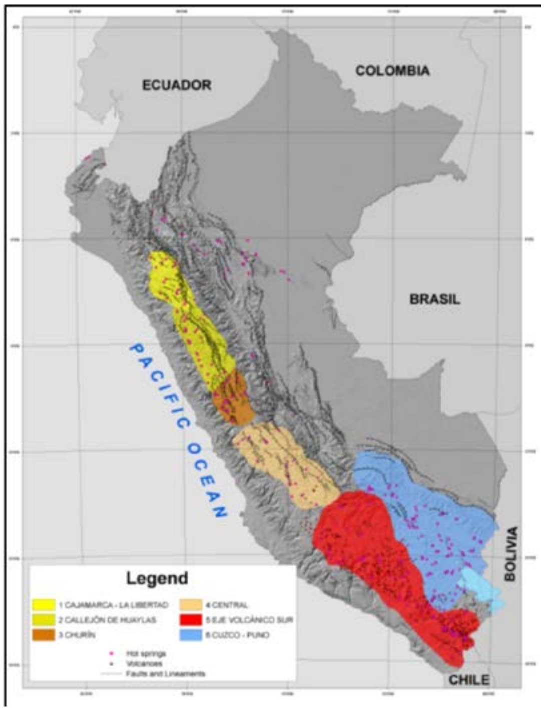


Source: EnergyPlus energy simulation software

7.1.4.3. Geothermal Energy Potential

Though Peru has high potential for geothermal energy generation, San Borja lies outside of the six geothermal regions of Peru (Figure 7-7). Therefore, generating geothermal energy in San Borja is not feasible in the short-term. However, this study recommends that long-term utilization of geothermal energy (e.g., extracting geothermal sources from nearby areas) be further researched. For example, a binary cycle power plant that utilizes geothermal fluids of relatively low temperature (60 ºC ~ 80 ºC) may be an effective source of decentralized energy.

Figure 7-7: Geothermal Map of Peru

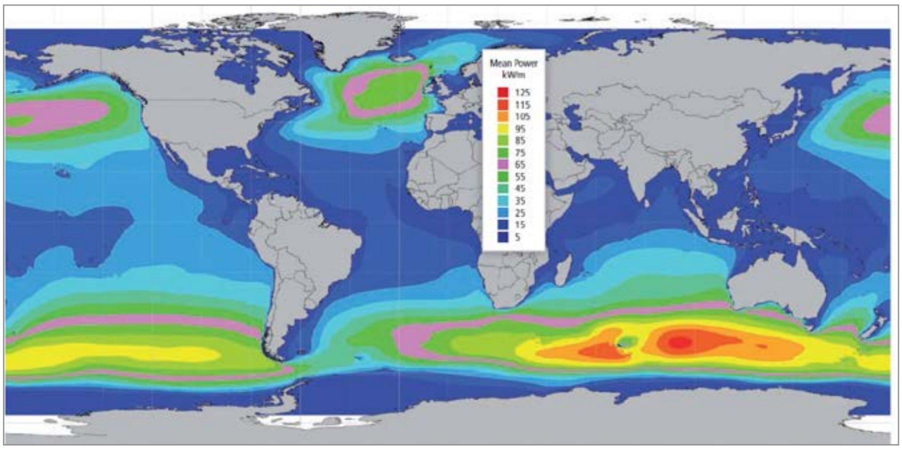


Source: Vargas & Cruz (2010). "Geothermal Map of Perú"

7.1.4.4. Tidal Energy Potential

The Ministry of Energy of Peru has expressed interest in the future development of ocean energy, but the offshore wave power potential near Lima is quite limited with a wave energy potential of approximately 15 kW/m (Figure 7-8). In addition, San Borja is located 4 km from the ocean, making infrastructure construction extremely challenging. Furthermore, the long term potential including the economic return of ocean energy has yet to be validated by studies. Therefore, this study does not recommend that San Borja pursue ocean/wave energy as a potential LCM.

Figure 7-8: Global Offshore Annual Wave Power Level Distribution



Source: Lewis, Estefen, Huckerby, Musial, Pontes & Torres-Martinez (2011). "Ocean Energy. In IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation".

7.2. Proposed Low Carbon Measures

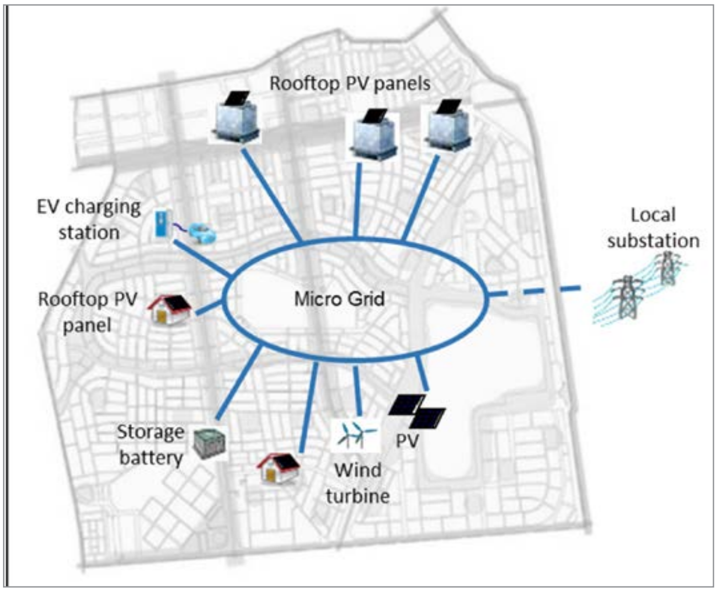
7.2.1. Area Energy Planning

As a result of future infrastructure development stemming from population growth and expansion of the Lima metropolitan area, electricity demand in Peru is forecasted to increase between 2012 and 2016 and there may be a short-term deficit before new supply capacity is fully online in Peru.[45] This demand will likely place increasing strain on the regional power grid, for which the primary feedstock is hydropower (56%) and natural gas (41%). A very limited supply comes from renewable energy (only 0.6%).

This study suggests that San Borja would benefit from a more decentralized power grid with multiple distributed energy sources such as kitchen waste-to-energy, hydropower, biomass energy, wind power, natural gas, and storage batteries and micro-grid implementation. To reduce the impact on the regional power grid and ensure the stability of the power supply, San Borja is interested in piloting a micro-grid system using untapped natural gas and renewable energy. They are, however, concerned about overall cost-effectiveness of a microgrid system, especially the costs for photovoltaic based-electric power generation. Figure 7-9 shows where the elements of a microgrid system could work together in San Borja.

45 BBVA Research (June 2012)." Economic Watch – Peru".

Figure 7-9: Possible Microgrid Application in San Borja



Source: Nikken Sekkei Research Institute

Table 7-1 summarizes the area-wide energy efficiency and management planning LCM, including microgrid implementation.

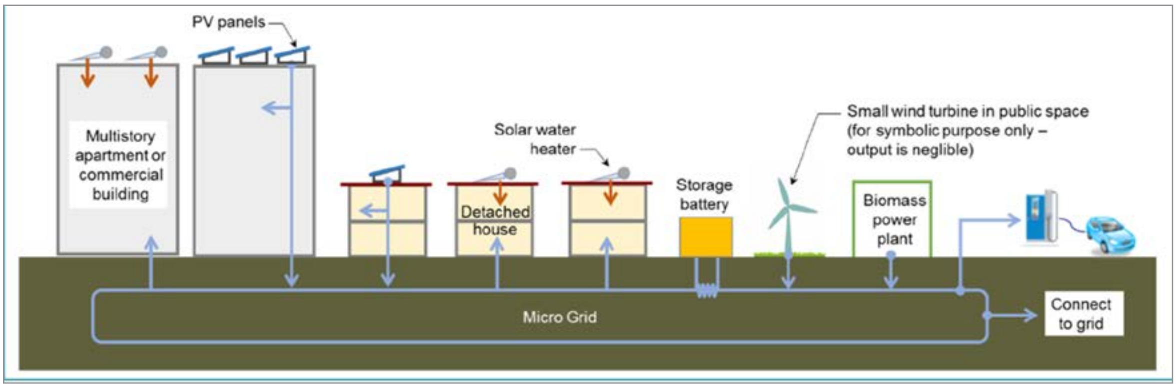
Table 7-1: Area-wide Energy Efficiency and Management Planning

Overview
Area-wide energy efficiency and management planning, specifically multi-source energy networks (microgrids), balances energy supply and demand and creates a decreased dependence and strain on regional utility grids and increased energy resilience. The results are: 1) supply redundancy and energy self-sufficiency; 2) reduced load on central power stations; 3) greater energy security by reducing the area's reliance on the grid; 4) back-up power for quick recovery after an outage event; and 5) more effective energy and load management.
Examples of Application
New York University (NYU), USA • Implemented a modern natural-gas fired combined heat and power facility. • Large up front cost, but were able to get tax exemptions. • Provides power to 22 buildings and heat to 37 buildings. • Achieved energy resilience for the entire university campus (successfully tested during Hurricane Sandy in 2012) Source: http://building-microgrid.lbl.gov/new-york-university;

Huatacondo, Chile

- Microgrid implementation in remote area in Chile, developed by the University of Chile.
- Microgrid includes a 150 kW diesel generator, 22 kW tracking solar PV system, a 3 kW wind turbine, a 170 kWh battery, and an energy management system.
- Renewable energy capacity is growing, making the area less dependent on the diesel generator.

Source: http://building-microgrid.lbl.gov/huatacondo



Source: Nikken Sekkei Research Institute

7.2.2. Community Energy Management System

This study recommends that San Borja consider implementing a community energy management system (CEMS) to monitor, report, and manage overall energy consumption, energy use intensity in buildings, and energy supply from local generation like such as PV systems throughout San Borja. Specifically, a CEMS could be implemented such that it:

- Connects BEMS[46] in large commercial/institutional buildings.
- Connects smart meters in commercial/institutional buildings.
- Connects smart meters or HEMS[47] in residential buildings.
- Is centrally managed by an energy management system center in a municipality office.

There is a possibility that the energy sector will go through further liberalization, thus creating competition between energy providers and generating options for users to choose energy suppliers. If this was to occur, there would be an opportunity to incorporate a smart metering system in the CEMS, which could help create a more liberalized market with pricing schemes such as dynamic pricing. Table 7-2 outlines the recommended LCM for implementation of a CEMS and future consideration for smart metering.

Table 7-2: Community Energy Management System and Smart Meter Implementation

Overview
CEMS can be used to monitor, report, and manage the overall energy consumption, energy use intensity in buildings and energy supply from local generation like such as PV systems throughout San Borja. CEMS benefits include: • Enabling performance management through visualization. • Pinpointing/prioritizing where to invest for more energy use reductions and savings. • Promoting energy-saving behaviors. • Helping to balance electricity supply and demand. • Guiding the collection, storage, monitoring, reporting, and management of energy performance metrics. Smart metering allows two-way communication between the meter (user side) and the power utility company (supply side) or central EMS by recording the real-time electricity consumption and communicating that information to the utility. This real-time electricity use data enables the power utility company or central EMS to control or regulate the power supply to a building or site under conditions of tight electricity supply. Consequently, large-scale blackouts could be prevented and power system reliability is enhanced. Energy awareness and changes in the energy consumption behavior of users are essential to realizing an energy-efficient and low carbon community. A smart metering system can help achieve this vision by providing users with improved energy data visualization, resulting to a better understanding of energy consumption trends and potential efficiencies/pricing options. Overall, smart metering offers the following potential benefits: User side • Self-initiated efficient use of electricity through monitoring of electricity consumption. • Quicker response to inquiries for issues such as contract changes. • Possibility of variety of electricity pricing options Utility side • Load leveling through peak demand control. • Revenue protection through early detection of fraud or unauthorized use of electricity. • Reduced operating costs related to non-paying customers (use restrictions, payment reminders, overdue collections, etc.) • Reduced operating costs due to meter readings. • Reduced environmental load through peak demand control. • Improved power supply reliability through supply- and demand-side data management.

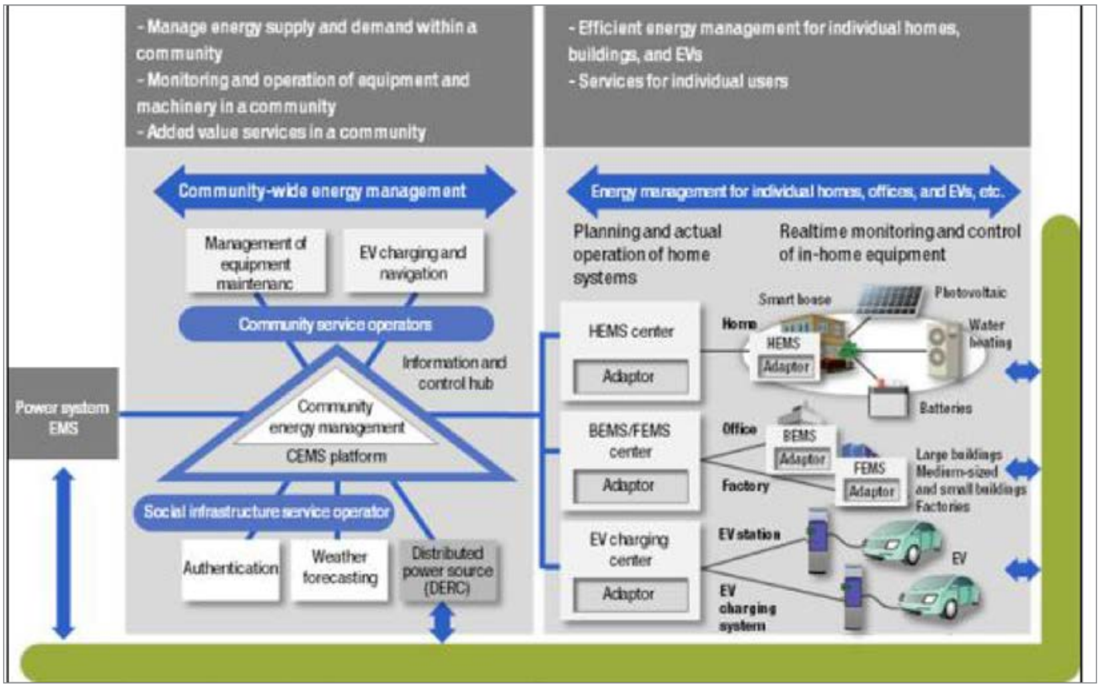
46 BEMS: Building Energy Management System
47 HEMS: Home Energy Management System

Examples of Application
Massachusetts (USA) Municipality Smart metering • Utility in an old Massachusetts municipality implemented a smart metering system to enhance reliability, reduce operating costs, and improve customer service. Spain Smart Meter Rollout • Directive in Spain that mandates installation of smart meters for 80% of existing meters by end of 2020. Sources: http://www.sourceone-energy.com/resources/case-studies/municipality-smart-metering-case-study/; http://www.dnvkema.com/Images/SG%20Data%20Communications%20Lab%20Madrid%20A4_070714.pdf

7.2.2.1. Possible Applications of Smart Meter Implementation

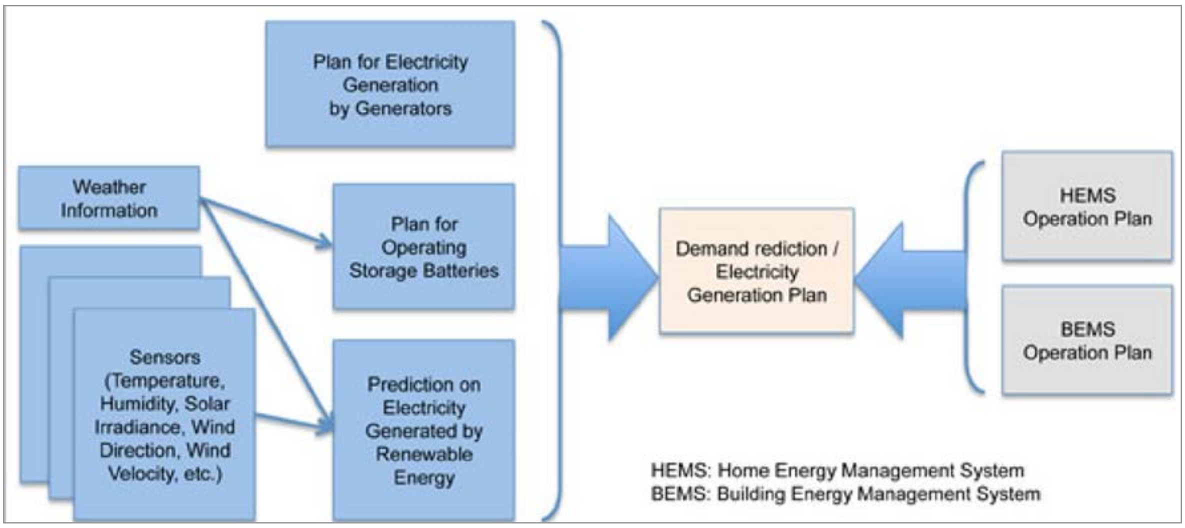
Figures 7-10 and 7-11 show the possible applications of smart meters for San Borja.

Figure 7-10



Source: Ministry of Economy, Trade and Industry of Japan (2013). Smart Meter Review Meeting

Figure 7-11

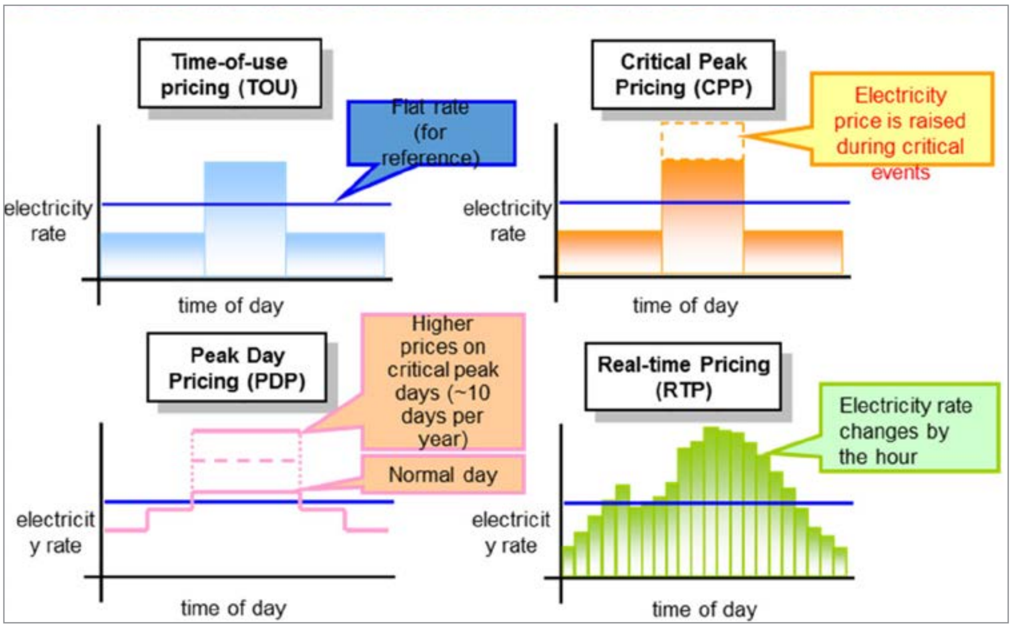


Source: http://www.hitachi.com/products/smartcity/solution/cems/

7.2.2.2. Possible Application of Demand Response

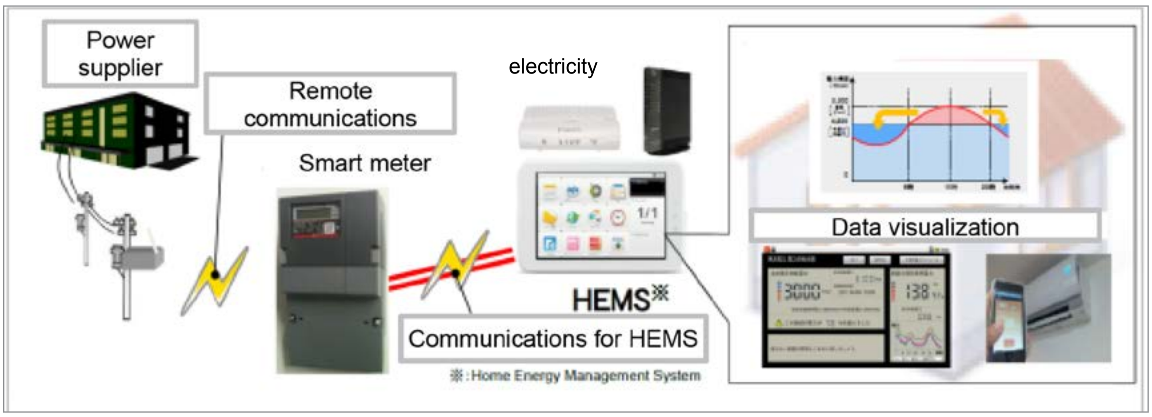
Additionally, San Borja could consider activating Demand Response (DR) during peak consumption periods. To do this, the utility would determine the Dynamic Pricing electricity rates according to the supply and demand loads. (See Figure 7-12) Upon receiving the DR notifications from CEMS, energy users could take voluntary actions and make energy consumption shifts based on their own preferences or pay the higher peak rate. Demand response could be a cost-effective way for reducing peak demand by altering users' behaviors. (See Figure 7-13)

Figure 7-12: Power Demand-Supply Forecast and EMS Operation Plans through CEMS (Kitakyushu Smart Community Project)



Source: Japan Smart City Portal homepage. http://jscp.nepc.or.jp/article/jscpen/20140520/398138/

Figure 7-13: Electricity Pricing for Demand Response



Source: Created by Nikken Sekkei Research Institute

7.2.2.3. Applying Area Energy Planning

When implementing a centralized energy management system to guide the collection, storage, monitoring, reporting, and management of energy performance metrics, this study recommends San Borja take the following factors into consideration:

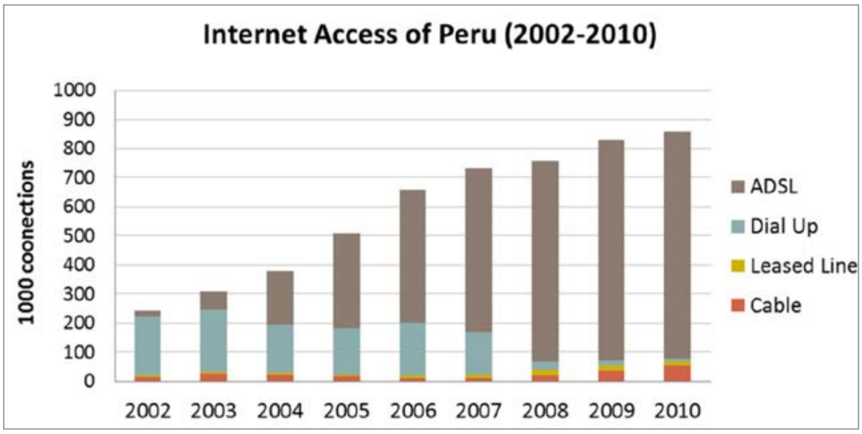
- Existing ICT infrastructure;
- Stakeholders;
- Available technologies; and
- Best practices globally.

A thorough evaluation of CEMS implementation should include the following:

- CEMS infrastructure and components,
- Connections with Energy Network (Smart Grid),
- Cost-benefit analysis,
- Business case and operation schemes,
- Financing mechanisms, and
- Best practice policies and procedures.

An additional consideration for San Borja is internet access, which is important for an efficient CEMS system. While the level of internet access in Peru has rapidly increased since 2002[48], it may still be insufficient to provide the infrastructure for the system (Figure 7-14). CEMS could be easily developed through wireless internet connections which help lower the construction cost of a full system.

Figure 7-14: Internet Access of Peru (2002-2010)



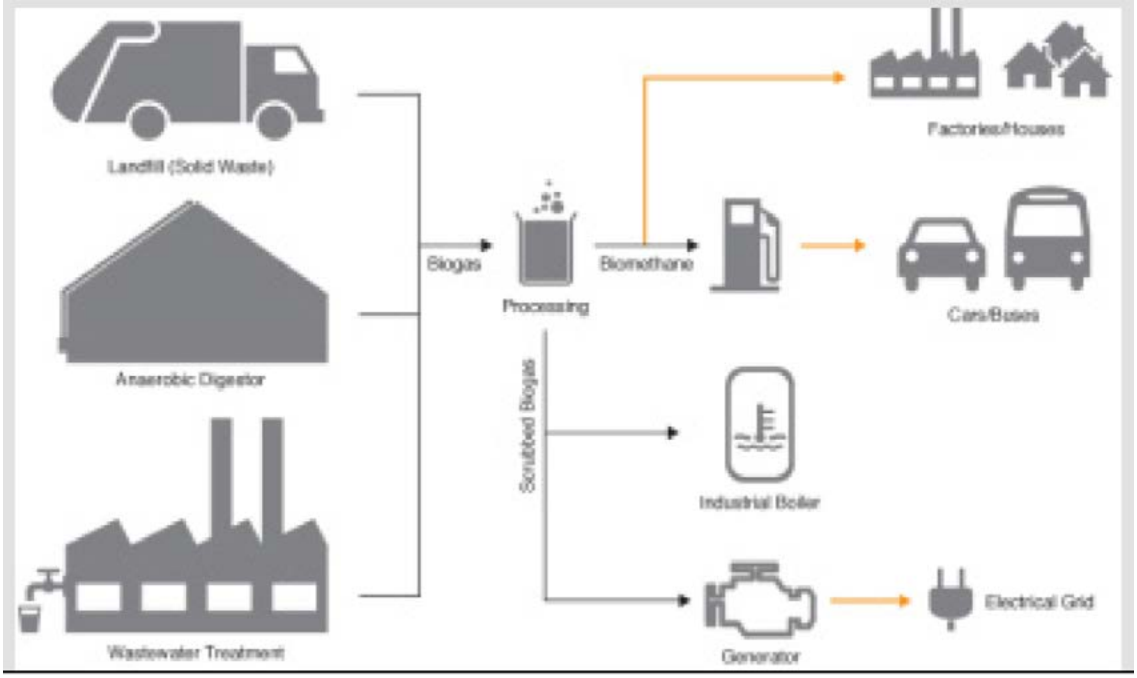
Source: Government of Peru (2011). "National Development Plan – Broadband in Peru (Plan Nacional Para El Desarrollo De La Banda Ancha En El Perú)".

7.2.3. Untapped Energy Planning

Untapped energy refers to waste-to-energy systems and the opportunity to reduce the emissions associated with landfill waste disposal. The example is capturing the waste heat from trash incineration and using it to generate electricity. Other examples include producing biogas and using it to generate electricity, create heat, and to produce fuel for motor vehicles. The GHG emissions reductions associated with this category are in the Solid Waste and Wastewater sector in the GHG accounting framework. Figure 7-15 illustrates the general process waste heat to energy as well as methane capture to energy. Waste-to-energy systems from organic waste are especially effective when combined with a waste separation and recycling system, or an anaerobic digester at a wastewater treatment plant.

48 Government of Peru (2011). "National Development Plan – Broadband in Peru (Plan Nacional Para El Desarrollo De La Banda Ancha En El Perú)".

Figure 7-15: Waste-to-Energy Conversion Process



Source: http://deepbluenrg.ca/applications/waste-to-energy/

Waste-to-energy, or the process of generating energy (electricity, heat and biofuel) from the processing (incineration, fermentation, or anaerobic digestion) of biomass waste, could provide San Borja with a new source of energy for either building heating and power or vehicle fuel. Potential biomass sources include commercial kitchen waste, home kitchen waste, yard clippings, and tree branches and leaves from forestry-thinning.

Table 7-3 summarizes the recommended LCM of implementing a waste-to-energy facility in San Borja.

Table 7-3: Waste-to-Energy

Overview
The two main types of waste-to-energy technologies include methane fermentation and generation of biomass diesel fuel. Waste-to-energy provides the following benefits: • Reduces methane emitted into the atmosphere. • Converts methane into useful energy, e.g., heat and electric power. • Repurposes materials that would otherwise go into a landfill into useful products, creating an ROI. • Increases the capacity of existing landfills to accommodate non-recyclable waste. There are two main types of waste-to-energy technologies: • Methane fermentation - Generating heat for District Heat and Cooling and electricity - Fuel for transportation • Biomass Diesel Fuel - Fuel for transportation Based on the waste volume San Borja can apply the methane fermentation technology for generating power, heat and fuel. The energy generated can be consumed locally or exported. See Figure 7-17 for details.

Expected CO2e Reduction Effect
• The net CO2e reduction from waste-to-energy is the CO2e emissions difference between waste disposal by landfill (before case) and waste-to-energy plant (after case). In the case of waste-to-energy plant, there would be an increase CH4 emissions and reduction in CO2 emissions. • Overall, we estimate that waste-to-energy would yield a net CO2e reduction of 139 tonns-CO2/day or 50,700 tonns-CO2/year if implemented in San Borja.
Examples of Application
Example waste-to-energy projects: • Switzerland Wastewater Treatment Plant (WWTP) - Green waste fermentation and composting area teamed with a nearby WWTP to become a common co-generator that efficiently transforms biomass into electricity and heat. • Floka Waste-to-Energy Facility, Chile - Facility is designed to treat organic waste from wastewater and other sources through biodigestion (humid fermentation) technology to produce biogas. Sources: http://www.iwaponline.com/wpt/006/0025/0060025.pdf; http://www.setatwork.eu/database/products/R162.htm

7.2.3.1. Applying Untapped Energy

San Borja would need to produce a minimum amount of waste to create an efficient waste to energy system. An urban town like San Borja has limited options for biomass energy sources such as commercial kitchen waste, home kitchen waste, yard clippings, and tree branches and leaves from forestry-thinning. A waste to energy system from organic wastes could be effective when it is combined with a waste separation and recycling system or an anaerobic digester at a Wastewater Treatment Plant. Current challenges to implementing waste-to-energy in San Borja include:

- San Borja generates 71.6 metric tons of solid waste from households daily (~ 0.64 kg/capita/day). The solid waste from households generation is expected to exceed 84.5 metric tons per day by 2021, and the daily per-capita generation has been projected to grow by 1% annually.
- Small recycling program (only 7,904 households).
- San Borja currently does not have a dedicated transfer station or landfill. The municipality wants (but does not want to own) a dedicated transfer station with waste segregation, waste repurposing, and waste-to-energy functioning.
- Only a few commercial enterprises contribute their used cooking oil to San Borja's demonstration of biodiesel production in Kallpa Wasi, but there are opportunities to expand this program with increased capacity to convert cooking oil to biodiesel.

Additional challenges to implementing a waste-to-energy system include:

- Initial construction costs.
- Time and cost of maintaining the waste-to-energy plant.

The following are short-, medium- and long-term strategies that San Borja could implement in the waste sector as shown in Table 7-4 below.

Table 7-4: Carbon Reduction Measures in the Solid Waste Sector

	Short term (2018)	Medium term (2021)	Long term (2035)
Waste-to-energy plant (biomass plant)	Form action plan and management body; select business operator	50% of capacity in operation	100% of capacity in operation
Waste recycling and repurposing	Education of residents; continue with vendors to recycle and convert trash to useful products	50% of capacity in operation	100% of capacity in operation

Based on waste volume, San Borja can apply the methane fermentation technology for generating power, heat, and producing biofuel (Figure 7-16). The energy generated can be consumed locally or exported. Below is an initial process for estimated waste to energy potential from landfill methane capture.

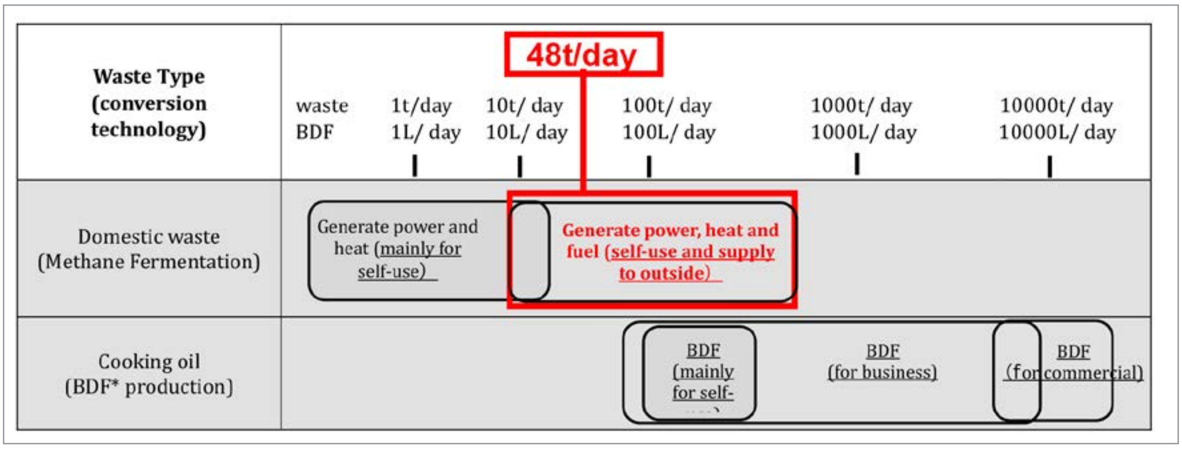
- Amount of solid waste from households in San Borja:
  - Total generation in 2021 = 84.5 Mt/day
  - Per capita generation in 2021 = 0.64* x 84.5 / 71.6** = 0.75 kg/capita/day

    *Current solid waste generation = 0.64 kg/capita/day

    *Current solid waste generation = 71.6 Mt per daily
- Amount of waste (combustible waste) to be converted to energy
  - Half of total solid waste generation in 2021 = 43 Mt/day
  - Half of total solid waste generation in 2035 = 43 + 84.5x1%* x (2035-2021) = 48 Mt/day

    *Projected annual growth of daily per-capita generation is 1%.

Figure 7-16: Waste Amount and Applicable Biomass Conversion Technologies



Source: Adapted from NEDO's "Biomass Energy Guidebook" (2010). *BDF: biodiesel fuel

7.2.4. Renewable Energy Planning

As described in Section 7.1.3, the potential for generating geothermal and wind energy in San Borja is limited. In addition, historically, the implementation of solar energy systems in San Borja has been limited due to perceived cost-ineffectiveness and limited sunny days. However, San Borja has an opportunity to overcome those obstacles by implementing photovoltaic (PV) technologies that work efficiently under overcast conditions. Furthermore, San Borja has a low average year-round temperature, which is beneficial to solar cell efficiency. Therefore, this study recommends that small-scale solar power sources be evaluated. Table 7-5 outlines the recommended renewable energy LCM.

Table 7-5: Solar Energy Technologies

Overview

Solar energy technologies applicable to this LCM include:

Solar PV power systems: PV technology that converts solar energy into electricity can generally be categorized into flat-plate and concentrating PV systems. Flat-plate panels do not require direct sunlight so they can work even when diffuse radiation is high. A PV system is made up of PV cells that interconnect to form PV modules. Currently, commercial PV modules are broadly divided into the following types:

- Water-based crystalline silicon: Crystalline silicon solar modules are the most widely used PV modules built using crystalline silicon solar cells. Crystalline silicon modules are typically subdivided in single crystalline and multi-crystalline. Multi-crystalline has lower efficiency but are less expensive than single crystalline silicon.
- Thin-films: Thin-film solar cells are made by depositing one or more thin layers of photovoltaic material on a substrate such as steel, glass or plastic. Thin film modules are generally subdivided into amorphous / micromorph silicon; cadmium telluride; and copper indium diselenide / copper indium gallium diselenide. They generally have lower operational efficiency under standard test conditions and lower manufacturing costs than crystalline silicons. However, a study in Europe have shown that amorphous silicon and copper indium diselenide are more efficient under overcast conditions.[49]

Solar Water Heating Systems: Like PV systems, solar collectors could can be either non-concentrating or concentrating. Since San Borja receives a high portion of diffused solar radiation, only non-concentrating solar collector technologies that could convert both direct and diffused solar radiation into heat are applicable. Currently, solar water heating systems are broadly divided into the following categories:

- Evacuated tube collectors: These collectors are usually made of parallel rows of transparent glass tubes, with each tube containing a glass outer tube and metal absorber tube attached to a coated fin that absorbs solar energy. The vacuum space between the two glass tubes minimizes conductive and convective heat loss. Evacuated tube collectors generally have higher solar yield than flat plate collectors with the same absorption area. However, the high installed costs of evacuated tube collectors make them an unattractive investment, especially for residential applications.
- Flat-plate collectors: Flat-pate solar collectors are the most common type of solar collectors in most countries (including Peru) because they are cheap to manufacture and easy to maintain. The main components of flat-plate collectors are a transparent front cover that reduces heat losses, and a dark flat-plate absorber that converts sunlight to heat and transfers it to fluid in tubes.
- Solar Water Heating Systems: Like PV systems, solar collectors could can be either non-concentrating or concentrating. Since San Borja receives a high portion of diffused solar radiation, only non-concentrating solar collector technologies that could convert both direct and diffused solar radiation into heat are applicable.

There are two main water heating methods: 1) active solar water heating systems with circulating pumps and controls; and, 2) passive solar water heating systems which rely on gravity to circulate water. Passive systems are usually less expensive, but also less efficient than active systems.

Examples of Application

Examples of Solar Energy Project Implementation:

- Local Solar Energy Implementation – Dezhau, China
  - Municipality of Dezhou centralized solar technology research and development, manufacturing, education and capacity building.
  - The city now has over 120 solar energy enterprises which generate an annual turnover of USD 3.46 billion
- Sao Paulo Solar Water Heating System
  - The Solar Ordinance of Sao Paulo requires new residential, commercial, and industrial buildings to install solar water heating systems (SWH) to cover at least 40% of the energy used for heating water

Source: International Renewable Energy Agency

49 Jardine, C. N., Conibeer, G. J. & Lane, K. (2001). “PV-COMPARE: Direct Comparison of Eleven PV Technologies at Two Locations in Northern and Southern Europe”.

7.2.4.1. Possible Solar Energy Applications

Possible solar energy applications for the residential sector in San Borja are shown in Figures 7-17 thorough 7-19.

To estimate the potential carbon emissions reductions from solar energy implementation in San Borja, the report exampled solar energy implementation under the following scenarios:

- Scenario 1: Install rooftop PV systems for 20% of residential and commercial buildings (calculated based on roof areas).
- Scenario 2: Install solar hot water systems for 20% of all residential buildings (calculated based on dwelling units).
- Scenario 3: Install rooftop PV systems for 10% of residential / commercial buildings and solar hot water systems for 10% of residential buildings.

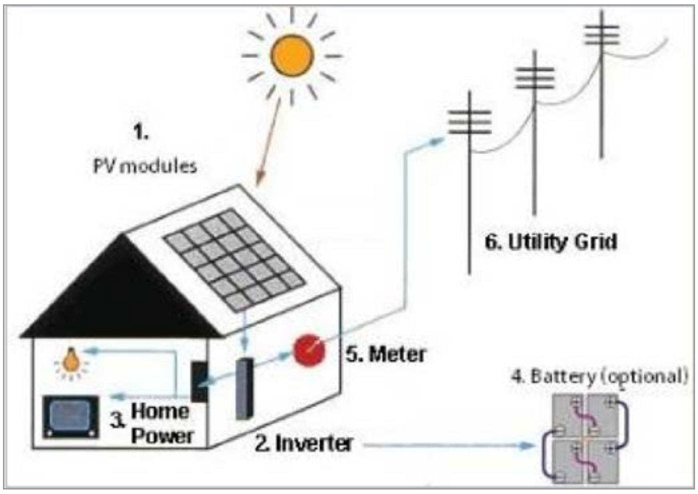
Table 7-6: Building Roof Areas and Number of Dwelling Units

Building Type	Total building roof area (m2) (% of total)*	Number of dwelling units**
Low-density residential buildings	2,265,052	15,100
Medium-density residential buildings	275,157	7,338
High-density residential buildings	300,300	12,012
Total	**2,840,509 (88.6%)**	**34,450**
Neighborhood type commercial buildings	35,304	
Retail and office buildings	312,767	
Medical facilities (clinics, hospitals)	10,886	
Total	**358,957 (11.2%)**	
Municipality Headquarters building	**4,800**	

*Building roof areas are assumed to be the same as those in Chapter 6.

**The number of dwelling units is assumed to be the same as those in Chapter 6.

Figure 7-17: Residential Grid Connected PV System



Source: http://www.marincounty.org/depts/cd/divisions/planning/sustainability/energy-programs/marin-solar-program/photovoltaic-basics?p=1

The energy output from the solar energy systems were estimated based on the following assumptions:

PV power generation systems:

- Annual global horizontal irradiation = 5,619 MJ/m2
- PV panels are installed flat on the roof and PV panel area equals 50% of roof area.
- Module conversion efficiency = 15%
- PV system efficiency (including all system losses and shading) = 70%
- PV output (MJ/year) = PV panel area (m2) x 5,619 MJ/m2 x 15% x 70%

Figure 7-18: Evacuated Tube Collectors and Flat-plate Collectors Common in Peru

Source: Organization of Energy of Latin American and the Caribbean (2012). “SWH Market Assessment Regional Report”.

Solar water heating systems:

- Overall energy savings rate is 20% of baseline hot water energy consumption.
- Energy consumption of water heating system in one dwelling unit is:

Q = m cp (Th - Tc) = 9,169,092 kJ/year = 2,547 kWh/year

where: cp = specific heat of water = 4.1868 kJ/kg-K

Th - Tc = temperature difference of water = (50-10) K = 40 K

m = water flow rate = (150L/day) (1kg/L) = 150 kg/day

Figure 19: Possible Solar Energy Application

Source: Nikken Sekkei Research Institute

The potential solar energy output solar from the three implementation scenarios above are summarized in Table 7-7 below.

Table 7-7: Scenarios for Solar PV Generating Electricity

Solar Energy System	Scenario 1	Scenario 2	Scenario 3
PV power generation: Total roof area (m2) PV panel area (m2) PV output (MJ/year)	 640,853 320,427 189,050,113		 320,427 160,213 94,525,056
Total PV output (kWh/year)	52,513,920		26,256,960
Solar water heating (SWH): Number of dwelling units Total energy demand from water heating system (kWh/year)		 6,890 17,548,623	 3,445 8,774,312
Energy savings (20%) from SWH output (kWh/year)		3,509,725	1,754,862
Total solar energy output (kWh/year)	52,513,920	3,509,725	28,011,822

7.3. GHG Reduction Analysis and Cost Estimates

7.3.1. Area Energy Planning

Reduction Analysis

The projected GHG emission reductions from “area energy planning” LCMs are estimated and summarized in Table 7-8.

Table 7-8: Projections of GHG Reduction Percentages from “Area Energy Planning” LCMs

Building Sector	GHG Reduction Projections from BAU (%)		
	Short term (2018)	Medium term (2021)	Long term (2035)
Residential	-5%	-5%	-5%
Commercial	-5%	-5%	-5%
Municipal	-5%	-5%	-5%

Note: The percentages of reduction shown above are based on the CO2e reductions achieved by actual installations in Japan. The reductions should be applied to the net building CO2e emissions after low building design strategies have been considered, not to the total building CO2 emissions in BAU scenario. Refer to Chapter 9 for details on the CO2e reduction analysis.

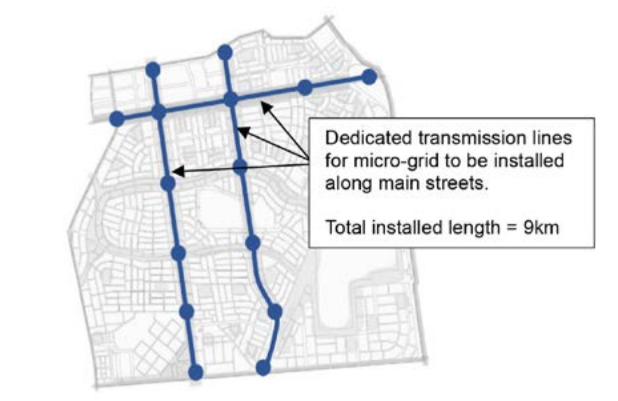
Cost Estimates

The accuracy of the cost estimates for micro-grid implementation is highly dependent on the construction costs of transmission lines for the grid. To estimate the construction costs for micro-grid implementation, the following two power transmission scenarios have been examined:

- Scenario 1: Utilize the existing power transmission network in San Borja. This scenario generates little to no costs.
- Scenario 2: Install new underground power transmission lines dedicated for the micro-grid. The potential installed length of the transmission line was estimated to be about 9 km based on the current street configuration in San Borja (Figure 7-20). Assuming a unit construction cost of USD 1,870,000/ km[50], the total construction cost would be USD 16,830,000.

50 The unit construction cost for San Borja was evaluated by referencing the installations costs in Japan with consideration of the cost ratio between Peru and Japan.

Figure 7-20: Potential Installation Routes of New Transmission Lines for Micro-grid



Source: Nikken Sekkei Research Institute

Table 7-9: Cost Estimates for Micro-grid Implementation

Cost Component	Initial Cost (USD)
Construction of new underground power transmission lines	16,830,000

7.3.2. CEMS

Reduction Analysis

The projected GHG emission reductions from "Community Energy Management System (CEMS)" implementation are estimated and summarized in Table 7-10.

Table 7-10: Projections of GHG Reduction Percentages from "CEMS" LCMs

Building Sector	GHG Reduction Projections from BAU (%)		
	Short term (2018)	Medium term (2021)	Long term (2035)
Residential	-5%	-5%	-5%
Commercial	-5%	-5%	-5%
Municipal	-5%	-5%	-5%

Note: The percentages of reduction shown above are based on the CO_2 reductions achieved by actual installations in Japan. The reductions should be applied to the net building CO2e emissions after low building design strategies have been considered, not to the total building CO2e emissions in BAU scenario . Refer to Chapter 9 for details on the CO2e reduction analysis.

Cost Estimates

The initial costs for CEMS includes the basic system platform for network, information system, and smart-meters. The cost estimate in Table 7-11 below is based on the following assumptions:

- The estimates cover the basic system platform for network, information system for CEMS, and smart-meters in each building.
- The unit initial costs for San Borja were evaluated by referencing the initial costs of current EMS installations in Japan with consideration of the cost ratio between Peru and Japan.
- The unit cost for installing smart meter is 209 USD/unit.
- Smart meters are installed in 50% of residential buildings and 100% of commercial buildings, retail and office buildings, medical facilities and Municipality Office building (Table 7-12).

- The initial costs for a CEMS System generally consists of hardware costs and software costs. For a typical CEMS installation in Japan, the cost share of hardware and software components is 40% and 60% respectively.

Table 7-11: Cost Estimates for CEMS in San Borja

Cost Component	Initial Cost (USD)
CEMS System Hardware (information platform etc.) Software (information system, applications, etc.)	$2,059,125
Smart meter	$3,834,796
Total initial cost (USD)	**$5,893,921**

Table 7-12 Number of Smart Meters by Building Type

Building Type	Number of floors (average)	Total land plot area (m^2)	Total building footprint (m^2)	Total building floor area (m^2)	Estimated number of dwelling units	Assumed floor area per unit (m^2)
Low-density residential buildings	2	3,235,789	2,265,052	4,530,105	15,100	300
Medium-density residential buildings	4	393,082	275,157	1,100,629	7,338	150
High-density residential buildings	6	429,000	300,300	1,801,798	12,012	150
Neighborhood type commercial buildings	2	44,130	35,304	70,608	101	700
Retail and office buildings	3	390,959	312,767	938,301	938	1000
Medical facilities (clinics, hospitals)	2	13,607	10,886	21,772	44	500
Municipality Office building	2	6,000	4,800	9,600	10	1000
				Total number of dwelling units	**35,543**	
				Assumption: Smart meters are installed in 50% of residential buildings, and, 100% of commercial buildings, retail and office buildings, medical facilities and Municipality Office building.	↓	
				Number of Smart meters	**18,318**	

7.3.3. Untapped Analysis

Reduction Analysis

The GHG emissions reduction from waste-to-energy plant (biomass plant based on methane fermentation technology) is estimated based on the following calculations.

- The CO2e emissions from the proposed waste-to-energy plant were estimated based on the GHG emission data of existing studies.
  - CO2 emissions (waste-to-energy plant): 161 kg-CO2/Mt[51]
  - CH4 emissions (kitchen waste in landfill disposal): 0.145 mt-CH4/Mt [52]
- The net CO2e reductions would be the CO2e emissions difference between waste disposal by landfill (before case) and waste-to-energy plant (after case). As shown in Table 7-13 there would be an increase in CO2 emissions and a reduction in CH4 emissions resulting in a net reduction in CO2e emissions.

51 Source: NPO waste recycle network in Japan.
52 Source: Ministry of the Environment of Japan. http://ghg-santeikohyo.env.go.jp/files/calc/itiran.pdf.

Table 7-13: CO2e Emission Factors and GHG Emission Rates of Waste-to-Energy Plant

	CO2e Emission Factors (kg-CO2e/Mt)				GHG Emission Rates		
					(kg-CO2/Mt)	(kg-CH4/Mt)	(kg-N2O/Mt)
GHG	CO2	CH4	N2O	Combined	CO2	CH4	N2O
rate	-161	3,045	-	**2,884**	161.0*	145.0	-

*CO_2 emissions avoided by the waste-to-energy plant.

- CO2e emissions reduction from the proposed plant:
  - 48Mt/day x 2,900 kg-CO_2/Mt = 139Mt-CO_2/day = 50,700 Mt-CO_2/year

Table 7-14: GHG Reduction Percentages from Landfill Waste-to-Energy

Sector	CO2 Reduction Projections (%)		
	Short term (2018)	Medium term (2021)	Long term (2035)
Waste	0%	0%	36%*

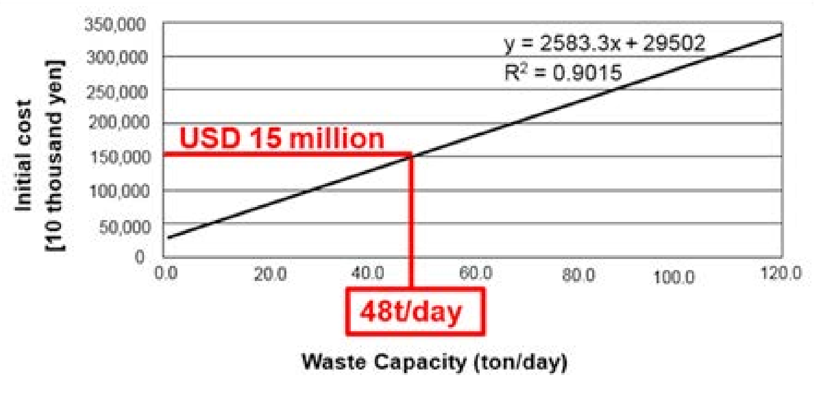
*The CO_2 emission in 2035 under BAU scenario was projected to be 141,355 Mt-CO2/year. Reduction rate = 50700/141355 = 36%.

Cost Estimates

- Initial Cost (using costs from actual waste-to-energy installations in Japan as reference)

Based on the “initial cost versus waste capacity of biomass plant” graph (Figure 7-21), the initial cost for the proposed waste-to-energy plant is estimated as USD 15 million (1.5 billion Japanese yen) for 48 tons/day of waste.

Figure 7-21: Initial Cost versus Waste Capacity of Biomass Plant



NEDO Biomass Energy Guidebook (3rd Edition) (2010)

- Operating Costs (using costs in Japan[53] as reference)
  - Maintenance costs: initial cost × 10%
  - Total operating cost is USD 1.5 million/year.

53 The cost estimation above includes labor, lighting, heating and water utility costs, taxes, residues of waste treatment, etc. The estimation is based on case studies in Japan.

7.3.4. Renewable Energy

The potential energy output and GHG reductions from the three solar energy implementation scenarios outlined at the beginning of this section are summarized in Table 7-15 below.

Table 7-15: Solar Energy Output and GHG Emissions Reductions

Solar Energy System	Scenario 1	Scenario 2	Scenario 3
Total solar energy output (kWh/year)	**52,513,920**	**3,509,725**	**28,011,822**
Total CO2e reduction (kg-CO2e/year)[54]	**7,120,888**	**475,919**	**3,798,403**
CO2e reduction (kg-CO2e/year) in:			
Residential sector	6,312,505	0	3,156,253
Commercial sector	797,715	475,919	636,817
Municipal sector	10,667	0	5,334
CO2e reduction (kg-CO2e/m2-yr) in:			
Residential sector	0.85	0.00	0.42
Commercial sector	0.77	0.46	0.62
Municipal sector	1.11	0.00	0.56

Reduction Analysis

Table 7-16 depicts GHG reductions by building sector based on the renewable energy planning LCM described in Scenario 3.

Table 7-16: Projections of GHG Reductions from "Renewable Energy Planning" LCMs

Building Sector	GHG Reduction Projections (kg-CO2e/m2)		
	Short term (2018)	Medium term (2021)	Long term (2035)
Residential	0.08	0.14	0.42
Commercial	0.12	0.20	0.62
Municipal	0.10	0.18	0.56

Note: The CO2e reductions for long term were calculated as shown in Chapter 7. The CO2e reductions for short and medium term were projected (calculated backward) based on the gaps between projection years.

Cost Estimates

The capital cost of a PV system consists of the PV module cost (raw material costs, manufacturing, and assembly costs) and the Balance of System cost (site preparation cost, costs of electrical systems such as inverter, transformer, wiring and installation). Studies have shown that the cost of PV systems has and will continue to rapidly decline (will likely be 40%-60% of current cost by 2020).[55]

The initial costs for implementing renewable energy systems in San Borja were estimated based on the following assumptions:

- Installed costs for photovoltaic systems is 443 USD/m2 of panel area.[56]

54 CO2 conversion factor: 135.6 grams of CO2e per 1 kWh of electricity.
55 Source: International Renewable Energy Agency (IRENA) (2013), "Solar Photovoltaics Technology Brief".
56 According to the U.S. Department of Energy's Lawrence Berkeley National Laboratory's "Tracking the Sun IV" (2013), the average installed costs for solar photovoltaic systems in the U.S. in 2012 was $5.30/W for residential and small commercial systems. Assuming a rated output of 100W for one square meter of PV panel area, the installed costs would be approximately $530/m2. Using the scaling factor described in section 6.4.3, the installed costs for PV system in Peru are $530/m2 x (23.3/27.9) = $443/m2

- Installed costs for solar water heating systems is 1,400 USD per dwelling unit.[57]
- Scenario 1: Install rooftop PV systems for 20% of residential and commercial buildings.
- Scenario 2: Install solar hot water systems for 20% of all residential buildings.
- Scenario 3: Install rooftop PV systems for 10% of residential/commercial buildings and solar hot water systems for 10% of residential buildings.

57 According to the “SWH Market Assessment Regional Report” (2012) by Organization of Energy of Latin American and the Caribbean, the equipment costs range between USD 800 and 2,000 for a solar water heating system in Peru.

8. ENVIRONMENTAL PLANNING

This chapter addresses the environmental planning areas of waste recycling, waste water re-use, and urban forestry. The first section provides an overview of San Borja's current practices related to these areas. The second section outlines recommended LCMs that build on the existing activities listed in San Borja's Sustainability Plan and the emissions targets outlined in San Borja's 2021 Low Carbon Plan. The third section summarizes the GHG emissions performance and cost performance of these measures.

8.1. Background and Issues

8.1.1. Environmental Planning Defined

For the purposes of this study, environmental planning incorporates the following three aspect areas:

Recycling Program Expansion: includes waste reduction, re-use, recycling, and resident education around sorting recyclable waste from waste that will be sent to the landfill. The GHG emissions reductions associated with this category do not include waste-to-energy systems and are in the Solid Waste and Wastewater GHG accounting framework.

Biofiltration for Wastewater Reuse: considers the impacts of water use related to the indirect emissions from the energy that it takes to treat and pump water to the end-user (in this, for irrigation of urban greenery, parks and forest) and the methane emissions associated with wastewater treatment and recycling. The GHG emissions reductions associated with water supply from biofiltration are in the Urban Greening Forest sector in the GHG accounting framework. The GHG emissions reductions associated with water reuse are accounted for in the Solid Waste and Wastewater section in the GHG accounting framework.

Urban Greening and Forestry Expansion: includes planting trees and shrubs along roadways, boulevards and residential streets, and incorporating green infrastructure (i.e., building-integrated natural infrastructure) in residential and commercial buildings. The GHG emissions, reductions, and sequestrations associated with these LCMs are accounted for within the Urban Greening and Forestry and Municipal sectors (i.e., implicit passive design to minimize heat load discussed in Chapter 6) in the GHG accounting framework.

8.1.2. Challenges and Responses

San Borja is an environmental planning leader within Lima Province. Park Felicidad, a frequently visited public park, is one example of this leadership. It has many environmental planning features, including a biofiltration treatment plant to supply water for nearby irrigation, recycling containers, and a set of stationary bicycles that provide power to the park's Christmas tree during the holiday season.

Understanding the need to involve the public in environmental planning of the municipality, San Borja environmental planning staff have established programs to engage residents in planning efforts.

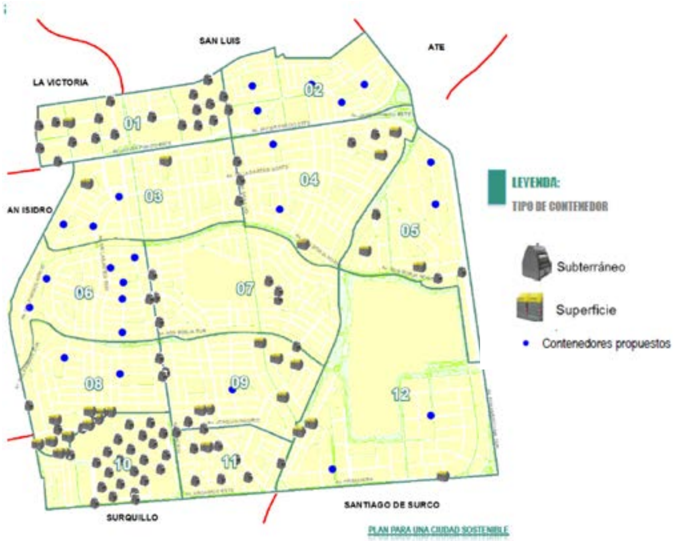
Case Study – San Borja Kallpa Wasi Project
In October, 2009, the San Borja District completed the Kallpa Wasi Project, a venture to create a sustainable and energy efficient park and public house. The park/house, whose purpose is to promote and educate citizens and tourists on sustainability, utilizes renewable energy and sustainable technologies to reduce its carbon footprint and preserve the local environment.
Program Areas
Kallpa Wasi employs the following sustainable practices and technologies: • Renewable Energy –lighting, water heating, and other energy needs at the park/house are supported by solar and wind technologies. • Composting – on-site composting of organic materials from the garden and landscaping. • Biodiesel – on-site biodiesel plant that creates fuel for municipal vehicles. • Wastewater Treatment - machine for treating sewage sludge.
Awards / Recognition
The Kallpa Wasi Project has been recognized for its leadership in sustainability implementation and environmental education. The project won first place in the 2012 Green Lima – Parks & Gardens Award – Citizen Interventions Category (organized by the newspaper El Comercio , the Municipality of Lima and SERPAR).

Sources: http://soytusanborja.wordpress.com/2013/10/30/casa-kallpa-wasi/
http://www.gestionpublica.org.pe/plantilla/rxv5t4/1029474941/enl4ce/2013/seti/revges_0913_22.pdf
http://www.munisanborja.gob.pe/index.php/historial-de-noticias/293-kallpa-wasi-obtuvo-el-primer-lugar-en-el-concurso-lima-verde-parques-y-jardines.html

8.1.2.1. Recycling Program Expansion

San Borja generates approximately 0.64 kg of solid waste per capita each day. Waste generation in the municipality averages 100 tons/day, and is comprised of trash generated by households (71.6 tons/day), by street sweeping (3.54 tons/day), and at commercial establishments, institutions, and schools (25.08 tons/day).[58] The District offers curbside trash collection to residents living in some areas of San Borja, with waste pick up contracted to a private company. However, most residents must deposit their solid waste in underground repositories. There are 74 underground containers with a 5 cubic meter capacity and 49 underground containers with a capacity of 2 cubic meters (see Figure 8-1).

Figure 8-1: Waste Collection Containers in San Borja

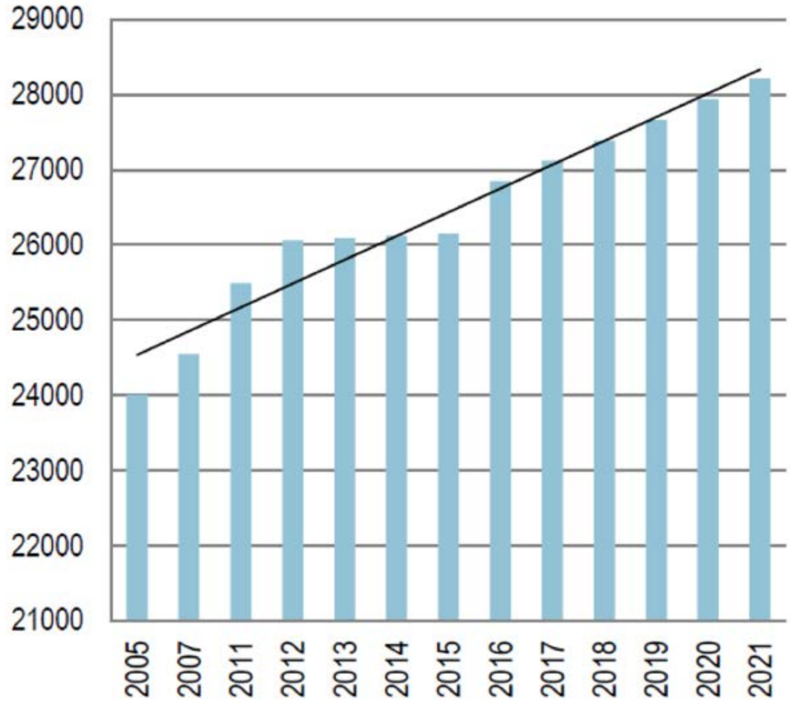


Source: 2035 Sustainable City Plan

58 2035 Sustainable City Plan

To ensure the waste area is large enough to manage predicted future increases in solid waste generation San Borja plans to add 25 new containers in high density areas in 2015.[59] Figure 8-2 below shows projected total tons of trash that San Borja will generate in a BAU scenario between 2014 and 2021.

Figure 8-2: Forecast of waste generation (metric tons) in San Borja



Source: 2035 Sustainable City Plan

San Borja is still in the early stages of developing its waste recycling program, but aims to recycle 100% of reusable solid waste and to treat 20% of organic wastes by 2021. The district currently offers a pilot trash separation and recycling program to residential households. Residents separate their trash into five waste streams: glass, plastic, paper, cardboard and aluminum. The majority of the trash, however, still goes to landfill. This study recommends that San Borja expand this program to include all residents and to continue moving toward recycling all trash. At present, the value of this program is mostly public education, awareness, and helping people learn to change behavior by doing. Benefits of public education on recycling:

- Earning community and stakeholder buy-in through direct participation;
- Reducing the amount of waste (i.e., plastic bottles) sent to landfill;
- Supporting methane waste-to-energy at one landfill;
- Enticing other residents to join the program; and
- Helping create jobs, revenue, and profit from trash (e.g., GEXIM factory).

The following are highlights from the current recycling program:

Plastic Bottle Recycling: All plastic bottles collected in San Borja are sent to GEXIM, a company that currently processes 250 metric tons of plastic per month from sources all around Lima Province. GEXIM takes plastic bottles, and through an industrial process transforms them into blankets, grocery bags, and

59 2035 Sustainable City Plan

bedding, and as well as geotextiles that construction companies can use for buildings and road construction. As of 2014, there are 7,904 of 36,000 San Borja families participating in the program, thereby helping San Borja avoid contributing several tons of trash each year to nearby landfills.[60] In 2012, the GEXIM plant helped San Borja reduce emissions by 17.2 MtCO2e by repurposing 7.4 short tons of plastic into useful products (Figure 8-3).

Glass Bottle Recycling: All glass bottles that are collected are managed by interagency agreement with FUNDADES, a Peruvian social non-profit that coordinates recycling efforts.

Composting: San Borja currently has a small pilot demonstration project for composting organic waste, but has yet to implement composting at a broad municipal scale.

Figure 8-3: Current Recycling Efforts in San Borja

Recycling Containers in Parks

Source: 2035 Sustainability Plan

GEXIM (water bottle repurposing facility)

Source: Hitachi Consulting

8.1.2.2. Biofiltration for Wastewater Reuse Expansion

San Borja is located within a desert, and in a desert all water (especially drinking water) is precious. San Borja wants to stop using drinkable water for irrigation of its parks, urban forest, and urban greenery and instead re-use wastewater, also known as “greywater.” In addition to its system of using canals for irrigation, San Borja currently has two biofiltration water treatment facilities that it is testing in a pilot program for this purpose (Figure 8-4).

60 Information retrieved during site visit on July 30 – August 1, 2014.

Figure 8-4: Biofiltration Water Treatment System on Irrigation Calans in San Borja

Source: Site visit, August 2014

Both facilities use a gravity system that can treat up to 500m3/day of water with a cumulative flow rate of three liters per second. There is not a disinfection unit so the water is not drinkable; it is, however, sufficiently clean to use for irrigation. The treatment steps of the gravity system are:[61]

Storage tank → Degreaser tank → Sediment tank →

Biofilter tank → Microfeeder tank → Ultraviolet filter

The source of the greywater is the Surco River, which is a canal (see the far hand picture in Figure 8-4 above) fed from the Rimac River that empties untreated wastewater directly into the Pacific Ocean. The current biofiltration facilities prevent untreated wastewater from flowing directly into the Pacific Ocean, and help San Borja avoids 49 metric tons of emissions each year (for just irrigation of green spaces and urban forest) by helping reduce fugitive nitrous oxides (N2O) emissions from the open canals running through San Borja. San Borja uses this water treated by its biofiltration system to irrigate its public parks, growing urban forest, and green space through a combination of a sprinkler system and controlled flooding in its parks, along its boulevards and roadways. The municipality also has plans to expand the use of sprinklers for irrigation as a replacement for the old model of using canals to flood an area (Figure 8-5). This will help improve the efficiency of water used for landscaping.

61 Information retrieved during site visit on July 30 – August 1, 2014.

Figure 8-5: Water Sprinklers in a Park in San Borja

Source: 2035 Sustainable City Plan

8.1.2.3. Urban Greening and Forestry Expansion

The total area of green space in San Borja is 1,357,236 m2, which is 13.51% of the District's total 10,044,158 m2 of land area. San Borja's goal is 25% total shade cover of its land area by 2035; as of 2012, the total percentage of shade cover was 10%. The existing green areas in San Borja are shown in Figure 8-6. This includes not only urban forest and shrubs, but also other green spaces, such as landscaping along boulevards, green roofs, and parks (Figure 8-7).

The most common tree type in San Borja is the eucalyptus. Inside Peru's national Department of Defense (DOD) property, located within San Borja's boundaries, there are approximately 25,000 eucalyptus trees that will become available for future transplantation (Figure 8-8). The planted area on DOD property functions as a nursery for growing seedlings into trees until they are ready for transplantation into the District. The CO_2 sequestered by the trees while on DOD land is not accounted for in San Borja's baseline inventory because these grounds are outside the accounting boundary of the District, and therefore outside the accounting parameters for the inventory per best practice GHG accounting guidelines.

Figure 8-6: Green areas in San Borja

Source: 2035 Sustainability Plan

Figure 8-7: Examples of Green Areas within San Borja

Source: 2035 Sustainability Plan

Figure 8-8: San Borja Tree Nursery

Source: Nikken Sekkei Research Institute

8.2. Proposed Low Carbon Measures

8.2.1. Solid Waste Recycling and Repurposing Expansion

Increase the number of households participating in recycling, and continue working with professional recycling and repurposing companies. Table 8-1 describes the LCMs for waste recycling

Table 8-1: Waste Recycling and Repurposing

Overview
This LCM may be realized through: **Increase Recycling through Education (e.g., Waste recycling guideline)** Recycling education and awareness may include publishing recycling guidelines, establishing K-12 education programs, establishing an adult education and awareness program for the residential and commercial communities, and evaluating best practices for applicability in San Borja. The direct benefits of this strategy include: • Supports knowledge growth, sharing, and management; • Instills community understanding, buy-in, and participation; • Helps prioritize disposal methods and recycling targets; and • Supports monitoring to ensure continuous recycling efforts. Recycling guidelines typically contain the following contents: • Disposal methods of recyclable waste; • Recycling targets; • List of waste management operators by area and by waste type; • Environmental education and awareness promotion; • Measures to discourage the practice of illegally removing recyclable waste; • Evaluation or award schemes, certification stickers, or good business operator certificates; and • Monitoring system to ensure continuous recycling efforts. **Composting (Community-Based Sorting and Processing)** The system promotes the aerobic decomposition of wastes and the resulting materials can be used as fertilizer or soil improvement agents. Kitchen waste, cow manure, and de-watered sewer sludge could be processed into high-quality compost, spread on agricultural land, and used to produce safe, worry-free crops. San Borja may consider utilizing underground storage containers for composting in order to reduce the amount of organics going to landfill and provide an opportunity to capture heat from the composting process to generate electricity. Use of the underground containers would help manage the odor associated with the composting material. This strategy could directly contribute to a reduction in GHG emissions by eliminating the emissions from landfills and by providing a renewable energy source through waste-to-energy processes. **High-Performance Waste Incineration Plant** For the high-efficiency incineration method using a stoker-type incinerator, the energy in the exhaust gas generated by incineration is recovered as steam in a boiler, and the steam is sent to a steam turbine generator to create electricity. Figures 8-9 through 8-11 provides examples of waste recycling and incineration.

Examples of Application

Education: Kitakyusyu Eco-Town in Japan

Aims to “utilize every waste product as another industry’s raw material, finally resulting in zero waste (zero emissions)” as part of the creation of a recycling-oriented society. Environmental targets were established as follows:

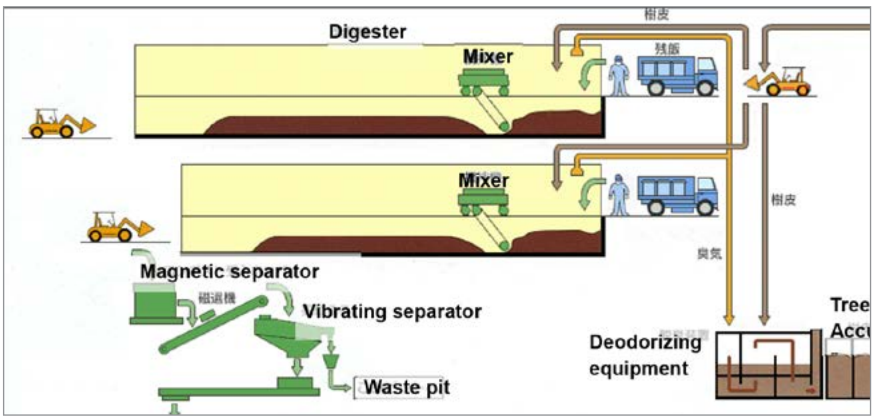
- Improved recycling;
- Reduction of final disposal rate;
- Reduction of CO_2 emission rate; and
- Reduction of water resource input rate

Source: http://www.kitaq-ecotown.com/torikumi/

Figure 8-9: Education: Example Recycling Guidelines

Source: Waste Management Northwest; http://www.wmnorthwest.com/beaverton/recycling.html

Figure 8-10: Composting (Community-Based Sorting Processing): Morioka-Shiwa District Environmental Facility



Source: http://mskankyo-iwate.jp/shisetsu/recycle.html

Incineration: Maishima Plant

In Japan, waste processing is centered on incineration, with 20% of common waste being recycled in general, the remaining 80% is incinerated to reduce its volume to 10%, and the residue is finally disposed of.

Note: The processing capacity of the Osaka City Environment Bureau's Maishima Plant is 900t/day, and the electricity generation capacity is 32,000kW.

Source: http://www.city.osaka.lg.jp/kankyo/cmsfiles/contents/0000019/19104/1page.pdf

Figure 8-11: Maishima Plant in Osaka city in Japan

8.2.2. Water Reuse and Recycling through Biofiltration

The purpose of using biofiltration for water reuse and recycling, in combination with an enhanced sprinkling system, is to help eliminate use of potable water for non-drinking purposes throughout San Borja and across all sectors. Other important objectives include reducing water pumping for irrigation and reducing the amount of Surco River fugitive emissions from greywater as its travels through San Borja's canals and empties unfiltered into the Pacific Ocean. Table 8-2 describes the LCMS for Water Reuse and Supply Management.

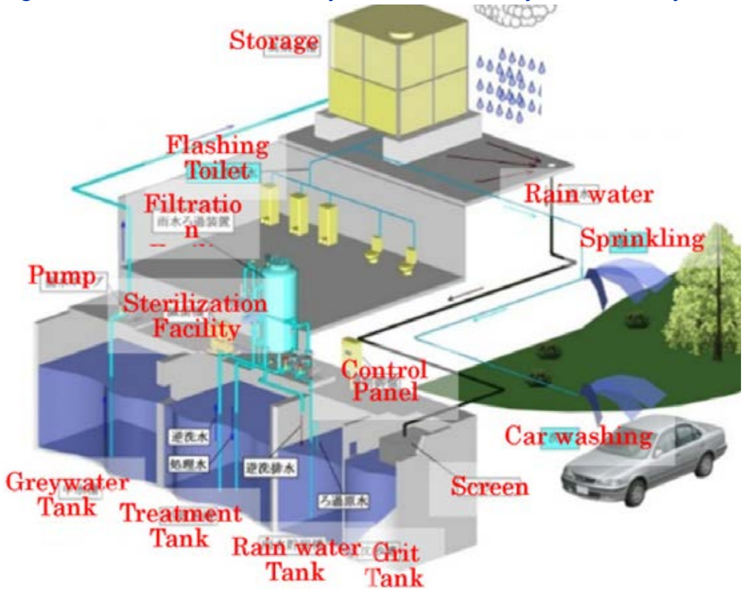
Table 8-2: Water Reuse and Supply Management

Overview
Strategies applicable to this LCM include: **Expand existing biofiltration systems to all parks:** The main purpose is to eliminate the use of potable water for non-drinking purposes throughout municipal-owned lands and facilities. This strategy includes: • Landscape irrigation on all municipal lands; • Toilet flushing for all parks and public facilities; • Cleaning outdoor areas in parks; • Coolant for municipality-owned machinery and equipment; and • Displace flooding method with sprinklers for irrigation to increase water efficiency. **Construct a multifunctional, high efficiency water treatment plant to allow reclaimed water use:** The main purpose is to eliminate the use of potable water for non-drinking purposes among commercial and industrial users throughout the district. The strategy includes using reclaimed water for: • Landscape irrigation on privately-owned lands; • Toilet flushing for all commercial, residential and municipal buildings; • Cleaning outdoor areas on privately-owned land; and • Coolant for privately-owned machinery and equipment.
Establish on-site treatment for water reuse: The main purpose is to eliminate the use of potable water for non-drinking purposes among residential and small business users throughout the district. The strategy includes using reclaimed kitchen wastewater. Figures 8-12 and 8-13 provide ideas. Applications and benefits include:

Application	Benefits
Toilet flushing	Reduced water and sewer costs
Cooling water for air conditioning equipment	Reduced electricity costs
Landscape irrigation	Reduced water and sewer costs Heat island mitigation
Car washing or equipment cleaning	Reduced water and sewer costs
Circulating water within the district	Reduced load on public infrastructure
Water for emergency and disaster use	Stored water for emergency

Examples of Application

Figure 8-12: Rainwater/Greywater Re-use System in Tokyo Midtown

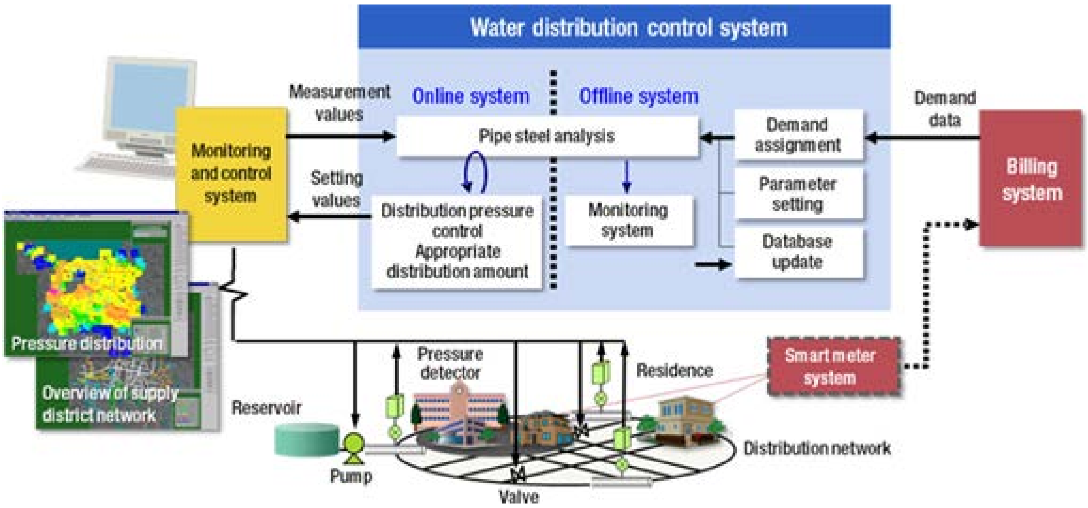


Source: http://www.fujikarosuiki.com/products_ama.html

Additional Ideas

This study recommends that San Borja continue working SEDAPAL (Servicio de Agua Potable y Alcantarillado de Lima), the region's water utility, to enhance the use of smart meters to forecast and detect leaks (Figure 8-12), particularly in new irrigation systems they establish in tandem with new biofiltration systems. As San Borja knows from its existing work with SEDAPAL, smart meters measure variations of flow volume and water pressure to identify where water leaks are occurring in the pipeline. In future assessments, this study recommends that San Borja consider smart meters for new irrigation systems. This study also recommends that San Borja seek to quantify the GHG emissions associated with the avoided use of treatment chemicals when using biofiltration.

Figure 8-13: Water Distribution Control System



Source: http://www.hitachi.com/products/smartcity/smart-infrastructure/water/solution.html

We propose assessing the potential for water reuse/recycling implementation in San Borja, and develop policies, plans, protocols and the business case for widespread policy design, investment, and management of waste/energy.

Source: Nikken Sekkei Research Institute

8.2.3. Urban Greening and Forest Expansion

This analysis is based on the current layout of the District, and San Borja's desire to increase tree canopy by an additional 15%. That increase in combination with the existing 10% of shady cover (and assuming San Borja can successfully preserve its existing shade cover) would achieve San Bora's goal of 25% total shade cover of the total land area by 2035.

Table 8-3: Urban Greening and Forestry (Sequestration)

Overview

Strategies applicable to this LCM include:

Incorporate Trees Along Main Streets and in Public Spaces: San Borja may consider opportunities to plant additional trees along main streets and in public spaces where they are not traditionally incorporated. Trees should be selected that require minimal irrigation and are an appropriate size. The Urban Function Planning chapter describes this LCM in more detail. The Urban Function sector in the GHG accounting framework accounts for the GHGs sequestered associated with this LCM. Figure 8-14 shows permeable paving design.

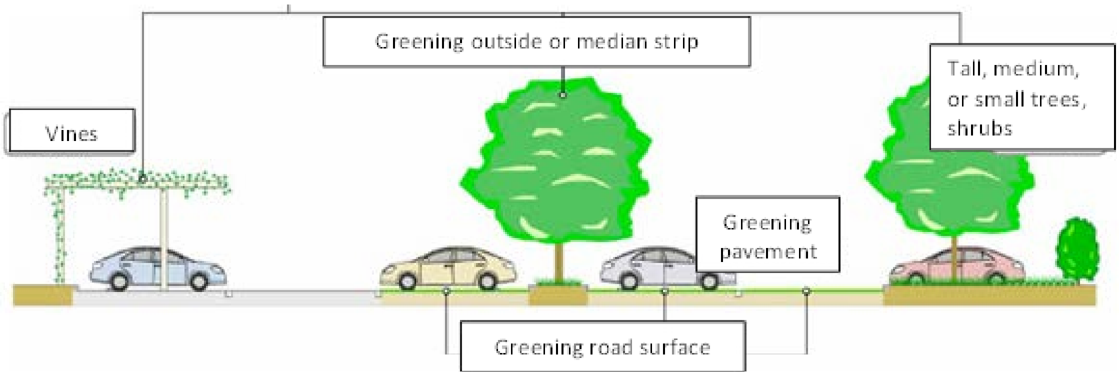
Incorporate Green Walls: Green walls (referred to here as building-integrated natural infrastructure or BINI), help keep temperatures low inside and around the building and subsequently reduce energy consumption. The Buildings Planning chapter encompasses this LCM as one of several passive design strategies. The Residential, Commercial and Municipal sectors in the GHG accounting framework account for the GHG reductions associated with the LCM. Figure 8-15 depicts building-integrated natural infastructure (BINI)

The co-benefits from both types of LCMs include:

- Energy efficiency and load reduction on buildings for cooling.
- Urban heat island mitigation, which also supports ambient air quality.
- Water conservation and habitat to support local biodiversity.
- Quality of life, recreational value, and landscape aesthetics.

Examples of Application

Figure 8-14: Permeable Paving and Green Parking Area



Source: JXDA Koide kanehisa report. https://www.kankyo.metro.tokyo.jp/nature/green/attachment/parking_plant.pdf,

Figure 8-15: Green Walls/Building-integrated Natural Infrastructure

Source: http://urbangreen.or.jp/ug/blog/daihatsu_gree/

8.2.3.1. Applying Urban Greening and Forest Expansion

Table 8-4 outlines the recommended application for tree planting and the associated total coverage area that may be achieved by 2035.

Table 8-4: Potential Solutions and Coverage Areas for Urban Greening and Forestry Expansion

Location	Measures	Current Total coverage area (see Table 8-5)	Long term (2035) Total coverage area*
Main streets, green belt	Tall tree (>5m) Permeable paving	44 ha	81 ha
Minor streets	Medium tree (>3m) Permeable paving	1 ha	2 ha
Public parks	Medium tree (>3m) Permeable paving	58 ha (49 public parks)	107 ha
Buildings, houses, parking areas	Shrub (<3m), grass, ivy Green parking, green wall and water mist	33 ha (31+2)	61 ha
Total		**136 ha (13.51%)**	**Tree coverage of 25% 251ha**

*Assumes that proportion of green areas in long term remains the same.

Table 8-5: Breakdown of Green Areas

Type	Coverage Areas in 2014 (m^2)	Coverage Areas in 2014 (%)
Public parks	584,583.7	43.1
Street berms	438,418.2	32.3
Berm passages	8,549.2	0.6
Triangular areas	10,846.5	0.8
Other public areas 314,838.6		23.2
Total	**1,357,236.2**	**100%**

Source: 2035 Sustainable City Plan

Figure 8-16 shows the recommended locations for planting trees along main streets, existing green belts, minor streets, and at public parks.

Figure 8-16: Location of Urban Greening Forestry

Source: Nikken Sekkei Research Institute

8.3. GHG Reduction Analysis and Cost Estimates

GHG reductions associated with the recommended LCMs are outlined below. For urban greening through Building integrated natural infrastructure, only the CO_2 absorption rate is estimated given that there are no other GHGs associated with this measure. A cost estimate for the urban greening section LCM is implicit in the costs for passive design strategies for residential, commercial, and municipal buildings.

A combined urban greening and forest expansion is provided below. CO_2 sequestration from urban forest preservation is discussed within Chapter 4. In both cases of urban forest preservation and expansion, the GHG accounting framework reflects the combined sequestrations of each in the Urban Forest sector. The assumptions for the modeling estimate are that San Borja maintains its current tree count of 18,804 eucalyptus trees as the 2012 baseline, adds that same number of eucalyptus trees each year, and that trees are 2.5 years old at planting, are 10.24 diameter squared (inches), and 8 feet tall. This study ran a simple model to determine the annual decline in CO_2 sequestration rates. The CO_2 sequestration totals in the GHG accounting reflect those results.

8.3.1. Solid Waste Repurposing, Recycling, Incineration

8.3.1.1. Reduction Analysis

By implementing ‘soft’ measures such as waste recycling guidelines and a waste sorting system, and assuming 36,000 households participate and that San Borja diverts trash from the landfill to recycling, GHG emissions from the solid waste sector would reduce by 10% in short term and 20% in medium term.[62] These estimates are included in the GHG accounting framework under the waste/wastewater sector, and are based on San Borja’s own reported activity data for the sector:

62 Recycling guidelines in Japan have typically resulted in about 10% and 20% of CO2 reductions in short and medium term.

- Short term: 94,316 ton-CO2e/year × 5% = 4,700 Mt-CO2e/year
- Medium term: 94,316 ton-CO2e/year × 10% = 9,400 Mt-CO2e/year

Additional 'hard' measures such as constructing a high-performance waste incineration plant may contribute significantly to reducing CO2e emissions.

The following assumptions inform the following reduction estimate from a high-performance waste incineration plant. Chapter 7 estimated reductions from capturing the current heat waste from the incineration process and using it to generate electricity, i.e., this is 'untapped energy.' These emissions are accounted for in the GHG accounting framework in the waste sector. The estimates below that characterize the difference between using a landfill and incineration to dispose of solid waste are not reflected in the GHG accounting framework. That is because this is not a new and additional LCM; it is a review of the discussion already underway in San Borja and within Lima Province. This study provides the information only as complementary to the waste sector.

- Fuel: Fossil fuel and organic waste
- CO_2 conversion factor: 135.6 grams of CO2 per 1 kWh of electricity
- Average power generation unit: 500kWh/ton[63]
- Average municipal waste generation in San Borja is 85 ton/day[64]
  - Note: The target amount of waste = 42 ton. Waste for combustion = 20 ton [= (85-43)/2]. 43 ton for Biomass Diesel Fuel (BDF) (refer to section 7.3). Waste for combustion is 75~80% of total waste.
- The net CO2e reductions would be the CO2e emissions difference between waste disposal by landfill (before case) and waste incineration plant (after case). There would be a reduction in CH4 emissions and an increase in CO2 and N2O emissions. The reductions in CH_4 offset increases in CO_2 and N_2O, resulting in a net decrease in GHG emissions.

GHG emissions reductions from the incineration plant under discussion in San Borja would be as follows:

- Electricity

  500 kWh/ton × 20 ton/day = 10,000 kWh / day

  → 10,000 kWh × 0.1356 kg-CO2e/kWh = 1,350 kg-CO2 = 1.3 ton-CO2e/day

  → 1.3 ton-CO2e/day × 365 = 4,700 Mt-CO2e/year

- Combustion
  - CO2 added emission: -240log(20) + 880 =570 kg-CO2/Mt [65]
  - CH4 emission reduction: 0.145 Mt-CH4/Mt[66]
  - N2O added emission: 0.0000567 Mt-N2O/Mt[67]

63 Source: http://www.city.suita.osaka.jp/home/soshiki/div-kankyo/energycenter/008732.html
64 San Borja 2035 Sustainability Plan
65 Source: Ministry of the Environment of Japan. http://www.env.go.jp/earth/ondanka/gel/pdf/manual201203.pdf (Table 4-1)
66 Ministry of the Environment of Japan. http://ghg-santeikohyo.env.go.jp/files/calc/itiran.pdf (Table 10 - waste disposal by landfill).
67 Ministry of the Environment of Japan. http://ghg-santeikohyo.env.go.jp/files/calc/itiran.pdf (Table 18 - waste disposal by incineration).

Table 8-8: GHG Emission Factors and GHG Emission Rates of Incineration Plant

GHG Type	CO2	CH4	N2O	Factor (kgCO2e)
Rate	-570.0* (kg CO2/Mt)	145.0** (kg CH4/Mt)	-0.06* (kg N2O/Mt)	
CO_2 equivalent (kg CO2/Mt)	-570	3,045	-18	2,457

*Emission rates of CO2 and N2O added by incineration plant.

**Emission rate of CH4 avoided by eliminating landfills.

Total GHG reduction rate = 20Mt/day x 2,457 kg-CO2e/Mt = 49 Mt-CO2e/day = 17,890 Mt-CO2e/year

8.3.1.2. Cost Estimates

For "soft" and "hard" measures (i.e., high-performance waste incineration plant), the costs were estimated based on the following assumptions:

- Annual operating costs are 10% of the initial investment cost for waste recycling and waste sorting system guidelines: 600,000 USD * 10% = 60,000 USD
- The target amount of incinerated waste is 20 tons/day.
- Initial cost: Unit cost of incineration capacity under 100 Mt/day[68] = USD 60,000/ton
- Operating costs: Unit cost/year: approximately 5% of initial cost[69] (Including labor cost, management cost, repair cost, etc.)

The calculation results are shown below:

- Public education and awareness guidelines = 60,000 USD
- Initial cost: 20 ton × USD 60,000/Mt = 12 million USD
- Operating costs: 12 million USD × 5% = 600,000 USD/year

8.3.2. Biofiltration Water Reuse and Recycling

Reduction Analysis

The GHG emissions reduction from using a biofiltration facility for irrigation is estimated based on the CO2e emissions savings from the existing biofiltration system verses a pumped water treatment system. Table 8-9 shows the emission factor rates. The assumptions are shown as follows:

- Volume of water treated per year = 500,000 liters per day x 365 day/year = 183,000,000 liters per year
- CO2e emission factor for waterworks system
  - CO2 emission: 0.0002 kg-CO2 per liter of water[70]
  - CH4 emission: 0.0000009kg-CH4/ℓ[71]
  - N2O emission: 0.0000002kg-N2O/ℓ[72]

68 Source: http://www.env.go.jp/recycle/waste_tech/index.html
69 Source: http://www.env.go.jp/recycle/waste_tech/index.html
70 Source: Ministry of Agriculture, Forestry and Fisheries of Japan http://www.maff.go.jp/form/pdf/syokuh-5.pdf.
71 Source: Ministry of the Environment of Japan. http://ghg-santeikohyo.env.go.jp/files/calc/itiran.pdf (Table 11 - sewage treatment plant).
72 Source: Ministry of the Environment of Japan. http://ghg-santeikohyo.env.go.jp/files/calc/itiran.pdf (Table 18 - waste disposal by incineration).

Table 8-9: GHG Emission Factors Emission Rates of Waterworks System

GHG Type	CO2	CH4	N2O	Factor (kg CO2e)
Rate	0.0002000 (kg-CO2/ℓ)	0.0000009 (kg-CH4/ℓ)	0.0000002 (kg-N2O/ℓ)	
CO2 equivalent (kg-CO2e/ℓ)	0.00020	0.00002	0.00005	0.00027

The annual CO2e emissions reduction was then calculated to be:

183,000,000 liter/year ×0.00027kg-CO2e/liter =49,410kg-CO2e/year = 49 Mt-CO2e/year

Cost Estimates

To implement a new biofiltration water treatment plant with the same capacity as the existing plant, the initial costs would be as follows:

- Unit cost: 4,000~5,000 USD/ m^3-day[73]
- Total cost : 4,000~5,000 USD/ m^3 • day× 500 m^3/day = 2~2.5 million USD

Note: The estimated cost only accounts for the equipment cost of the biofiltration water treatment system and does not include the costs for a water storage tank, water pumps, piping and labor.

8.3.3. Urban Greening and Forest Expansion

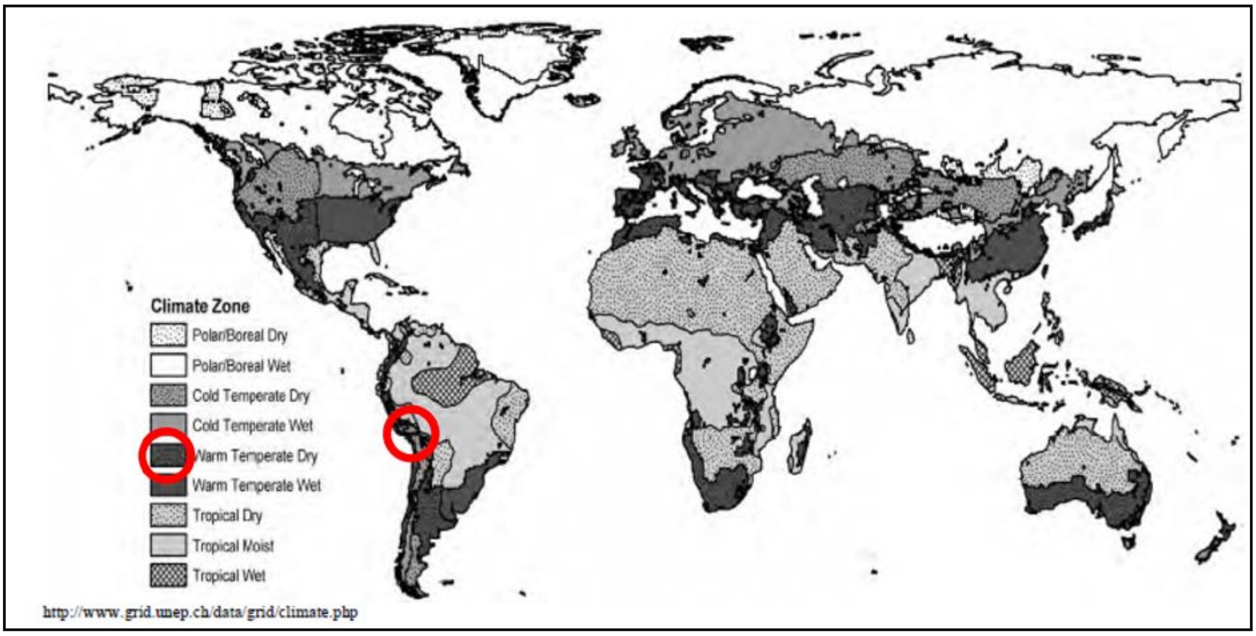
Reduction Analysis

The reduction in GHG emissions were estimated per the following steps:

- Estimation of green areas
  - The total green areas in 2035 (long term) has been estimated to be 251 ha (Table 8-2). "Buildings, houses, parking areas" are disregarded in this analysis.
- Estimation of CO_2 absorption rate.
  - According to the IPCC, Peru belongs to the "Warm Temperate Dry" climate zone and its absorption rate is approximately 1.4 MtCO_2/ha/year for litter (See Figure 8-17). Multiplied by 3.67 to account for below ground and above ground carbon stock, the absorption rate is 5.1 MtCO2/ha/year) (Table 8-10). This rate is used below to calculate total CO2 absorption rate for the proposed San Borja urban greening and forestry expansion LCM.

73 Based on the installation costs of similar plant in Japan.

Figure 8-17: Delineation of Major Climate Zones



Source: IPCC National Greenhouse Gas Inventories Programme Good Practice Guidance for Land Use, Land-Use Change and Forestry

Table 8-10 Defaults for Liter Carbon Stock and Transition Period

Climate	Forest Type							
	Broadleaf Deciduous	Needleleaf Evergreen	Broadleaf Deciduous	Needleleaf Evergreen	Broadleaf Deciduous	Needleleaf Evergreen	Broadleaf Deciduous	Needleleaf Evergreen
	Litter carbon stock of mature forests (tonnes C ha^{-1})		Length of transition period (years)		Net annual accumulation of litter C over length of transition period [b,c] (tonnes C ha^{-1} yr^{-1})		Net annual accumulation of litter C, based on 20 year default (tonn[illegible]	
Boreal, dry	25 (10-58)	31 (6-86)	50	80	0.5	0.4	1.2	[illegible]
Boreal, moist	39 (11-117)	55 (7-123)	50	80	0.8	0.7	2.0	[illegible]
Cold Temperate, dry	28 (23-33)[a]	27 (17-42)[a]	50	80	0.6	0.4	1.4	1.4
Cold temperate, moist	16 (5-31)[a]	26 (10-48)[a]	50	50	0.3	0.5	0.8	1.3
Warm Temperate, dry	28.2 (23.4-33.0)[a]	20.3 (17.3-21.1)[a]	75	75	0.4	0.3	1.4	1.0
Warm temperate, moist	13 (2-31)[a]	22 (6-42)[a]	50	30	0.3	0.7	0.6	1.1
Subtropical	2.8 (2-3)	4.1	20	20	0.1	0.2	0.1	0.2
Tropical	2.1 (1-3)	5.2	20	20	0.1	0.3	0.1	0.3

C ⇒ CO2

1.4 x 44/12 = 5.1

Source: Siltanen *et al.*, 1997; and Smith and Heath, 2002; Tremblay *et al.*, 2002; and Vogt *et al.*,1996, converted from mass to carbon by multiplying by conversion factor of 0.37 (Smith and Heath, 2002).

Note: Ages follow Smith and Heath (2002).

[a] Values in parentheses marked by superscript "a" are the 5th and 95th percentiles from simulations of inventory plots, while those without superscript "a" indicate the entire range.

[b] These columns indicates the annual increase in litter carbon when starting from bare ground in land converted forest land.

[c] Note that the accumulation rates are for carbon being absorbed from the atmosphere. However, depending on the methodology, these may be transfers from other pools.

- Calculations
  - Total green areas of main streets and green belt (81 ha), minor Streets (2 ha) and public parks (107 ha) is 190 ha.
  - The age of trees in 2035 will be below 20 years. (CO2 absorption rate for trees over 20 years = zero).
  - The estimation method uses an absorption rate of 0.01 Mt-C/ha/year from tree canopy covering area.
- Calculation results

Total CO_2 absorption rate

- Short term: 2,000 Mt-CO2/year × 4% ((2018-2014)/20year) = 80 Mt-CO2/year
- Medium term: 2,000 Mt-CO2/year ×7% ((2021-2014)/20year) = 140 Mt-CO2/year
- Long term: 190ha × 2.9 Mt-CO2/ha/year × 44/12* = 2,000 Mt-CO2/year

* Ratio of molecular weight of CO2 and C

Cost Estimate

The initial costs for urban greening and forestry expansion were estimated based on the following assumptions:

- The total green areas in public parks (Table 8-4) to be planted with Eucalyptus trees is 49 ha.
- The initial estimated unit cost for planting (equipment, installation, and labor) Eucalyptus trees in the green areas above is USD 10/m2.[74]
- The adjusted estimated unit cost for planting Eucalyptus trees is USD 5/m2 given that the Peruvian DOD provides the initial equipment, installation, and labor for nurturing trees from seedlings through to transplantation in San Borja.

The total initial cost was calculated to be USD 5/m2 x 490,000 m2 = USD 24.45 million.

74 A Japanese report estimated that one hectare of industrial Eucalyptus plantation in Brazil requires an initial investment of USD 3,400. For non-industrial eucalyptus planting in an urban area like San Borja, the unit cost was estimated to be a minimum of USD 10 per square meter. (Source: http://www.bizpoint.com.br/jp/reports/morita/0010.htm)

9. GHG REDUCTIONS ANALYSIS AND COST PERFORMANCE OF LCMS

This chapter address the GHG emissions associated with all of San Borja's emissions sources across the six action areas in its LCP 2021: 1) Residential, 2) Commercial, 3) Transport, 4) Solid Waste, 5) Institutional, and 6) Urban Forestry. It outlines this study's use of the Global Protocol for Community-Scale Greenhouse Gas Emissions Inventories (GPC, version 2.0) as the normative, internationally recognized and accepted standard for GHG accounting and reporting used in this study, the chapter then details San Borja's enhanced 2012 GHG baseline and inventory resulting from use of the GPC Framework.. Finally, the chapter summarizes the projected GHG emissions reduction performance for all LCMs and estimated costs.

9.1. Background and Issues

This Feasibility Study uses the GPC for GHG Accounting (version 2.0) developed by the World Resources Institute (WRI) in coordination with the C40 Climate Leadership Group and ICLEI-Local Governments for Sustainability, as the normative standard protocol for the GHG baseline inventory and emissions reductions accounting and reporting. A standardized protocol allows for inventory results and performance benchmarks that are comparable with neighboring municipalities.

An objective of this study is to ascertain whether San Borja could exceed its 15% GHG emissions reduction target by 2021, and if so, help:

- Expedite LCM performance by 2021 in order to determine a 2035 reduction target;
- Demonstrate credible reductions in order to scale the LCMT model across other municipalities; and
- Provide leadership in order to scale the LCMT model to Lima Province.

9.2. GPC Framework Overview

The GPC sets out requirements and provides guidance for GHG quantification, accounting and reporting municipal-level GHG inventories, consistent with the *2006 IPCC Guidelines for National GHG Inventories*[75]. The intended users of the GPC are local authorities or city governments who exercise jurisdiction over a defined geographical area. A local authority, defined by ISO/TR-14069, is a public body recognized as such by legislation or by the directive of a higher-level government to set general policies, plans or requirements.[76] The GPC framework also supports consistent accurate, transparent reporting by harmonizing existing international protocols and standards for municipal-level GHG inventories.

For this study, San Borja's six action areas in its LCP 2021 (described in Chapter 3, Figure 3-2) were mapped to and accounted for within the GPC's six primary GHG accounting categories for emissions sources: 1) Stationary; 2) Mobile; 3) Waste; 4) Industrial Process and Product Use; 5) Agriculture, Forestry and Land use (AFOLU); and 6) Other Direct Emissions. The projected GHG reductions within APEC's five "design categories" (described in Chapter 3, section 3.1.2) also were mapped to the GPC categories

75 IPCC Guidelines for National GHG Inventories (2006); http://www.ipcc-nggip.iges.or.jp/public/2006gl/
76 GPC, version 2.0

and accounted for as either a Scope 1, 2 or 3 reduction. Final reporting by this study on baseline, projected BAU inventories, and potential LCM reductions (see Table 9-13) remained consistent with San Borja's six action areas, with the exception of urban function. In table 9-4, San Borja's reported GHG emissions from the construction sector are reflected in Table 9-2 as commercial emissions.

9.2.1. Key Features

The output from the GPC Framework is usually a desktop tool in the form of a spreadsheet or database, that helps city managers, municipal staff and political leadership demonstrate measurable results and achievement of desired outcomes by quantitatively linking LCM performance to the baseline and monitoring performance metrics. Using performance metrics allows GHG inventory managers to measure past results, monitor current progress, and estimate future performance. Primary objectives of the GPC Framework include:

- Supporting development of a comprehensive, robust GHG inventory for climate action planning;
- Providing international best practice guidance for consistent and transparent GHG quantification, accounting across sectors and scopes, and reporting;
- Enabling aggregation from sub-national to national level GHG baselines, inventories, measurable reductions, and estimates of future performance; and
- Demonstrating the important role cities play in mitigating the impacts of human activities on climate.

9.2.1.1. Unit of Measure

The unit carbon dioxide-equivalent (CO_2e) is a universal unit of measurement used to compare emissions from different gases based upon their global warming potential (GWP). To convert GHGs into CO_2e units, multiply the GHG by a 100-year GWP coefficient per IPCC "Guidelines", and report in metric tons (i.e., $MtCO_2e$).[77]

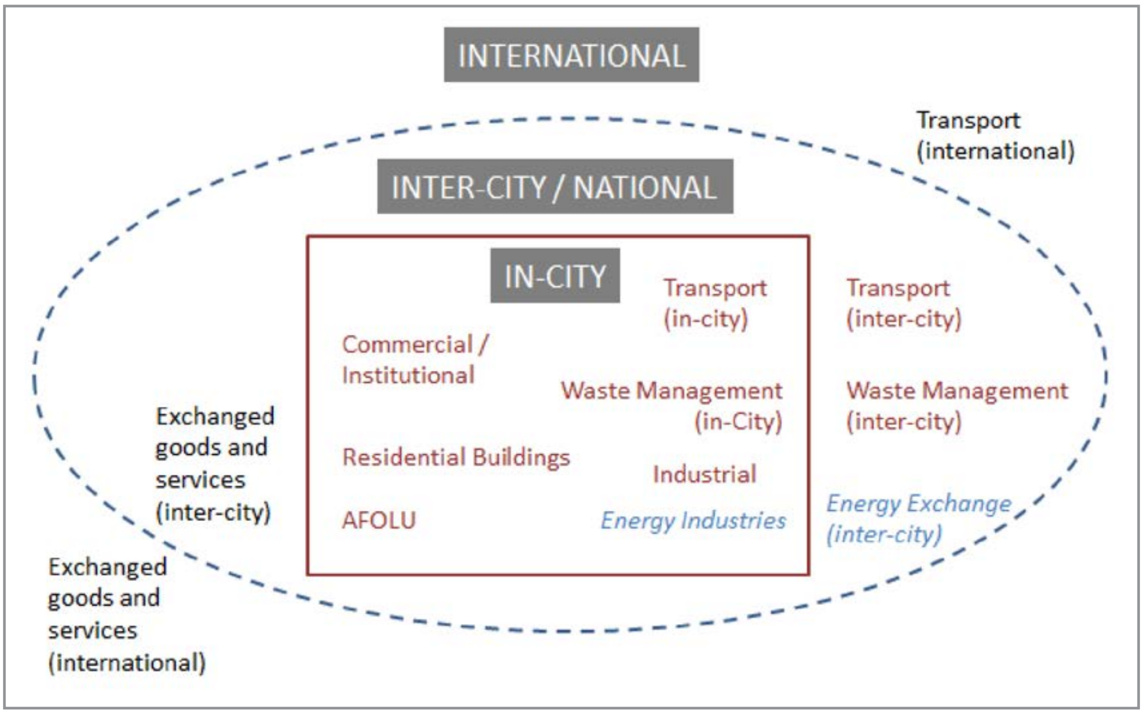
9.2.1.2. Inventory Boundary

The boundary for San Borja's GHG inventory is the same set of geopolitical boundaries described in Chapter 2. A challenge with this approach is that some GHG sources within the boundary may result in emissions outside the district, and likewise GHG sources outside the boundary may result in emissions within the District. Figure 9-1 shows the GHG sources and accounting boundaries. Definitions are below:

- *Direct* emissions are emissions from sources within the municipality's boundary.
- *Indirect* emissions are a consequence of the activities within the District boundary, but which occur from outside the District. They also include GHG sources outside the boundary which result in emissions within the District.

77 Reference IPCC guidelines in the GPC version 2 document.

Figure 9-1: Sources and Boundaries of Community-Scale GHG Emissions



Source: GPC v.1

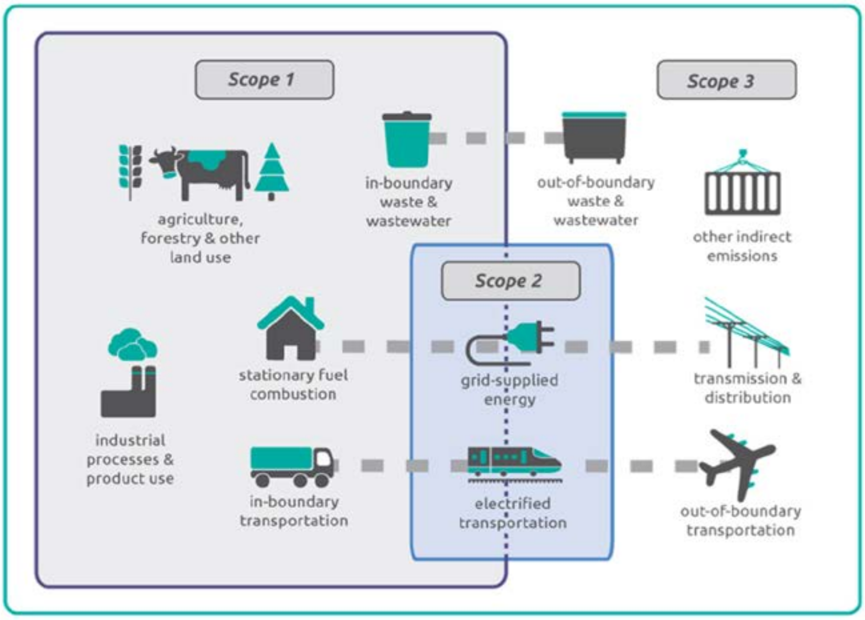
9.2.1.3. Scopes 1, 2 and 3 Emissions

The following defines GHG scopes, specific to San Borja's boundary:

- **Scope 1**: All direct emissions from sources within San Borja's geopolitical boundaries.
- **Scope 2**: Indirect emissions that occur outside the community boundary because of consumption/ use of grid-supplied electricity, heating and/or cooling, (i.e. purchased electricity or heating and/ or cooling), or generation of solid waste and wastewater within the district's boundary (i.e., waste treatment services operating outside the boundary).
- **Scope 3**: All other indirect emissions that occur outside the boundary because of activities within San Borja's geopolitical boundary, as well as trans-boundary emissions due to the exchange/use/ consumption of goods and services.

Figure 9-2 below illustrates the concept of direct and indirect emissions, and the relationships among a local, regional, or national inventory. Direct emissions (Scope 1) include sources located within the district boundary (i.e., the solid line). These include in-city transit systems, energy use from buildings and emissions from industrial activities. The hashed-line represents regional boundaries, such as other municipalities and provinces. Some activities in San Borja transcend the District's boundary into other districts (and vice versa).

Figure 9-2: Description of Scopes 1, 2 and 3 in GHG Accounting



Source: GPC 2.0 Guidance Document,

The following activities could potentially cause emissions to be shared between municipalities and cities and are therefore considered indirect emissions (Scopes 2 and 3) -– outside of the San Borja geopolitical boundary but within Lima Province:

- The Metropolitano BRT system
- The MetroLima rail system
- Electricity generation and use
- Solid waste disposal
- Waste water treatment
- Freight and commercial cargo transport
- Transboundary commuters
- Exchange of goods and services

9.2.1.4. Notation Keys

Per IPCC Guidelines, the GPC encourages the use of notation keys to explain the exclusion or partial accounting of GHG emission source categories. This practice accommodates limitations in data availability, as well as differences in emissions sources between government agencies and municipalities. Table 9-1 defines the notation keys.

Table 9-1: Notation Keys for GHG Accounting

Notation key	Definition	Explanation
IE	Included Elsewhere	GHG emissions for this activity are in another category of the inventory. A notation says where they are.
NE	Not Estimated	There are emissions, but there is not quantification or report of them available.
NO	Not Occurring	An activity or process does not occur or exist within the city.

9.2.2. Methodological Limitations

There are two calculation methods to determine GHG inventories: one is to calculate using consumption-based data, the other is to calculate using production-based data. Of the two methodologies, consumption-based quantification is a better reflection of the behavior patterns of urban residents and businesses. However, consumption-based data are typically more challenging to obtain. San Borja has some consumption data for some sectors, but does not have it consistently and reliably across all sectors. San Borja has used, and should continue to use as needed, a dual approach that quantifies GHG emissions based on consumption and activity data where possible, and filling in the remaining aspects with production data.

Another limitation in San Borja's inventory (and all local community inventories) is a lack of international consensus on best practices and methodologies for quantifying and accounting for the emissions from cross-boundary transportation, urban forestry, solid waste disposal, waste water treatment, recycling, and grid electricity (between Scope 1 and Scope 2). There also is a lack of best practice methodologies for quantifying a city's full Scope 3 emissions. To address these limitations, this Feasibility Study recorded all data and assumptions underlying the calculation in a spreadsheet, thereby making the assumptions, variables, and emissions factors accessible and transparent. Data transparency gives San Borja municipal staff the option to review the data and, pending a reasoned and defensible justification, adjust estimates as needed.

Another limitation of the GPC is that it does not provide an accompanying desktop quantification tool that has the underlying mathematical formulas, variables, assumptions, and emissions factors to support its written recommendations for quantification. In the absence of such a tool, local governments are constrained by their ability to engage in basic analytical modeling to compare LCM past performance and estimate future performance. To overcome this limitation, this feasibility study modified the U.S. Federal Energy Management Performance (FEMP) Workbook by inserting Peru or Lima-specific emissions factors and utilizing San Borja consumption activity data to the extent possible. The FEMP Workbook is an Excel™-based desktop tool used by U.S. federal government agencies and many private sector companies to collect, organize, store, analyze, and report GHG emissions baselines and inventories. The FEMP tool also allows the user to engage in rudimentary predictive modeling by manipulating growth assumptions, waste and energy-intensities, emissions factors and GWP updates, and integrating economic and social variables.

The FEMP Workbook also provides CO2e quantification methodologies for energy-related emissions across sectors (i.e., buildings, industrial processes, renewable energy planning), as well as emissions related to urban function (i.e., land use, waste water treatment and re-use), transportation planning, and environmental planning.

9.3. GPC Applied: Baseline, Inventory and Scope

A credible GHG baseline and subsequent annual inventory presents information based on six principles: relevance, completeness, consistency, transparency, accuracy, and measurability. The GPC normative standard requires districts such as San Borja to report is GHG emissions based on these principles and in accordance with its categories. This study used Notation Keys as justification for missing data and information, which is consistent with national level reporting. Table 9-2 below provides an example of Stationary Sources from the San Borja inventory. An important observation is that wherever the notation

"NE" appears, more research is necessary to either rule out the activity as a source of GHGs, or if it is a source, to then quantify and add it to the baseline inventory.

Table 9-2: Partial Example of San Borja's GHG Accounting Table

San Borja GHG Accounting and Reporting Tool: Results Summary			Base Year: Calendar Year (CY) 2012			
Greenhouse Gas Emissions Source	Scope	Notation Keys	Greenhouse Gases Net Emissions for CY12 Baseline: (MT CO2e)			
			Total GHG Emissions (MT CO2e)	Total CO2 Sequestered (MT CO2e)	Total GHG Avoided (MT CO2e)	NET GHG Emissions (MT CO2e)
I. STATIONARY SOURCES						
Residential Buildings						
Emissions from in-boundary fuel combustion	3		5.06	0.0	0.0	5.06
Emissions from consumption of grid-supplied electricity, steam, heat, chilled water	3		18,587.8	0.0	0.0	18,587.76
Transmission and distribution losses from grid-supplied electricity, steam, heat, chilled water	3		216.0	0.0	0.0	215.96
F-gases from in-boundary refrigeration and AC	3		10,699.0	0.0	0.0	10,698.97
Sequestration from in-boundary urban forestry and agriculture	3	NE	0.0	0.0	0.0	0.00
			29,507.7	0.0	0.0	29,507.7
Commercial Buildings						
Emissions from in-boundary fuel combustion	3		21,694.2	0.0	0.0	21,694.2
Emissions from consumption of grid-supplied electricity, steam, heat, chilled water	3		17,410.3	0.0	0.0	17,410.3
Transmission and distribution losses from grid-supplied electricity, steam, heat, chilled water	3		202.3	0.0	0.0	202.3
F-gases from in-boundary refrigeration and AC	3	NE	0.0	0.0	0.0	0.0
Sequestration from in-boundary urban forestry and agriculture	3	NE	0.0	0.0	0.0	0.0
			39,305.7	0.0	0.0	39,306.7
Industry Buildings (Factories)						
Emissions from in-boundary fuel combustion	3	NO	0.0	0.0	0.0	0.0
Emissions from consumption of grid-supplied electricity, steam, heat, chilled water	3	NO	0.0	0.0	0.0	0.0
Transmission and distribution losses from grid-supplied electricity, steam, heat, chilled water	3	NO	0.0	0.0	0.0	0.0
F-gases from in-boundary refrigeration and AC	3	NO	0.0	0.0	0.0	0.0
Sequestration from in-boundary urban forestry and agriculture	3	NO	0.0	0.0	0.0	0.0
			0.0	0.0	0.0	0.0
Municipal-owned and Managed Buildings, Lands, Facilities						
Emissions from in-boundary fuel combustion	1		3,052.7	0.0	0.0	3,052.7
Emissions from consumption of grid-supplied electricity, steam, heat, chilled water	2		1,012.0	0.0	0.0	1,012.0
Transmission and distribution losses from grid-supplied electricity, steam, heat, chilled water	3		11.8	0.0	0.0	11.8
F-gases from in-boundary refrigeration and AC	1	NE	0.0	0.0	0.0	0.0
Sequestration from in-boundary urban forestry and agriculture	1	NE	0.0	-139.3	0.0	-139.3
			4,076.5	-139.3	0.0	3,937.2
Municipal-leased Buildings and Facilities Managed/Operated by Others						
Emissions from in-boundary fuel combustion	2	NE	0.0	0.0	0.0	0.0
Emissions from consumption of grid-supplied electricity, steam, heat, chilled water	2	NE	0.0	0.0	0.0	0.0
Transmission and distribution losses from grid-supplied electricity, steam, heat, chilled water	3	NE	0.0	0.0	0.0	0.0
F-gases from in-boundary refrigeration and AC	2	NE	0.0	0.0	0.0	0.0
Sequestration from in-boundary urban forestry and agriculture	2	NE	0.0	0.0	0.0	0.0
			0.0	0.0	0.0	0.0
National Government Buildings and Facilities						
Emissions from in-boundary fuel combustion	3	NE	0.0	0.0	0.0	0.0
Emissions from consumption of grid-supplied electricity, steam, heat, chilled water	3	NE	0.0	0.0	0.0	0.0
Transmission and distribution losses from grid-supplied electricity, steam, heat, chilled water	3	NE	0.0	0.0	0.0	0.0
F-gases from in-boundary refrigeration and AC	3	NE	0.0	0.0	0.0	0.0
Sequestration from in-boundary urban forestry and agriculture	3	NE	0.0	0.0	0.0	0.0
			0.0	0.0	0.0	0.0
Municipal Combined Heat and Power						
Emissions from in-boundary electricity production and heat used in operations	1	NO	0.0	0.0	0.0	0.0
Emissions from consumption of grid-supplied CHP electricity and heat	2	NO	0.0	0.0	0.0	0.0
Transmission and distribution losses from grid-supplied CHP electricity and heat	3	NO	0.0	0.0	0.0	0.0
			0.0	0.0	0.0	0.0

Source: Project Team

9.3.1. Validation Results

9.3.1.1. Sector Baseline Results by Target Year

The results of the GHG validation review (performed by this Feasibility Study) are shown below in Table 9-3. Based on the review, San Borja has a 2012 baseline GHG inventory of 207,805 MtCO2e, 82% greater than the original baseline estimate (113,704 MtCO2e). The difference between the two baselines is mainly due to new data and/methodologies used by this study, including greater use of Peru-specific emissions factors for quantification, San Borja–specific activity data that the previous inventory did not include, a more complete and accurate inventory of in-boundary and out-of-boundary GHG sources, and use of CO2e as the unit of measure. The enhanced inventory provided by this study builds from San Borja's own initial inventory by offering municipal staff additional insights into GHG sources and opportunities for reductions.

Table 9-3: Enhanced San Borja 2012 GHG Baseline and Inventory by Sector (MtCO2e)

TARGET YEAR SECTOR	2012 *Baseline	2021 (BAU Emissions)[1]	2021 (Reductions)[2]	2021 (Inventory)[3]
Residential	29,508	37,860	9.834	28,026
Commercial	39,355	58,864	16,667	42,197
Transportation	66,162	93,227	11,187	82,040
Solid Waste & Wastewater	66,842	95,484	10,057	85,427
Institutional Municipal	4,077	4,862	1,470	3,392
Urban Forest	(139)	(32)	929	(961)
TOTAL Net Emissions	**207,805**	**290,265**	**50,144**	**240,121**

[1] Projected emissions under a business as usual (BAU) scenario
[2] Projected emissions in 2021 under LCMT vision
[3] Projected CO_2e reductions estimated for LCMs

The following represent important aspects of the results above:

- The solid waste sector includes all GHGs, including methane (CH4) and nitrous oxide (N2O) in the quantification of CO2e, and includes solid waste that while separated into appropriate waste streams, was still disposed of in a landfill with no CH4 flaring or capture.
- The revised baseline accounts explicitly for avoided and sequestered GHG emissions from the repurposing of trash from many San Borja households, modal switching to less carbon-intensive transportation (e.g., bicycle transport), and CO2 sequestered by San Borja's urban forest.
- In situations where Lima-specific or Peru-specific emissions factors were not available, the calculations used the default emission factors as defined by the IPCC as the premier authority on GHG accounting practices at the national level.

9.3.1.2. Baseline Results by Sector

Table 9-4 separates the 2012 GHG baseline according to the institution type from which the emission originated. The results show that the majority of San Borja's GHG emissions originate in the buildings sector. The second largest contributor is the transportation sector. The smallest contributor is the institutional sector, which is primarily from San Borja's municipal building electricity use and fuel, and street lighting for the District. San Borja's urban forest in its parks and along its boulevards, including the 18,804 trees planted on municipal lands in 2012, sequestered 0.07% of the municipality's total GHG emissions.

Table 9-4: Enhanced San Borja 2012 GHG Baseline and Inventory by Institution ($MtCO_2e$)

Institution Sector	Residential	Commercial	Industrial	Municipal	Net Emissions	% Contribution
Solid Waste	0	0	0	70,061	70,061	32
Transportation	39,643	4,835	2,418	32,217	79,113	33
Buildings	29,508	39,307	0	4,076	72,891	35
Construction	0	49	0	0	49	0.02
Urban Forestry	0	0	0	(139)	(139)	(0.07)
Total Net Emissions	**64,107**	**44,191**	**2,418**	**97,089**	**207,805**	**100%**

*Totals include avoided and sequestered CO2e.

The relevance to San Borja of distinguishing emissions according to sectors is that it informs where the District might want to focus strategically on public policies, market incentives, and regulatory compliance in order to meet its reduction targets. The information also conveys the relative contribution of different institutions to San Borja's GHG emissions.

9.3.1.3. GHG Emissions Baseline Results by Scope

Table 9-5 provides the same information as above according to Scopes 1, 2, and 3. International best practices call for GHG accounting to identify the scope of the GHG emissions, i.e., whether the emissions are "direct" or "indirect". Direct GHG emissions are from sources that are owned or controlled by the reporting entity. Indirect GHG emissions are emissions that are a consequence of the activities of the reporting entity, but occur at sources owned or controlled by another entity.

This study assumes that the "reporting entity" is the San Borja Municipal Government. The relevance to San Borja of distinguishing between direct and indirect emissions is that it begins to delineate who has "ownership" of the emissions, and therefore the responsibility and accountability for reducing them. For instance, San Borja has the direct capacity to reduce its Scope 1 emissions through its decisions about how to operate and manage all District-owned buildings, motor vehicles and equipment, lands, and other assets. San Borja also has the authority to address Scopes 2 and 3 emissions through its procurement decisions, negotiations with vendors, and public policy decisions. Scope 3 emissions are the greatest contributor to emissions at 54%. The smallest is Scope 1 at 1% of emissions. This study recommends that San Borja address its Scope 1 emissions first because that is where it has, as a local government, the authority to make change and to demonstrate leadership. The other Scopes, while larger contributors to overall emissions, are more complicated to address since they are not directly owned or operated by San Borja.

Table 9-5: Enhanced San Borja 2012 GHG Baseline and Inventory by Scope (MtCO2e)

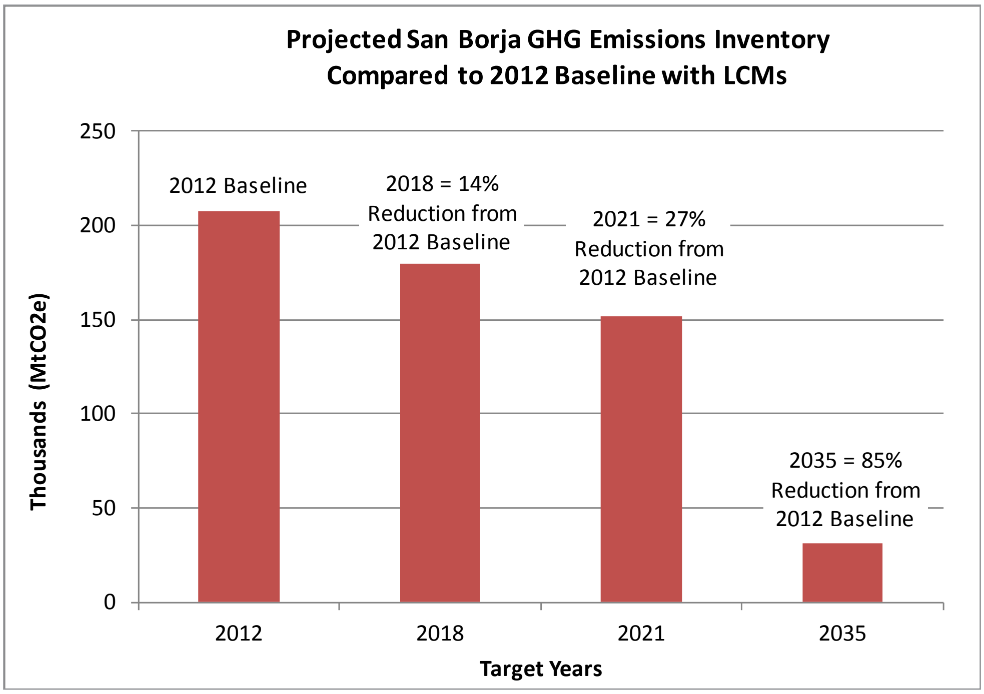
Emitted Scope	All GHS Emitted	Avoided GHGs	Sequestered GHGs	Net Emissions	% Contribution
Scope 1	3,232	0	(139)	3,092	1
Scope 2	101,857	(9,126)	0	92,731	45
Scope 3	117,025	(5,044)	0	111,981	54
Total	222,114	(14,170)	(139)	207,805	100%

9.4. GHG Emissions Reductions Analysis from LCMs

San Borja will benefit from applying the proposed additional LCMs to its existing portfolio of strategies outlined in its LCP 2021. This section describes the analytical approach for determining GHG reductions within each of the five LCM design categories: 1) Urban Function; 2) Transportation Planning; 3) Buildings Sector: Residential and Commercial; 4) Energy Planning; and 5) Environment Planning.

Figure 9-4 shows the emissions reduction potentials with LCMs for 2018, 2021, and 2035 compared to the 2012 baseline.

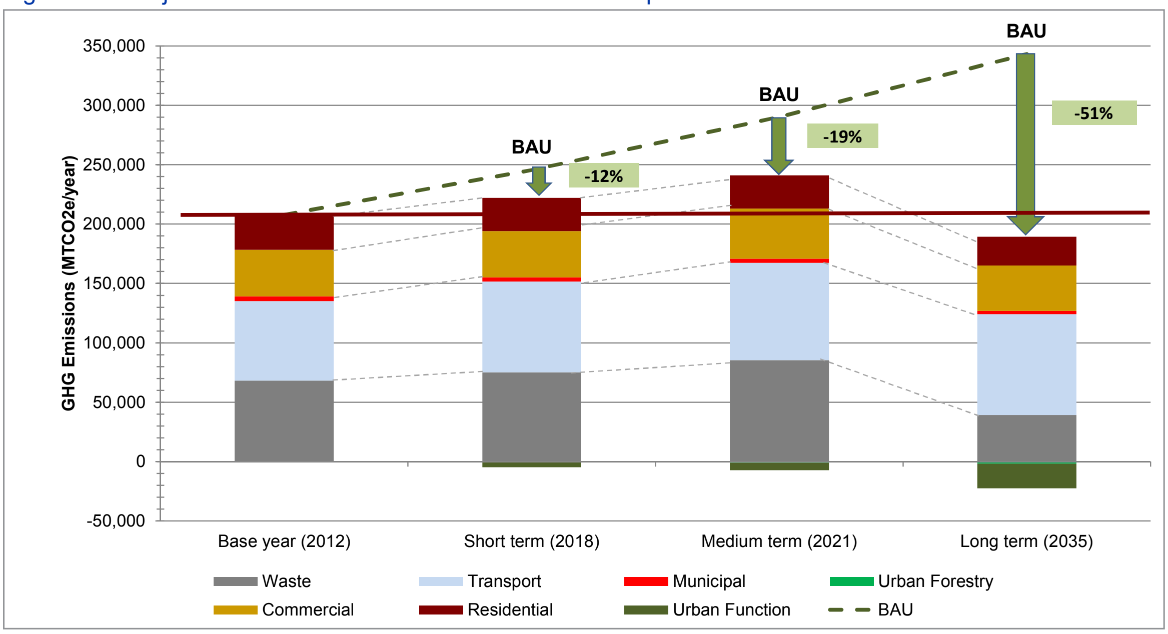
Figure 9-4: Projected Emissions Inventory with LCMs Compared to 2012 Baseline



Source: Project Team

Figure 9-5 shows projected emissions reductions with LCMs for 2018, 2021, and 2035 compared to BAU. San Borja's GHG reduction target is a 15% reduction from its 2012 baseline by 2021. With the portfolio of LCMs recommended in this study, San Borja could achieve a 27% reduction by 2021, exceeding its target by 12% by 2021.

Figure 9-5: Projected Emissions Reductions with LCMs Compared to BAU



Source: Project Team

9.4.1. Urban Function Sector

Table 9-9 below presents the projected reductions from three proposed LCMs in the Urban Function Planning Category.

Table 9-9: Projections of GHG Emissions Reductions in Urban Function Sector

Urban Function LCMs	GHG Reduction Projections (% of Baseline)		
	Short term (2018)	Medium term (2021)	Long term (2035)
Transit oriented development (TOD) planning for mixed-use land use development	.05%	1%	4%
Market-based solutions and public-private partnerships for urban greening and forest preservation	1%	1%	3%
Information and communication technologies (ICT) for city management performance	.05%	1%	3%
Total Emissions Reduction/ Yr	4,156 $MtCO_2e$	6,234 $MtCO_2e$	20,780 $MtCO_2e$

Source: Working Group III contribution to the Intergovernmental Panel on Climate Change (IPCC) 5th Assessment Report (AR5) "Climate Change 2014: Mitigation of Climate Change". *Chapter 8: Transport* of the IPCC's AR5 has reviewed scores of studies, and reviewed 1,200 scenarios involving dozens of LCMs related to urban function (e.g., mixed land use zoning) and transportation (e.g., transit-oriented design) in order to analyze and estimate relative GHG reduction potentials. These studies and scenarios have demonstrated CO2e emission reduction potential from LCM implementation ranging between 15% and 50%. Results depend on the comprehensiveness of the LCMs over time. The findings in AR5 constitute the percentages of reduction shown above, although this Feasibility Study is conservative in its estimates, i.e., choosing the low end of the scale in order to avoid overstating potential reductions.

9.4.2. Transportation Sector

Table 9-10 below present the projected reductions from three proposed LCMs in the transportation sector.

Table 9-10: Projections of GHG Reductions in Transportation Sector

Transportation Sector LCMs	GHG Reduction Projections (% of Baseline)		
	Short term (2018)	Medium term (2021)	Long term (2035)
Modal switching and mixed- mobility solutions to reduce GHG-intensity per kilometer of travel	3%	7%	14%
Travel demand management (TDM) to reduce travel demand by private passenger car	1%	2%	4%
Intelligent transportation systems (ITS) to reduce traffic congestion and increase travel speeds	.05%	2%	4%
Total Emissions Reduction/Yr	3,189 $MtCO_2e$	11,187 $MtCO_2e$	23,896 $MtCO_2e$

Source: Working Group III contribution to the Intergovernmental Panel on Climate Change (IPCC) 5th Assessment Report (AR5) "Climate Change 2014: Mitigation of Climate Change". *Chapter 8: Transport* of the IPCC's AR5 has reviewed scores of studies, and reviewed 1,200 scenarios involving dozens of LCMs related to urban function (e.g., mixed land use zoning) and transportation (e.g., transit-oriented design) in order to analyze and estimate relative GHG reduction potentials. These studies and scenarios have demonstrated CO2e emission reduction potential from LCM implementation ranging between 15% and 50%. Results depend on the comprehensiveness of the LCMs over time. The findings in AR5 constitute the percentages of reduction shown above, although this Feasibility Study is conservative in its estimates, i.e., choosing the low end of the scale in order to avoid overstating potential reductions.

9.4.3. Buildings Sector

Appendix C is a detailed methodology for estimating GHG reductions for buildings.

Table 9-11 below present the projected reductions from two proposed LCMs (active design and passive design) for three types of buildings: residential, commercial, and municipal in the Buildings Sector.

Table 9-11: Projections of GHG Emissions Reductions in Building Sector

Buildings Sector LCMs	GHG Reduction Projections Compared to BAU		
	Short term (2018)	Medium term (2021)	Long term (2035)
Residential (Passive and Active Design)	1,671	5,679	12,865
Commercial (Passive and Active Design)	4,813	11,773	28,796
Municipal (Passive and Active Design)	43	939	1,991
Emissions Reductions/Yr	6,527 MtCO2e	18,391 MtCO2e	43,652 MtCO2e

See methodology outlined in Appendix C. GHG emissions reflected in GHG accounting framework by sector: residential, commercial, and institutional/ municipal.

9.4.4. Energy Sector

Table 9-12 below presents the projected reductions from three proposed LCMs for the residential and commercial sectors, and four LCMs for the municipal sector in the Energy Sector.

Table 9-12: Projections of GHG Emissions Reductions in Energy Sector

Energy Sector LCMs	GHG Reduction Projections Compared to BAU		
	Short term (2018)	Medium term (2021)	Long term (2035)
Residential	**3,711**	**4,155**	**9,967**
Renewable Energy	595	1,041	3,122
Area Energy Planning	1,558	1,557	1,345
CEMS	1,558	1,557	1,345
Commercial	**4,444**	**4,849**	**4,895**
Renewable Energy	124	206	639
Area Energy Planning	2,160	2,344	2,128
CEMS	2,160	2,344	2,128
Municipal	**476**	**530**	**51,465**
Renewable Energy	96	172	519
Area Energy Planning	190	179	123
CEMS	190	179	123
Untapped Energy	0	0	50,700
Emissions Reductions/Yr	8,631	9,534	66,372

See methodology outlined in Appendix C. GHG emissions reflected in GHG accounting framework by sector: residential, commercial, and institutional/ municipal.

9.4.5. Environmental Sector

Table 9-13 presents the projected reductions from four proposed LCMs in the Environmental Planning Sector.

Table 9-13: Projections of GHG Reductions in the Environmental Planning Sector

Environmental Planning Sector LCMs	GHG Reduction Projections Compared to Baseline		
	Short term (2018)	**Medium term (2021)**	**Long term (2035)**
Solid Wastewater Education Recycling Expansion	4,872	9,745	23,203
Biofiltration Wastewater Re-use • biofiltration irrigation • household kitchen greywater	265	312	1,217
Urban Greening and Forest Expansion	190	340	970
Emissions Reductions/Yr	5,327 MtCO2e	10,397MtCO2e	25,390 MtCO2e

Note: Refer to chapters 7 and 8 for detailed analysis of CO2e reductions from individual LCMs.
Note: Project team modeled these reductions using the FEMP workbook

9.4.6. Summary of GHG Emissions Reductions

The overall GHG emissions projections and reductions achieved by applying the LCMs proposed by this Feasibility Study are summarized in Table 9-14 below.

Table 9-14: 2012 Baseline and Overall Projections of Emissions Reductions/Yr.

San Borja GHG Emissions Baseline, Projected Reductions and Inventory: 2018 - 2035		2012 MtCO2e	2018 MtCO2e	2021 MtCO2e	2035 MtCO2e
Residential	*BAU GHG emissions/yr*	29,508	33,424	37,860	42,884
	Projected reductions/yr from LCMs	n/a	(5,382)	(9,834)	(18,677)
	Total GHG emissions/yr with LCMs	n/a	28,042	28,026	24,207
Commercial	*BAU GHG emissions/yr*	39,355	48,131	58,864	71,991
	Projected reductions/yr from LCMs	n/a	(9,256)	(16,667)	(33,691)
	Total GHG emissions/yr with LCMs	n/a	38,875	42,197	38,300
Transportation	*BAU GHG emissions/yr*	68,162	79,715	93,227	109,029
	Projected reductions/yr from LCMs	n/a	(3,189)	(11,187)	(23,986)
	Total GHG emissions/yr with LCMs	n/a	76,526	82,040	85,043
Solid Waste & Wastewater	*BAU GHG emissions/yr*	66,842	79,890	95,484	114,122
	Projected reductions/yr from LCMs	n/a	(4,843)	(10,057)	(74,920)
	Total GHG emissions/yr with LCMs	n/a	75,047	85,427	39,202
Municipal	*BAU GHG emissions/yr*	4,077	4,452	4,862	5,309
	Projected reductions/yr from LCMs	n/a	(910)	(1,470)	(2,757)
	Total GHG emissions/yr with LCMs	n/a	3,542	3,392	2,552
Urban Function	*BAU GHG emissions/yr*	0	0	0	0
	Projected reductions/yr from LCMs	n/a	(4,156)	(6,234)	(20,780)
	Total GHG emissions/yr with LCMs	n/a	(4,156)	(6,234)	(20,780)
Urban Greening & Forestry	*BAU GHG emissions/yr*	(139)	(41)	(32)	(14)
	Projected sequestration/yr from LCMs	n/a	(571)	(929)	(1727)
	Total GHG emissions/yr with LCMs	n/a	(612)	(961)	(1741)
2012 Baseline GHG Emissions		207,805	n/a	n/a	n/a
All BAU GHG emissions/yr		n/a	245,571	290,265	343,321
All reductions/yr from LCMs		n/a	(28,307)	(56,378)	(176,538)
Total GHG emissions/yr with LCMs		n/a	217,264	233,887	166,783
% GHG reductions compared to BAU with LCMs		n/a	-12%	-19%	-51%
% GHG reductions from 2012 baseline with LCMs		n/a	-14%	-27%	-85%

Source: Project Team

9.5. Cost Performance of LCMs by Sector

To achieve the LCP 2021 emissions reduction target of 15% of the 2012 baseline, and to help determine longer-term goals for San Borja, development of a practical and effective approach to LCM implementation is necessary. This section provides estimates of the cost effectiveness of the LCMs recommended by this study. The below estimates, in combination with the information provided in Chapter 10, will support implementation.

9.5.1. Assumptions for Cost Performance Analysis

This study had the following assumptions when evaluating cost-effectiveness of LCMs:

- The dollar basis for the quantitative assessment is the cost required to reduce 1 ton of CO2e (USD/MtCO2e-year).
- The assumed annual operating costs of all LCMs is equal to 2% of the total cycle cost, unless otherwise stated.
- In cases where there is a construction cost involved, the annual expense of each LCM is the total of value of construction cost per year (initial construction cost divided by life cycle of 20 years) and annual operating cost.
- The assumed life cycle of all LCMs is 20 years (from 2015 to 2035).

Table 9-14: Candidate LCMs for Cost Performance Analysis

LCM Category	LCMs with GHG Reduction Projections
Urban Function Planning	• Transit oriented development (TOD) planning for mixed-use land use development • Market-based solutions and for urban greening and forest preservation • Information and communication technologies (ICT) for city management performance
Transportation Planning	• Modal switching and mixed- mobility solutions to reduce GHG-intensity of travel • Travel demand management (TDM) to reduce travel demand by private passenger car • Intelligent transportation systems (ITS) to reduce traffic congestion
Buildings Design Planning	• Low carbon building passive design • Low carbon building active design
Energy Planning	• Area-wide energy efficiency and management planning and microgrid implementation • Community energy management system and smart meter implementation • Renewable energy: solar energy • Untapped energy (waste-to-energy)
Environmental Planning	• Solid waste recycling expansion (discusss incineration) • Biofiltration waste water reuse system expansion • Urban greening and forest expansion

9.5.2. Cost Performance Analysis: Urban Function and Transportation

The table below offers the estimates of initial construction cost (USD), life cycle (year), value of construction cost per year (USD/year), annual operating cost (USD/year), total annual expense (USD/year), and CO2e reduction (Mt-CO2e/year). On the basis of these estimated costs, the table then presents each LCM's unit cost of CO2e reduction (USD/Mt-CO2e-year). This section presents the cost performance analysis for LCMs in Urban Function Planning and Transportation Planning.

Table 9-15 below summarizes GHG average initial investment cost per year. Table 9-16 summarizes the per unit cost of GHG reductions.

Table 9-15: GHG Average Initial Investment Cost/Year

Low Carbon Measure	Total Initial Investment Cost (USD)	Life cycle (year)*	Average Initial Investment Cost/Year (USD/year)
Urban Function Planning			
Transit oriented development (TOD) planning for mixed-use land use development	1,901,369	20	95,068
Market-based solutions and public-private partnerships for urban greening and forest preservation	1,527,329	20	76,366
Information and communication technologies (ICT) for city management performance	900,000	20	45,000
Transportation Planning			
Modal switching and mixed- mobility solutions to reduce GHG-intensity per kilometer of travel	3,627,534	20	181,377
Travel demand management (TDM) to reduce travel demand by private passenger car	1,041,125	20	52,056
Intelligent transportation systems (ITS) to reduce traffic congestion and increase travel speeds	1,250,000	20	62,500

*The life cycle (20 years) is assumed to be same as the lifespan of the LCMT term (2015~2035).

Table 9-16. Unit Cost of GHG Reductions/Yr.

Low Carbon Measure	Average Initial Investment Cost/ Year (USD/year)	Annual Evaluation Cost ** (USD/ year)	Total Annual Expense (USD/year)	Average CO2e reduction (MTCO2e/ year)	Unit Cost of CO2e Reduction (USD/MTCO2e-year)
Urban Function Planning					
Transit oriented development (TOD) planning for mixed-use land use development	95,068	76,055	76,055	6,286	12
Market-based solutions and public-private partnerships for urban greening and forest preservation	76,366	61,093	61,093	4,987	12
Information and communication technologies (ICT) for city management performance	45,000	54,000	54,000	4,831	11
Transportation Planning					
Modal switching and mixed- mobility solutions to reduce GHG-intensity per kilometer of travel	181,377	145,101	145,101	12,134	12

Travel demand management (TDM) to reduce travel demand by private passenger car	52,056	41,645	41,645	3,431	12
Intelligent transportation systems (ITS) to reduce traffic congestion and increase travel speeds	62,500	75,000	75,000	3,319	23

**For equivalent comparison, annual policy and strategy evaluation costs for Category 1 LCMs is assumed as 4% of the initial investment cost, with the exception of ICT and ITS for which there is an annual 6% operating costs representing a combined annual policy evaluation (4%) and annual system operating costs (2%) of the initial investment cost.

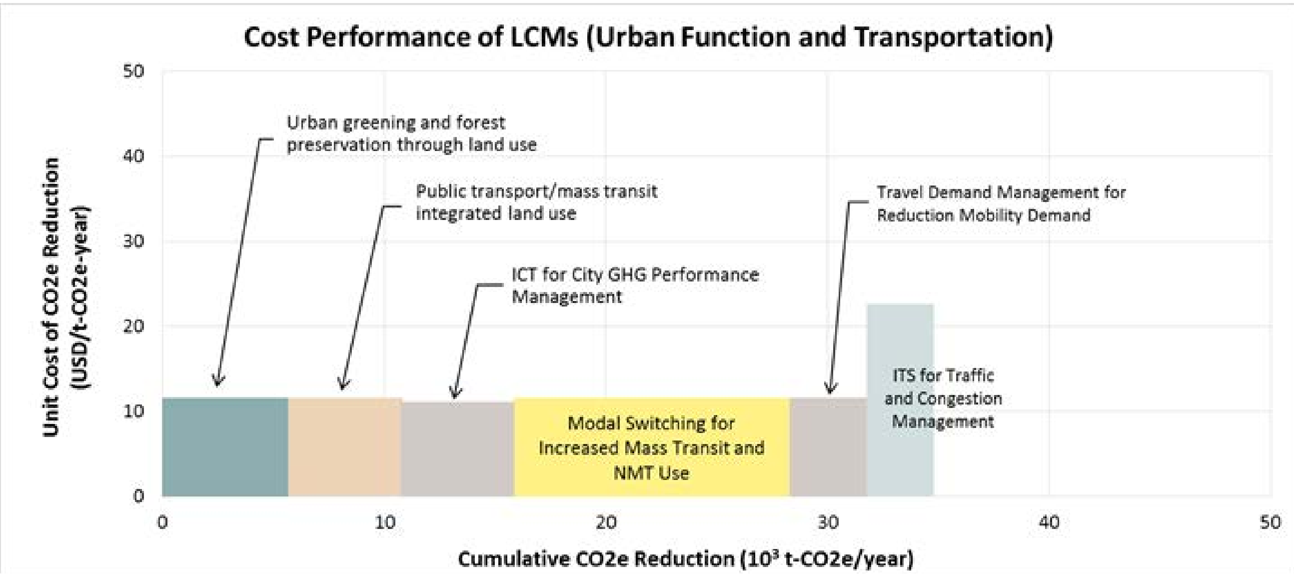
Observations

The following represent important observations from the analysis:

- In general, the LCMs in Urban Function Planning and Transportation Planning have similar cost performance. Among them, 'modal switching' appears to have the best cost performance (low cost and high CO2e reduction rate).
- The LCMs in Urban Planning and Transportation Planning generally have lower unit cost of CO2e reduction (USD/t-CO2e-year) than the LCMs in Building Sector, Energy Planning and Environment Planning (refer to section 9.6.3).
- By comparing the unit cost of CO2e reduction (USD/MtCO2e-year), it is evident that ICT has the best cost performance (low cost and high CO2e reduction rate).
- When compared with the LCMs above, ITS has a relatively low CO2e reduction rate and requires higher investment and operating costs.

The results of the cost performance analysis above are plotted in Figure 9-6 below, with y-axis representing unit cost of CO2e reduction and the x-axis representing the cumulative CO2e reduction rate.

Figure 9-6: Cost Performance of Low Carbon Measures (Urban Function and Transportation)



Source: Project Team

9.5.3. Cost Performance Analysis: Building, Energy, and Environmental

The table below offers the estimates of initial construction cost (USD), life cycle (year), value of construction cost per year (USD/year), annual operating cost (USD/year), total annual expense (USD/year), and CO2e reduction (t-CO2e/year). On the basis of these estimated costs, the table then presents each LCM's unit cost of CO2e reduction (USD/t-CO2e-year).

Table 9-17 average initial investment cost per year. Table 9-18 summarizes the per unit cost of GHG reductions.

Table 9-17: Breakdown of Unit Cost of CO2e Reduction for Selected LCMs

Low Carbon Measure	Total Initial Construction Cost (USD)	Life cycle (year)*	Average Initial Construction Cost/ Year (USD/year)
Buildings Sector Planning			
Low carbon building design	156,844,551	20	7,842,228
Energy Planning			
Area wide energy planning & microgrid	16,830,000	20	841,500
Renewable energy(solar energy)	75,316,720	20	3,765,836
Community Energy Management System (CEMS)	5,893,921	20	294,696
Untapped energy(waste-to-energy)	15,000,000	20	750,000
Environment Planning			
Solid waste recycling expansion and awareness	60,000	20	3,000
***Solid waste incineration plant	12,000,000	20	600,000
**Urban greening and forest expansion	4,950,000	20	247,500

*The life cycle (20 years) is assumed to be same as the lifespan of the LCMT term (2015~2035)
**The initial investment cost includes USD 2.5 million for the biofiltration facility for irrigation and USD 2.45 million related to the unit cost of planting eucalyptus within 490,000 m2.
***This is not included in San Borja's GHG accounting and reporting.

Table 9-18: Unit Cost of GHG Reductions/Yr

Low Carbon Measure	Average Initial Construction Cost/Year (USD/ year)	Annual Operating Cost ** (USD/year)	Total Annual Expense (USD/year)	Average CO2e reduction (MtCO2e/year)	Unit Cost of CO2e Reduction (USD/MtCO2e-year)
Buildings Sector Planning					
Low carbon building design	7,842,228	3,136,891	10,979,119	43,652	252
Energy Planning					
Area wide energy planning & microgrid	841,500	336,600	1,178,100	3,596	328
Renewable energy (solar energy)	3,765,836	1,506,334	5,272,170	4,280	1,232
Community Energy Management System (CEMS)	294,696	117,878	412,574	3,596	115

Untapped energy (heat waste-to-energy)	750,000	75,000	825,000	50,700	16
Environment Planning					
Solid waste recycling expansion	3,000	600	3,600	1,789	2
Solid waste incineration	600,000	30,000	630,000	11,385	35
Urban greening and forest expansion	247,500	4,950	252,450	831	304

**For equivalent comparison, annual operating cost of all LCMs is assumed as 2% of the initial investment and construction cost with the exception of solid waste recycling at 20%, solid waste incineration at 5%, untapped energy (heat waste-to-energy) at 10%.

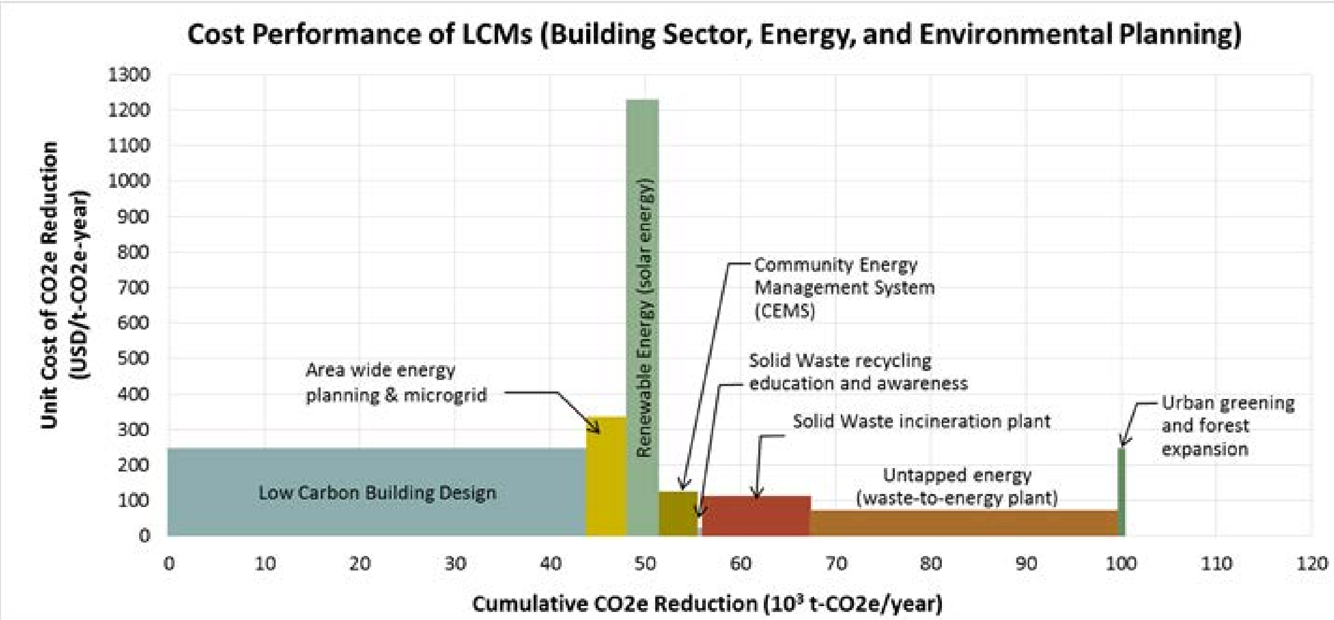
Observations

The following represent important observations from the analysis:

- By comparing the unit cost of CO2e reduction (USD/Mt-CO2e -year), it is evident that "solid waste recycling expansion" and "untapped energy (waste-to-energy)" have the best cost performance (low cost and high CO2e reduction rate).
- When compared with the LCMs above, "area wide energy planning and microgrid" and "renewable energy (solar energy)" have relatively low CO2e reduction rate but require higher investment.

The results of the cost performance analysis above are plotted in Figure 9-7 below, with y-axis representing *unit cost of CO2e reduction* and the x-axis representing the *cumulative CO2e reduction rate*.

Figure 9-7: Cost Performance of Low Carbon Measures (Building Sector, Energy, and Environmental Planning)

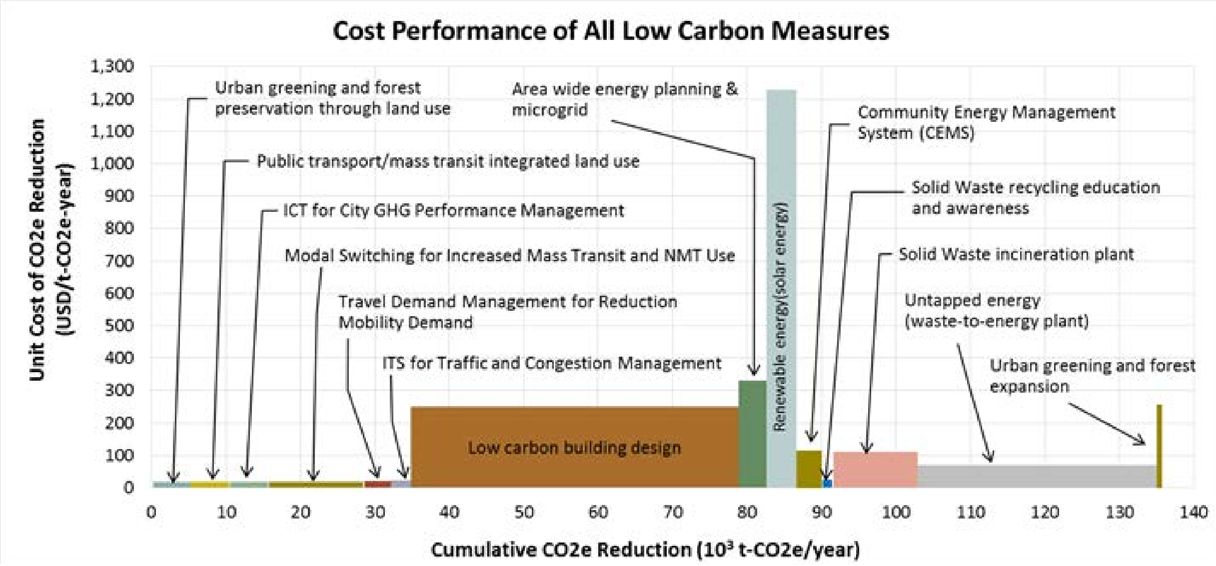


Source: Project Team

9.5.4. Cost Performance Analysis: All LCMs

It is anticipated that the implementation of high performance LCMs could bring significant and sustainable benefits to San Borja within a relatively short period of time. Figure 9-8 below shows the cost performance of all low carbon measures in all LCM categories.

Figure 9-8: Cost Performance of All Low Carbon Measures



Source: Project Team

This study recommends San Borja include the following four considerations, (in addition to considering the per unit cost of MtCO2e reduced), when prioritizing LCM investment:

1) Does San Borja have director management control of over the emissions the LCM is to reduce (i.e., Scope 1 emissions);

2) Could San Borja reduce its Scope 2 emissions through procurement policies;

3) Could San Borja reduce Scope 3 emissions from greater employee and resident awareness and education; and

4) Would San Borja be using a multi-criteria investment analysis to identify LCMs with significant benefit to cost ratios.

The implementation of these LCMs would require technology transfer and technical support from countries with experience in the relevant low carbon technologies. Subsidies or financing support from the public sector or other entities would also be essential in the preparation, procurement and operation of such low carbon projects. Chapters 10 and 11 discuss project implementation models and financing options for all LCMs.

10. CARBON REDUCTION MEASURE IMPLEMENTATION RECOMMENDATIONS

10.1. Overview of Implementation Recommendations

This Feasibility Study recommends that San Borja consider the following to successfully implement the recommended LCMs and achieve the associated GHG emissions reductions:

- Formation of an LCMT Community Planning Council (LCMT-CPC)
  - The LCMT-CPC should lead low carbon efforts by performing the overall planning and management for all carbon reduction measures.
  - The LCMT-CPC should consist of various stakeholder groups and departments within the San Borja Municipality.
- Project Implementation Business Schemes
  - The business scheme for each carbon reduction measure should be designed based on the characteristics of the measure.
  - There are a variety of project implementation schemes, such as public-based projects and public-private partnership (PPP) projects.
- Financing
  - LCMT-CPC projects could be funded by one of the following sources:
    - San Borja's Municipality budget;
    - Peru's national budget;
    - An international or domestic funding source (refer to Chapter 11); or
    - Private financing.

This chapter includes a recommended approach for the formation of the LCMT-CPC and for project implementation business schemes. Financing options are discussed in the project implementation business scheme section and in Chapter 11. This chapter concludes with a sample roadmap for San Borja to realize its LCMT vision.

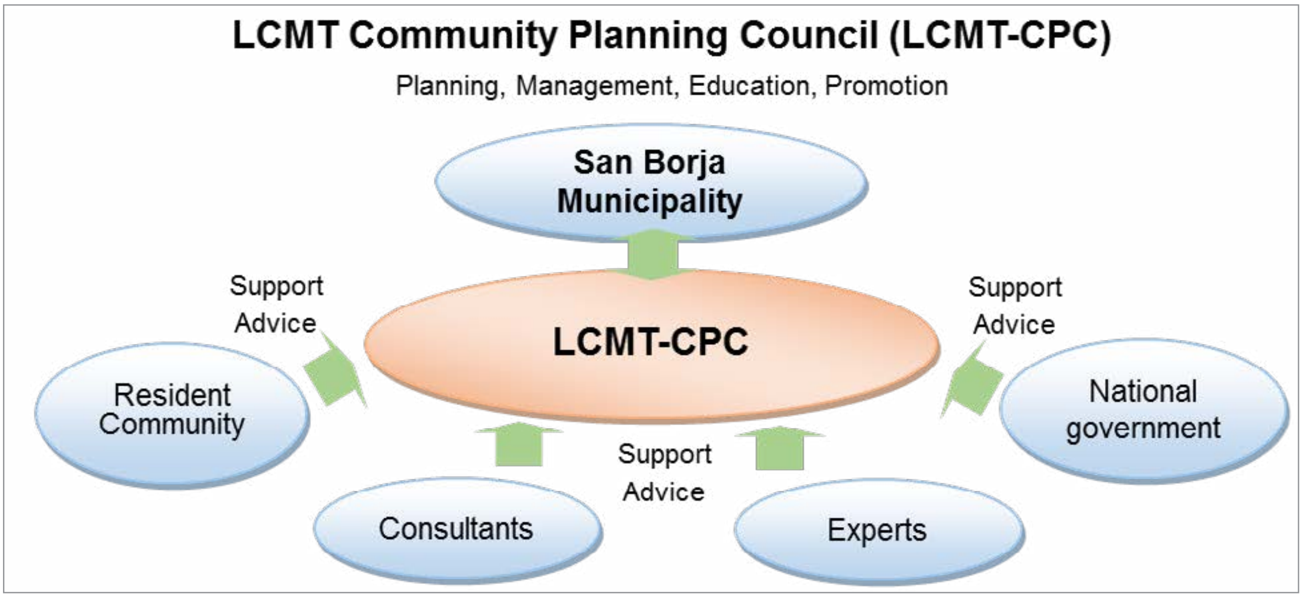
10.2. Formation of an LCMT Community Planning Council (LCMT-CPC)

10.2.1. Proposed LCMT-CPC Structure

For LCMT success, it is essential that San Borja have a leadership team to initiate and oversee activities, as well as coordinate with stakeholders and monitor progress and results. This Feasibility Study recommends that San Borja develop an LCMT-CPC which would be responsible for the following tasks:

- Undertaking initiatives to maintain town quality of life and the environment;
- Setting annual targets for activities in each district;
- Assigning roles and responsibilities for LCMT activities;
- Developing and exchanging information and expertise;
- Coordinating and collaborating with Lima city, Peru, and other regions; and
- Helping establish the business case for investment and helping to secure financing.

Figure 10-1: Proposed Structure of LCMT-CPC



Source: Nikken Sekkei Research Institute

Table 10-1 outlines the possible members and a description of associated member roles and responsibilities. Table 10-2 shows the proposed implementation structure for the LCMT-CPC.

Table 10-1: Members of LCMT-CPC

Member	Description / Roles & Responsibilities
San Borja municipal governments	Main management body that manages all sectors within the district. LCMT-CPC should be established within the existing municipal departments.
Other priority municipal governments	Main management body that manages all sectors within the district. LCMT-CPC should be established within the existing municipal departments.
Lima Province government	Provide subsidies and assistance for LCMT projects.
National government	Provide subsidies and assistance for LCMT projects.
San Borja residents	Provide input and feedback and express concerns regarding LCMT initiatives (via 1-2 representatives from each administrative zone).
San Borja Chamber of Commerce	Help generate business opportunities.
Real estate developers	Provide stakeholder perspective and help generate business opportunities.
Academic or professional experts	Provide subject matter expertise and local knowledge (e.g. from local universities or colleges).
Third-party consultants	Provide expertise in environment planning, energy planning, economics, etc. Support operations of LCMT-CPC. Help secure subsidies and/or foreign investments.

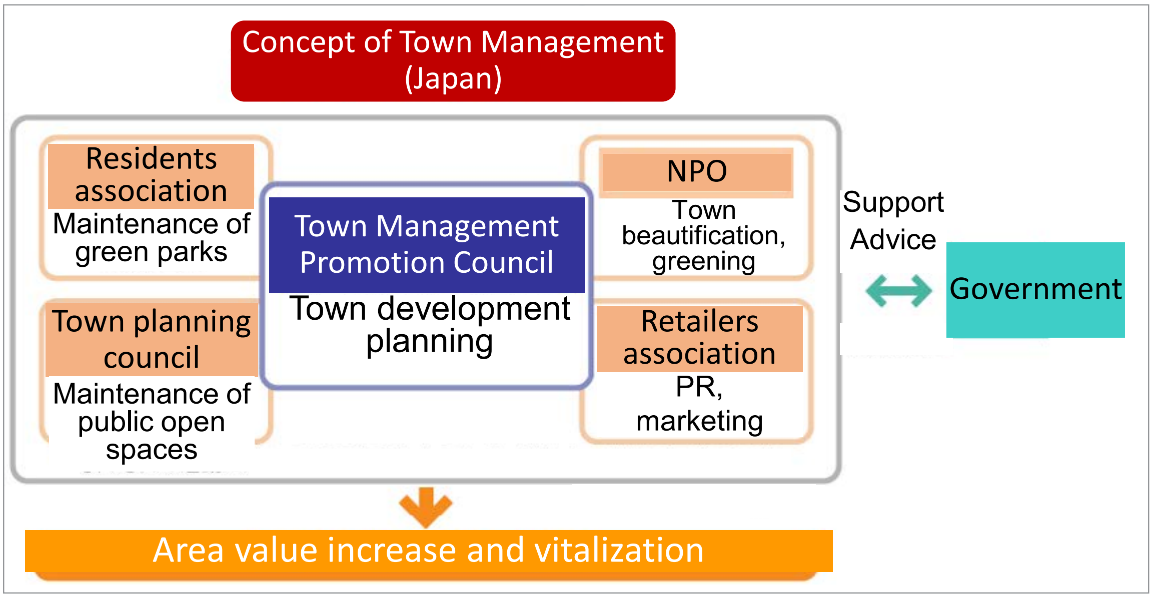
Table 10-2: Implementation Structure of LCMT-CPC

Category	Descriptions
System of community (stakeholders, number)	Representatives from APEC LCMT advisory group Local resident representatives Secretariat for APEC LCMT, GHG Emission Credit Trading

Category	Descriptions
Activities	Manage tree planting, solid waste/recycling, human resources, etc. Provide educational activities, such as site visits to environmental points of interest Implement eco-point system, which could include eco-labeling and reward incentives Coordinate eco-friendly events, such as eco-cars and green purchasing Develop guidelines for landscaping
Selecting members for LCMT-CPC	Identify one or two representatives from each of the 12 administrative zones
Management of the LCMT-CPC	Establish a location for the LCMT-CPC headquarters inside the municipality building
Best practice policies and procedures	Consider existing models for community involvement in town management, for example the model presented in Figure 10-3
Financing mechanisms	Membership fees from residents, private sponsorships, subsidies from the municipality, etc.

Figure 10-2 below provides a model of town management typically seen in Japan. Local stakeholders, including residents, business owners, and landowners undertake initiatives in maintaining the living environment and values of their town. This example is provided as a model for structuring the LCMT-CPC within the overall municipal management structure.

Figure 10-2: Town Management in Japan



Source: http://machi.smrj.go.jp/

Other examples of city management approaches based on stakeholder involvement include:

- **Strategic Planning Approach:** Strategic Planning (SP) has contributed to the emergence of a new style of urban governance based on participation, co-operation and shared responsibility. In Merida, Mexico more than 600 people participated in workshops and meetings during the strategic planning process. As each of the SP projects was developed, another round of participation was initiated. The extensive consultation process also included interviews and socio-economic household surveys to provide an accurate assessment of the city's socioeconomic conditions.[78]

78 Source: http://ella.practicalaction.org/node/952; http://ella.practicalaction.org/sites/default/files/111129_ENV_UrbEnvGov_BRIEF3.pdf

- **Stage 1 – Diagnosis:** Identify critical problems to establish strategic lines of action. Simultaneous analyses of projects already discussed and approved that are considered strategic. Identify indicators for assessment and monitoring, including gauging strengths, opportunities, weaknesses, and risks.
- **Stage 2 – Confirmation:** Confirm diagnosis of critical problems at the neighborhood level. Prioritise problems with residents and define vision, strategic objectives, and projects that are coherent with these objectives.
- **Stage 3 – Action Plan:** Definition of the action program and discussion of alternative options for implementation. In the management stage of the plan, stakeholders define their own responsibilities in the projects and design monitoring systems.
- **Stage 4 – Monitor and Revise:** The projects and changes in the city are monitored, and new needs for city development are evaluated

- **Multi-stakeholder environmental management structure (e.g., Moreno Argentina):** Local research teams were set up, as were diverse Working Teams composed of NGOs, local government officials, and community members. The Working Teams collected information, diagnosed problems, and planned projects for which specific funds were allocated. The projects identified by multi-stakeholder discussions were implemented and monitored by local community teams, with constant levels of participation and communication, and careful documentation.[79]

10.2.2. Participation of San Borja Municipality's Departments

Existing departments within the San Borja District should also participate in the LCMT-CPC. Different departments will serve in primary roles in the implementation of the different LCMs. For example, a selected number of staff members from the Department of Neighborhood Involvement, Department of Strategic Planning, and Department of Legal Counsel could serve in leadership roles in managing the LCMT-CPC. Other departments will support the LCMT-CPC through information sharing and distribution. Table 10-3 identifies departments that may be most appropriate to focus on implementation of the LCMs from each category of this Feasibility Study.

The mechanisms and benefits of the three project schemes are presented in Figure 10-3. Public works and PPP are mainly applicable for "public infrastructure and public service projects"; the difference is that private funding could be utilized in PPP projects.

Table 10-3: Participation of San Borja District Departments in LCM Implementation

Departments in San Borja Municipality		LCMT Manage-ment	Urban Function Planning	Transpor-tation Planning	Buildings and Houses	Energy Planning	Environ-mental Planning	Finance
Spanish	English							
Gerencia de Rentas	Department of Revenue							✓
Gerencia de Fiscalización y Autorizaciones	Department of Supervision and Authorization		✓					
Gerencia de Desarrollo Urbano	Department of Urban Development	✓	✓	✓			✓	✓

79 Source: file:///C:/Users/jgeiger/Downloads/111129-env-urbenvgov-brief2.pdf

Departments in San Borja Municipality		LCMT Management	Urban Function Planning	Transportation Planning	Buildings and Houses	Energy Planning	Environmental Planning	Finance
Spanish	English							
Gerencia de Desarrollo de la Ciudad y Cooperación Técnica	Department of City Development and Technical Cooperation			✓	✓	✓	✓	
Gerencia de Tránsito y Seguridad Ciudadana	Department of Traffic and Public Safety		✓	✓				
Gerencia de Medio Ambiente y Obras Públicas	Department of Environment and Public Works		✓	✓			✓	
Gerencia de Desarrollo Humano	Department of Human Development						✓	
Gerencia de Participación Vecinal	Department of Neighborhood Involvement	✓	✓	✓			✓	
Gerencia de Planificación Estratégica	Department of Strategic Planning	✓	✓	✓			✓	
Gerencia de Tecnologías de la Información	Department of Information Technology	✓	✓	✓	✓	✓	✓	
Gerencia de Administración y Finanzas	Department of Administration and Finance							✓
Gerencia de Asesoría Jurídica	Department of Legal Counsel	✓						

Note: The official Spanish names of the Divisions in the San Borja Municipality were retrieved from http://www.munisanborja.gob.pe/. The unofficial English translations were performed by the author.

10.3. Project Implementation Schemes

10.3.1. Overview

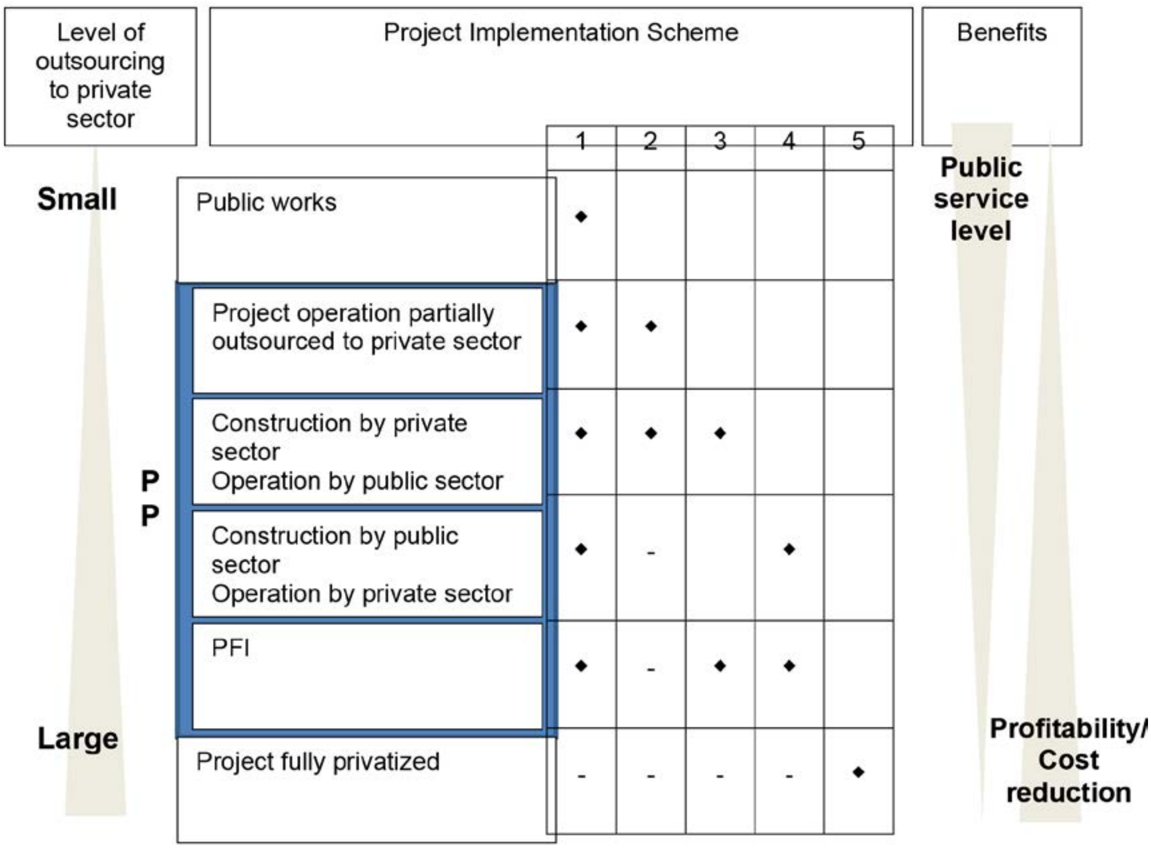
As stated above, LCMs proposed in this study could be funded and implemented by either the public sector or private sector depending on project scale and interest. There are also project schemes that could be simultaneously implemented by both the public and private sectors, such as a PPP which is a joint business venture, funded and operated through a partnership of government and private enterprises, to provide a government service.

Table 10-4 shows potential types of project implementation schemes. Figure 10-3 graphically compares mechanisms of PPP, including private finance initiatives (PFI), with other financing mechanisms.

Table 10-4: Types of Project Implementation Schemes

Scheme	Description	Applicable Projects
Public works	The public sector provides the funding and select service providers from the private sector through bidding process.	Public infrastructure and public service projects
Public Private Partnership	The private sector performs construction and administration with its own funding, collecting service payments from users. The project shortfall is funded by the public sector. Another model of public private partnership is where the private developer funds and builds the asset according to public sector specifications; the public sector operates and ultimately owns the asset after a long-term lease arrangement.	Projects with operating costs subsidized by public sector
Fully privatized projects	The private sector performs construction and administrative services with its own funding, collecting service payments from users. There is no financial support from the public sector.	Profitable projects

Figure 10-3: Comparison of PPP with Other Financing Mechanisms



1. Cleaning and legal inspections by private sector.
2. Project operation partially outsourced to private sector
3. Construction by private sector (private fund)
4. Entire project operation outsourced to private sector
5. Construction and operation by private sector (without contract with public sector)

Source: Cabinet Office, Government of Japan. http://www8.cao.go.jp/pfi/tebiki/kiso/kiso03_01.html

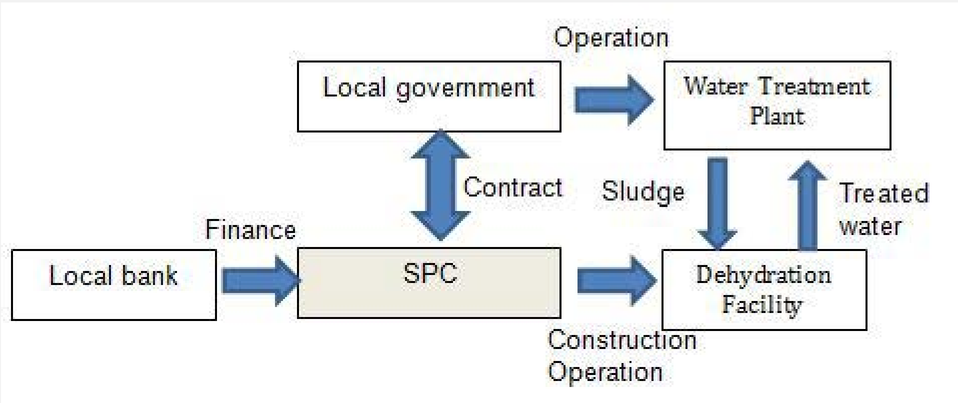
The call-out box below shows an example of a private financing scheme used recently in Samukawa, Japan when implementing a wastewater treatment plant renovation project. This Feasibility Study recommends that San Borja review this and the following case studies when selecting a project implementation scheme for LCM implementation.

Other examples of innovative financing schemes for public infrastructure projects include:

- **Low Carbon Growth Path – Mexico City, Mexico**. The plan received $500 million from the Clean Technology Fund, which was supported by eight governments, managed by the World Bank, and administered by the World Bank Group and other multilateral development banks. Mexico is among the first countries to tap the $5.2 billion fund that provides grants and low-interest financing to pilot and scale up low carbon technologies and make other changes that reduce energy use and pollution.[80]
- Columbia received $20M US in funding for the building of Transit-Oriented-Development neighborhoods in five cities across the country through the Center for Clean Air Policy (CCAP) and Columbian Development Bank FINDETER. This multi-sector Nationally Appropriate Mitigation Action (NAMA) was developed through CCAP's Mitigation Action Implementation Network (MAIN) project over the past two years in close coordination with FINDETER, the national Ministries of Transport, Environment, Housing and Planning, local officials, private developers, university researchers and local. The NAMA will create a project pipeline and a policy framework to engender broad replication by mobilizing additional private, national, and international funds.[81]

Figure 10-4: Wastewater Treatment Plant Renovation Project in Samukawa Town (Japan)

A 30-year old wastewater treatment plant in Samukawa Town underwent a renovation of its dehydration facility between 2003 and 2005. The project employed a Private Finance Initiative (PFI) financing scheme which included the following steps:



- The local government (public sector) contracted with SPC (special purpose company).
- The local government was responsible for the overall operation of the wastewater treatment plant.
- The construction and operation of the dehydration facility was funded by the SPC but the dehydration facility was part of the wastewater treatment plant.
- The SPC was financed by a local bank.

Source: http://www8.cao.go.jp/pfi/tebiki/jirei/jirei17_01.html

80 Source: http://web.worldbank.org/WEBSITE/EXTERNAL/NEWS/0,,contentMDK:22212269~pagePK:34370~piPK:34424~theSitePK:4607,00.html

81 Source: http://ccap.org/colombia-transit-oriented-development-nama-selected-for-funding/

10.3.2. Applicability of Project Implementation Schemes to LCMs

The applicability of the three project implementation schemes described above to the proposed LCMs in each design category are summarized in Table 10-5 through 10-9.

Table 10-5 through 10-9 are presented to show the applicability of the three schemes for each LCM. Notes have been added below each graph to explain how the applicability was determined.

Table 10-5: Applicable Project Implementation Schemes for Urban Function Planning

Project Scheme	Land use for urban forest and shade preservation	Land use to increase public transport and mass transit	ICT for city performance Management
Public works	✓	✓	✓
PPP		✓	✓
Fully privatized projects			✓

Note: Urban Function Planning in general requires strong initiation and leadership from the public sector. The implementation of “land use and market based strategies for urban forest preservation” would most likely be initiated by the public sector. TOD would most likely be implemented by the public sector but there have been successful cases with the PPP scheme. There have been successful cases in which “ICT” was implemented by the private sector alone.

Table 10-6: Applicable Project Implementation Schemes for Transportation Planning

Project Scheme	Modal switching for increased public transport and mass transit use	Travel demand management programs to reduce mobility demand (TDM)	Intelligent transport system for traffic and congestion management
Public works	✓	✓	✓
PPP	✓	✓	✓
Fully privatized projects			✓

Note: Transportation Planning in general requires strong initiation and leadership from the public sector. The implementation of ‘modal switching’ and ‘TDM’ could be feasible through sole initiation by the public sector or PPP. ‘Intelligent transport system’ could be implemented by either public or private sector.

Table 10-7: Applicable Project Implementation Schemes for Buildings

Project Scheme	Low carbon building design measures				
	Passive design strategies	Active system design – lighting	Active system design – HVAC	Active system design – water conservation	Active system design – solar energy
Public works					
PPP	✓	✓	✓	✓	✓
Fully privatized projects	✓	✓	✓	✓	✓

Note: In most countries, ‘low carbon building design measures’ are be initiated or promoted by the public sector but implemented by the private sector. These measures could also be initiated and implemented by the private sector when profitability could be foreseen.

Table 10-8: Applicable Project Implementation Schemes for Energy Planning

	Area wide energy planning & Microgrid			
Project Scheme	**Micro Grid**	**Demand response**	**Renewable energy (solar energy)**	**Community Energy Management System (CEMS)**
Public works				
PPP	✓		✓	✓
Fully privatized projects		✓		

Note: 'Micro grid' is most likely to be implemented as a PPP or fully privatized project as demonstrated in many developed countries. 'Demand response' implementation would be most likely implemented solely by the power company. 'Renewable energy' and 'CEMS' would mostly likely be initiated by PPP.

Table 10-9: Applicable Project Implementation Schemes for Environment Planning

Project Scheme	Solid waste recycling education and awareness	Solid waste incineration plant	Untapped energy (waste-to-energy plant)	Urban greening and forest expansion
Public works	✓	✓	✓	✓
PPP		✓	✓	✓
Fully privatized projects		✓		

Note: 'Solid waste recycling education and awareness' could be implemented by public sector. 'Solid waste incineration plant' could be implemented by either public or private sector. 'Waste-to-energy plant' and 'urban greening and forest expansion' are public infrastructure, and therefore possible for PPP schemes.

10.3.3. Proposed Project Implementation Models

In this section, the PPP-based project implementation models for a selected number of LCMs are proposed. The projects presented meet the following criteria:

- The projects are principally performed by the public sector or public enterprises;
- Project implementation have been difficult in the private sector because return of investment cannot be ensured or the profitability is low;
- The projects cannot be profitable without subsidies or financing support; and
- If implemented, the projects could make significant contributions to energy efficiency and GHG mitigation, as well as create positive socio-economic impact to the local area.

In regard to low carbon building design, the building construction industry belongs to the private sector; both new constructions and retrofits are generally performed by private contractors only. Therefore, "low-carbon building design" LCM has not been selected for PPP models.

Table 10-10: Candidate LCMs for PPP-based Project Implementation Models

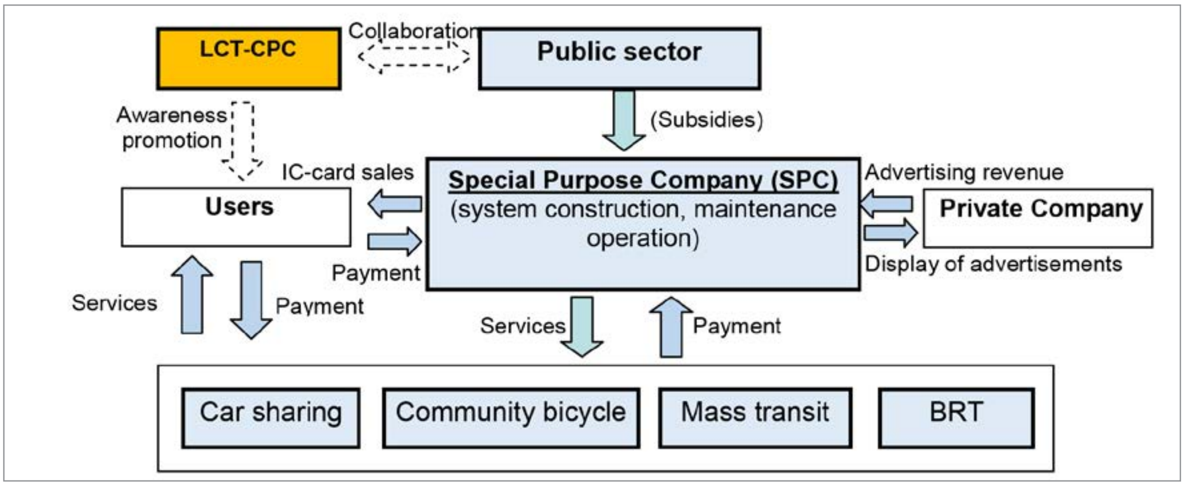
Design Category	LCMs
Transportation Planning	Travel demand management (TDM)
Energy Planning	Renewable energy (solar energy)
	Community Energy Management System (CEMS)
Environmental Planning	Untapped energy (waste- to-energy plant)

1. Travel demand management (TDM)

A project implementation model for TDM (see section 5.2.2 for details) that integrates the use of IC (Integrated Circuit) cards in community bicycle program, public mass transit, and car sharing system is presented in Figure 10-5 below. In this model:

- A Special Purpose Company (SPC), mainly private enterprises, is responsible for the construction, maintenance, and operation of the TDM system.
- Users purchase the IC-cards and use them for eligible transport modes.
- Each transportation company pays the SPC for the services received.
- The SPC earns operating revenue from service payments from participating transportation companies.

Figure 10-5: Proposed Project Implementation Model for TDM

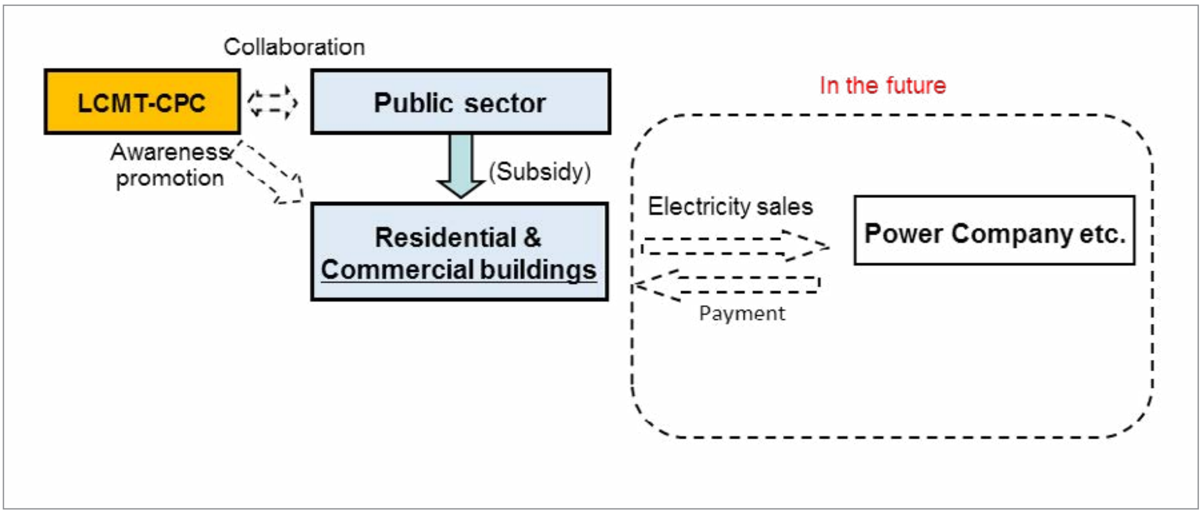


2. Renewable energy (solar energy)

A project implementation model for the rooftop PV power system in residential and commercial buildings as proposed in Chapter 7 is presented in Figure 10-6 below. In this model:

- Residential and commercial buildings purchase PV panels with the subsidies from the public sector (if available).
- If feed-in tariff schemes for renewable energy are introduced in the future, PV system owners may sell the excess power to the power company.

Figure 10-6: Proposed Project Implementation Model for PV Power Generation



3. Community Energy Management System (CEMS)

A project implementation model for the CEMS proposed in Chapter 7 is presented in Figure 10-9 below. In this model:

- Large commercial buildings are installed with a building energy management system (BEMS) and residential buildings are installed with a home energy management system (HEMS). Smart meters are installed by the SPC or the local government at no cost to the building owner.
- EMS center (inside the Municipality office) is managed by the SPC under the supervision of San Borja District.
- The pricing for electricity and heating services are not uniform. Demand response (dynamic pricing) is performed to manage the peak demand.
- The introduction of subsidies by the national or local government should be promoted. For example, in some European countries, the government provides subsidies or tax incentives.

Figure10-7: Operation Image of CEMS (Copy of Figure 7-18)

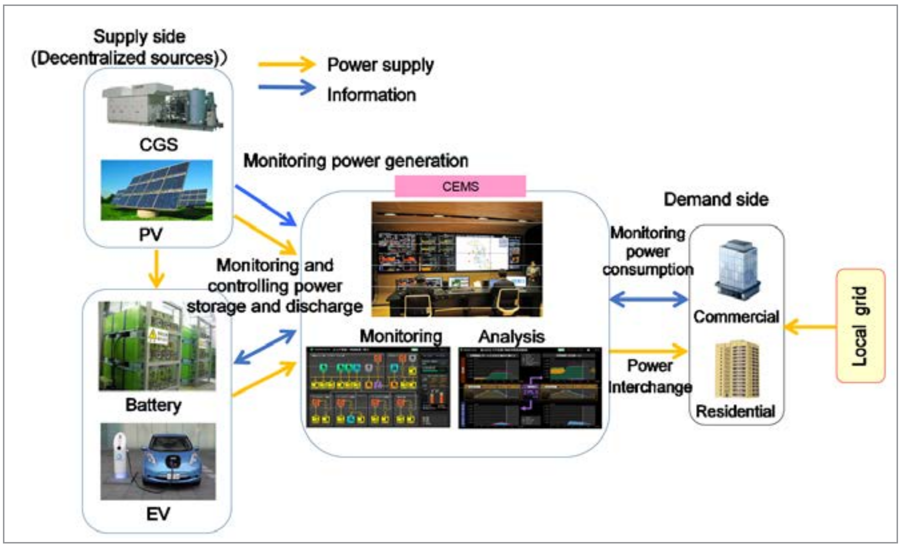
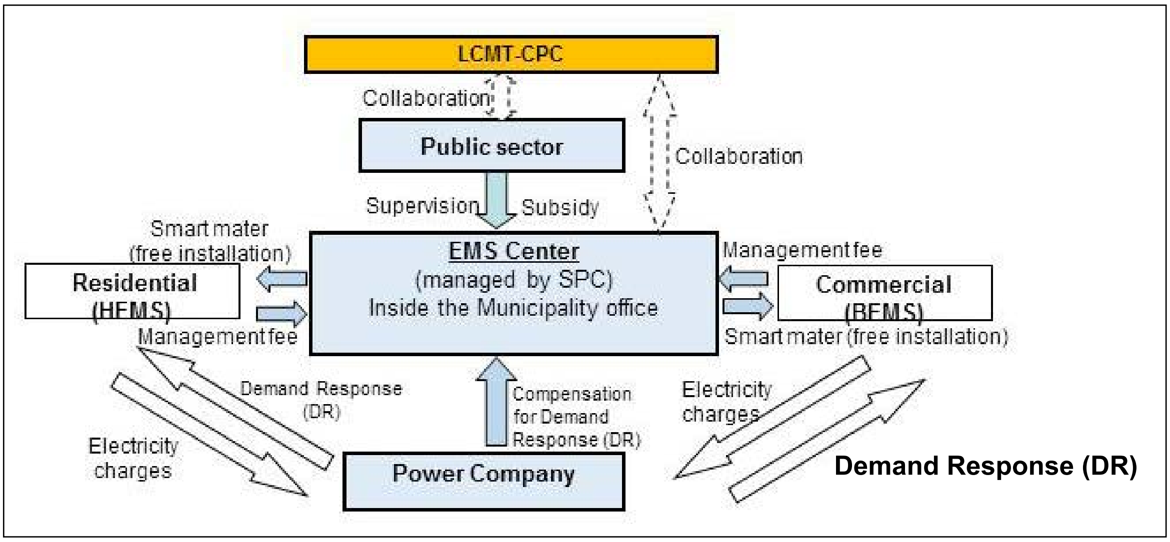


Figure 10-8: Proposed Project Implementation Model for CEMS

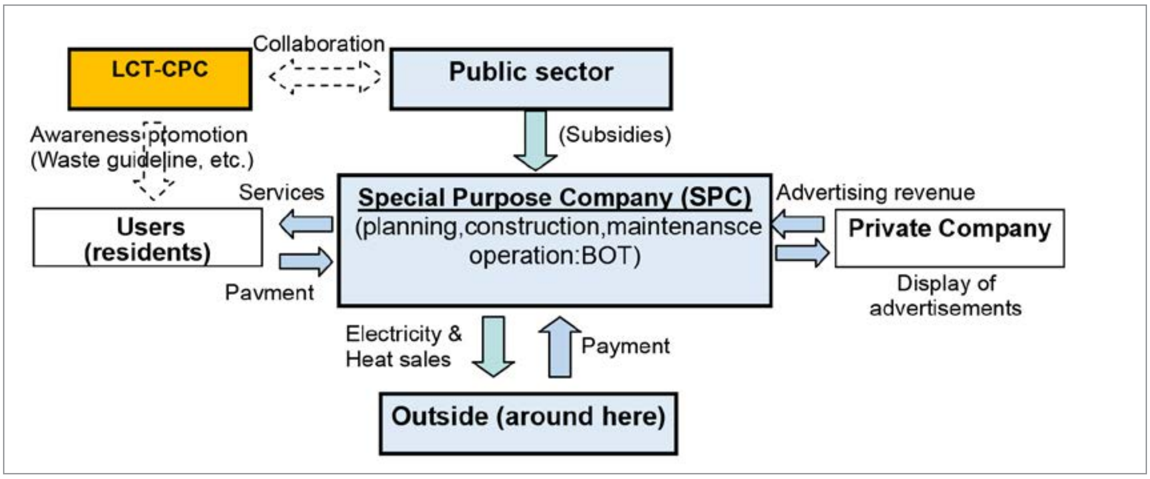


4. Untapped energy (waste- to-energy plant)

A project implementation model for the waste-to-energy system proposed in Chapter 7 is presented in Figure 10-9 below. In this model:

- An SPC consisting of mainly private enterprises, will be responsible for the entire project implementation process (planning, construction, maintenance, and operation).
- Through Build-Operate-Transfer (BOT) financing, the SPC earns operating revenue from service payments, sales revenue, and advertising revenues.
- Electricity generated from the system will be consumed within the District and exported (for profit).
- Heat generated from the system will be supplied to entities outside the District (for profit).
- The SPC will contract with the public sector and will collect waste management fees from the public sector. The public sector will collect fees from residents.

Figure 10-9:Proposed Project Implementation Model for Waste-to-Energy Plant



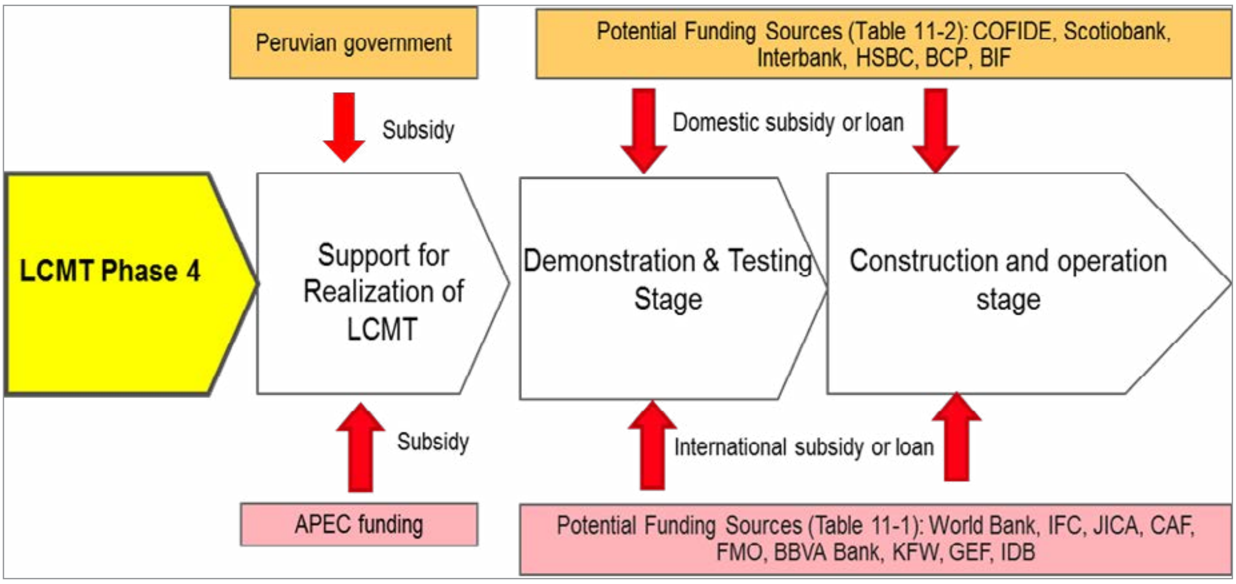
In this study, SPC has been removed from the project implementation model for PV system.

The proposed model is based on Scenario 3 (which was used as the base for GHG analysis and cost estimate for Renewable Energy) that includes rooftop PV systems for 10% of residential/commercial buildings (mostly residential buildings in San Borja). The original model included an SPC to promote the deployment of PV systems and manage the PV systems for residents and building tenants. This study has since concluded that SPC would not be necessary for PV system implementation in the residential sector. We propose that the promotion of PV system be led by LCMT-CPC instead of a SPC.

10.3.4. Roadmap for Realization of the Low Carbon Model Town Framework

This study recommends that San Borja develops a roadmap and process flow for LCM implementation. Figure 10-10 details the process flow and potential financing options, and Table 10-11 details the next steps to realize the LCMT.

Figure 10-10: Roadmap for Realization of Low Carbon Town in San Borja



Source: Adapted from APEC model by Hitachi Consulting

Table 10-11: Key Steps for Realization of LCMT

Step	Descriptions
1. Select LCMs	Select the LCMs with the greatest potential for sustainable implementation based on the outputs from this study
2. Create technical outlines for LCMs	Prepare the technical outlines and the operating and maintenance criteria for the selected LCMs. Prepare business plan in concrete detail (e.g. location, scale, and project period).
3. Develop finance project scheme	Identify stakeholder groups, project implementing body, and investors. Assess financing options. Conduct risk assessment and prepare risk management plan.
4. Conduct meetings with enterprises interested in project participation	Conduct preliminary meetings with enterprises who are interested in bidding for the project.
5. Project assessment	Develop a project plan (e.g. cost and profit assessment, identification of potential project management issues).
6. Prepare for business operators selection	Decide on evaluation criteria for business operators (e.g. technical abilities and experience in construction, operation and management of advanced technologies in the related sector, company's financial status).

11. RECOMMENDED FUNDING SOURCES FOR LCM IMPLEMENTATION

This chapter presents and recommends potential funding sources that the District of San Borja may be able to access to support implementation of the LCMs. The first section summarizes all of the LCMs presented in earlier chapters of the report. The summary is organized by category and includes a brief description of each measure. The second section outlines potential funding sources, and the third section identifies which funding sources should be used for each LCM type.

11.1. Summary of Recommended LCMs

Table 11-1 summarizes all of the LCMs recommended in the feasibility study.

Table 11-1: Summary of Recommended LCMs for San Borja

LCM Category	LCM	Description
Urban Function Planning	Transit oriented development (TOD) planning for mixed-use land use development	Development that prioritizes use of public transit, non-motorized transport (i.e., bicycle infrastructure) safe pedestrian access to public and mass transit, and land use development patterns that move toward making the community less dependent on motor vehicles to access the services they needs and places they want to go.
	Transit oriented development (TOD) and transit station planning for mixed-use development	Market-based techniques and public-private partnerships that support land use decisions that balance between urban growth and urban greening and forest preservation. Transfer of growth from places where a community would like to see less development to places where a community would like to see more development.
	Information and communication technologies (ICT) for city management performance	ICT that transforms data into information and insight for performance management and predictive analytics. Includes indicators for city services, quality of life, and resilience as a foundation for an integrated data management system.
Transportation Planning	Modal switching and mixed-mobility solutions	Transportation policies, infrastructure, incentives and services that encouraging modal switching from more to less GHG-intensive modes, and also supporting mixed-mobility solutions such as us of bicycles to access public transit nodes. offsetting the weaknesses of each, includes use of electric powered streetcars to connect existing transportation networks, including the BRT and electric train.
	Travel demand management (TDM)	Management system to help reduce travel demand, particularly single occupant private vehicles, or redistributing mobility demand at peak commute hours instead of increasing roadway supply. Focus on system efficiencies across all m`odes.
	Intelligent transportation systems (ITS)	Systems to enable people and businesses to make more informed mobility choices that best suit their needs at the time of their need through real-time information, and to better manage transportation congestion. Focus on circulation plans, routes, and cargo transportation.

LCM Category	LCM	Description
Buildings Design Planning	Low carbon passive design	An architectural design method that harnesses natural phenomenon such as sunlight, solar heat, and direction of wind. Includes implementation of photovoltaic power systems or solar water heating systems.
	Low carbon active design	An architectural design method that utilizes mechanical systems for heating, cooling, dehumidification, and lighting to ensure efficient energy use which will reduce GHG emissions, reduction in building operating costs and improvement in comfort and quality of the interior environment.
Energy Planning	Area-wide energy efficiency and management planning and microgrid Implementation	Implementation of a multi-source energy network to balance energy supply and demand and create a decreased dependence and strain on regional utility grids, resulting in increased energy resilience.
	Community energy management system and smart meter implementation	Implementation of a community management system, including smart metering, to help the community identify and implement improvements in energy efficiency and management.
	Untapped energy: waste-to-energy	The process of generating energy (electricity and/or heat) from biomass waste, providing municipalities/organizations with a new source of energy for either building heating and power or vehicle fuel.
	Renewable energy: solar energy	Implementation of photovoltaic power systems or solar water heating systems for low carbon power generation.
Environmental Planning	Biofiltration water reuse expansion	Expansion of wastewater capture and biofiltration treatment infrastructure to reuse or recycle water for irrigation and other purposes
	Urban greening and forest expansion	Increase in tree planting to help sequester carbon and increase shade coverage.
	Solid waste recycling expansion	Implementation/enhancement of a recycling program to divert the sorted waste from landfills, continue working with vendors to increase recycling and repurposing of waste, and increase participating households in diverting of waste from landfills. Review of waste incineration in San Borja.

11.2. Funding Sources for LCMs Implementation

11.2.1. International Financial Institutions

The following is a list of international entities with potential interest in providing funding for low carbon projects in San Borja[82]:

- ***International Finance Corporation (IFC)*** – IFC is a global development institution and member of the World Bank Group that provides investment and advisory services for the private sector in developing countries, with promoting climate change as one of its goal. The Sustainable Energy Finance (SEF) Program of IFC aims to "promote opportunities for sustainable energy finance" through supporting financial institutions with the development of sustainable energy projects. IFC has participated in the financing of several renewable energy projects in Peru. It has an operations office in San Isidro of Lima. (Website: http://www.ifc.org/lac)
- ***World Bank (Peru)*** – World Bank provides loans, credits, and grants to developing countries for projects in a wide range of sectors including the projects for environmental sustainability and clean energy. World Bank has recently approved funding to the Ministry of Environment of Peru for the "Investments for Environmentally Sustainable Development" project that aims to enhance the environmental management mechanisms in Peru. (Website: http://www.worldbank.org)
- ***KFW Banking Group (KFW)*** – KFW is a German government-owned development bank group. KFW has provided finance for renewable projects in Peru through cooperation agreements with the Peruvian government and COFIDE, the Peruvian national development bank. The KFW Development Bank provides international financing to developing countries in a range of sectors including water supply, energy, biodiversity, urban development, environment, and sustainability. (Website: https://www.kfw.de)
- ***Global Environmental Facility (GEF)*** - The GEF is an international partnership of institutions, civil society organizations, and the private sector, including UN Development Programme, UN Environment Programme, and World Bank to address global environmental issues. It supports a broad range of climate change projects in developing countries, focusing on the areas of renewable energy, energy efficiency, sustainable transport, and management of land use, land-use change, and forestry. (Website: http://www.thegef.org/gef/)
- ***Clean Development Mechanism (CDM)*** - The CDM is a mechanism developed by the UNFCCC that allows governments/organizations to earn certified emission reduction (CER) credits for all emission-reduction projects implemented in developing countries (including Peru). CERs can be traded and sold to other entities, and count towards part of the country's emission reduction targets under the Kyoto Protocol. (Website: https://cdm.unfccc.int/)
- ***Dutch Development Bank (FMO)*** – FMO is a development bank based in the Netherlands that

82 Sources: International Finance Corporation (IFC) (2011) "Assessment of the Peruvian Market for Sustainable Energy Finance - Executive Summary"; International Renewable Energy Agency (IRENA) (2012) "Financial Mechanisms and Investment Frameworks for Renewables in Developing Countries"; Latin American Energy Organization(OLADE) & United Nations Industrial Development Organization (UNIDO) (2011) "Observatory of Renewable Energy in Latin America and the Caribbean – Peru"; and homepages of the listed entities.

provides financing to private sector, focusing on energy, agribusiness, food and water. FMO funded a 20MW photovoltaic power plant in Peru that completed construction in 2012. (Website: http://www.fmo.nl)

11.2.2. Regional Development Banks

The following is a list of regional development banks with potential interest in providing funding for low carbon projects in San Borja[83]:

- ***Corporación Andina de Fomento*** – CAF (Development Bank of Latin America) – A development bank with offices in ten Latin American countries, CAF's mission is to promote sustainable development and regional integration by providing financing and technical services for projects in the public and private sectors of Latin America. Areas covered by CAF's financing include sustainable energy, climate change, urban development, and environment. CAF has provided funding for a hydropower plant and a biofuels plant in Peru. (Website: http://www.caf.com)
- ***Inter-American Development Bank (IDB)*** – IDB is composed of shareholders from 48 member countries. It provides loans to mainly national, provincial and municipal governments within Latin America. Through financing, technical cooperation, and knowledge and capacity building, IDB promotes climate change mitigation with focus on energy efficiency, sustainable urban transport, water resource management and sanitation, and renewable energy, among others. (Website: http://www.iadb.org)

83 Sources: International Finance Corporation (IFC) (2011) "Assessment of the Peruvian Market for Sustainable Energy Finance - Executive Summary"; International Renewable Energy Agency (IRENA) (2012) "Financial Mechanisms and Investment Frameworks for Renewables in Developing Countries"; Latin American Energy Organization(OLADE) & United Nations Industrial Development Organization (UNIDO) (2011) "Observatory of Renewable Energy in Latin America and the Caribbean – Peru"; and homepages of the listed entities.

11.2.3. Bilateral Funding Institutions

The following is a list of bilateral entities with potential interest in providing funding for low carbon projects in San Borja[84]:

- ***Japan International Cooperation Agency (JICA)*** – JICA offers a range of technical and financial assistance to developing countries including Official Development Assistance (ODA) Loans, Grant Aid (by the Japanese government), Public-Private Partnerships (PPP), and technical cooperation projects. JICA has executed several projects in Peru and currently has an operations office in San Isidro of Lima. (Website: http://www.jica.go.jp/peru/english/index.html)
- ***United States Agency for International Development (USAID)*** – USAID helps to promote and fund broad-scale projects with a social or environmental benefit, including mitigation/climate adaptation projects focused on reducing or offsetting carbon emissions. USAID already offers financial support and leadership to carbon reduction / mitigation projects in Peru, including forest conservation and initiatives for improved local environmental management. (Website: http://www.usaid.gov/)
- ***United Kingdom Department for Environmental Food and Rural Affairs (Defra)*** – Defra offers both grant funding and programmatic support to environmental, food, and rural projects both within and outside of the United Kingdom, including carbon mitigation projects. Defra has already provided financial support to projects in South America, including a recent grant supporting implementation of sustainable/low-carbon farming methods in Brazil85. (Website:https://www.gov.uk/government/organisations/department-for-environment-food-rural-affairs)

84 Sources: International Finance Corporation (IFC) (2011) "Assessment of the Peruvian Market for Sustainable Energy Finance - Executive Summary"; International Renewable Energy Agency (IRENA) (2012) "Financial Mechanisms and Investment Frameworks for Renewables in Developing Countries"; Latin American Energy Organization(OLADE) & United Nations Industrial Development Organization (UNIDO) (2011) "Observatory of Renewable Energy in Latin America and the Caribbean – Peru"; and homepages of the listed entities.

85 http://climate-l.iisd.org/news/uk-defra-grant-promotes-low-carbon-agriculture-and-poverty-reduction-in-brazil/

11.2.4. Investment Banks

The following is a list of investment banks with potential interest in providing funding for low carbon projects in San Borja[86]:

- ***Banco Bilbao Vizcaya Argentaria (BBVA Bank)*** – BBVA is a Spanish banking group with large presence in South America (second-largest bank in Peru). Through support from the IFC, BBVA provided funding for two small hydropower plants in Peru in 2012. In early 2014, it provided loans to renewable energy companies in Chile and Mexico to fund renewable energy projects in South America. (Website: http://www.bbva.com/)
- ***Corporación Financiera de Desarrollo, S.A. (COFIDE)*** – As the Peruvian national development bank, COFIDE has established strategic alliances with international organizations including United Nations Environment Programme (UNEP), IDB, KFW, World Bank, and JICA to support financing for renewable and energy efficiency projects in Peru. (Website: http://www.cofide.com.pe)
- ***Banco de Crédito del Perú (BCP)*** – BCP is the largest bank in Peru. It supports projects across all sectors, and is part of a selected group of banks that could provide the 'Green Credit Line' which is designed and supported by the Swiss State Secretariat for Economic Affairs (SECO) to promote investments in clean technologies. BCP has financed hydroelectric power station projects in Peru. (Website: https://www.viabcp.com)
- ***Scotiabank*** – Scotiabank is part of the Scotiabank Group, the third largest bank in Canada. Like BCP, it also could provide the 'Green Credit Line' by SECO. It provides financial and advisory support for energy efficiency, GHG reduction, and clean energy projects globally. Scotiabank has funded projects under the Renewable Energy Resources (RER) auctions implemented by the Ministry of Energy and Mines (MINEM). (Website: http://www.scotiabank.com.pe)
- ***Other*** – Other local banks such as Interbank, Banco Interamericano de Finanzas (BIF), and HSBC have funded renewable energy projects under the RER auctions held by MINEM.

11.2.5. Carbon and Environmental Finance

Carbon finance refers to investment in GHG emission reduction projects and the creation (origination) of carbon offsets that are tradeable in the carbon markets, including the U.S. Voluntary Carbon Market. Each offset represents the reduction or removal from the atmosphere equivalent to one MTCO2e. The contracting of offsets for purchase often takes place directly between buyer and seller through over-the-counter (OTC) transactions, facilitated by a Registry system or on an approved, linked offset exchange. Examples of carbon offset project types potentially appropriate within San Borja include:

- Water Purification
- Fugitive Methane Emissions
- Transport / Fleet Efficiency

86 Sources: International Finance Corporation (IFC) (2011) "Assessment of the Peruvian Market for Sustainable Energy Finance - Executive Summary"; International Renewable Energy Agency (IRENA) (2012) "Financial Mechanisms and Investment Frameworks for Renewables in Developing Countries"; Latin American Energy Organization(OLADE) & United Nations Industrial Development Organization (UNIDO) (2011) "Observatory of Renewable Energy in Latin America and the Caribbean – Peru"; and homepages of the listed entities.

- Landfill Gas Capture & Combustion
- Renewable Energy and Energy Efficiency

There are also private investment firms that provide equity and debt investment opportunities such as green bonds, and energy efficiency financing through energy service company arrangements.

11.2.6. Summary of Funding Sources for LCM

Tables 11-2 and 11-3 summarize the funding sources that may be applicable for the implementation of the LCMs proposed in this study.

Table 11-2: International Funding Sources for LCMs by Design Category

Funding Source	Urban Function Planning	Transportation Planning	Buildings and Houses	Energy Planning	Environment Planning
Japan International Cooperation Agency (JICA)	✓	✓	✓	✓	✓
International Finance Corporation (IFC)	✓	✓	✓	✓	✓
World Bank	✓	✓	✓	✓	✓
Corporación Andina de Fomento (CAF)	✓	✓	✓	✓	✓
Dutch Development Bank (FMO)				✓	✓
Banco Bilbao Vizcaya Argentaria (BBVA Bank)				✓	
Inter-American Development Bank (IDB)	✓	✓	✓	✓	✓
KFW Banking Group (KFW)	✓	✓	✓	✓	✓
Global Environmental Facility (GEF)	✓	✓	✓	✓	✓

Table 11-3: Domestic Funding Sources for LCMs by Design Category

Funding Source	Urban Function Planning	Transportation Planning	Buildings and Houses	Energy Planning	Environment Planning
COFIDE	✓	✓	✓	✓	✓
Banco de Crédito del Perú (BCP)	✓	✓	✓	✓	✓
Scotiabank		✓		✓	✓
Interbank		✓	✓	✓	
Banco Interamericano de Finanzas (BIF)		✓	✓	✓	
HSBC		✓	✓	✓	

External funding, especially international funding, would be especially important for the low carbon projects that require high capital costs. These projects are predominantly those in the energy planning design category, including projects for implementing micro-grid, waste-to-energy, solar energy, and CEMS.

APPENDIX A

San Borja LCP 2021 Baseline Inventory

Table A-1: Initial San Borja 2012 GHG Baseline and Sector Inventory (MTCO2e)

Sector	Orig. 2012 Baseline	2021 (BAU[1])	2021 (LCP)	MtCO2e Reduction	% Reduction from 2012
Residential	29,425.00	33,330	26,062	3,363	11.43%
Commercial	38,070.50	46,574	37,749	320.80	0.84%
Transportation	34,415.40	40,249	29,109	5,305.70	15.42%
Solid Waste	7,453.00	8,907	1,648	5,804.10	77.88%
Institutional	4,340.00	4,746	1,958	2,381.68	54.88%
Urban Forest	0	0	(550)	550.00	0.005%
TOTAL	**113,703.90**	**133,808.60**	**95,978.62**	**17,725.29**	**15.60%**

Table A-2 below depicts the relative percentage contributions by sector to San Borja's total 2012 GHG baseline emissions.

Table A-2: Percent Contributions by Sector in San Borja's 2012 GHG Emissions Baseline

Residential	Commercial	Transportation	Solid Waste	Institutional	Urban Forestry	Total CO2e Emissions
29,425	38,070	34,415	7,453	4,340	0	113,704
25.9%	33.5%	30.3%	6.6%	3.8%	0%	100%

87 Business as Usual

APPENDIX B

OBJECTIVE 1 **RESIDENTIAL SECTOR**

Goal : Reduce by 11% CO2 emissions in the residential sector of San Borja from the year 2012

STRATEGIC ACTION	LINEA BASE AL 2012	GOAL TO 2014	GOAL TO 2018	GOAL TO 2021
Increase by 500% the number of residential users of natural gas (with connection in home) to replace propane gas (gas container)	Only 3% of the population uses natural gas, 97% uses porpane gas	The 4% of the residential sector uses natural gas	10% of the residential sector uses natural gas	15% of the residential sector uses natural gas
	Indicator : Polls district and metropolitan			
	accordance : Ley 27133 "Development Promotion Act of the Natural Gas Industry" Decreto Supremo Nº053-2007-EM "Law for			
	responsible for monitoring : Municipality of San Borja / GMAOP			
Promote the efficient use of electric power within households, and use saving device.	Currently 58% of the emissions generated by use of electric power residential	Reduce by 3% emissions from electricity, based on the efficient use of energy in the home.	Reduce emissions by 5%, based on the efficient use of energy in the home	Reduce by 11% emissions from electricity, based on the efficient use of energy in the home.
	Indicator : Encuestas distritales , Consumo de electricidad facurado pro la empresa Luz de Sur.			
	accordance : Decreto Supremo Nº053-2007-EM "Law for Promotion of efficient use of energy" Guia Nº01. Project			
	responsible for monitoring : Municipality of San Borja / GMAOP			

OBJECTIVE 2 **COMMERCIAL SECTOR**

Goal : Decrease by 1% GHG emissions for the year 2012

STRATEGIC ACTION	LINEA BASE AL 2012	GOAL TO 2014	GOAL TO 2018	GOAL TO 2021
Reduce by 31% the CO2 emission Fuel switching portion in the commercial sector	The 58% of emissions are given by the use of fuels in the commercial sector for the different activities they perform.	10% of the commercial use of fuel moved by the natural gas, reducing emissions by 10%.	50% of the commercial use of fuel moved by the natural gas, reducing emissions by 22%.	80% of the commercial use of fuel moved by the natural gas, reducing emissions by 31%.
	Indicator : Annual CO2 Emission by trade			
	accordance : Ley 27345 "Law for Promotion of efficient use of energy"			
	responsible for monitoring : Municipality of San Borja / GMAOP			
Reduce by 5% the CO2 emission by implementing energy efficiency in the commercial sector	The 42% of emissions are given by the use of electricity in the commercial sector for the different activities they perform.	The 10% of skilled trades implement energy efficiency measures, reducing emissions by 2%.	The 50% of skilled trades implement energy efficiency measures, reducing emissions by 4%.	The 80% of skilled trades implement energy efficiency measures, reducing emissions by 5%.
	Indicator : Annual CO2 Emission by trade	Indicator :Annual CO2 Emission by trade and list of trainings.		
	accordance : Ley 27345 "Law for Promotion of efficient use of energy"			
	responsible for monitoring : Municipality of San Borja / GMAOP			

OBJECTIVE 3 **TRANSPORT SECTOR**
Goal : A sustainable and human mobility in 15% reduces GHG emissions associated with the transportation industry

SUB SECTOR **TRANSPORTING OF PASSENGERS**
Goal : 25% Decrease in GHG emissions associated with the transportation of passengers for the year 2012

STRATEGIC ACTION	LINEA BASE AL 2012	GOAL TO 2014	GOAL TO 2018	GOAL TO 2021
Increase by 500% the number of trips by non-motorized means of transportation from, strongly promoting the use of bicycles	Only, 0.9% of all trips in the district are performed using a bicycle as transportation	The 2% of all trips in the district are performed using the bike or otrao through complimentary non-motorized	The 4% of all trips in the district are taken using the bicycle or other non-motorized means of transportation from	6% of all trips in the district are taken using the bicycle or other non-motorized means of transportation from
	Indicator : Polls district and metropolitan			
	accordance : Ley 29593 “promoting cycling law”			
	responsible for monitoring : Municipality of San Borja / GMAOP / GTSC			
Increase by 50% average occupancy rate in private cars	The average occupancy rate is 1.37 passengers / trip	average occupancy rate of the private automobile is 1.45 passengers / travel	average occupancy rate of private cars is 1.8 passengers / travel	average occupancy rate of private car is 2 passengers / travel
	Indicator : Polls district and metropolitan			
	accordance :			
	responsible for monitoring : Municipality of San Borja / GMAOP / GPV			
Improve passability through intelligent traffic lights and traffic control and increasing the speed of transrito pormedio in 20%	The average travel speed is 14 km / hr (Source: Urban Mobility Observatory CAF)	The average travel speed in San Borja is 14.5 km / hr	The average travel speed in San Borja is 15.4 km / hr	The average travel speed in San Borja is 16.8 km / hr
	Indicator : Polls district and metropolitan			
	accordance :			
	responsible for monitoring : Municipality of San Borja / GMAOP / GTSC			
Reduce by 20% the Number of trips made in smaller units for vans and buses substitution pattern	Currently, 36% of trips in the district are made by minivan serving or by bus	Only 32% of trips in the district are made by minivan serving or by bus	Only 25% of trips in the district are made by minivan serving or by bus	Only 16% of trips in the district are made by minivan serving or by bus
	Indicador : Reports of the GTU-MML Surveys by type Number of trips mobility			
	accordance : Metropolitan plans			
	responsible for monitoring : Metropolitan Municipality of Lima			

SUBSECTOR **FREIGHT SUB SECTOR CONSTRUCTION AND TRADE**
GOAL : 10% Decrease in GHG emissions by 2021 expected

STRATEGIC ACTION	LINEA BASE AL 2012	GOAL TO 2014	GOAL TO 2018	GOAL TO 2021
Improve walkability through circulation plans, routes and schedules for cargo transportation within the district	The average travel speed is 14 km / hr (Source: Urban Mobility Observatory CAF)	The average travel speed in San Borja is 14.5 km / hr	The average travel speed in San Borja is 15.4 km / hr	The average travel speed in San Borja is 16.8 km / hr
	Indicator : Polls district and metropolitan			
	accordance :			
	responsible for monitoring : Municipality of San Borja / GMAOP / GTSC			

OBJECTIVE 4 **SOLID WASTE**

Goal : Decrease by 78% GHG emissions associated with solid waste generated in the municipality of San Borja

STRATEGIC ACTION	Línea Base al 2012	GOAL TO 2014	GOAL TO 2018	GOAL TO 2021
Ensure proper treatment and disposal of waste from municipal Organic.	Currently not treated organic waste from municipal	presents a 5% reuse of organic wastes treated properly (compost, humus, BIOL)	shows a 10% reuse of organic wastes treated properly (compost, humus, BIOL)	shows a 20% reuse of organic wastes treated properly (compost, humus, BIOL)
	Indicator : Percentage ecocaracterizacion report on solid waste reused of Municipality of san Borja			
	responsible for monitoring : Municipality of San Borja / MINAM			
Minimize the generation, improve segregation, selective collection and recycling of municipal solid waste.	Segregates and recycles currently only 1% of recyclable solid waste district.	25% of solid waste is recycled reusable	75% of reusable solid wastes are recycled	100% of reusable solid wastes are recycled
	Indicator : Percentage ecocaracterizacion report on solid waste reused			
	responsible for monitoring : Municipality of San Borja / MINAM			

OBJECTIVE 5 **INSTITUTIONAL SECTOR**

Goal : Reduce by 55% GHG emissions at the institutional level by finding the energy eficicencia

STRATEGIC ACTION	LINEA BASE AL 2012	GOAL TO 2014	GOAL TO 2018	GOAL TO 2021
Reduce by 64% the CO2 emission per unit change of LPG CNG vehicle of the Municipality of San Borja	The 70% of emissions are given by the emission of the vehicle units Municiplidad of San Borja.	The 10% of the vehicles of the Municipality changed fuel by natural gas vehicles, reducing emissions by 27%.	The 50% of the vehicles of the Municipality changed fuel by natural gas vehicles, reducing by 57% the emissions.	El 50% de los vehículos de la Municipalidad cambiaron de combustible por el de gas natural vehicular, reduciendo en un 57% las emisiones.
	Indicator : Inventory reports of the Municipality of San Borja			
	accordance : Ley 27345 "Law for Promotion of efficient use of energy", Ley Nº 27972 "Local Government Act, Article 4"			
	responsible for monitoring : Municipality of San Borja / GMAOP / GAF			
Reduce by 15% CO2 emissions by implementing energy efficiency in the premises of the Municipality of San Borja	The 30% of emissions are given use of electricity in the local dieferentes the municipality of San Borja.	The 10% of the premises of the Municipality of San Borja implement energy efficiency measures, reducing emissions by 3%.	The 50% of the premises of the Municipality of San Borja implement energy efficiency measures, reducing emissions by 7%.	The 80% of the premises of the Municipality of San Borja implement energy efficiency measures, reducing emissions by 15%.
	Indicator : Inventory reports of the Municipality of San Borja. Electrical Expenditure Report			
	accordance : Ley 27345 "Law for Promotion of efficient use of energy", Ley Nº 27972 "Local Government Act, Article 4"			
	responsible for monitoring : Municipality of San Borja / GMAOP / GAF			

OBJECTIVE 6 **URBAN FORESTRY**

Goal : Capture 550 Ton of CO2 from the atmosphere by biomass per year.

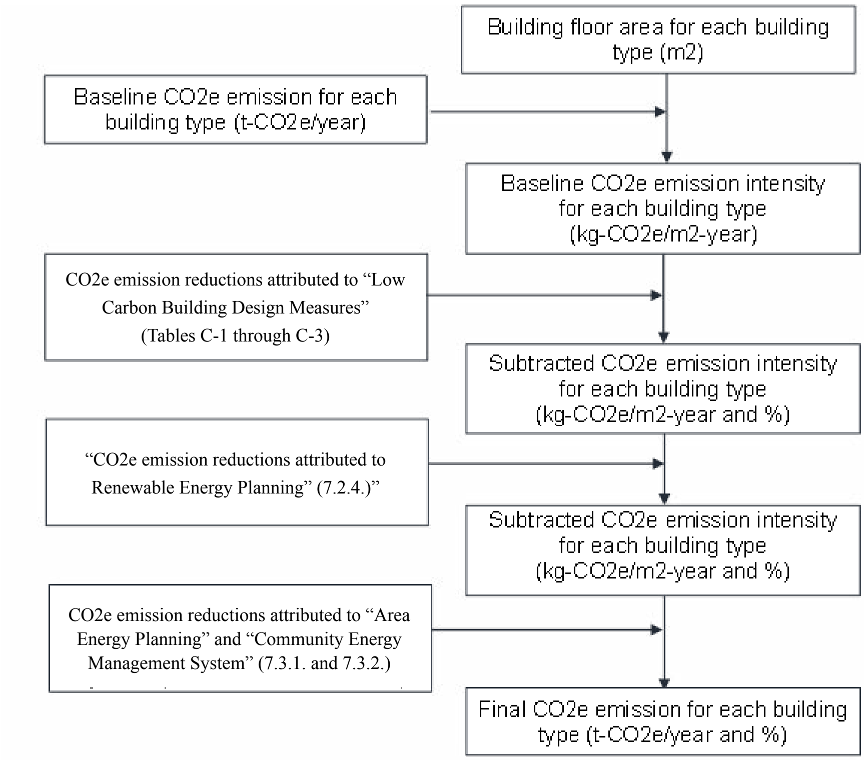
STRATEGIC ACTION	LINEA BASE AL 2012	GOAL TO 2014	GOAL TO 2018	GOAL TO 2021
Perform technical planting 50,000 new trees that will have a tree density of 23% of the total area of the district	The district has 18,900 adult trees of 80 different species	Have been planted and successfully established 25,000 new trees	Have been planted and successfully established 35,000 new trees	Have been planted and successfully established 50,000 new trees
	Indicator : Inventory reports of the Municipality of San Borja.			
	accordance : Coordinated Development Plan San Borja 2011 - 2016			
	responsible for monitoring : Municipality of San Borja / GMAOP			

APPENDIX C

Buildings Sector Methodology

This study evaluated the GHG emissions reductions from the building sector by following the methodology described in Chapter 3 of APEC's "The Concept of the Low-Carbon Town in the APEC Region (Third Edition)." The study also adopted a hierarchical approach for assessing the effectiveness of the proposed LCMs. The main purpose of this approach is to quantify the effectiveness of combined measures, i.e., portfolios of LCMs as opposed to individual LCMs. Figure C-1 illustrates the flow of CO2e reduction analysis for the building sector (residential, commercial and municipal sector). The calculation flow repeats for each building type and each LCM. Tables C-6 through C-8 show the calculation results.

Figure C-1: Flowchart of Analysis of GHG Reductions in Building Sector



Source: NSRI.

Results from this analysis are below.

Table C-1: Baseline GHG Emission Intensities

Building Type	Total Building Area (m2)	Baseline CO2e Emissions (t-CO2e) [CO2 Emissions Intensity (kg-CO2e/m2)]			
		Base Year 2012	Short term (2018)	Medium term (2021)	Long term (2035)
Residential	7,432,532	29,508 *[3.97]*	33,424 *[4.50]*	37,860 *[5.09]*	42.884 *[5.77]*
Commercial	1,030,681	39,355 *[38.13]*	48,131 *[46.70]*	58,864 *[57.11]*	71,991 *[69.85]*
Municipal	9,600*	40* *[4.13]*	43* *[4.51]*	47* *[4.92]*	52* *[5.38]*

*Note: The total building area and baseline CO_2e emissions for institutional buildings shown above only represent the estimated values for the Municipality Headquarters Building since no precise data on energy use or CO_2e emissions by all institutional buildings are available. The calculated "CO_2 Emissions Intensity" for the Municipality Headquarters Building is assumed to represent the emissions intensity for all institutional buildings.

Table C-2: Projections of GHG Emissions Intensity in Building Sector

	Building Type	Baseline CO2e Emissions Intensity (kg-CO2e/m2)	CO2 Reduction Projections (% or kg-CO2e/m2)		Subtracted CO2e Emissions Intensity (kg-CO2/m2)	CO2e Reduction Projections (%)		Final CO2e Emissions intensity (kg-CO2e/m2)
			Low Carbon Building Design	Renewable Energy		Area Energy Planning	CEMS	
Short Term (2018)	Residential	4.50	-5%	(0.08)	4.19	-5%	-5%	3.77
	Commercial	46.70	-10%	(0.12)	41.91	-5%	-5%	37.72
	Municipal	4.51	-10%	(0.10)	3.96	-5%	-5%	3.56
Medium Term (2021)	Residential	5.09	-15%	(0.14)	4.19	-5%	-5%	3.77
	Commercial	57.11	-20%	(0.20)	45.49	-5%	-5%	40.94
	Municipal	4.92	-20%	(0.18)	3.76	-5%	-5%	3.38
Long Term (2035)	Residential	5.77	-30%	(0.42)	3.62	-5%	-5%	3.26
	Commercial	69.85	-40%	(0.62)	41.29	-5%	-5%	37.16
	Municipal	5.38	-40%	(0.56)	2.67	-5%	-5%	2.40

Table C-3: Projections of GHG Reductions in Building Sector

	Building Type	Projected CO_2e Emissions intensity (kg-CO_2e/m2)	Total building floor area (m2)	Projected CO_2e Emissions (t-CO_2e/year)	CY2018 BAU CO_2e Emissions (t-CO_2e/year)	CO_2e Emissions Reduction (t-CO_2e/year)
Short Term (2018)	Residential	3.77	7,432,532	28,042	33,424	5,382
	Commercial	37.72	1,030,681	38,875	48,131	9,256
	Municipal	3.56	-	3,424	4,334	910
Medium Term (2021)	Residential	3.77	7,432,532	28,206	37,860	9,834
	Commercial	40.94	1,030,681	42,197	58,864	16,667
	Municipal	3.38	-	3,227	4,697	1,470
Long Term (2035)	Residential	3.26	7,432,532	24,207	42,884	18,677
	Commercial	37.16	1,030,681	38,300	71,991	33,691
	Municipal	2.4	-	2,221	4,978	2,757

APEC Project: EWG18/2013A

Produced by
Hitachi Consulting
51 Monroe Street, Suite PE08
Rockville, Maryland 20850 USA
Tel: (01) 301-354-8500
Website: www.hitachiconsulting.com

For
Asia-Pacific Economic Cooperation Secretariat
35 Heng Mui Keng Terrace
Singapore 119616
Tel: (65) 68919 600
Fax: (65) 68919 690
Email: info@apec.org
Website: www.apec.org

APEC#214-RE-01.24