Putrajaya Green City 2025

Baseline and Preliminary Study

Revised Edition

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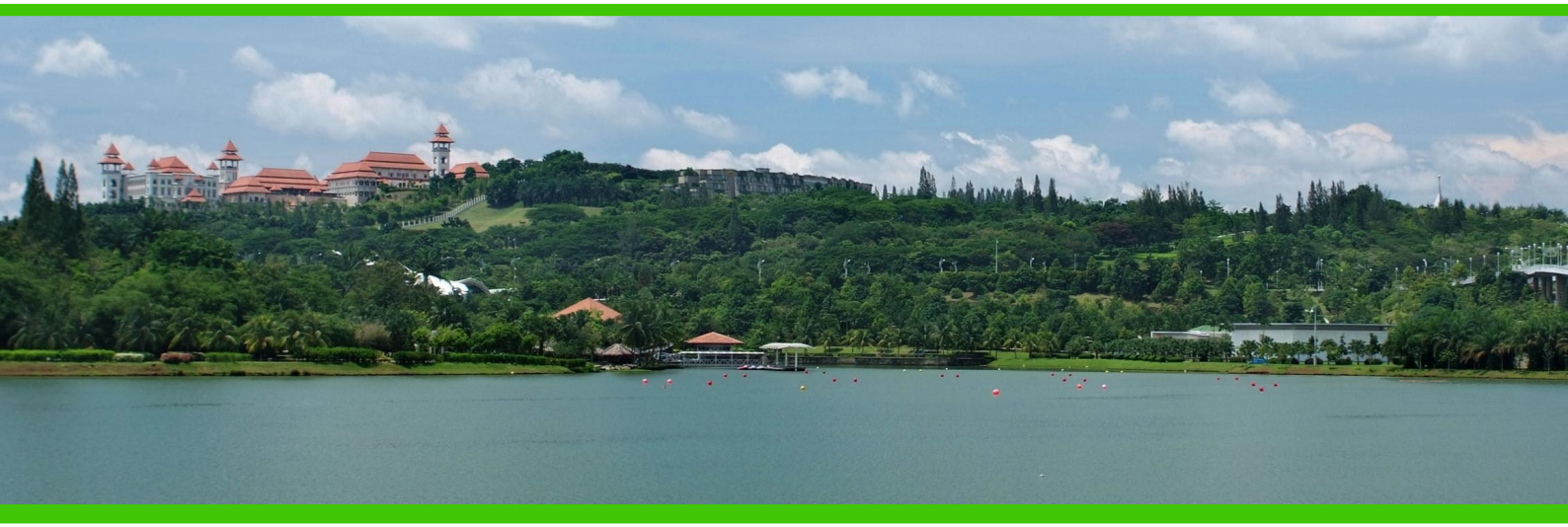

Preface

In line with the Malaysian Government's aspiration to reduce 40% of CO_2 emission intensity by the year 2020 as compared with 2005 levels, this Putrajaya Green City 2025 project will become the benchmark for future urban development. This project is the outcome of project discussion on development of low-carbon cities with the Director General of Federal Town and Country Planning Department and the Director of Town Planning of Putrajaya Corporation in May 2010.

The study has the generous support from collaboration among key oversea experts from Kyoto University, Okayama University, National Institute for Environmental Studies (NIES), Asia-Pacific Integrated Model (AIM) team and local experts from Universiti Teknologi Malaysia (UTM) as well as Malaysian Green Technology Corporation (MGTC).

This report is the follow up to the research framework report - "Towards Putrajaya Green City 2025- Feasibility Study" which was published in October 2010. Based on the feedback, data collection and analysis, this report outlines the low-carbon scenarios and pathway of Putrajaya in the next 15 years based on quantitative integrated modeling of the future society, economy and environment. This is a document to communicate at local city level where policy makers can integrate climate change actions in the preparation of a new master plan or amendment of existing development plan. We hope that this preliminary baseline report will provide direction for the preparation of the roadmap for Putrajaya Green City development. It should also serve as a platform for further intensive discussions among stakeholders and related parties, which include local residents, public agencies and business communities towards the preparation of a comprehensive and practical roadmap for Putrajaya.

Finally, we would like to thank all public and private agencies in Putrajaya for their cooperation in providing data, information and other technical support which has assisted in making this Putrajaya Green City 2025 project possible.

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Executive Summary

The aim of this study is to evaluate the potential of developing Putrajaya as a Green City and formulate proposed actions. There are three main themes which are looked into and studied in this research in the process of developing a green city. The three main themes are Low-carbon Society, Urban Heat Island and Solid Waste Management.

This study has three main objectives which feature each of these three themes and they are as follows:

1. To reduce Green House Gasses (GHG) emission intensity related to energy use by 60%,
2. To reduce peak temperature by 2°C and
3. To reduce the final disposal of solid waste and GHG emission per waste generation by 50%.

The main indicators used in this research are shown in Table 1. The population of Putrajaya in 2007 is 49,452 and will increase seven times to 347,700 in 2025.

The base year for this research is set as 2007 due to the data availability and the target year is 2025 based on Putrajaya Structure Plan-Laporan Pemeriksaan Rancangan Struktur Putrajaya 2025, June 2009 (Perbadanan Putrajaya, 2009).

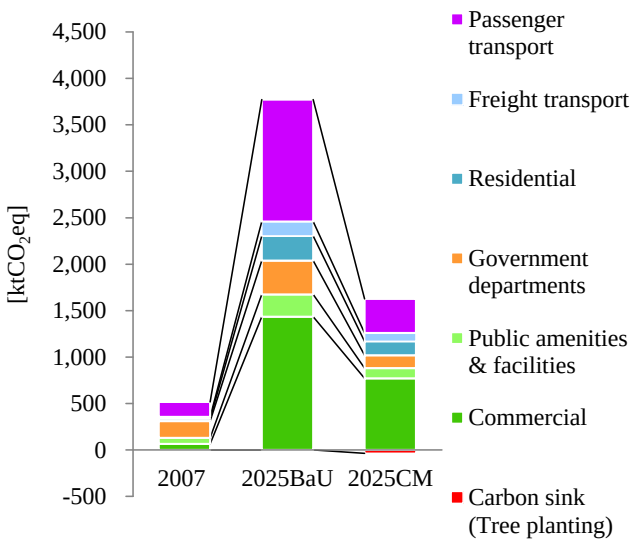


Figure 1: GHG emission from energy use

Table 1: Main data and result

	2007	2025BaU	2025CM	2025BaU /2007	2025CM/ 2007	2025CM/ 2025BaU
Population [no.]	49,452	347,700	347,700	7.0	7.0	1.0
Employment [no.]	45,000	164,500	164,500	3.7	3.7	1.0
Per capita GDP in Malaysia [Mill.RM/capita]	23,605	50,337	50,337	2.1	2.1	1.0
Economic activity (2007=1)	1	7.8	7.8	7.8	7.8	1.0
Passenger transport demand [Mill.pass-km]	585	4230	3719	7.2	6.4	0.9
Freight transport demand [Mill.t-km]	109	851	681	7.8	6.2	0.8
Final energy demand [ktoe]	135	908	411	6.7	3.0	0.5
Final energy demand per economic activity (2007=1)	1	0.9	0.4	0.9	0.4	0.5
Primary energy demand [ktoe]	1,339	10,092	5,277	7.5	3.9	0.5
GHG emission [$ktCO_2eq$]	664	4,186	1,780	6.3	2.7	0.4

Low-carbon Putrajaya study identified the emission from seven sectors in Putrajaya, namely; Commercial, Public amenities and facilities, Government Departments, Residential, Passenger Transportation and Freight transportation sector (Figure 1). The estimated GHG emission from energy use for 2007 is 516ktCO_2eq and this total emission is estimated to increase about seven times to 3,772ktCO_2eq in 2025 Business as Usual (BaU) case. With the introduction of suitable low-carbon countermeasures, the emission levels can be lowered by nearly 60% to achieve 1,591ktCO_2eq in 2025 Countermeasures (CM) case.

Putrajaya, the new Federal Government Administrative Centre of Malaysia, is estimated to have the highest GHG emission from the government departments in 2007 with 180ktCO_2eq, and is followed closely by the passenger transport sector with 161ktCO_2eq. This is because currently the passenger transport sector is dominated by private transportation, with 70-30 ratio on private and public transportation.

However, this scenario will be changed in 2025. This is because, Putrajaya plans to diversify its economy and intends to develop the commercial sector. Therefore, in year 2025BaU the commercial sector is estimated to be the highest GHG emitter with 1,435ktCO_2eq, which is about 22 times higher than its emission levels in base year (65ktCO_2eq). The second highest emitter in 2025BaU is the passenger transport sector with 1,313ktCO_2eq.

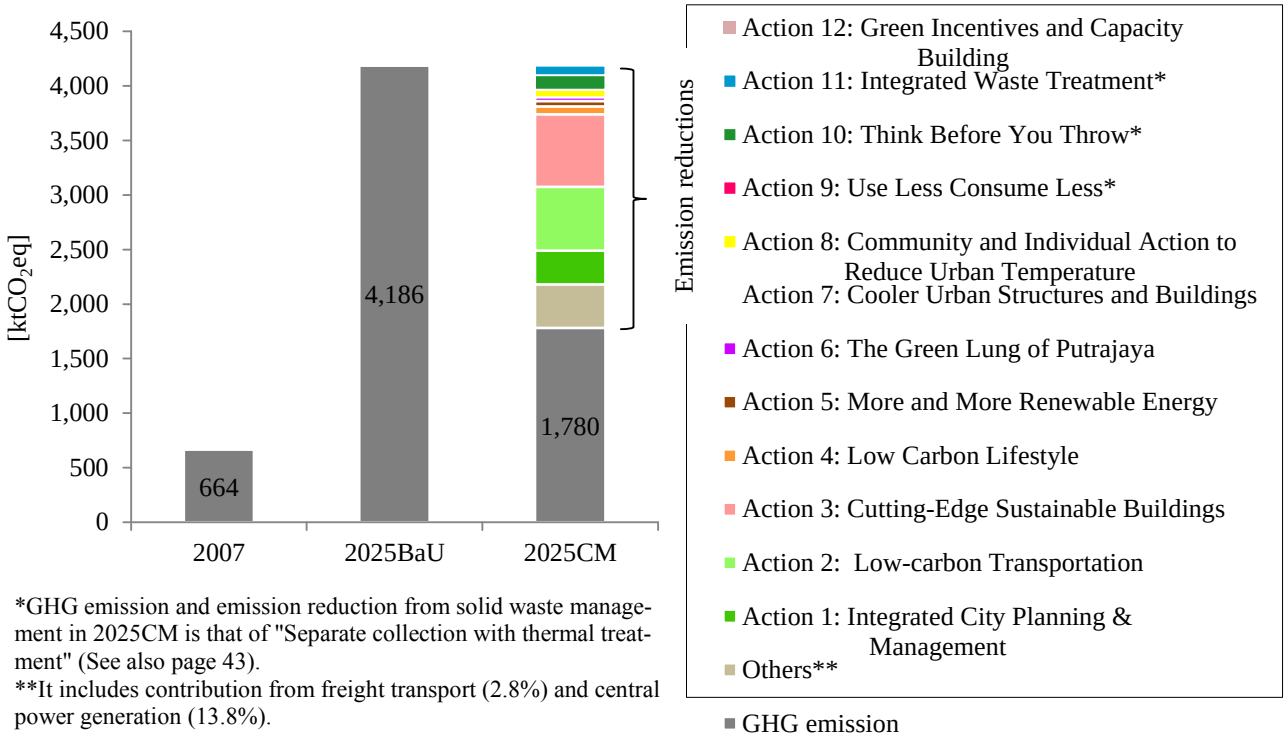
Figure 2: Scenery in Putrajaya

Executive Summary (cont.)

The findings from the Cooler Putrajaya research shows that the daily maximum temperature in Putrajaya is over 30°C, and it exceeds 35°C during the month of January to May (Source: Planning Department of PJC. See also Figure 24). Based on the findings of this research, countermeasures are introduced to enable Putrajaya lower the maximum temperature by 2°C. The results for this study is done using the Urban Heat Island (UHI) Modeling tool - WRF version 3.2 to quantify the effects of countermeasures for Cooler Putrajaya.

The third component of this study is 3R Putrajaya (Reuse, Recycle and Reduce). The two main targets of 3R Putrajaya in 2025 are, to reduce 50% of the solid waste volume which is landfilled, and to reduce 50% of GHG emission, both from 2025BaU. The proposed countermeasures aim to reduce both household and business waste. In 2025BaU, there is a four times increase in GHG emission from 2007 levels. However, under countermeasures, the volume of landfilled waste and the emission of GHG can be reduced more than 50% from the BaU levels. There are three options suggested and with the suitable waste treatment options, the GHG emission can be reduced to less than half of the BaU case.

Figure 3: Scenery in Putrajaya



*GHG emission and emission reduction from solid waste management in 2025CM is that of "Separate collection with thermal treatment" (See also page 43).
**It includes contribution from freight transport (2.8%) and central power generation (13.8%).

Figure 4: GHG emission reduction of all three components (Low-carbon, Cooler, 3R)

This report aims to propose a dozen actions which can be implemented by Putrajaya Corporation (PJC) and various other government departments, private organizations and individuals towards achieving The Green City Putrajaya status. These actions focus on all three components as mentioned above. Figure 4 shows the GHG emission by Actions which include all three categories (Low-carbon, Cooler and 3R Putrajaya).

Actions 1 to 6 focus on Low-carbon Putrajaya, Actions 7 and 8 are for Cooler Putrajaya, Actions 9 to 11 are for 3R Putrajaya category respectively. Action 12 does not contribute directly to emission reduction through a specific category, therefore this is an action that focuses on capacity building and increasing the environmental awareness in the residents and individuals in Putrajaya. Besides all these 12 actions proposed, there is also emission contributed from the central power generation for the energy consumption and also from freight transportation which come from outside the borders of Putrajaya. These two emission contributors need actions from the National Level to be implemented to reduce the GHG emission, therefore it is not highlighted here in this report.

Each of these 12 actions will be discussed in detailed in this report, sub-actions and programmes are proposed for each action. The amount of emission reduction contributed by each action is identified and various programmes that can be conducted by PJC or any other relevant agency or individual is suggested in this report. The overall contribution of total GHG emission in 2007 is 664ktCO_2eq and the emission in 2025BaU increases about 7 times to 4,185ktCO_2eq. With countermeasures introduced, the emission can be reduced by about 57% in 2025CM to 1,780ktCO_2eq.

Figure 5: Scenery in Putrajaya

Figure 6: Scenery in Putrajaya

The Actions, sub-actions and programme introduced here in this report are identified and suggested after intensive discussion between the researchers and PJC and also various government agencies in Putrajaya. PJC also conducted a two days workshop to gather individual specialist from various field of professions to have a brainstorming session in order to discuss the proposed actions. This is a baseline and preliminary study for this Putrajaya Green City project, and there is much room for further research to develop an action plan or roadmap towards making this Putrajaya the pioneer Green City in Malaysia.

Background

PUTRAJAYA—THE FEDERAL GOVERNMENT ADMINISTRATIVE CENTRE OF MALAYSIA

The creation of a new Federal Government Administrative Centre at Putrajaya marks a new chapter in the development history of modern Malaysia. The development of this city was prompted by the government's desire and the dire need to balance and disperse development to areas outside of the capital city of Malaysia, Kuala Lumpur, hence improving the urban environment and quality of life, as well as easing the pressure on the overstretched infrastructure of Kuala Lumpur.

Its development provided a golden opportunity for PJC, the local planning authority for Putrajaya to embark on innovative planning to represent Malaysian values and multi cultural background. Putrajaya is planned to be equipped with the latest technologies and facilities to allow improvement in the effectiveness of the government's machinery and productivity as well providing amenities that will greatly contribute towards a good quality of urban living and working environment.

Planning Concept and Philosophy

Putrajaya is a plan driven city based on two underlying concepts, the city in the garden and the intelligent city. The adoption of these concepts to guide its physical development was aimed at a balanced and sustainable development, environmentally, socially, as well as economically. Sustainability concept is clearly evident in the designation of almost 40% of its total city area of 4,931ha specifically for green and open spaces in the Putrajaya Master Plan.

In brief, the distinguishing features of the Master Plan are as follows:

- Planned population is about 347,000 people.
- A large proportion of the city area is designated as green open space;
- A large water body (600ha) of man-made lakes and wetlands was formed by utilizing the small rivers which run through the area;
- The lake creats a 38-km-long waterfront area;
- Open spaces are developed according to a complete hierarchy, including 12 metropolitan parks;
- A 4.2-km-long boulevard forms the central spine of the city.

Table 2: Land Use Components

Land Use	Area [ha]	Percentage [%]
Government	225	4.6
Residential	711	14.4
Commercial	139	2.8
Mixed Use	41	0.8
Special Use	138	2.8
Service Industry	11	0.2
Public Amenity	344	7.0
Open Space	1,930	39.2
Infrastructure & Utility	483	9.8
Road	908	18.4
Total	**4,931**	**100**

(May not sum to total due to rounding error.)

Source: Perbadanan Putrajaya (2009)

Current Status of Development

Up to date, with 14 years of development, 17 ministries and more than 50 government departments and agencies have been relocated to Putrajaya. The city at present has a population of approximately 70,000 people, and are equipped with numerous community facilities, retail outlets, sport and recreational amenities. By year 2012, the remaining 4 ministries in Kuala Lumpur will be moved to Putrajaya.

Challenges & Way Forward

At the Copenhagen COP15, Malaysia Prime Minister made a conditional commitment of a reduction of CO_2 emission intensity of Malaysian GDP, of up to 40% by 2020 from a 2005 baseline and this is followed by the Prime Minister announcement in the 2010 Malaysian Budget speech, that the government will "develop Putrajaya and Cyberjaya as pioneer township in Green Technology, as a showcase for the development of other townships" .

Rising up to the challenge, PJC in collaboration with the Ministry of Energy, Green Technology and Water and the Sepang Municipal Council, have taken a bold step forward to formulate a Green City Action Plan for Putrajaya and Cyberjaya. To start with, PJC has taken the initiative to conduct a carbon emission baseline study for Putrajaya.

Table 3: Current Status of Development for Major Components

Component	Status	Percentage [%]
Government	17 Ministries	81
Commercial	437,000 m^2	10
Housing	21,204 units	33
Public Amenity	149 ha	43
Infrastructure & Utility	678 ha	79
Road	666 ha	73
Open Space (including lake & wetland)	1,456 ha	75

Source: Directly obtained from Planning Department of PJC

Figure 7: PJC office building

A Dozen Actions Towards Green City

Three Environmental Targets

The goal for Putrajaya Green City 2025 (PGC2025) in term of quantitative environmental targets are outlined in three themes. The three themes are "Low-carbon Putrajaya" for climate change mitigation, "Cooler Putrajaya" for mitigating urban heat environment, and "3R Putrajaya" for recycle-based society.

Low-carbon Putrajaya: GHG Emission Intensity Related to Energy Use -60%

The target for "Low-carbon Putrajaya" is reducing GHG emission intensity (per economic activity) related to energy use by 60% compared to year 2007 level. This target was set in line with the National Target of 40% reduction of CO_2 emission intensity by 2020 and also based on the future plan as stated in the Putrajaya Structure Plan (Perbadanan Putrajaya, 2009). Therefore the City Planning Department of PJC set this target for this study. To achieve this target, energy efficiency improvement, utilization of renewable energy and low-carbon transport and structures will have to be introduced.

Cooler Putrajaya: Peak Temperature -2°C

Mitigating urban heat environment and lowering peak temperature are important for not only comfortable life of Putrajaya residents and workers, but also reducing air-conditioning demand that will be effective for "Low-carbon Putrajaya". For "Cooler Putrajaya", the target is reducing peak temperature 2°C from year 2005 level.

3R Putrajaya: Final Disposal of Solid Waste -50%, GHG Emission per Waste Generation -50%

Currently, most of the solid waste from Putrajaya is landfilled. However, because of limited natural resource of the earth, it is required to convert current material consumption style to more recycle-oriented, sustainable one. It also can contribute to reduce energy demand, waste-related GHG emission, and carbon footprint. Therefore, two targets were set for "3R Putrajaya"; reducing final disposal of solid waste and GHG emission from solid waste management by 50% compared to 2025BaU level.

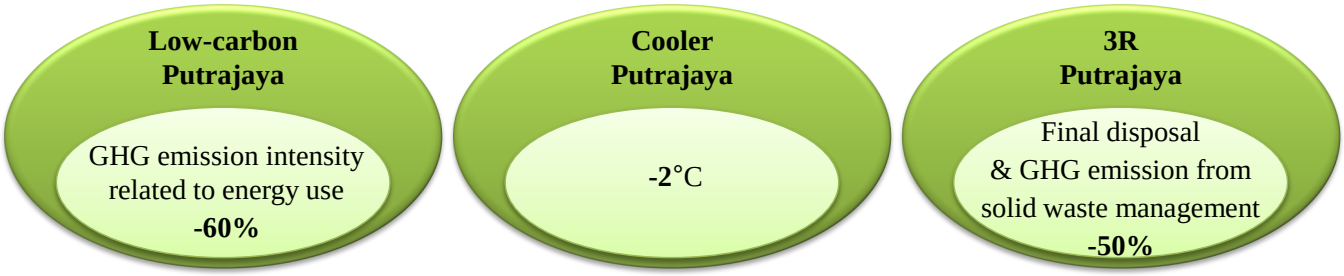


Figure 8: Three environmental targets

Figure 9: Scenery in Putrajaya

A Dozen Actions

Towards achieving a Green City in Putrajaya, 12 actions are introduced here in this study. These actions are divided according to the three environmental targets. The detailed action names and the amount of GHG emission reduction contributed by each action can be seen in Table 4.

There are 6 low-carbon actions introduced here, these low-carbon actions propose measures which can be undertaken by PJC, various relevant authorities and individuals towards reducing the GHG emission in Putrajaya.

Three actions are introduced in efforts to reduce waste using the 3R (Reuse, Recycle and Reduce) and waste management. Two actions for the reduction of peak temperature by 2°C are introduced for the "Cooler Putrajaya" scenario.

This research determines the GHG emission in Putrajaya for year 2007 as the base year and estimates for 2025. The 12 actions introduced here interpret these calculation results into a form which can be understood easily. Action 3 which is Cutting edge sustainable buildings, has the highest contribution towards lowering GHG emission. This comes from lowering the energy consumption in all buildings and implementing a suitable lifestyle which is considered towards energy consumption.

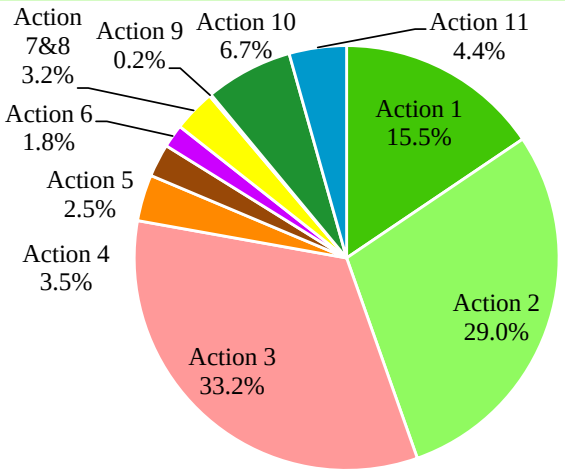


Figure 10: Contribution of each action to GHG emission reduction

Table 4: GHG emission reduction amount

Action Number	Name of actions	GHG emission reduction [$ktCO_2eq$]	Contribution in total reduction [%]
1	Integrated City Planning & Management	312	15.5
2	Low-carbon Transportation	583	29.0
3	Cutting-Edge Sustainable Buildings	666	33.2
4	Low-carbon Lifestyle	71	3.5
5	More and More Renewable Energy	50	2.5
6	The Green Lung of Putrajaya	35	1.8
7	Cooler Urban Structures and Buildings	64	3.2
8	Community and Individual Action to Reduce Urban Temperature		
9	Use Less Consume Less	3	0.2
10	Think Before You Throw	134	6.7
11	Integrated Waste Treatment	88	4.4
12*	Green Incentives and Capacity Building	-	-
Total of PGC2025 Actions		**2,006**	**100**
Others**		400	-
Total		**2,405**	-

(May not sum to total due to rounding error.)

*Action 12 does not have its emission reduction.
**It includes contribution from freight transport (2.8%) and central power generation (13.8%).

Integrated City Planning & Management

Action 1

Integrated urban planning approach underlines good practices in urban development, and it has to go hand in hand with simultaneous activities which are related to policy sectors; both medium and long terms. Urban planning in Putrajaya involves mixed land use planning, massive tree planting activities and traffic planning. These plans will significantly contribute to the improvement of the overall ecological balance of the city. The Putrajaya Structure Plan and other future development plans have to continuously improved in favour of energy conservation and GHG emission reduction.

The promotion of low-carbon policies has to be a main theme especially in related sectors; Residential, Transportation, Commercial, Public Amenities & Utilities, Government Institutions and Power Generation land use. The implementation of Integrated City Planning and Management through development plans and the implementation of Low-carbon Society scenario, it is expected to reduce 312ktCO_2eq which contributes to about 15.5% in total reduction (Figure 12).

Table 5 identifies the sub-actions and programmes which can be implemented in Putrajaya by the relevant departments to realize this action. It also shows the contribution of GHG emission reduction of this action.

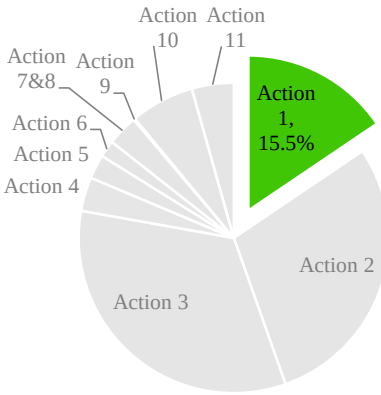


Figure 12: Contribution to GHG emission reduction of Action 1

Make Putrajaya a Bikeable & Walkable City

In planning towards a low-carbon city, non-motorized movement by walking and cycling are highly encouraged as a mode of travelling through the provision of an integrated network of pedestrian/cycling paths. These integrated networks are planned comprehensively to link together the numerous public facilities, social amenities and commercial centres with the residential areas. Even though currently Putrajaya already has the network for pedestrian and cyclist; the ease and security of using these facilities should be enhanced. This is to encourage residents to shift from automobile usage to walking or cycling around Putrajaya.

Figure 11: Pedestrian walkway

The programmes shown in Table 5 are suggestions as to how this action can be implemented. Putrajaya, becoming a Garden City which is well know for its parks and green, should make good use of this special feature and further encourage non motorized mode of transportation. School going children should be encouraged to use bicycles or walk to school instead of parents driving them to school. To realize this, the relevant authorities should play an important role in ensuring the safety of the cycling paths and walkways.

The government offices should encourage their employees to cycle to work; especially those living within Putrajaya. To encourage this, office managements and employers should provide facilities for employees to freshen up once they reach the work place.

Enhance Mixed-use & Diversified Development

As Putrajaya's population is expected to increase 7 times in size from 2007 to 2025, this city has to continuously develop to provide for the growing needs of its residents. Putrajaya city planning is driven by sustainable concepts and contemporary response to the Garden City concept. This emphasises neighbourhood planning; where self-contained residential areas are placed near workplaces. Residents can live and work within short distance to minimize crowded and time-consuming commuting trips from home to work. The sustainable planning concept will help shorten the passenger transport lengths and vehicle mile travel (VMT), and in some cases help to further promote cycling and walking trips.

Table 5: Sub-actions & Programmes in Action 1

Sub-action	Programmes	GHG emission reduction [$ktCO_2eq$]	Contribution in the Action [%]	Contribution in total reduction [%]
1-1 Make Cycling as Preferred Transport Option (Bikeable City)	1) Separate route for cyclist and pedestrian	53	17	3
	2) Facilities for bicycle (bicycle parking spaces)			
	3) Facilities for cyclist (shower facilities etc.)			
	4) Bicycle, tricycle rental/shared bicycle, tricycle program			
	5) Celebrity cyclist encouragement program			
	6) Provide more shade through landscape			
	7) Bicycle repair shop			
	8) Incentive for setting up bicycle & repair shop			
	9) Planning & design action plan for cyclist			
	10) Priority lighting for cyclist			
	11) Improvement on the existing cyclist lane			
	12) Safer school route			
1-2 Make Walking as Preferred Transport Option (Walkable City)	1) Separate route for cyclist and pedestrian			
	2) Covered pedestrian walkways			
	3) Pedestrianized streets			
	4) Apply Universal Design Concept (Disable, Senior Citizen, Children etc.)			
	5) Safer school route			
	6) Crime Prevention Through Environmental Design (CPTED)			
	7) Planning & Design Action Plan for pedestrian			
	8) Pedestrian R & R			
	- Drinking water			
	- Benches			
	- Information kiosk			
	- Police beat			
1-3 Enhance Mixed-use and Diversified Development	1) Encourage Putrajaya Holdings Sendirian Berhad (Sdn Bhd) (PHSB) to expedite the development of existing mixed-use plots	259	83	13
	2) Mixed activities within the same building (flexible usage)			
1-4 Residential Layout Planning	1) Orientation/Alignment of the house/building			
	2) Introduce residential element within other development plots (Small Office/Home Office, SOHO)			
1-5 Introduce Low Carbon Planning Control & Development Plans & Practices	1) Encourage Putrajaya Holdings Sdn Bhd (PHSB) to expedite the development of existing mixed-use plots			
	2) Mixed activities within the same building (flexible usage)			
1-6 Allocate Land for Solid Waste Management Facilities / Management Plan	1) Orientation/alignment of the house/building	-	-	-
	2) Introduce residential element within other development plots (SOHO)			
Total		**312**	**100**	**16**

Low-carbon Transportation

Action 2

Through this current study, it is identified that the Passenger Transportation sector, in 2007 is the second highest contributor of GHG emission; contributing about 31% of the total emission of 161ktCO_2eq, and this number will increase about 8 times in BaU case in 2025 with a total contribution of 1,314ktCO_2eq. This therefore summons the need for Low-carbon Transportation measures; where the dependency on individual vehicles is reduced and a high level of mobility is ensured. This Action will contribute about 29% of the total GHG emission reduction which numbers to about 583tCO_2eq in total reduction in Putrajaya (Figure 13).

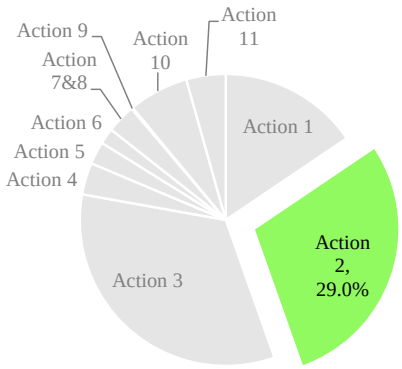


Figure 13: Contribution to GHG emission reduction of Action 2

Low Emission Vehicles & Intelligent Transportation System

Switching from fossil fuel to renewable energy source is one of the effective actions in low-carbon transport policy actions. PJC should promote and encourage the use of Electric Vehicles (EV) and Hybrid Vehicles (HV) by planning the supporting facilities such as service station. In order for more effective implementation; policies which support and encourage government official vehicles and public transportation to switch to EV and HV should be introduced.

Intelligent Transportation System (ITS) should also be introduced in Putrajaya. This is the general term used for new road transportation systems driven by advanced information and communication technology. The ITS will manage factors such as vehicles, load, routes to improve safety, reduce vehicle wear, transportation times and fuel consumption.

Actions such as Advances in Navigation Systems, Electronic Toll Collection, Assistance for Safe Driving, Optimization of Traffic Management, Increasing Efficiency in Road Management, Support for Public Transport, Increasing Efficiency in Commercial Vehicles, Support for Pedestrians, and Support for Emergency Operations can be adopted or introduced into the traffic management system by the appropriate departments in Putrajaya.

Integrated Transportation System

An Integrated Transportation System is designed to economically move anyone, anything, anywhere, anytime on time. The central areas of Putrajaya are well connected with each other by public transportation networks. Currently, natural gas buses and taxies are already operated in Putrajaya; however this number should be increased to meet the increasing demand. It is also important to have a good network which connects all the modes of Public transportation within Putrajaya. This will ensure a better connection from one location to another and reduce the time spent for waiting. In addition to this, the existing rail base network and facilities should be utilized and widened to support the existing public bus and Express Rail Link (ERL) services. To encourage a higher usage of public transportation, Putrajaya has to convince its residents and commuters that the use of public transportation is not only convenient but also can be trusted to be on time.

Figure 14: Natural gas buses "Nadiputra" and ERL

Table 6: Sub-actions & Programmes in Action 2

Sub-action	Programmes	GHG emission reduction [$ktCO_2eq$]	Contribution in the Action [%]	Contribution in total reduction [%]
2-1 Encourage the Use of Low-carbon Emission Vehicles	1) Encourage walking/cycling to school 2) Total ban of diesel engine buses from entering Putrajaya (buses can be parked at Park And Ride) 3) Expend Nadiputra's services to the surrounding areas (within 25km radius) 4) Government to promote hybrid/electric vehicle 5) Government to assist petrol station operators to provide infrastructure needed 6) Government agencies to use hybrid/electric vehicle 7) Incentives (rebate, tax reduction, etc.) for the usage of hybrid/electric vehicle for Putrajaya resident 8) Government to expedite to regulate Euro 4M fuel and to assist petrol station operators to provide infrastructure needed for Euro 4M fuel 9) Incentives (rebate, tax reduction, etc.) for the usage of Euro 4M vehicle for Putrajaya government and resident	362	62	18
2-2 Implement Integrated Transportation System	1) Government to implement Bus Rapid Transit (BRT)/ Dedicated Transport System (DTS) to Putrajaya 2) To implement rail system inbound Putrajaya residential area and government complex 3) The Putrajaya rail system is to be connected to central rail system (MRT & LRT) 4) To study the feasibility of using water taxi (battery/ electric operated) 5) Implementation bicycle/tricycle for rent	61	11	3
2-3 Implement Intelligent Transportation System	1) To enhance the existing traffic light system 2) To enhance the existing Variable Message Sign (VMS) 3) To implement congestion/cordon charging 4) To enhance the existing Advanced Public Transportation System (APTS) 5) To implement bus junction priority 6) To regularly introduce new transport management technology/system			
2-4 Encourage Transit Oriented Development (TOD)	1) Identify high density nodes for station development 2) Review land use density along rail base transport route 3) Parking management at transit station 4) Integration of all modes of transportation to transit station 5) Mixed used and high density development at transit station			
2-5 Increase Public Transport Provision & Usage	1) Limit parking spaces for private vehicle 2) Impose traffic restraint into core island 3) Improve Bus Routing to reduce travel time 4) Increase bus trip frequency 5) Introduce water taxi (solar power/battery) 6) Introduce rail base transport in Putrajaya 7) Rail base connectivity between Kuala Lumpur (KL) - Putrajaya (Greater KL) 8) Real time schedule information	159	27	8
Total		**583**	**100**	**29**

(May not sum to total due to rounding error.)

Cutting-Edge Sustainable Buildings

Action 3

The energy consumption of buildings in Putrajaya, mainly due to three main sectors, namely; government, commercial, residential and public amenities & facilities. In 2007 the government department has the highest amount of GHG emission which is 180ktCO_2eq, and this is expected to increase twice in 2025(BaU). The commercial sector, on the other hand, only has a contribution of 65ktCO_2eq in 2007, however this number increases about 22 times to 1,435ktCO_2eq; which is the highest emitter in 2025(BaU). The increase of GHG emission in this sector is in line with the increase in the employment of this sector. Since buildings are identified to be high GHG emitter, this action will also be the highest reduction target; which will contribute 33.2% (about 666ktCO_2eq) of the total emission reduction in Putrajaya (Figure 15).

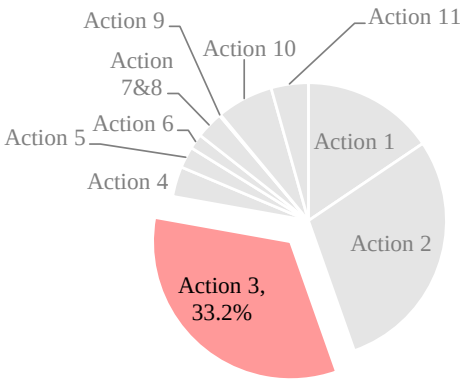


Figure 15: Contribution to GHG emission reduction of Action 3

PJC can promote appropriate and advanced tropical sustainable buildings by using Asian oriented methodologies, technologies in order to sustain buildings with long life and high performance. It can support new constructions whereby the design use local and renewable buildings materials and products. This will be the challenging action which upgrades building sustainability.

Building Evaluation and Training

PJC or relevant government organizations should adopt existing building evaluation methods, e.g. Green Building Index (GBI), Leadership in Energy and Environmental Design (LEED), Comprehensive Assessment System for Built Environment Efficiency (CASBEE) etc., to label buildings. In the future, Putrajaya should work towards achieving a standard where all governmental buildings will be labeled as green building. At the same time, it will continue to improve the energy saving efficiency and GHG reduction efficiency measures for all buildings. Training and capacity building for professionals and technicians on building technology will be established in universities, and organizations such as the Construction Industry Development Board (CIDB) and other training institutions. This will be done in each region for training of designer and construction workers on the knowledge of energy-efficient building technologies and designs.

Environmental Efficiency Labeling

PJC commences an energy efficiency labelling system for buildings. This newly-developed evaluation method aims at long-term energy saving target. The values will be set for each type of building usage in incremental steps. The certification and registration of labelling will be mandatory at the time of purchase for newly-built houses, at the time of renovation for existing buildings, and also at certain intervals for lease properties and commercial buildings.

Figure 16: Energy Commission building

Table 7: Sub-actions & Programmes in Action 3

Sub-action	Programmes	GHG emission reduction [$ktCO_2eq$]	Contribution in the Action [%]	Contribution in total reduction [%]
3-1 Eco Friendly Building Materials & Energy Efficient Labeling for Equipments & Appliances	1) Promotion of building materials which are recyclable or low-carbon materials	501	75	25
	2) To use high energy efficiency appliances in buildings			
	3) Water saving equipment in toilets (e.g. faucets, flushing, etc.)			
3-2 Building Energy Management System (BEMS)*	1) To introduce BEMS in all government buildings	115	17	6
	2) Improvement of the building automated system			
	-Review the default temperature of air conditioner to be higher			
	-During off peak hours and weekend to minimize the number of elevators used			
	-To have sensors for lightings in buildings (e.g. Low occupancy areas- stairwells, toilets, walkways)			
	-To review existing regulations/law with regards to electricity supply and Gas District Cooling (GDC)			
3-3 Eco Friendly Building Materials	1) To look not only at the design of the building, but also the interior design and maintenance of the building	50	7	2
3-4 To Integrate Recycling Facilities in Building Designs	1) Have proper recycling facilities in buildings to replace the current waste bins in buildings (For standardization in all buildings, and for estatic and cleanliness of building surroundings)	-	-	-
3-5 Impose Building Rating System to All Buildings	1) PJC will decide on the rating tool - Green Building Index or equivalent to achieve all buildings certified green by 2025	-	-	-
	a. Existing buildings (Public)			
	-Audit status of all buildings			
	-Retrofit these buildings within the next 15 years to achieve certified rating. By 10th year - 75% of all existing buildings			
	b. Under construction			
	-To upgrade within 5 years after completion to fulfill minimum certified rating - Mostly upgrading of active elements only			
	c. New buildings			
	-All new buildings must have minimum certified rating			
	d. Private commercial buildings			
	-Same as public buildings			
	-Local authority to come out with incentives. (e.g. Reduction in development charges, fast green lane approval, etc.)			
	-Buildings to be have a minimum rating Type: GBI certified or equivalent			
Total		**666**	**100**	**33**

* CO_2 emission reduction by this Sub-action includes the effect of energy saving behavior.

Low-carbon Lifestyle

Action 4

Low-carbon Lifestyle is an action which concentrates on measures that involve the public.

The residential sector in Putrajaya contributes about 23ktCO_2eq to the total GHG emission in Putrajaya in 2007. However this number increases about 11 times higher to 266ktCO_2eq in 2025. The floor area in the residential sector increases about 5.6 times from 2007 to 2025. The emission in the residential sector is mainly contributed by the use of electricity mainly for space cooling, lighting and use of electrical appliance. This eco concisions home action, aims to reduce 3.5% of the total GHG emission reduction (Figure 17).

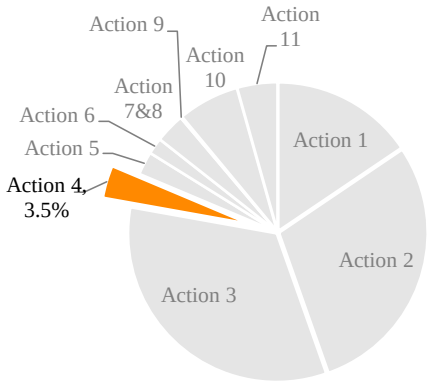


Figure 17: Contribution to GHG emission reduction of Action 4

Dissemination of Energy Saving and Control Technologies

Practical use of Information and Communication Technologies (ICT), such as Home Energy Management System (HEMS) has made it possible for autonomous operation and control of appliances. This system will automatically suspend the operation in spaces and periods of time when people are not present. Furthermore, the appropriate organizations in Putrajaya should establishes the product labelling system and promote to improve the efficiency of equipments through continual appliance repairs and exchange of parts as well as updating to the latest high-efficiency appliances. The citizens also should be more aware and educated on the energy saving behaviors which can be practiced at home.

Promoting Low-Carbon Products

Since Putrajaya does not have a large industrial sector, all products, foods and other materials are imported from outside the boundaries. It is important for Putrajaya to promote local products and low-carbon local foods. The imported may preferably be from low-carbon farming locally in Malaysia or outside. Consumers will be given a wide range of choices in selection of foodstuffs in supermarkets and restaurants. However these items should be labelled with health related information, and GHG emission to promote popularity of environmental awareness of low-carbon agricultural products. Specifically, consumers prefer locally grown vegetables by farmers that make various innovations to ensure lower carbon emission. Putrajaya shall also encourages supermarkets and other stores to support their efforts to promote low-carbon products by introducing eco-points and other similar incentives.

Figure 18: Example of HEMS (NEC Corporation, 2010) and Scenery in Putrajaya

Table 8: Sub-actions & Programmes in Action 4

Sub-action	Programmes	GHG emission reduction [$ktCO_2eq$]	Contribution in the Action [%]	Contribution in total reduction [%]
4-1 Energy Efficient Appliances in Homes	1) Promotion to create awareness 2) High rise residential areas (Apartments/condos) - The common spaces to be retrofitted with energy management system - Existing buildings to be retrofitted within the next 5 years	55	77	3
4-2 Home Energy Management System (HEMS)*	1) House automated system (for lighting, security, etc.)	16	23	1
4-3 Promoting Organic / Low-carbon Products	1) Provide more outlets to sell organic/low-carbon products 2) Incentives: introducing eco points and other similar incentives 3) To encourage and intensify the "Bumi Hijau" initiative (Organic Food are low-carbon because food is not imported from outside of Putrajaya)	-	-	-
4-4 To Integrate Recycling Facilities in High rise Residential Building Designs	1) Have proper recycling facilities in high rise residential buildings (Especially government quarters) 2) This will be imposed as a regulation in all government quarters (For standardization in all buildings, and for cleanliness of building surroundings)	-	-	-
Total		**71**	**100**	**4**

* GHG emission reduction by this Sub-action includes the effect of energy saving behavior.

Figure 19: Scenery in Putrajaya

More & More Renewable Energy

The power generation for the energy demand in Putrajaya is supplied from outer boundary. In term of energy security, it is necessary for Putrajaya to generate and manage electricity. The More and More Renewable Energy Action focuses on enhancing the use of renewable energy in Putrajaya. This action contributes about 2.5% of the total emission reduction (Figure 20).

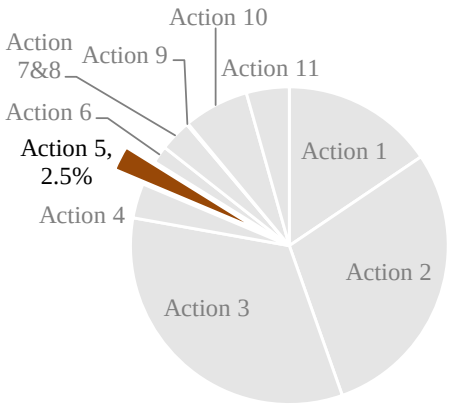


Figure 20: Contribution to GHG emission reduction of Action 5

Life Supported by the Sun

PJC together with the suitable agencies should encourage the installation of low cost photovoltaic systems in housing areas. It is possible to design and install them on various parts of buildings including the roof, walls and windows to ensure it will not affect the townscape and aesthetic value of the building. In many cases, photovoltaic are installed in not only residences and buildings but also in fallow lands for the purpose of selling the generated power. Here in Putrajaya, photovoltaic panels should also be used by other buildings such as government offices, department buildings, and commercial buildings. The advantageous effect is expected to reduce 50ktCO_2eq, which contributes about 2% in total reduction. Currently with the collaboration with Tenaga National Berhad, PJC has started a 5 megawatt solar farm project. This project will be the beginning of many other projects which involve solar harvesting.

Local Production and Consumption of Renewable Energy

PJC can also promote the diffusion of autonomous and grid-independent system for renewable energy generation while minimizing its influence on existent power systems. Solar power generators and wind power generators are equipped with energy storage devices, enabling stable electricity supply. A part of generated electricity is used for the hydrogen production, which in turn is supplied to fuel cells in residences and offices and even to fuel cell vehicles. In addition, beyond individual energy storage systems, some precincts should have their own electricity supply systems that adjust demand and supply of electricity within the precinct by joint utilization of solar, wind, and biomass.

Biomass Production and Utilization

PJC promotes the biomass production and utilization plans. The fallen leaves or residuals from street greens will provide the biomass supply. At the same time, the waste-type biomass generated within each region is also utilized to the full extent. It is expected that the market share of bio-energy for heat and electricity is on the increase.

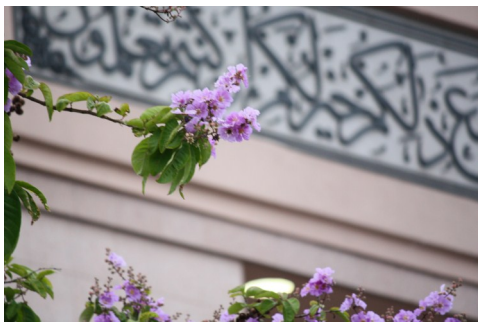


Figure 21: Solar PV on rooftop and scenery in Putrajaya

Table 9: Sub-actions & Programmes in Action 5

Sub-action	Programmes	GHG emission reduction [$ktCO_2eq$]	Contribution in the Action [%]	Contribution in total reduction [%]
5-1 Photovoltaic Power Generation and Utilization	1) To implement 5 megawatt project solar farm (TNB)	50	100	3
	2) To study the feasibility of using PV/(+hybrid) power generation on these buildings/facilities			
	a Administrative and commercial building lighting with efficient lamp			
	b. Residential area			
	c. Bus stop			
	d. Traffic light			
	e. Advertisement/road signage			
	f. Street lighting			
	g. Irrigation solar pump			
	h. Charging station electric vehicles			
	i. Solar air conditioning unit			
	3) To implement measure identified if feasible			
	4) To review existing regulation/law and agreement with regard to electricity supply			
5-2 Alternative Fuel Source from Solar Assisted Power Generation	1) To study feasibility of using hydrogen production for fuel cell for public transportation	-	-	-
	a. To implement measure identified if feasible			
	b. To review existing regulation/law			
5-3 Explore Possibilities of Utilizing Solar Thermal	1) To study the feasibility of using solar thermal for the following application	-	-	-
	a. Hot water for domestic use, hospital and hotel			
	b. Concentrated Solar Power (CSP)			
	c. Solar desiccant			
5-4 Biomass Production & Utilisation	1) To study the feasibility of anaerobic digestion of municipal waste, sewerage waste for methane production	-	-	-
	2) To study the feasibility of anaerobic digestion of direct combustion using incinerator or plasma for heat production			
5-5 Research & Development for RE Local Consumption	1) To study the feasibility of using water from lake for thermal sink (lower temperature of the lake bed water) for GDC operation (Presint 5) - The water temperature difference between the water on the surface and bottom of lake. (e.g. pump water from bottom of lake will be (Cooler water) to chill in GDC)	-	-	-
	2) To explore opportunities for Co-generation from existing GDC plants			
	a. To review existing regulation/law			
	b. To implement the use of waste heat from GDC to generate			
	-Electric			
	-Heat			
	-Cooling (absorption chiller)			
	3) To explore the feasibility of using small wind turbine system (+hybrid) with low speed for electricity generation			
Total		**50**	**100**	**3**

The Green Lung of Putrajaya

Putrajaya city is among the few planned cities in Malaysia that have more than a third of total area allocated for functional green open spaces. These planned urban green in the forms of urban parks, city parks and pocket parks at the neighborhood area provide residents with the opportunity to experience greenery, nature and wildlife at the door steps. Apart from the aesthetically pleasing, these green resources and wetland are not only effective to reduce the heat island phenomena, but also GHG absorption by the photosynthesis mechanism. Trees planting by the pedestrian walkway and urban parks help to absorb GHG emitted from the vehicles on the streets. Through urban green improvement and maintenance planning, it creates comfortable and valuable urban environment for citizens in Putrajaya. The carbon sink by tree planting is expected to reduce 35ktCO_2eq, which contributes 1.8% in total reduction (Figure 22).

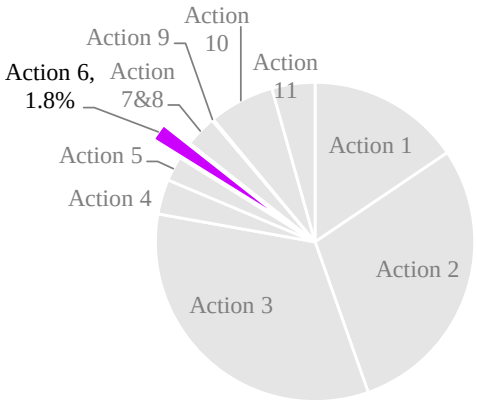


Figure 22: Contribution to GHG emission reduction of Action 6

Action Plan for "One Million Trees"

In this action, a total of one million trees should be planted in Putrajaya by 2025. Towards starting an action plan for urban reforestation, Putrajaya firstly has to develop a tree inventory database to identify the types of tree which are planted around this area, so that the carbon accounting can be done. With this database, the relevant departments in Putrajaya can determine the specific species of trees which can be planted around the suitable areas in Putrajaya.

Encourage Greenfrastructure Management in City Planning Practice

There should be a good integration between the green and the infrastructure in the areas in Putrajaya. About 40% of the total land area of Putrajaya is already planned as open space and green area. Therefore there has to be enhancement in the city planning practices to plant more suitable trees for these areas.

Putrajaya also has a very big water body which encompasses about 600ha (Lake and Wetlands), which can be used for rainwater harvesting.

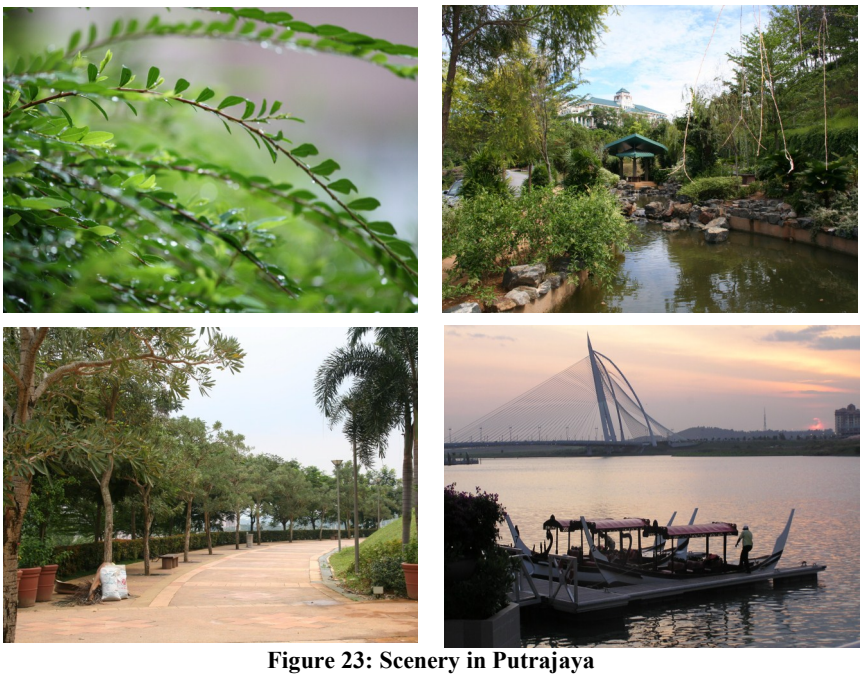


Figure 23: Scenery in Putrajaya

Table 10: Sub-actions & Programmes in Action 6

Sub-action	Programmes	GHG emission reduction [$ktCO_2eq$]	Contribution in the Action [%]	Contribution in total reduction [%]
6-1 To Develop an Action Plan for Urban Reforestation	1) To identify Suitable species for planting at different locations:	35	100	2
	a. Along roadsides			
	b. Monorail reserves			
	c. Buffer zones			
	d. Around lake area for filtration			
	e. Tree planting programme integrates with rain water harvesting			
	2) To increase urban forest areas by:			
	a. Naturalize planting; instead of plantation			
	b. Native/indigenous species			
	c. Wider planting strips			
6-2 To Encourage Greenfrastructure Management in City Planning Practices	1) Urban forest			
	a. Plant selection contributing to carbon sink - saff flower			
	b. Urban forest management plan			
	2) Wetlands-plant selection contributing to carbon sink			
	3) Lake - Water harvesting for irrigation			
	4) Parks & Open spaces - introduce plant with highest carbon sink (bamboo)			
	5) To regulate the use of centralized chilled water from GDC in all commercial buildings within the CBD			
	6) To encourage and introduce rainwater harvesting			
6-3 To Develop a Detailed Tree Inventory Database	1) To collect these data:	-	-	-
	- Number of trees planted			
	- Species of trees planted			
	- Diameter of trees			
	- Growth speed			
	2) To derive the carbon accounting from the inventory data			
6-4 To Ensure Connectivity between Fragmented Forests	1) Create wild life crossings and animal bridges	-	-	-
	2) Enhance ecology			
6-5 Innovation and Research & Development	1) Explore possibilities of using green areas, lake and wetland as carbon sink	-	-	-
	2) Extensively promote roof top and vertical gardens			
	3) Conduct research & development activities on tree selection, maintenance, carbon sequestration, carrying capacity, etc.			
	4) Composting of tree waste below ground as carbon storage			
Total		**35**	**100**	**2**

Cooler Urban Structure and Building

Action 7

Strategies of Urban Heat Island (UHI) Mitigation

Mitigation measures of an urban heat island demonstrate a big effect not only to raise a comfort of local residents but also to bring a co-benefit with a low-carbon policies. Here, we propose the strategy of reducing peak outdoor temperature in the daytime by 2°C. Two groups of countermeasures package are shown and the effects are quantified by UHI model simulation. In Action 7, we propose the countermeasures related to the Urban structure and building. In Action 8, countermeasures in community and individual scale, such as modal shift and energy saving action, are proposed. For some sub-actions, the thermal energy balance in the urban area was quantitatively estimated by using the meso-scale meteorological model.

Designing Urban Structure for More Ventilation

In Asian region especially in hot and humid climate, wind velocity is the most effective factor to increase pedestrian comfortable environment, even if either air temperature or humidity are high. However, the density of urban area is usually high and it causes the efficiency of air changing worse. Moreover, the group of high-rise buildings makes the large wall, and blocks the urban wind flow. Consequently, all buildings constructed in Putrajaya need to be considered making wind corridor in the design process.

Also, since wind field is dominated by land use of surrounding area, suitable land use planning is necessary to be considered.

Maximizing the Cooling Effect by Green

Greening has a strong effect in mitigation of UHI. Since Putrajaya is abundant in open space and water front, if a suitable plant is grown, the relaxation of UHI can be maximized. Moreover, the rooftop gardening and wall greening can also inhibit the intrusion of heat to the inside of a building, and energy consumption of air conditioning can be reduced.

Guideline for Building to Reduce UHI Effect

Generally, buildings composing urban environment cause the enhancement of UHI effect. It means surfaces of buildings make a part of urban surface, and exhausted heat from buildings are also influential factors for the UHI. Consequently, satisfied consideration in building design or landscape design around the building are essential. Wind corridors and shady paths among buildings can be planned by building orientation or composition. Choices of surface materials of the grounds or building facades should also be considered. In building system design, exhausted heat in the air should be reduced by means of changing heat exchange by latent heat or raising energy efficiency higher. In order to promote well consideration for UHI, design guideline is effective tool such as CASBEE-Heat Island (HI).

Table 11: Peak Temperature reduction by Action 7&8*

Calculation case (explanations are described in pages 40-41)	Reflection of solar radiation [W/m^2]	Sensible heat flux [W/m^2]	Latent heat flux [W/m^2]	Peak temperature reduction** [°C]	Total contribution [%]
Urban Green Case	0	-275.0	+275.0	-1.65	83
High reflecting paint Case	+48.3	-37.4	-11.0	-0.23	11
Reduced artificial heat from Vehicle Case	0	-9.0	-1.5	-0.06	3
Reduced artificial heat from building Case	0	-11.5	-1.8	-0.07	4
Total	**+48.3**	**-332.9**	**+260.7**	**-2.01**	**100**

(May not sum to total due to rounding error.)

* Preliminary calculation. Some of countermeasures have not be included in this calculation.
** Average peak temperature is 34.6°C in selected calculation days.

Table 12: Sub-actions & Programmes in Action 7

Sub-action	Programmes	Enhance ventilation by wind*	Reflecting incoming solar radiation*	Reduction of sensible heat flux*	Reduce sensible temp.*
7-1 Urban Wind Ventilation	1) Land use planning of surrounding area - Suitable allocation of forest, lake, and developed area	◎			○
	2) Building orientation/wind direction	◎			○
	3) Ventilation path from/to lake and river	◎			○
7-2 Greening	1) Urban Greening - Planting more suitable tree	○		◎	○
	2) Rooftop gardening - shrubs - selected existing flat roof and future development (National Hydraulic Research Institute of Malaysia, 2009)			◎	○
	3) Wall greening - Green curtain			◎	○
	4) Reduce road surface/driveway - increase grasscrete areas			◎	○
7-3 Reflection of Solar Radiation	1) Usage of high reflectance material/ finishes for rooftop		◎		
	2) Usage of high reflectance material/ finishes for building wall		◎		
	3) Usage of heat shield pavement		◎	○	○
7-4 Building	1) Energy saving building			◎	
	2) Heat insulating roof/wall to save energy for air conditioning		◎	○	○
	3) Suitable design and material for wall of building to reduce emission of radiative heat to urban street canopy		◎	○	○

* ◎: Major mechanism of countermeasure, ○: Effective

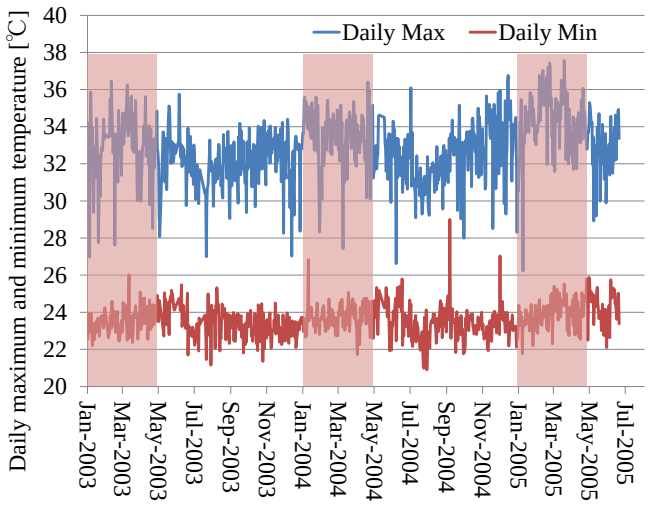


Figure 24: Daily maximum and minimum temperature
(Monitored temperature in Taman Putra Perdana, Precinct 1, Putrajaya, Directly obtained from Planning Department of PJC)

Daily maximum temperature in Putrajaya is over 30°C. Especially, it exceed 35°C from January to May. Model Calculation targets this period.

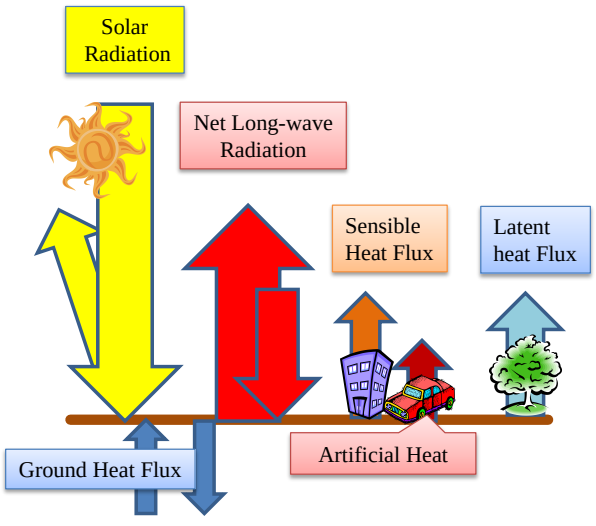


Figure 25: Urban Heat Balance

Community and Individual Action to Reduce Urban Temperature

Action 8

Reducing Artificial Heat Exhaust

One of the reasons of urban heat island is an artificial exhaust heat. The major sources of artificial exhaust heat in Putrajaya are the waste heat from air conditioning and automobiles.

So, the modal shift to public transportation can reduce the exhaust heat from vehicles. And, the energy saving actions can suppress the exhaust heat from building.

The Active Use of the Water

When the water evaporates, heat is taken away and the ambient air temperature is mitigated. Watering the pavement, where the temperature becomes very hot by direct sunlight, can reduce ambient temperature. Also, a water-retentive pavement material can sustain the effect of reducing the temperature. In addition, water sprinkling to the pavement and grassland enhances the evaporation and reduces surface temperature.

Lowering Sensible Temperature

Direct sunlight is the largest heat stress to pedestrians and bicyclist. By making the shade by the roadside tree or artificial shading, sensible temperature can be reduced significantly. Also, mist spray has significant effect of lowering local temperature with little energy. It is effective to install them at the bus stop and intersection.

Education and Diffusion of Energy Saving Action

It is necessary to expand education and a mechanism to diffuse modal shift and an energy saving action. In order to increase the preset temperature of air conditioning in the office, it is important to popularize a cool dress like Smart Casual. In addition to the improvement of public transportation network, it is necessary to install facilities such as the bus location system using an Information Technology (IT) to promote modal shift. Also, the installation of the signboard which shows the distance to the destination is expected to raise the convenience of the walker.

Actions for reducing UHI also have co-benefit for Low-carbon Society. The advantageous effect is expected to reduce 64ktCO_2eq, which contributes 3.2% in total reduction (Figure 26).

Reduction of Cooling Demand

Highly raised air temperature causes the increase cooling demand in buildings. In case of heat pump air conditioning system, high outdoor air reduces the efficiency of heat exchange, as a result, cooling systems consume more energy. Therefore, the relaxation actions for UHI is expected to reduce GHG emission in building or residential sectors. The advantageous effect is expected to reduce 19ktCO_2eq, which contributes 1.0% in total reduction.

Modal Shift

Heat island phenomenon makes the outdoor air temperature high, and pedestrians suffer the overheating affection. Severe and unbearable outside situation makes the pedestrians get away from walking or bicycle, consequently, they uses the vehicles or other devices. PJC plans several countermeasures for UHI and these actions also help reducing GHG emission. The advantageous effect is expected to reduce 45CO_2eq, which contributes 2.2% in total reduction.

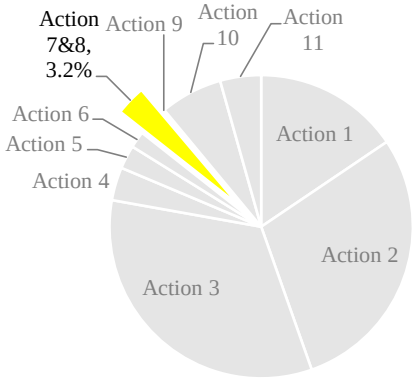


Figure 26: Contribution to GHG emission reduction of Action 7 & 8

Table 13: Sub-actions & Programmes in Action 8

Sub-action	Programmes	Enhance ventilation by wind*	Reflecting incoming solar radiation*	Reduction of sensible heat flux*	Reduce sensible temp.*
8-1 To Reduce Artificial Heat Exhaust	1) Modal shift to the public transportation			◎	
	2) Electric-powered vehicle and hybrid car			◎	
	3) Use of district cooling system			◎	
	4) Save energy by cutting down on air conditioning			◎	
8-2 Active Utilize of Water	1) Watering paved surfaces/Water-retentive pavement			◎	◎
	2) Fountain/water park			◎	○
	3) Water sprinkling			○	◎
8-3 To reduce Sensible Temperature	1) Pedestrian shading – canopy/ linkages				◎
	2) Open spaces-green pocket, green connector between buildings				◎
	3) Water mist along the walkway				◎
8-4 Human Parameters (Behavior Change)	1) Cool Biz'			○	◎
	2) Education for energy saving/suitable air conditioning			○	
	3) Signage's of distance to encourage people to walk			○	
	4) Encourage public transport usage			○	

* ◎: Major mechanism of countermeasure, ○: Effective

Table 14: GHG emission reduction by Action 8

Low-carbon countermeasure	GHG emission reduction [$ktCO_2eq$]	Contribution in the Action [%]	Contribution in total reduction [%]
Reduction of cooling demand (by UHI mitigation)	19	30	1.0
Modal shift from automobile to bicycle & walk (by UHI mitigation)	45	70	2.2
Total	**64**	**100**	**3.2**

Figure 27: Countermeasures to lower urban temperature

Putrajaya Green City 2025 Workshop

PJC, as the local authority of Putrajaya, plays an important role in the stakeholders discussion sessions and decision making process which lead to the compilation of this report. This workshop was held as an initiative towards creating Putrajaya as a Green Township by the Prime Minister of Malaysia. There were about 100 participants from 35 different agencies from both public and private sectors as well as Non-Governmental Organizations (NGOs) and representatives from the Putrajaya Resident Association who attended this workshop.

A two days Putrajaya Green City Workshop was organized by PJC from 12th-13th February, 2011. The objectives of this workshop are as follows:

1. To create a platform where professionals gather to share knowledge and ideas towards creating Putrajaya as a Pioneer Green City.
2. To get the involvement and participation of various stakeholders to get their corporation in the process of collecting data and get their views and opinion about their roles in the implementation of these Programmes.
3. To get the feedback and suggestion from the participants of the workshop about the first draft of the actions proposed in this report.

The participants were also put into groups according to their professions in order to brainstorm and give their feedback about the first draft of actions drawn up by the task force of this project. The results of the discussion in this workshop was taken into consideration for the sub-actions and programs identified in this PGC report.

Figure 28: Putrajaya Green City 2025 Workshop, held during 12th-13th February, 2011

Use Less Consume Less

Action 9

Our daily consumption preference influences our waste generation. In order to balance the economic growth and the natural resource saving with our concern towards sustainable development, it is important to reduce consumed goods, as a result, this consumption lifestyle depresses GHG emission as well as waste reduction.

"Reduce" is the first pillar of 3R in Solid Waste Management (SWM). It is defined as "reducing the amount of waste by increasing the efficiency of resource use and extending the useful life of products". Efforts of reduction activities save money not only of household but also of authority's waste treatment cost.

By practice of "reduce" activities in home, GHG emission from household waste can be reduced by 2.85ktCO_2eq, which contributes 93% of the reduction by this action. Remaining 6% and 1% are carried out by restriction of plastic bag use in business sector and promotion of IBS (Industrialized Building System) which should be applied in 70% of future building construction (See also pages 42-43).

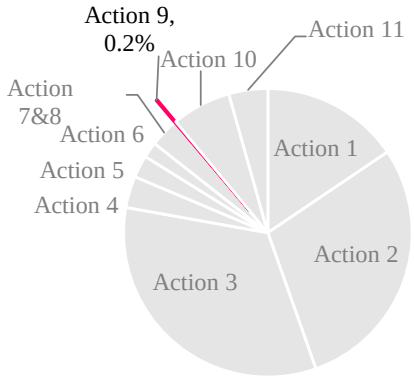


Figure 29: Contribution to GHG emission reduction of Action 9

Table 15: Sub-actions & Programmes in Action 9

Sub-action	Programmes	GHG emission reduction [ktCO_2eq]	Contribution in the Action [%]	Contribution in total reduction [%]
9-1 Implement Reduction of Waste at Source	1) Reduction of household waste reduction	2.85	93	0.142
	a. Reduction in household consumption			
	b. Increase public awareness in consumption reduction			
	2) Reduction of business waste reduction	-	-	-
	a. Intensify waste reduction programs in schools, offices and businesses			
	b. Introduces and intensify paperless operations in businesses			
	c. Shops and retail outlets, to restrict the usage of plastic bags	0.18	6	0.009
	3) Reduction of construction waste	0.04	1	0.002
	a. Promote extensive use of IBS (Industrialized Building System) in building constructions			
9-2 Introduce Regulatory Framework	1) Make green accreditation mandatory	-	-	-
	a. Government offices to restrict/refrain from using PET bottles and Styrofoam utensils in events/ functions			
	b. Impose penalty for the disposal of reusable construction/renovation material			
Total		**3.07**	**100**	**0.153**

Think Before You Throw

Before we throw useless things, we should think of "reuse" and "recycle" to reduce GHG emission as well as waste. "Reuse" and "Recycle" are the second and third pillars of 3R in SWM, and respectively mean to repair for longer use, to use in other manner or to pass to who desires and to process it in order to get back to the products or their materials.

This action contributes to reduction of 134ktCO_2eq in 2025. The biggest reduction is from waste separation at source with 72% from office and commercial, and 24% from household sector. Implementation of waste sorting at source should work together with separate collection and both selections are based on waste treatment.

Build More Facilities to Enhance Reuse

However, before waste products are sent to the final treatment, some can be reused after going through minor pre-treatment. Introduction of medium such as Flea market, car boot sale and drop off point is one way to enhance reuse by household. In 2025, Putrajaya will have 7 Park and Ride facilities, that serve as parking area, these facilities can be transformed into open space to enhance reuse. Park and Ride area can be the location for car boot sale during the weekend. Other open spaces in residential area or government office can also play the same role.

Putrajaya Buy Back Centre

Buy back centers in Putrajaya provide the public opportunity to sell their unneeded items. The centre was launched in August 2010, and it is the only one daily operating permanent buy back centre. Currently there are two permanent and three mobile centres that are operating in Putrajaya. The residents can choose from two different methods of payment; by cash or point system, since the introduction of "Putrajaya Green Card".

Encourage of Composting at Source

Natural circulation of biomass waste is essential countermeasure for waste and GHG reduction. For reduction at source, composting of food waste should be the main focus. Four levels of composting were introduced in the estimation, which are home, community, on-site and centralized composting. While conventional composting at home is very easy to carry out, farming in community

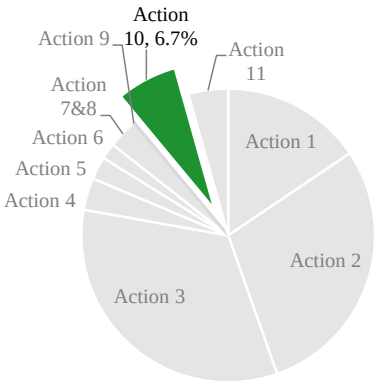


Figure 30: Contribution to GHG emission reduction of Action 10

garden will give extra benefit of socializing and enjoyment. Community farming is one of PJC ongoing program known as "Kempen Bumi Hijau". Large amount of food waste from school/office/ restaurant is treated using composting machine efficiently at the on-side facility, and landscape waste and sewage sludge is treated in centralized composting facility located in Putrajaya Integrated Solid Waste Recovery Facility.

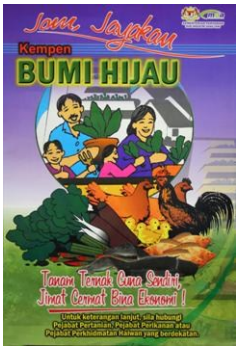


Figure 31: Kempen Bumi Hijau by PJC

Waste Separation at Source

PJC together with Alam Flora, provide household and offices garbage bins for waste separation. Commercial sectors such as restaurants, cafeterias and hotels are also provided with organic-waste bin for composting purpose. It is targeted by 2025 that waste separation, recycling and composting center allocation become mandatory in Putrajaya.

Introduce IBS to Building Construction

Industrial building system suppresses waste generation at construction site by prefabrication of construction materials.

Figure 32: Putrajaya Buy Back Centre in Precint 8

Table 16: Sub-actions & Programmes in Action 10

Sub-action		Programmes	GHG emission reduction [ktCO$_2$eq]	Contribution in the Action [%]	Contribution in total reduction [%]
10-1	**Expansion of Products Lifespan**	Encourage the reuse of household waste	1.2	0.9	0.06
10-2	**Build More Facilities to Enhance Reuse**	1) Introduce flea market where residents can resell their unused belonging. (electrical items, furniture, books, etc.)	-	-	-
		2) Provide locations for car boot sale (eg. At Park & Ride facilities, open space in residential areas, etc.)			
		3) Drop off point for reusable waste (e-waste, household waste, etc.)			
		4) Libraries to introduce books sharing activities			
10-3	**Introduce and Encourage**	1) Household - home composting	3.7	2.8	0.19
		2) Conventional method			
10-4	**Recovery of Used Cooking Oil**	1) Encourage household to separate used cooking oil for collection	0.2	0.1	0.01
		2) Impose food and beverage outlets, school/office canteens to separate used cooking oil for collection	0.1	0.1	0.01
10-5	**Introduce Regulatory Framework to Impose Waste Separation at Source**	1) Residential area	128.4	96.1	6.40
		a. Recyclable			
		b. Organic (food, used cooking oil, garden waste)			
		c. Others (e-waste, bulky, etc.)			
		* Impose mandatory waste separation in all government quarters			
		2) Office			
		a. Recyclable			
		b. Others (e-waste, bulky, etc.)			
		* Mandatory allocation of recycling center in buildings			
		3) Commercial			
		a. Recyclable			
		b. Organic (food, used cooking oil, landscape)			
		c. Others (e-waste, bulky, etc.)			
		* Mandatory allocation of recycling/composting center in facilities/parks			
Total			**133.5**	**100**	**6.66**

(May not sum to total due to rounding error.)

Figure 33: Night market as reuse promotion venue

Figure 34: Waste separation bins

Integrated Waste Treatment

Action 11

Recycle, treatment, and disposal facilities support to the robust solid waste management. There are several options for waste treatment in order to recover all the valuable resources and to minimize the needs to use virgin materials.

This action reduce GHG emission by 88ktCO_2eq or 4.4% of total emission reduction. Composting contributes to 88% of GHG reduction in this action. Especially composting by commercial sector is important.

In order to enhance recycling activities in Putrajaya, in 2025 more buy back center should be provided. From the estimation, this program reduce 5ktCO_2eq.

The model estimation includes not only GHG emission from waste treatment but also waste handling stage: GHG from waste collection and transportation. Introduction of Integrated Solid Waste Recovery Facility in Putrajaya reduces GHG emission from waste handling itself.

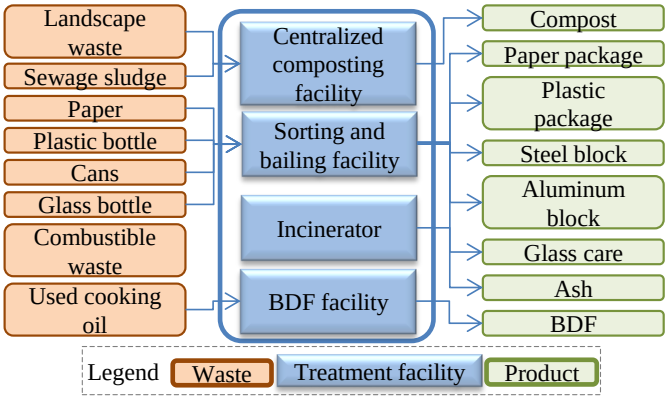


Figure 35: Process of waste treatment

Integrated Solid Waste Recovery Facility

To save energy and cost, an integrated solid waste recovery facility will necessary to be constructed as a recycle home base.

Thermal Treatment

This is a treatment process that involves the combustion of organic substances contained in waste materials. It can significantly reduces the necessary volume for final disposal up to roughly 90% in volume. Another benefit is that this treatment produces power in the process of waste burning.

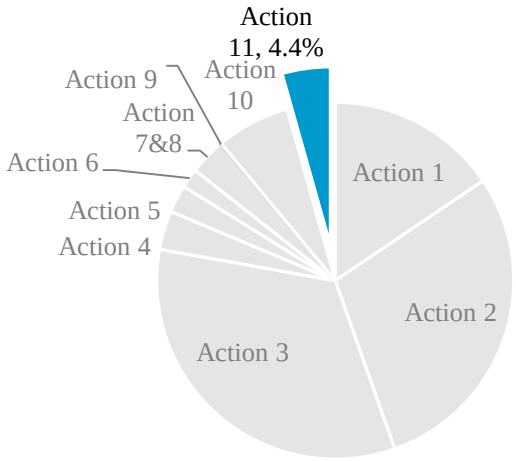


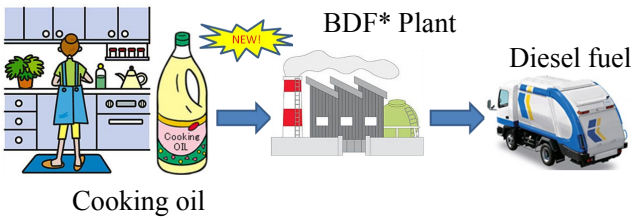
Figure 36: Contribution to GHG emission reduction of Action 11

Utilization of Bio-Diesel Fuel

Waste cooking oil is collected and utilized as fuel. Bio-diesel fuel generated from treatment of used cooking oil has similar quality to the diesel oil. Therefore it can be directly used in conventional transportation engine. Usage of generated bio-diesel fuel in waste transportation truck is the most applicable option. The recovery of used cooking oil not only reduces amount of waste sent to landfill but also reduces GHG emission because cooking oil belongs to "carbon natural" by regarding the nature of cooking oil as "carbon neutral".

Pay As You Throw

"Pay As You Throw" system is known as unit pricing or variable-rate pricing. Due to the introduction of this system, household in Putrajaya will be charged according to the amount of their discharged waste. This program will create direct incentive to recycle more and generate less waste.



*BDF: Bio Diesel Fuel

Figure 37: Process of bio-diesel fuel utilization

Table 17: Sub-actions & Programmes in Action 11

Sub-action	Programmes	GHG emission reduction [$ktCO_2eq$]	Contribution in the Action [%]	Contribution in total reduction [%]
11-1 Integrated Solid Waste Recovery Facility	1) Mini thermal treatment plant for non- recyclable or compostable waste	Contribution of these programmes are included in Sub-action 10-5.		
	2) Sorting center for recyclable waste			
	3) Baling facility for recyclable waste before transported			
	4) Bio- diesel fuel plant for used cooking oil	Contribution of this program is included in Sub-action 10-4.		
	5) Crushing facility for construction waste	Contribution of this program is included in Sub-action 9-1, program 3.		
	6) Centralized composting center for landscape waste and sewage sludge	75.87	86.65	3.8
	7) Biogas plant for organic waste			
	8) Sewage treatment			
11-2 Introduce Regulatory Framework	1) To provide more composting facility	-	-	-
	a. Household - community composting - Provide common compost bins for garden waste in residential areas.	1.46	1.67	0.07
	- Provide common compost bins for garden waste in residential areas.			
	b. Commercial - On-site composting machine for F&B outlets/markets/hotels	4.75	5.42	0.24
	- On- site composting machine for F&B outlets/ markets/hotels			
	* Impose regulations for landscape activities to use compost produced in Putrajaya			
	2) Provide more buy back center	5.48	6.26	0.27
	a. Fixed facilities			
	- Boutique for recycle product			
	- Daily operation			
	b. Mobile facilities			
	- Vehicles that go around residential areas			
	- Weekly operation			
	3) Introduce separate collection	-	-	
	- Fixed schedule by Alam Flora			
	4) Study on “Pay As You Throw” system	-	-	-
Total		**88**	**100**	**4.37**

(May not sum to total due to rounding error.)

Figure 38: Thermal treatment facility
(Picture of Eastern Clean Centre, Okayama, Japan)

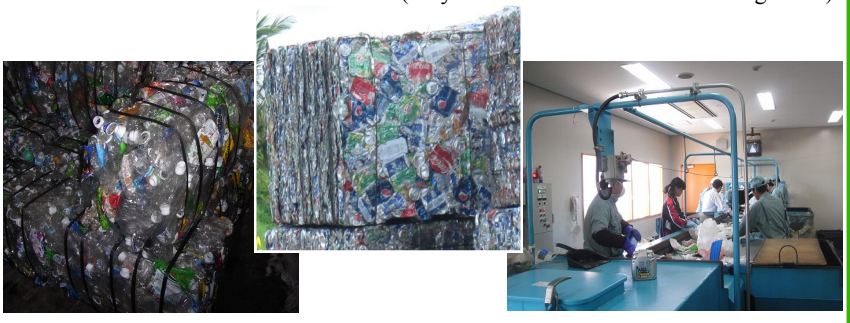


Figure 39: Bailing and sorting at Material Recovery Facility

Green Incentives and Capacity Building

Action 12

The Green Incentives and Capacity Building Action

Policy framework with the support of national government has to be established to ensure businesses with potentials to create and operate low-carbon market are able to realize it in Putrajaya. Supply of low-carbon, high value-added goods and services through energy efficient production systems should be actively encouraged through the introduction of appropriate policy measures.

Business Derivative by Economic Incentive

Programmes to encourage business organizations to support GHG emission reduction targets set by PJC should be introduced and internalized by those organizations through setting their own emission reduction targets voluntarily. Government organizations and departments should also actively participate in emission reduction programmes especially in the services provided to/by government organizations and departments. Third-party organizations to evaluate GHG reduction targets should be established or employed by PJC to assess the achievement of the set reduction targets.

Framework for incentives such as tax reduction measures can be gradually introduced through suitable means.

Demand Pull by "Low-Carbon" Value Permeation

Consumers have come to prefer low-carbon products and services, and accordingly, companies are increasing their development investment in low-carbonization of their manufacturing technologies and services. In addition, since monetary investment on companies actively implementing low-carbonization is on the increase, low-carbonization of company activities has become an important element from the viewpoint of corporate competitiveness. Consequently, a number of revolutionary technologies have been put into practice. Putrajaya, as a large consumer, should support the trials for low-carbonization of products and services.

Education Framework in Cooperation with Green Experts

The Ministry of Education in collaboration with PJC should create educational materials and curriculum to match the capacity for all school going children. Moreover, by developing educational programs which require the participation of parents and children will defuse the "child-to-parent" and "child-to-sibling" spill-over of knowledge effect for dissemination of environmental awareness. It is also important to organize environmental training sessions for teachers in order to improve their knowledge. In cooperation with NGOs and other private companies, provision of proper information to the general public will be achieved through holding of environmental events and training sessions.

Capacity Building and Environment Education

In educational institutions from primary to secondary schools, environmental education should become a compulsory subject and must be implemented in various educational programs. To support this, PJC should introduce programs to certify government officers with a certification system as low-carbon society advisors. All Government departments and agencies should hire a certain number of low-carbon society advisors to be part of the workforce of the department. These advisors play an important role in educating on low-carbon practices and giving advice to their organizations management to be low-carbon emitters.



Figure 40: Discussion between PJC and stakeholders, and Environment education

Table 18: Sub-actions & Programmes in Action 12

Sub-action	Programmes
12-1 Demand Pull by "Low-carbon" Value Permeation	1) Networking (smart partnership)
	2) Testing and evaluation of products and technologies by PJC or Federal Government
12-2 Education Framework in Cooperation With Green Experts	1) Organize public forum
	2) Activities on International Green Days (World Environtment Day, Earth Day, World Habitat Day etc.)
	3) Infuse environmental studies in educational system
	4) In-house in service environmental/sustainability awareness program (PJC staff, government departments and agencies)
	5) Community information board & newsletter
	6) Development of the educational materials (interactive multimedia, DVD, posters, flyers, manuals etc.) in collaboration with Environmental NGOs
12-3 Environment Education	1) Putrajaya Greening Programme
	2) Educational programs and awareness on green technology - Community/society, school children, office staff
	3) To develop green technology and environmental awareness modules
	4) Competition and recognition (Biggest Loser)
	5) Community College for Sustainable Development
	6) Promote the public health and environmental benefits of supporting locally grown organic foods (school canteens, office cafeteria, and food outlets)
	7) Identify and eliminate products/chemicals harmful to the ecosystem (water, ground, air)
12-4 Public Awareness (Putrajaya Greening Programme)	1) Education greening programmes
	2) Plant in/outside school compound
	3) Education for young/school children - forest education in the nursery
	4) Existing forests to be used as exemplary sites
	5) Public able to access information on Putrajaya urban forest planning at strategic places i.e. bus stops; transportation stations
12-5 Tax Incentives for Energy Efficiency	1) New home constructions to incorporating energy efficiency and renewable energy features:
	a. Modular home construction, retrofitting
	b. Roofing (insulations)
	c. Rain water harvesting
	d. Solar (photovoltaic) panels
	e. Solar water heaters
	f. Passive cooling (rooftop garden)
	g. Cars: hybrids/battery-electric
	2) Incentives: Eco points/subsidies/rewards
12-6 Green Ambassadors	1) Appoint individuals as green ambassador in every department in the organization – and rewarding them and their staff for their effort
	3) Green Ambassador will create and monitor the green activities in the organization

Overview of the Methodology

"Backcasting" towards Green City

Methodology of "Backcasting"

For creating scenarios to achieve a low-carbon society in this study, a methodology based on the concept of backcasting is applied. According to the definition of Robinson JB (1990), the backcasting method involves working backwards from a particular desired end-point to the present in order to determine the physical feasibility of that future and what policy measures would be required to reach that point. This method is suitable for problems which is long-term, requiring major change, and difficult to solve if present trend continues.

From a technical perspective, the backcasting approach can be divided into two phases (Figure 42). In the first phase, a desired goal ("vision") is described while in the second phase, the means of attaining that goal ("roadmap") from the current situation is sought.

Application to Putrajaya

As first trial for Putrajaya Green City study, this report mainly focuses on the first phase, developing the "vision". The vision includes aspects of demography, economy, transport, land use, buildings, energy demand, environmental load, and actions and countermeasures to achieve the environmental targets. It shows a snapshot of Putrajaya in 2025, which achieves three environmental targets while maintaining planed development.

We identified the three environmental targets through discussion between policy makers and researchers; reduction of GHG emission intensity related to energy use (-60%), waste final disposal (-50%), waste-related GHG emission (-50%) and mitigation of urban heat island. (-2°C). These targets were considered "given", thus, the "vision" should achieve all of three targets using available countermeasures (See also page 8).

To describe the vision based on quantitative analysis, quantification models were applied, which have been developed by Universiti Teknologi Malaysia and Asia Pacific Integrated (AIM) modeling group since several years ago (see next page for general information on utilization of models, and also following pages for application of each model by environmental targets).

Figure 41: Scenery in Putrajaya

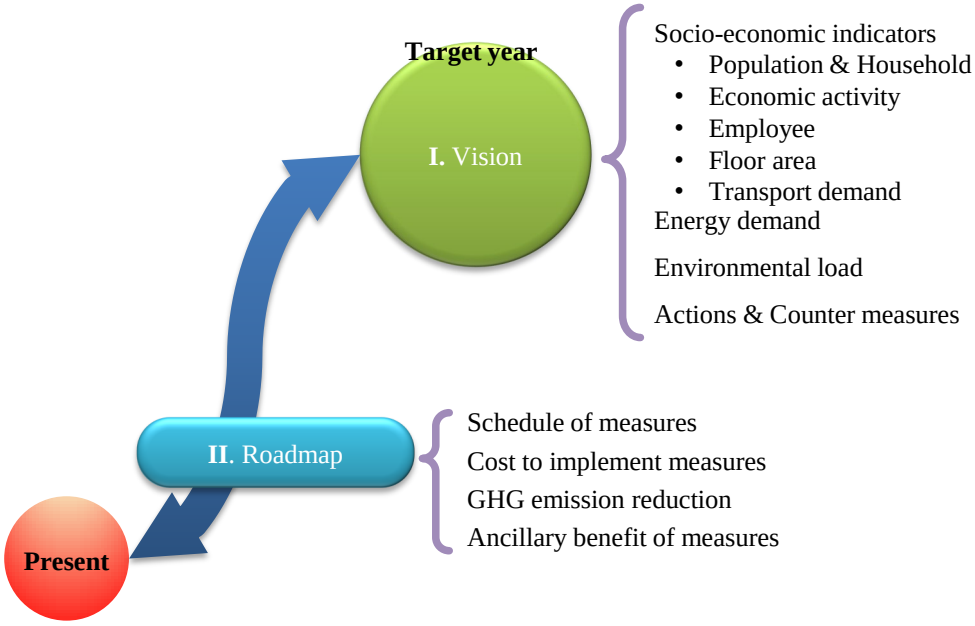


Figure 42: Methodology of backcasting

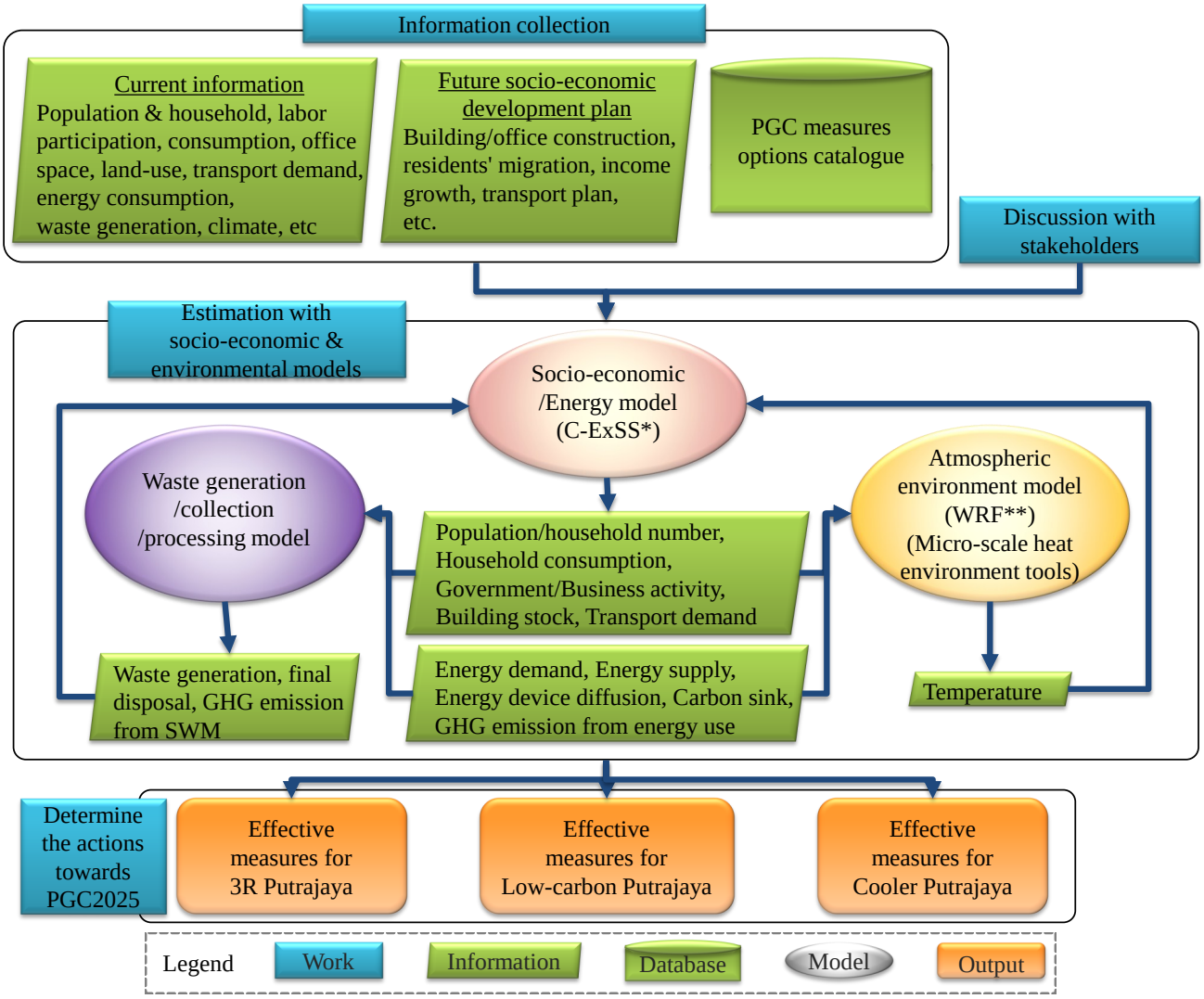
Integrated modeling approach

Models for Decision Making

In order to identify necessary actions, "integrated modeling" based on "backcasting" approach is applied. The models estimate balanced and quantitative future activity levels, environmental emission, and measures to be implemented to achieve the targets.

Information collection is the first step in the modeling work. Socio-economic information as well as environmental information in the base year (2005) were collected and analyzed, and current emission are identified. Besides such information, feasible options for PGC2025 is collected and a catalogue will be developed based on the latest technology and policy information.

For future projection, based on planned development, the models estimate socio-economic activity level including household number, consumption, land area and building stock, transport demand and other variables. Based on them, environmental loads are calculated with or without countermeasures ("Options"), and necessary and effective measures are identified through iterative calculation and discussions.



*ExSS: Extended Snapshot Tool. A static, accounting type model to design quantitative future societies as goals of low-carbon society scenarios. It was developed by Kyoto University and NIES, and will be improved in order to adjust to Putrajaya's own situations.

** WRF: Weather Research and Forecasting model. It was developed by NASA and other organizations in the U.S. and widely used for study on weather and atmospheric environmental research.

Figure 43: Methodology for decision making

Socio-Economic Scenario

Socio-Economic Development to 2025

Base Year Information

The base year for this research of Putrajaya Green City 2025 is set as 2007, this is because of the availability of data from PJC. The base year information is obtained mostly from the Draft Laporan Pemeriksaan Rancangan Struktur Putrajaya, June 2009 (Perbadanan Putrajaya, 2009). This document describes development plan, and enabled us to use it to determine the base year information. As for some detailed figures which we were not able to get for Putrajaya as a City, some assumptions were made. This can be seen in the Information source, refer to Table 22 in pages 44-45.

Assumption of Socio-economic Development

The assumption of the socio-economic development in the target year is estimated using the socio-economic tool; Community Extended Snapshot (C-ExSS) (Figure 43).

Since Putrajaya is a Planned city and it has a Master Plan which designs the future scenario, some variables such (e.g. population, employment, floor area of government buildings, etc.) were already planed by PJC. These variables were input to C-ExSS as exogenous variables, and based on additional assumptions, other variables (e.g. residential floor area, passenger transport demand) were estimated. These socio-economic indicators (Table 19) play a very important role in the design and storyline of the future scenario of Putrajaya in 2025.

Result of Main Variables

As planned by PJC, population in Putrajaya will increases 7 times from 2007 to 2025, to 347,700 (Figure 44). Figure 45 shows the Household number in Putrajaya which grows simultaneously with the population. Passenger transport will grow in proportion to the population. Transport demand is different in 2025BaU and 2025CM. This is because Putrajaya will increase the use of public transportation in 2025CM, especially with the rail (See Action 1 and 2 for more detail).

Employment is estimated to increase about 3.7 times in total, while employment in the commercial sector shows very large growth, about 21 times from 4,061 in 2007 to 85,500 in 2025 (Figure 46). Growth of floor area shows similar pattern (Figure 47).

To calculate the emission intensity, it is important to have the Gross Regional Production (GRP) of Putrajaya. However, since this data is not available, as an alternative indicator, "economic activity" is applied here. Economic Activity is defined as "number of employment in Putrajaya multiplied by the Malaysian per capita GDP" and is shown in relative scale compared with base year. As a combined effect of employment growth in Putrajaya and Malaysian expected per capita GDP growth, the economic activity in 2025 is about 7.5 times greater than base year.

Table 19: Socio-economic assumptions

Socio-economic indicators	Assumption
Population	347,700 persons in year 2025
Household	79,023 household in year 2025
In-coming persons	76,059 persons per day in year 2025
Out-going persons	56,573 persons per day in year 2025
Floor area	17,187,625 m^2 in year 2025 (4.5 times compared to 2007 level)
Employment	164,500 employees in year 2025 (3.7 times compared to 2007 level)
Economy in Malaysia	Per capita GDP will grow approximately an average of 4.3% per year
Passenger transport generation	It is assumed not to change from year 2007 to 2025 because following factors will cause increase and decrease; [Factor in increase] Increase in leisure & recreation time [Factor in decrease] Aging society, IT society
Modal share of passenger transport trip	Modal share will shift from "Bicycle, Walk", "Motorcycle" to "Automobile" because of economic growth
Average trip distance	Trip distance of bicycle and walk will decrease because of modal shift to Automobile
Freight transport demand	It will increase in proportion to economic activity (7.8 times compared to 2007 level) beacause number of freight vehicle is assumed to grow with economic activity
Energy service demand	Per floor area or per capita energy service demand will increase by 1 to 2.13 times

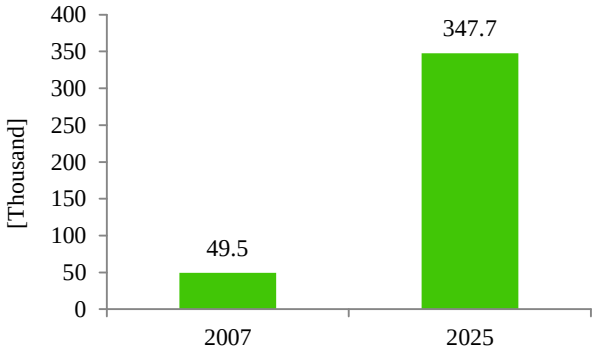


Figure 44: Population

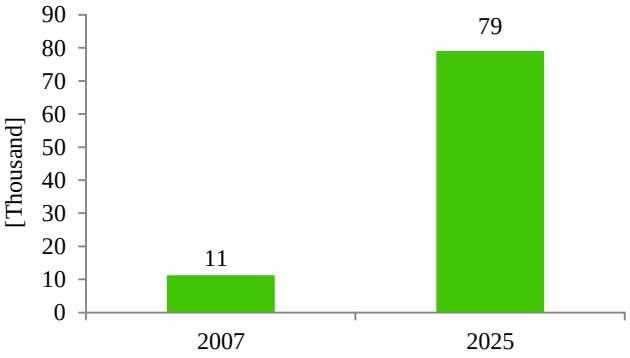


Figure 45: Household

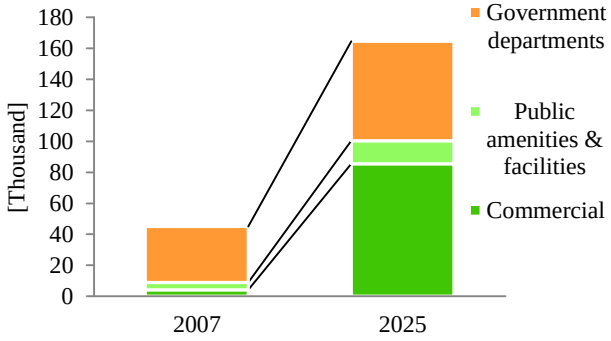


Figure 46: Employment

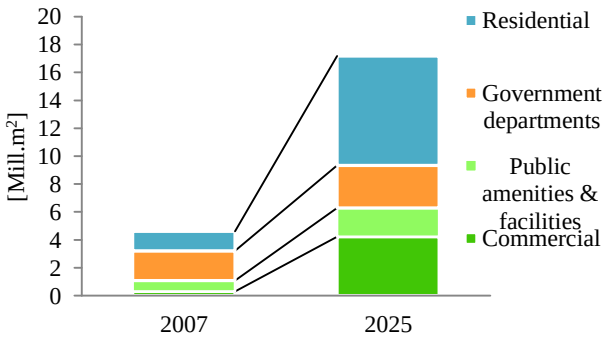


Figure 47: Floor area

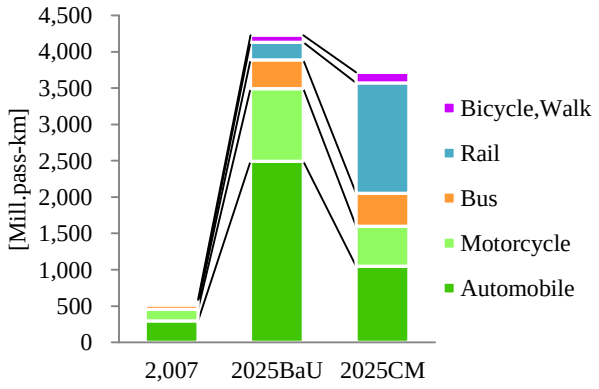


Figure 48: Passenger transport demand

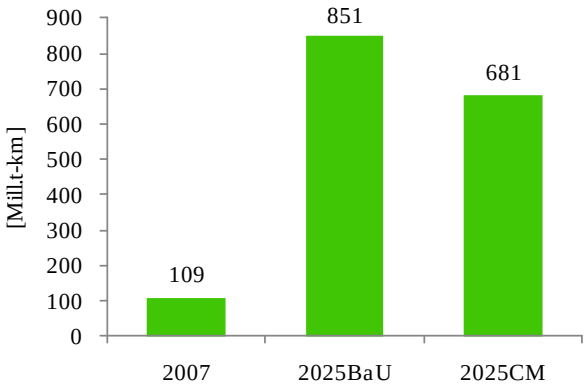


Figure 49: Freight transport demand

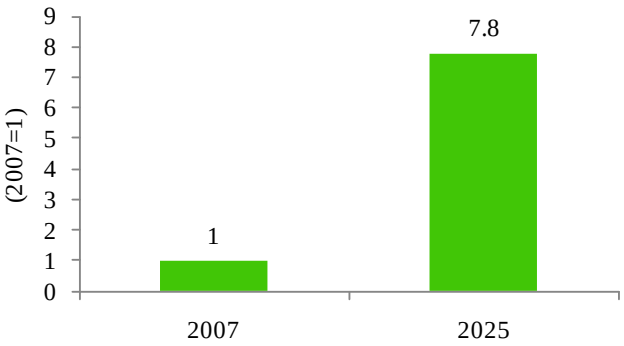


Figure 50: Economic activity

Figure 51: Scenery in Putrajaya

Low-carbon Putrajaya

Community-ExSS

Development of Quantification Tool

In order to quantify socio-economic indicators, energy demand, GHG emission from energy use and carbon sink, we developed a tool named “Community Extended Snap-shot Tool (C-ExSS)”. C-ExSS is an estimation tool for designing a low-carbon society in communities or towns which do not have large industrial sector. It illustrates the quantitative future snapshot of the city including energy demand, GHG emission and a portfolio of measures to meet the low-carbon target.

The features of C-ExSS are;

1. It is a multi-sector static model. The sectors in this study are: Commercial, Public amenities & facilities, Government departments and Residential.
2. The household sector is classified by income classes, so it is possible to consider household structure change.
3. The energy demand is driven by population, floor area and the number of employment.

Figure 52: Scenery in Putrajaya

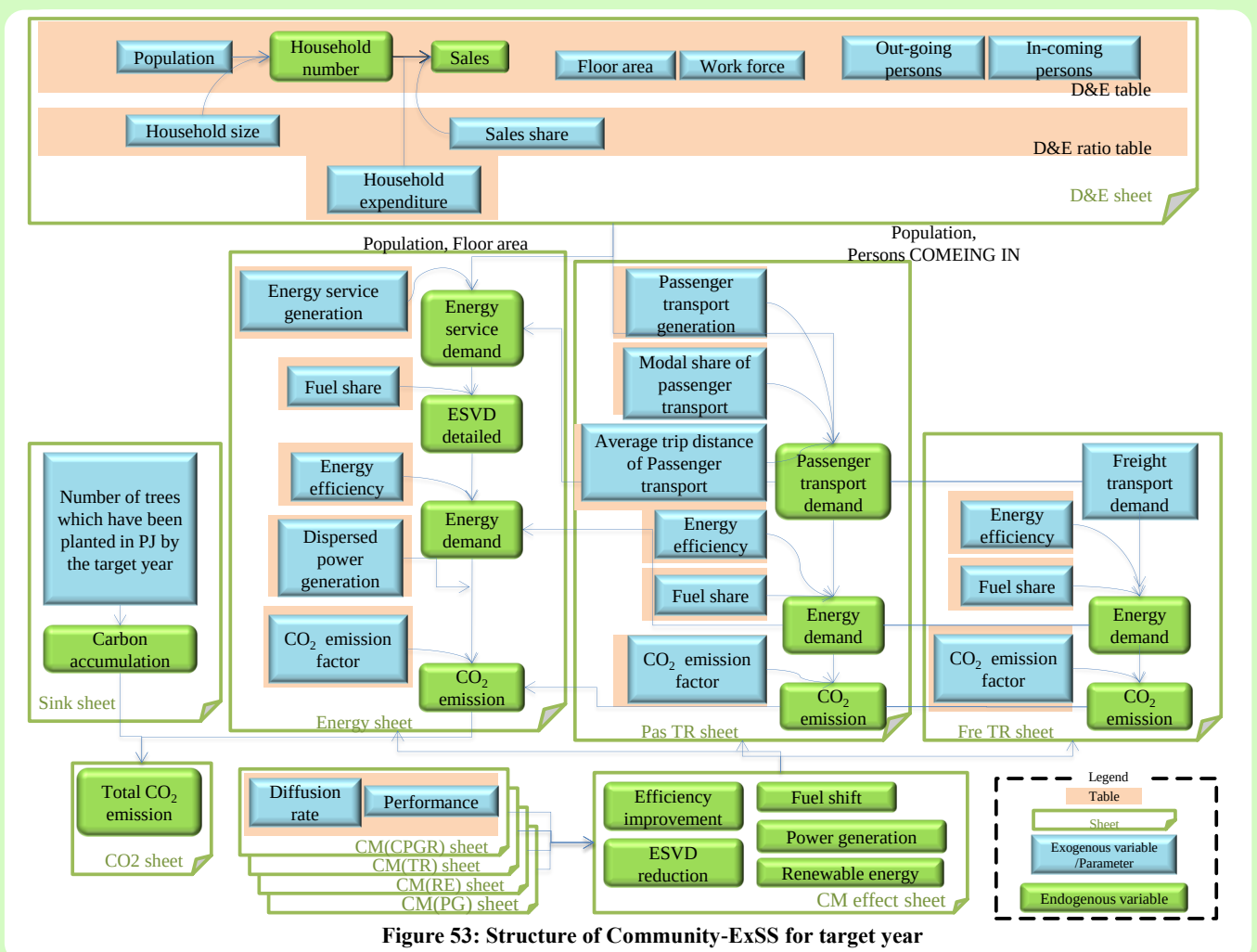


Figure 53: Structure of Community-ExSS for target year

Energy demand and GHG emission

Energy Demand

The energy consumption in Putrajaya during the base year is 135ktoe and increases to 908ktoe in 2025BaU, which is reduced by nearly 45% to 411ktoe in 2025CM. The commercial sector is estimated to have the highest increase in energy consumption from base year to target year about 22 times (Figure 56). Future energy demand is estimated using C-ExSS (Figure 53). C-ExSS calculates energy consumption based on socio-economic indicators and information of energy-consuming equipments. Two scenarios established are: 2025BaU in which current energy consumption structure is unchanged and development goes on as normal, and 2025CM in which low-carbon countermeasures are applied in order to reduce energy consumption and GHG emission.

GHG Emission from Energy Use & Carbon Sink

The over all GHG emission from energy use and carbon sink for base year is 516ktCO_2eq, and this is estimated to increase about 7 times to 3,772ktCO_2eq in BaU case, which can be reduced to 1,591ktCO_2eq in CM case (reduction of about 58%). The commercial sector has the highest emission in 2025BaU (Figure 57). This is followed by the passenger transport sector. The per capita GHG emission (Figure 58) is 10.4tCO_2eq/capita in base year, and in 2025(BAU) it drops to 10.9tCO_2eq/capita. However, with suitable countermeasures it can be reduced to 4.6tCO_2eq/capita. Introduction of each countermeasure is determined based on discussion between PJC and the research team, and finally a set of suitable measures which reduce GHG emission from energy use & carbon sink by 60% is identified. The largest reduction potential is found in energy efficiency improvement of commercial sector (Figure 69).

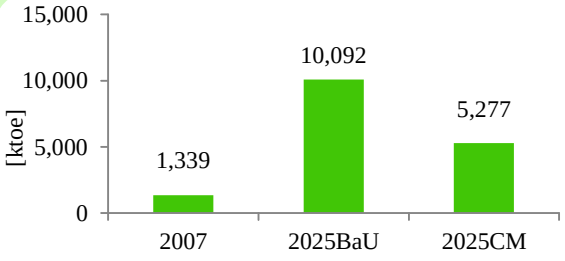


Figure 54: Primary energy demand

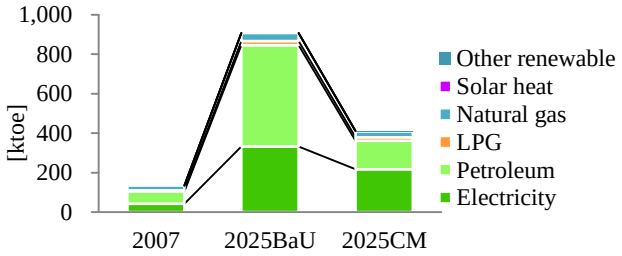


Figure 55: Final energy demand by fuel

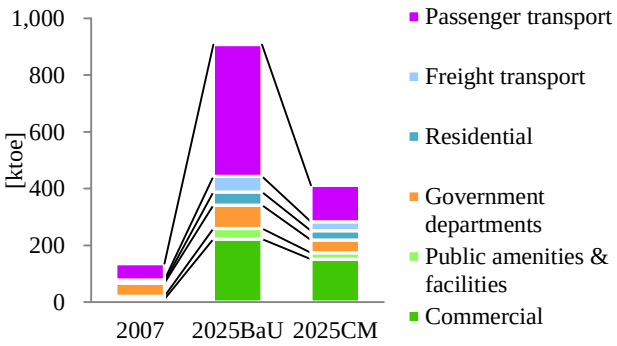


Figure 56: Final energy demand by sector

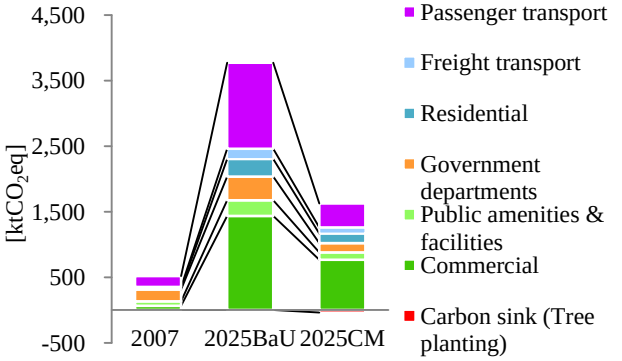


Figure 57: GHG emission from energy use & carbon sink

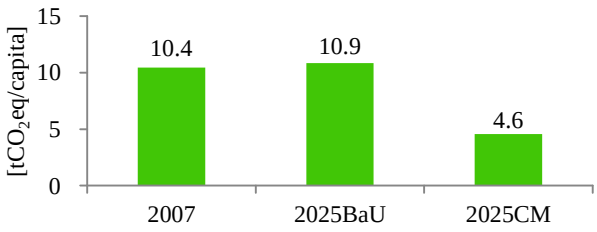


Figure 58: GHG emission per capita from energy use & carbon sink

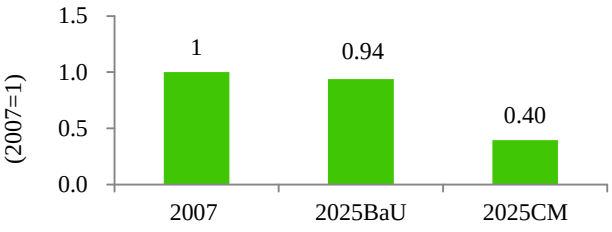


Figure 59: GHG emission per economic activity from energy use & carbon sink

Cooler Putrajaya

The model:

Overview of the Urban Heat Island Model

Meso-scale meteorological model and an urban canopy model are essential tool to investigate the effect of countermeasures for urban heat island quantitatively. Weather Research and Forecasting model (WRF) version 3.2 is used in this study. This model has implemented an urban canopy model.

Essential input data for the meteorological model is Grid Point Value (GPV) data of synoptic meteorological field of target period and land surface information of model domain. An energy balance between land surface and atmosphere are determined by surface albedo, soil moisture, surface emissivity and surface roughness, which are translated from land use/land cover categories. The mitigation countermeasures are implemented in the model by changing land use category and its physical parameters, such as albedo and moisture availability.

United States Geological Survey (USGS) 24-category land use data are used, and for Putrajaya region, detail land use information were translated from GIS master plan and satellite image.

Effect of countermeasures in community scale or personal scale, such as dry mist spray and shade pavement, are handled after WRF simulation, because meso-scale meteorological model cannot treat such a small scale directly.

Model Calculation

WRF simulation was performed with tree nesting domains shown in Figure 21. Grid size of each domains are 5km, 1km, and 200m. Calculation period is January to December, 2005. Calculation was validated by comparing the model output with observation. Countermeasures to mitigate UHI is shown in Table 20.

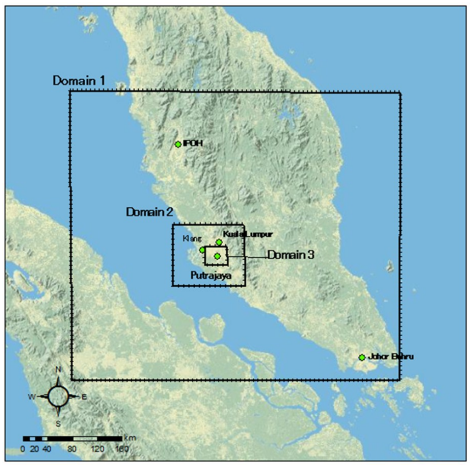


Figure 60: Calculation Domains

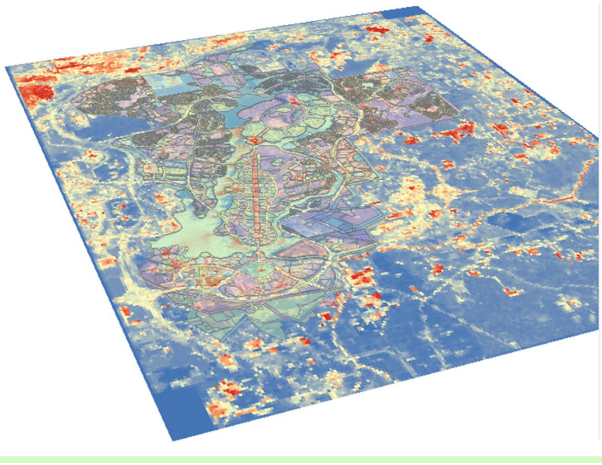


Figure 61: Land Surface parameter for Model input on GIS platform

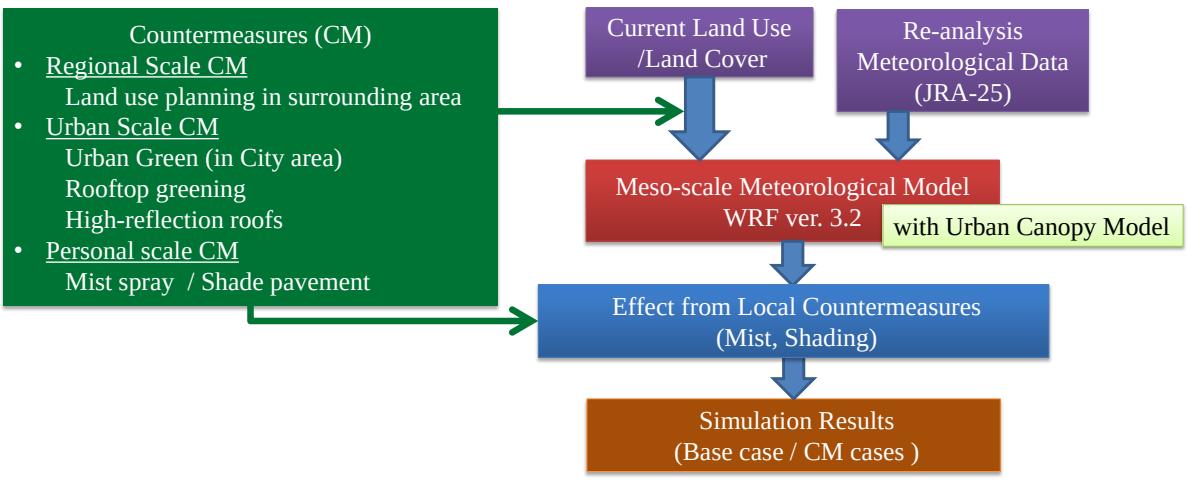


Figure 62: Methodology of UHI Model

Table 20: Calculation cases for urban heat island simulation

Cases	Description
Base Case	Calculation based on the development in line with current Master Plan without any countermeasures. All planned block is categorized to "Urban area" . Current Green area is kept. As a boundary condition, meteorological objective analysis data of 2005 was used.
Green Case	420,000 trees are added to Base case in Putrajaya area. (Broadleaf tree) In the calculation additional trees are equally distributed. In this case, evapotranspiration by tree is key factor.
High reflection painting Case	All rooftop of building are painted by high reflection paint. And material of high reflectivity are used for 10% of the pavement. By this countermeasure, we assumed that albedo of urban area change from 0.15 to 0.22.
Reduced Artificial Heat from vehicle Case	We assumed that artificial heat exhaust from only vehicle is reduced by LCS countermeasure. Based on the petroleum consumption of passenger and freight transportation of BaU and CM case within the Putrajaya urban area, when we assumed that it is distributed equally to all urban area during daytime 12 hours, artificial heat from vehicle is reduced from 12.6W/m^2 to 3.6W/m^2.
Reduced Artificial Heat from building Case	We simply used total energy consumption in building in BaU and CM case. We assumed that daytime energy consumption is double of nighttime. Also, we assumed that it is distributed equally to all urban area. Then, artificial heat from building is reduced from 32.3W/m^2 to 20.8W/m^2.

Figure 63: Countermeasures for urban heat island

3R Putrajaya

GHG emission from waste treatment

The two main targets of 3R Putrajaya are, to reduce 50% of the solid waste volume which is land filled from the 2025 (BaU) case, and to reduce 50% of GHG emission from the 2025 (BaU) case. Waste amount is estimated at three levels as mentioned below:

1. From waste collected after reduction at source
2. From Waste after it is treated at selected treatment facilities
3. At landfill site for final disposal

The GHG emission are estimated from waste treatment including final disposal, and transportation of waste from source to treatment facilities to landfill site. GHG emission from waste collection and transportation are estimated from travel distance of collection truck. GIS estimates the trip distance of waste transportation among locations of waste source, treatment facilities and landfill site, using road networks as well as waste generation and location.

Countermeasures for reduce, reuse and recycle

"3R" means Reuse, Reduce and Recycle. Tables 21 and 22 show some example of countermeasures which can be practiced in order to "reduce" and "reuse" household waste. These activities should be enhanced by the programs in Action 9 to 11. As for "recycle", separate collection is the most important practice. It requires integrated collection systems and facilities.

All 3R practices can reduce waste landfill, hence methane emission from landfill site. 3R, as well as thermal treatment, can contribute to reduce overall GHG emission significantly, since methane has stronger greenhouse effect than CO_2 .

Future simulations

The future simulation was conducted in four different cases (Table 21). In 2025BaU, all waste go to landfill as in the base year. The other three countermeasure cases, 2025CM, simulate combination of two groups of countermeasures: (1) Separate collection, (2) Thermal treatment, and (3) The both. In all three 2025CM cases, "reduction at source" (= home composting and other "reduce" activities) is considered. GHG calculation from waste transportation is calculated in this study using road network which is shown in Figure 64.

Figure 66 shows the result of waste treatment in the four cases. In BaU case, amount of landfilled waste will be increased more than 4 times than 2005. In 2025CM cases, reduction of landfill is the most in the case 2025CM(3), which shows 73% of reduction. However, from the view point of GHG emission reduction, 2025CM(1) emits least GHG, and therefore thermal treatment is not the best choice. Considering the balance of two targets, we decided to adopt 2025CM(3) for the proposal of Actions 9 to 11.

In addition, waste reduction at source and home composting are the best solutions for SWM since it is an effective for both GHG emission reduction and landfill reduction. More detailed results are shown in Tables 28 and 29 in page 50.

Table 21: Combination of treatment option and collection waste type

Cases	Treatment option
2025BaU	Landfill
2025CM(1) Separate collection	Landfill, home composting, recycling, and Bio Diesel Fuel (BDF)
2025CM(2) Thermal treatment	Landfill, home composting, BDF, and thermal treatment
2025CM(3) Thermal treatment with separate collection	Landfill, home composting, recycling, BDF and thermal treatment

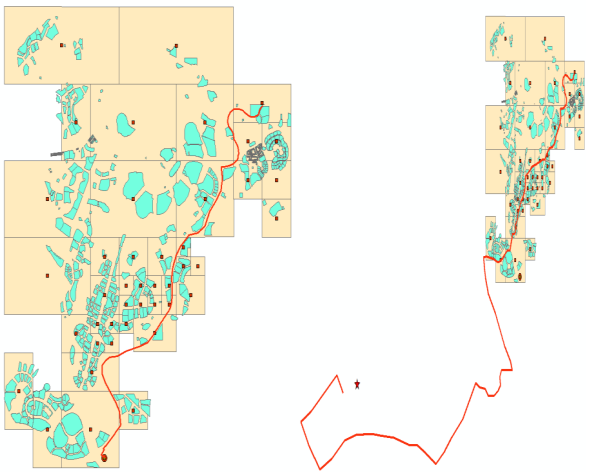


Figure 64: Route of waste collection and transportation

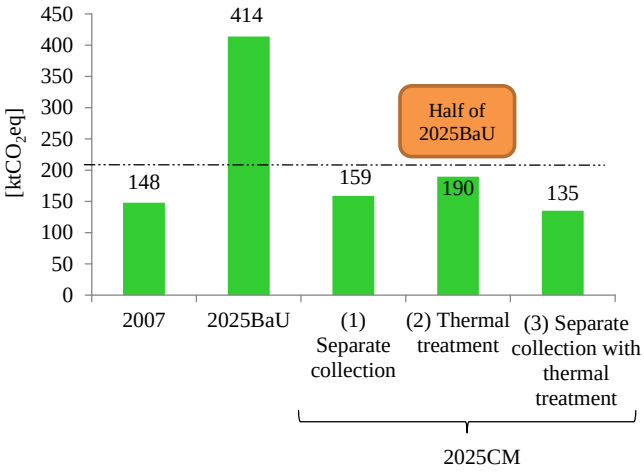


Figure 65: GHG emission from waste treatment selections

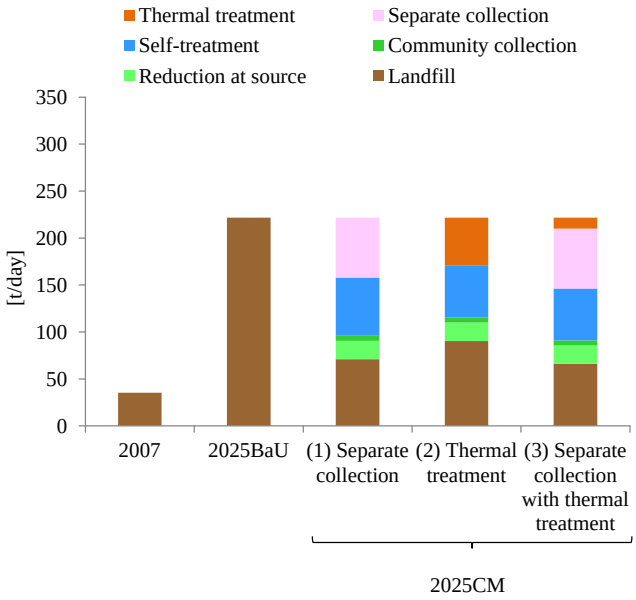


Figure 66: Amount of household and business waste by treatment selections

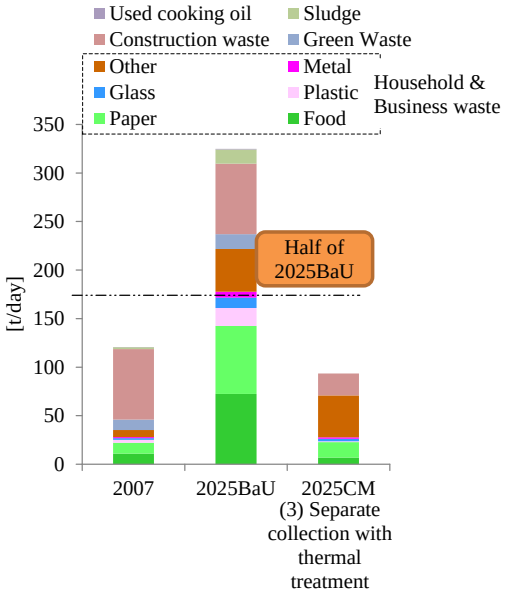


Figure 67: Amount of landfilled waste by waste types

Figure 68: Scenery in Putrajaya

Information Source

Table 22: Information source

Indicator		Methodology	Information source
Demography and Economy			
Population		=Nighttime population	Perbadanan Putrajaya (2009)
Daytime population		=Population+In-coming persons -Out-going persons	-
Household size			Perbadanan Putrajaya (2009)
Household number		=Population/Household size	-
Per capita GDP in Malaysia		=GDP/Population	[for GDP] The Economic Planning Unit, Prime Minister's Department, Putrajaya (2010) Department of Statistics, Malaysia (2010) [for Population] Department of Statistics, Malaysia (2010)
Total hosehold expenditure in Putrajaya		=Per household expenditure*Household number Per household expenditure was estimated with expenditure patterns and national average household expenditure.	[for Expenditure patterns] Department of Statistics, Malaysia (2006) [for National average household expenditure] World bank (2010)
In-coming persons		People those who come to Putrajaya from outside. Estimated from traffic coming in during morning peak hour	[for Traffic volume at station 1 to 6] Directly obtained from Planning Department of PJC (Traffic survey data for Perbadanan Putrajaya (2009)) [for Traffic volume at station A1] KW Associate Planners Sdn Bhd (2008) [for The number of passenger of train] Directly obtained from Finance & Revenue Management Department, Express Rail Link Sdn Bhd [for Average number of passenger in Automobile and Bus] Perbadanan Putrajaya (2004) [for Average number of passenger in Motorcycle] Assumed by the research team, to be 1 passenger.
Out-going persons		People those who go to outside from Putrajaya. Estimated from traffic going out during morning peak hour	-
Floor area, Employment			
Floor area	Commercial	-	Divide restaurants from Shop/shop office and Shopping mall by Number of employment by job types in Malaysia. [for Overall employment] Directly obtained from Planning Department of PJC [for Number of employment by job types in Malaysia] Department of Statistics, Malaysia (2009)
	Public amenities & facilities	-	Directly obtained from Planning Department of PJC
	Government departments	-	Directly obtained from Planning Department of PJC
	Residential	=Floor area per household*Household Allocate residential classification for house type as follows,. Low income: Affordable home Middle income: Terrace/Townhouse,Apartment/Condominium High income: Bungalow, Semi-detached	[for Average floor area by house types] Directly obtained from Planning Department of PJC (Housing delivery schedule of Putrajaya Holdings Sdn Bhd)*
Employment	Commercial	-	Perbadanan Putrajaya (2009)
	Public amenities & facilities	=Total public employment-Government employment	[for Total public employment] Perbadanan Putrajaya (2009)
	Government departments	-	Directly obtained from Planning Department of PJC
Passenger transport			
Passenger transport generation		Estimation made by Directly obtained from Planning Department of PJC and PGC2025 research team.	-
Modal share of passenger transport trip		Based on Sustainable Iskandar Malaysia, 2nd report, [Domestic travel] Assumed that share of Rail is 0, and it moves to Bus. [Cross border travel] Devided the total share of Bus+Rail in Malaysia into each mode with number of passenger per year.	[for National modal share] Universiti Teknologi Malaysia *et al.* (2011) [for Number. of passenger of Bus] Directly obtained from Transportation and Traffic Division, Department of Urban Services, PJC [for Number. of passenger of Rail(ERL)] Directly obtained from Finance & Revenue Management Department, Express Rail Link Sdn Bhd
Average trip distance	Bicycle, Walk	-	Universiti Teknologi Malaysia *et al.* (2011)
	Motorcycle	Assumption based on geographic distance and number of people who travel to & from Putrajaya.	-
	Automobile		
	Bus		
	Rail	Estimated from the distance between Putrajaya and Kuala Lumpur.	
Freight transport			
Freight transport demand		Freight transport demand for Malaysia(t-km) was downscaled with the number of freight vehicle in Malaysia and the freight vehicle coming into Putrajaya per day.	[for Malaysia's freight transport demand] Universiti Teknologi Malaysia *et al.* (2009) [for Number of freight vehicle coming into Putrajaya per day] KW Associate Planners Sdn Bhd (2008) Directly obtained from Planning Department of PJC (Traffic survey data for Perbadanan Putrajaya (2009)) [for Number of freight vehicle possessed in Malaysia] Ministry of Transport, Malaysia (2008)
Fuel share of transport mode		-	Universiti Teknologi Malaysia *et al.* (2011)
Energy efficiency of transport mode		-	Mizuho information & research institute, inc. (2005)

Indicator		Methodology	Information source
Energy & GHG emission from energy use			
Energy efficiency of electric appliances		-	Mizuho Information & Research Institute, Inc. (2005) Research project to establish a methodology to evaluate mid to long term environmental policy options towards Asian low-carbon societies (2007) Malaysia Energy Centre (2007)
Final energy demand	Commercial	[for Electricity]: National final energy demand was downscaled with floor area [for LPG]: National final energy demand was downscaled with employment	-
	Public amenities & facilities	[for Electricity, Airconditioner]: Assumed that per floor area demand is same as Commercial [for Electricity, Other services]: Assumed that per floor area demand is same as Government [for LPG]: National final energy demand was downscaled with employment	-
	Government departments	[for Electricity]: Directly obtained from Planning Department of PJC [for LPG]: National final energy demand was downscaled with employment	-
	Residential	National final energy demand was downscaled with Household	-
GHG emission factor from energy use		-	Roadmap Committee, Shiga Prefecture Sustainable Society Research team (2006)
Solid waste & GHG emission from SWM			
Waste generation	Commercial	=Number of emloyment*Waste generation rate	[for Waste generation rate] Fujiwara *et al.*(2009)
	Public amenities and facilites	[for Schools] =Floor area*Waste generation rate [for Others] Assumed to be 0.	[for Waste generation rate] Ministry of Housing and Local Government, Malaysia (2006)
	Government departments	=Number of emloyment*Waste generation rate	[for Waste generation rate] Fujiwara *et al.* (2009)
	Residential	=Population*Waste generation rate	[for Waste generation rate] Ministry of Housing and Local Government, Malaysia (2006)
Used cooking oil	Commercial	=Shops number*Used oil generation rate	[for Shops number] Directly obtained from Planning Department of PJC [for Used oil generation rate] Directly obtained from Okayama City, Japan
	Residential	=Population*Used oil generation rate	[for Used oil generation rate] Directly obtained from Okayama City, Japan
Sewage sludge		=Population*Sewage generation rate*Sludge generation rate	[for Sewage generation rate] Directly obtained from Planning Department of PJC*
Green waste		=Park area*Brach or grass generation rate	[for Park area] Directly obtained from Planning Department of PJC [for Branch and grass generation rate] Chiba Prefecture (2004)
Construction waste		=Construction floor area/year*Waste generation rate	Directly obtained from Putrajaya Holdings Sdn Bhd
GHG emission factor from SWM		-	Japan Environmental Management Association for Industry (2006)
Collection and transportation		=Road distance/Collection truck energy efficiency* GHG emission factor	[for Road distance] Directly obtained from Planning Department of PJC [for Energy efficiency] Japan Environmental Management Association for Industry (2006)
Temperature			
Objective analysis data (Meteorological data)		-	Japanese Meteorological Agency and Central Research Institute of Electric Power Industry (2004)
Meteorological observation data (Daily maximum temperature , Daily minimum temperature, Precipitation, Wind velocity/Direction)		-	Directly obtained from Planning Department of PJC
GIS master plan data		-	
Satellite image 2009		-	

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Data tables

Table 23: Floor area and number of employment

		Floor area [m²]			Employment [no.]		
		2007	2025	2025 /2007	2007	2025	2025 /2007
Commercial	Office/Commercial complex	52,297	2,075,644	39.7	743	42,019	56.5
	Shop/Shop office	74,716	661,210	8.8	1,062	13,386	12.6
	Hotel	16,129	206,007	12.8	229	4,170	18.2
	Shopping mall	81,654	81,654	1.0	1,160	1,653	1.4
	Restaurant	53,368	253,537	4.8	758	5,133	6.8
	Mix development (housing + commercial)	0	905,160	-	0	18,324	-
	Petroleum station	6,832	18,760	2.7	97	380	3.9
	Service industry	0	16,642	-	0	337	-
	Private amenities	751	4,868	6.5	11	99	9.2
Commercial subtotal		**285,746**	**4,223,480**	**14.8**	**4,061**	**85,500**	**21.1**
Public amenities & facilities	Public kindergarten	940	495	0.5	6	4	0.6
	School	417,915	882,161	2.1	2,552	6,353	2.5
	Hospital/Clinic	50,173	205,250	4.1	306	1,478	4.8
	Mosque/Small mosque	75,666	225,576	3.0	462	1,624	3.5
	Fire Department	14,179	50,130	3.5	87	361	4.2
	Police station	21,192	41,990	2.0	129	302	2.3
	Neighbourhood Complex	64,907	233,719	3.6	396	1,683	4.2
	Food Court (landed)	6,477	6,477	1.0	40	47	1.2
	City service center	27,047	176,195	6.5	165	1,269	7.7
	Recycle center	99	99	1.0	1	1	1.2
	Market	4,404	4,404	1.0	27	32	1.2
	Utility	115,687	231,193	2.0	706	1,665	2.4
Public amenities & facilities subtotal		**798,686**	**2,057,687**	**2.6**	**4,877**	**14,818**	**3.0**
Government departments	Parcel A - PM's office	67,127	67,127	1.0	906	800	0.9
	Parcel B - Prime Minister's Department	155,639	155,639	1.0	2,682	2,682	1.0
	Parcel C - Ministry Of Science, Technology & Inovations & Other Agencies	155,190	155,190	1.0	3,660	3,660	1.0
	Parcel D	214,758	214,758	1.0	5,109	12,998	2.5
	Parcel E	312,313	312,313	1.0	8,539	7,573	0.9
	Parcel F	0	260,925	-	0	6,600	-
	2G1 - Ministry of Finance	68,567	68,567	1.0	1,305	1,305	1.0
	2G2 - Perbendaharaan & Kastam	101,021	101,021	1.0	1,431	1,431	1.0
	2C1 - Ministry of the federal territory and welfare of town	47,708	47,708	1.0	301	301	1.0
	2G3 - Ministry Of Dosmetic Trade and Cosumers Affair	77,135	77,135	1.0	728	728	1.0
	2G4 - Ministry Of PlantationsIndustries and Commo-doties	78,565	78,565	1.0	1,628	1,628	1.0
	2G5 - National Registration Department	66,659	66,659	1.0	954	954	1.0
	2G6 - Ministry Of Entrepreneur and Co-operative Devel-opment (MEDC)	49,308	49,308	1.0	721	721	1.0
	2G7 - Foreign ministry	57,297	57,297	1.0	546	546	1.0
	2G8 - Housing loan department	92,969	92,969	1.0	1,346	1,346	1.0
	2C15 - Energy commission	0	14,229	-	0	284	-
	2C10 - Election commission	0	15,148	-	0	250	-
	3G1 - Department of Judiciary & Law Affairs	32,295	32,295	1.0	620	620	1.0
	3G2 - Putrajaya Corporation	82,781	82,781	1.0	755	859	1.1
	3G3 - Palace Of Justice	53,082	53,082	1.0	700	700	1.0
	3M2+C2+C3 - Pilgrimage fund boad complex	0	41,249	-	0	2,612	-
	4G1 - Ministry Of Agriculture and Agro - Based Indus-tries)	65,510	65,510	1.0	1,179	1,179	1.0
	4G2 - Fisheries Department	30,129	30,129	1.0	1,122	1,122	1.0
	4G3 - Ministry Of Natural Resources and Environment	61,102	61,102	1.0	1,005	1,005	1.0
	4G4 - Ministry Of Youths and Sports	54,542	54,542	1.0	725	725	1.0
	4G5 - Ministry of road transportation	0	65,510	-	0	1,122	-
	4G7 - Attorney General's Chamber	0	43,380	-	0	868	-
	4G8 - Ministry of rural and regional development	0	50,766	-	0	996	-
	4G9 - Ministry of information, communication, arts, and culture	0	74,558	-	0	1,275	-
	4G10 - Ministry of Housing and Local Government	0	74,169	-	0	2,205	-
	4G11 - Ministry of women, family, and community development	0	63,239	-	0	1,317	-
	5G2 - Ministry of higher education, and Ministry of tourism	0	147,789	-	0	3,620	-
	Other government building	201,452	283,678	1.4	100	150	1.5
Government departments subtotal		**2,125,149**	**3,058,338**	**1.4**	**36,062**	**64,182**	**1.8**
Residential	High income	293,132	1,613,700	5.5	-	-	-
	Middle income	969,845	5,681,400	5.9	-	-	-
	Low income	130,205	553,020	4.2	-	-	-
Residential subtotal		**1,393,182**	**7,848,120**	**5.6**	**-**	**-**	**-**
Total		**4,602,763**	**17,187,625**	**3.7**	**45,000**	**164,500**	**3.7**

(May not sum to total due to rounding error.)

Table 24: Energy demand [ktoe]

		2007							2025BaU							2025CM						
		Electricity	Petroleum	LPG	Natural gas	Solar heat	Other renewable	**Total**	Electricity	Petroleum	LPG	Natural gas	Solar heat	Other renewable	**Total**	Electricity	Petroleum	LPG	Natural gas	Solar heat	Other renewable	**Total**
Commercial	Cooling	1.3	0.0	0.0	0.0	0.0	0.0	**1.3**	19.0	0.0	0.0	0.0	0.0	0.0	**19.0**	3.3	0.0	0.0	4.9	0.0	0.0	**8.2**
	Hot water	2.0	0.0	0.0	0.0	0.0	0.0	**2.0**	29.6	0.0	0.0	0.0	0.0	0.0	**29.6**	17.9	0.0	0.0	0.0	0.0	0.0	**17.9**
	Cooking	0.2	0.0	0.4	0.0	0.0	0.0	**0.6**	3.7	0.0	5.2	0.0	0.0	0.0	**8.9**	1.6	0.0	6.6	0.0	0.0	0.0	**8.2**
	Lighting	1.9	0.0	0.0	0.0	0.0	0.0	**1.9**	28.7	0.0	0.0	0.0	0.0	0.0	**28.7**	16.3	0.0	0.0	0.0	0.0	0.0	**16.3**
	Other electric appliances	4.3	0.0	0.0	0.0	0.0	0.0	**4.3**	135.8	0.0	0.0	0.0	0.0	0.0	**135.8**	101.2	0.0	0.0	0.0	0.0	0.0	**101.2**
	Total	**9.8**	**0.0**	**0.4**	**0.0**	**0.0**	**0.0**	**10.1**	**216.8**	**0.0**	**5.2**	**0.0**	**0.0**	**0.0**	**222.0**	**140.3**	**0.0**	**6.6**	**4.9**	**0.0**	**0.0**	**151.8**
Public amenities & facilities	Cooling	3.6	0.0	0.0	0.0	0.0	0.0	**3.6**	9.2	0.0	0.0	0.0	0.0	0.0	**9.2**	2.9	0.0	0.0	0.0	0.0	0.0	**2.9**
	Hot water	1.5	0.0	0.0	0.0	0.0	0.0	**1.5**	4.6	0.0	0.0	0.0	0.0	0.0	**4.6**	2.8	0.0	0.0	0.0	0.0	0.0	**2.8**
	Cooking	0.2	0.0	0.4	0.0	0.0	0.0	**0.6**	0.5	0.0	1.1	0.0	0.0	0.0	**1.6**	0.3	0.0	1.1	0.0	0.0	0.0	**1.4**
	Lighting	1.5	0.0	0.0	0.0	0.0	0.0	**1.5**	3.8	0.0	0.0	0.0	0.0	0.0	**3.8**	2.2	0.0	0.0	0.0	0.0	0.0	**2.2**
	Other electric appliances	3.3	0.0	0.0	0.0	0.0	0.0	**3.3**	18.0	0.0	0.0	0.0	0.0	0.0	**18.0**	12.8	0.0	0.0	0.0	0.0	0.0	**12.8**
	Total	**10.0**	**0.0**	**0.4**	**0.0**	**0.0**	**0.0**	**10.5**	**36.2**	**0.0**	**1.1**	**0.0**	**0.0**	**0.0**	**37.2**	**20.9**	**0.0**	**1.1**	**0.0**	**0.0**	**0.0**	**22.0**
Government departments	Cooling	1.5	0.0	0.0	24.5	0.0	0.0	**25.9**	2.1	0.0	0.0	35.2	0.0	0.0	**37.3**	0.0	0.0	0.0	16.9	0.0	0.0	**16.9**
	Hot water	4.0	0.0	0.0	0.0	0.0	0.0	**4.0**	7.1	0.0	0.0	0.0	0.0	0.0	**7.1**	3.7	0.0	0.0	0.0	0.0	0.0	**3.7**
	Cooking	0.5	0.0	3.1	0.0	0.0	0.0	**3.6**	0.7	0.0	4.5	0.0	0.0	0.0	**5.2**	0.8	0.0	3.3	0.0	0.0	0.0	**4.1**
	Lighting	3.9	0.0	0.0	0.0	0.0	0.0	**3.9**	5.7	0.0	0.0	0.0	0.0	0.0	**5.7**	2.7	0.0	0.0	0.0	0.0	0.0	**2.7**
	Other electric appliances	8.7	0.0	0.0	0.0	0.0	0.0	**8.7**	26.8	0.0	0.0	0.0	0.0	0.0	**26.8**	17.5	0.0	0.0	0.0	0.0	0.0	**17.5**
	Total	**18.6**	**0.0**	**3.1**	**24.5**	**0.0**	**0.0**	**46.3**	**42.4**	**0.0**	**4.5**	**35.2**	**0.0**	**0.0**	**82.2**	**24.8**	**0.0**	**3.3**	**16.9**	**0.0**	**0.0**	**45.0**
Residential	Cooling	0.3	0.0	0.0	0.0	0.0	0.0	**0.3**	1.7	0.0	0.0	0.0	0.0	0.0	**1.7**	0.4	0.0	0.0	0.0	0.0	0.0	**0.4**
	Hot water	0.1	0.0	0.0	0.0	0.0	0.0	**0.1**	0.9	0.0	0.0	0.0	0.0	0.0	**0.9**	0.5	0.0	0.0	0.0	0.1	0.0	**0.5**
	Cooking	0.1	0.0	1.4	0.0	0.0	0.0	**1.5**	0.7	0.0	10.1	0.0	0.0	0.0	**10.8**	1.7	0.0	6.7	0.0	0.0	0.0	**8.4**
	Lighting	0.4	0.0	0.0	0.0	0.0	0.0	**0.4**	2.2	0.0	0.0	0.0	0.0	0.0	**2.2**	1.2	0.0	0.0	0.0	0.0	0.0	**1.2**
	Other electric appliances	2.1	0.0	0.0	0.0	0.0	0.0	**2.1**	30.9	0.0	0.0	0.0	0.0	0.0	**30.9**	22.1	0.0	0.0	0.0	0.0	0.0	**22.1**
	Total	**3.0**	**0.0**	**1.4**	**0.0**	**0.0**	**0.0**	**4.4**	**36.4**	**0.0**	**10.1**	**0.0**	**0.0**	**0.0**	**46.6**	**25.8**	**0.0**	**6.7**	**0.0**	**0.1**	**0.0**	**32.6**
Passenger transport		**0.2**	**56.1**	**0.0**	**0.8**	**0.0**	**0.0**	**57.1**	**1.1**	**457.9**	**0.0**	**5.4**	**0.0**	**0.0**	**464.5**	**5.2**	**113.8**	**0.0**	**9.2**	**0.0**	**0.0**	**128.1**
Freight transport		**0.0**	**7.1**	**0.0**	**0.0**	**0.0**	**0.0**	**7.1**	**0.0**	**55.1**	**0.0**	**0.0**	**0.0**	**0.0**	**55.1**	**0.0**	**31.4**	**0.0**	**0.0**	**0.0**	**0.3**	**31.7**

(May not sum to total due to rounding error.)

Table 25: Contribution of countermeasures

Sector	Action	Low-carbon countermeasure	GHG emission reduction [$ktCO_2eq$]	Contribution in the sector [%]	Contribution in total reduction [%]
Commercial		Cooling	57.2	13	2.4
	3	High efficiency heat pump air conditioner			
	3	District cooling			
		Hot water	59.5	13	2.5
	3	High efficiency electric boiler			
		Cooking	7.4	2	0.3
	3	High efficiency Cooking			
	3	IH cooking heater			
		Lighting	64.4	14	2.7
	3	LED (substitute incandescent light)			
	3	Other electric appliances**	155.9	35	6.5
	3	BEMS*	102.3	23	4.3
	3	Building insulation			
	3	Energy saving behavior*			
	8	UHI countermeasure			
	4	Photovoltaic power generation at buildings	5.1	1	0.2
	Subtotal		**451.7**	**100**	**18.8**
Public amenities & facilities		Cooling	22.0	24	0.9
	3	High efficiency heat pump air conditioner			
		Hot water	9.2	10	0.4
	3	High efficiency electric boiler			
		Cooking	1.0	1	0.04
	3	High efficiency Cooking			
	3	IH cooking heater			
		Lighting	8.5	9	0.4
	3	LED (substitute incandescent light)			
	3	Other electric appliances**	24.8	27	1.0
	3	BEMS*	25.5	27	1.1
	3	Building insulation			
	3	Energy saving behavior*			
	8	UHI countermeasure			
	4	Photovoltaic power generation at buildings	2.5	3	0.1
	Subtotal		**93.5**	**100**	**3.9**
Government departments		Cooling	15.5	8	0.6
	3	District cooling			
		Hot water	17.0	9	0.7
	3	High efficiency electric boiler			
		Cooking	1.2	1	0.1
	3	High efficiency Cooking			
	3	IH cooking heater			
		Lighting	15.1	8	0.6
	3	LED (substitute incandescent light)			
	3	Other electric appliances**	42.6	23	1.8
	3	BEMS*	55.9	30	2.3
	3	Building insulation			
	3	Energy saving behavior*			
	8	UHI countermeasure			
	4	Photovoltaic power generation at buildings	37.0	20	1.5
	Subtotal		**184.3**	**100**	**7.7**

Sector	Action	Low-carbon countermeasure	GHG emission reduction [$ktCO_2eq$]	Contribution in the sector [%]	Contribution in total reduction [%]
Residential		Cooling	3.1	4	0.1
	3	High efficiency heat pump air conditioner			
		Hot water	2.3	3	0.1
	3	High efficiency electric boiler			
	3	Solar water heater			
		Cooking	0.9	1	0.04
	3	High efficiency Cooking			
	3	IH cooking heater			
		Lighting	5.7	7	0.2
	3	LED (substitute incandescent light)			
	3	Other electric appliances**	42.8	55	1.8
	3	HEMS*	16.9	22	0.7
	3	House insulation (Next generation level)			
	3	House insulation (New standard)			
	3	Energy saving behavior*			
	8	UHI countermeasure			
	4	Photovoltaic power generation at buildings	5.7	7	0.2
	Subtotal		**77.3**	**100**	**3.2**
Passenger transport		Efficiency improvement of motorcycles, automobiles, buses	386.2	41	16.1
	2	High efficiency motorcycle			
	2	High efficiency internal combustion vehicle			
	2	Hybrid vehicle			
	2	Electric vehicle			
	2	High efficiency natural gas vehicle			
	2	Efficiency improvement of trains	8.6	1	0.4
		Modal shift	285.8	30	11.9
	8	UHI countermeasure			
	2	Enhancement of bus system			
	1	Pedestrian-friendly city development (Modal shift from automobile to bicycle & walk)			
	2	Introduction of new rail line			
		Shorter trip distance	258.8	28	10.8
	2	Introduction of new rail line			
	1	Mixed use development (Shorter trip distance)			
	Subtotal		**939.4**	**100**	**39.1**
	6	Carbon sink (Tree planting)	35.4		1.5
	9,10,11	Solid waste management****	224.2		9.3
Total of PGC2025 Actions			**2.0**		

Others***		Efficiency improvement of freight vehicle	40.3	60	1.7
	-	High efficiency bio-diesel freight vehicle			
	-	Efficiency improvement of logistics	26.7	40	1.1
	Subtotal		**66.9**	**100**	**2.8**
	-	Central power generation	332.6		13.8
Total			**2,405.4**		

(May not sum to total due to rounding error.)

* The difference between "HEMS/BEMS" and "Energy saving behavior" is that the former is contribution of introducing HEMS/BEMS device, and the latter is action such as switching off the light when leave the room.

** Other electric appliances includes Vending machine, Elevator, Printer, TV, Refrigerator etc.

*** They are not included in GHG reduction by Actions.

**** Its GHG emission reduction is from SWM, and is excluded from targeted GHG emission reduction in "Low-carbon Putrajaya" (60% reduction).

Table 26: Waste amount by waste types

[t/day]	2007	2025BaU	2025CM(3) (Thermal treatment with separate collection)		
	Waste to Landfill	Waste to Landfill	Waste to Landfill	Reduction at source	Waste to treatment
Food	10.98	72.34	6.90	3.34	62.09
Paper	11.19	70.06	15.83	4.12	50.11
Plastic	2.96	18.47	0.88	11.28	6.31
Glass	1.83	10.82	2.66	2.62	5.54
Metal	1.01	6.04	1.42	2.78	1.84
Other	7.37	44.04	43.22	0.82	0.00
Green waste	10.67	15.19	0.00	0.00	15.19
Construction waste	72.57	72.57	22.64	22.88	27.05
Sludge	2.08	14.67	0.00	0.00	14.67
Used cooking oil	0.10	0.74	0.00	0.00	0.74
Total	**120.75**	**324.94**	**93.54**	**47.85**	**183.54**

(May not sum to total due to rounding error.)

Table 27: Waste amount by treatment selections

[t/day]	2007	2025BaU	2025CM		
			(1)Separate collection	(2)Thermal treatment	(3)Thermal treatment with separate collection
Reduction at source	0.0	0.0	19.6	19.6	19.6
Community collection	0.0	0.0	5.4	5.4	5.4
Separate collection	0.0	0.0	63.8	0.0	63.8
Self-treatment (Composting)	0.0	0.0	62.1	55.2	55.2
Thermal treatment	0.0	0.0	0.0	51.2	11.7
Landfill	35.3	221.8	70.9	90.4	66.1

Table 28: Reduce: ten good practices towards household waste reduction

Practice	Explanation
Buy according to needs	Excessive expenditure will leads to excessive waste generation.
Buy in bulk	Buy a bigger quantity of product, instead of buying the same product in a few smaller packaging.
Buy refill and concentrated products	Refills and concentrated products mostly comes in simple packaging and large amount
Buy local product	1. Most local products are sold directly before packaging is done. 2. Local products usually have shorter transport distance and require minimum packaging
Not to buy over-packaged product	Choosing products with simple packaging to prevent the generation of packaging waste.
Decline packaging bag unless necessary	Choose to decline the use of packaging bags when buying in small amounts.
Rent or borrow instead of buying	Opt to rent or borrow products that are rarely used. It saves money, storage space, and reducees the amount of waste generated.
Use online services	This apply to all service than can be obtained online such as, online music, newspaper, magazines and etc.
Pack left over food.	This reduces the amount of food waste and the needs to buy food.
Sharing	Big items such as party supplies or big machines (grass cutter, gardening tools) can be shared within the community

Table 29: Reuse: five good practices towards household reuse

Practice	Explanation
Buy durable items	Durable items are longer lasting.
Buy products from recycled material	This will encourage the recycling activities and also reduce the use raw materials.
Repair broken items	Exchanging partly broken item prevent excess generation of waste.
Use reusable items	Choose reusable containers helps prevent the generation of containers waste.
Use “my bag”	The use of personal bags - “my bag” prevents generation of plastic bag waste and promotes “reuse” of textile waste for hand-made bag.

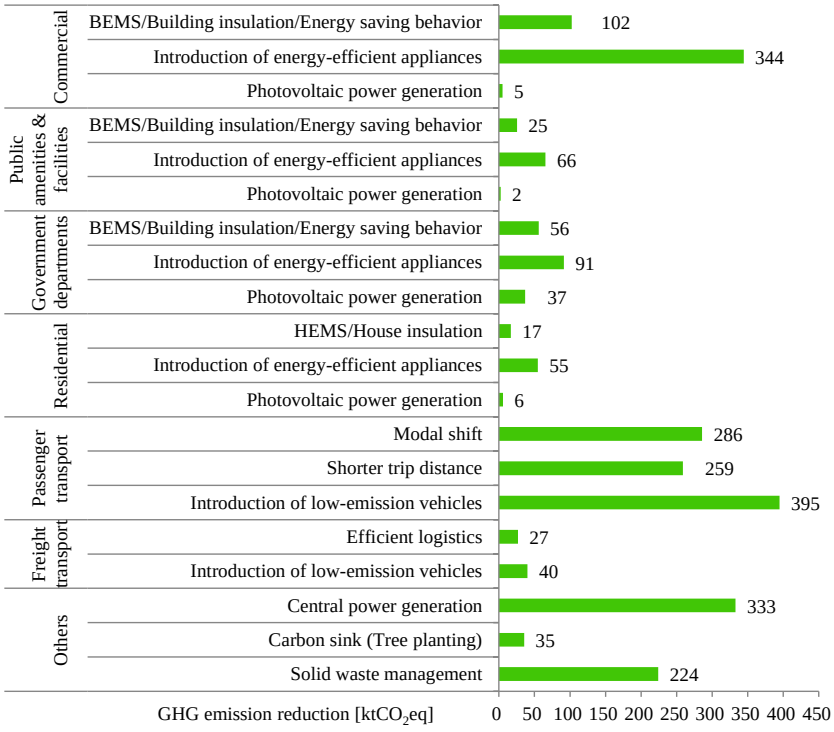

Figure 69: GHG emission reduction by countermeasure types

Figure 70: Scenery in Putrajaya

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