ASIA-PACIFIC NETWORK FOR
GLOBAL CHANGE RESEARCH

Final Technical Report
CRRP2017-07SY-Farzaneh

Multiple Benefits Assessment of the Low Emission Development Strategies in Asia-Pacific Cities

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Project Overview

Project Duration	**:**	1 year
Funding Awarded	**:**	USD 40,000
Key organisations involved	**:**	1) Kyushu University Platform of Inter/Transdisciplinary Energy Research, Japan (Ms Maiko Kawabata) 2) Kyoto University, Institute of Advanced Energy, Kyoto University, Japan 3) The University of Tokyo, Japan (Mr Nikolaos Iliopoulos) 4) National Institute of Advanced Industrial Science and Technology, Japan (Dr Yuki Kudoh) 5) Tongji University, China (Mr Haixing Meng) 6) University of Technology Sydney, Australia (Ms Emily Prentice) 7) Institute for Global Environmental Strategies (IGES) (Dr Eric Zusman)

1. Project Summary

This research aims to create a collaborative network consisting of scholars, experts, and stakeholders from a number of the most global cities in the Asia-pacific region to demonstrate how LEDS and clean energy policies and programs can help achieve multiple urban energy, environmental, health, and economic benefits cost-effectively. It will provide an analytical framework for conducting regular synthesis and assessment together with supporting expert workshops for scientists and encouraging stakeholder involvement in main outcomes of the research. In the first phase of the study, activities focus on evaluating the existing LEDS and clean energy policy developments, countermeasures, and challenges in selected cities. In the second phase, activities concentrate on designing strategic plans that achieve greater or border benefits in selected cities. The main expected outputs of this research may be outlined as:

- How the concept of LEDS has evolved in the climate policy discourse and explores how it could usefully add to a large number of existing strategies, action plans, and reporting documents that are already available.
- Gaps that LEDS could fill, the elements it could contain, and how LEDS can be prepared to ensure that they are productive and efficient in delivering their intended goals.

Keywords: (Urban system, Low Emission Development Strategies, Asia-Pacific cites, Energy modeling, Climate co-benefits)

Project outputs and outcomes

Project outputs:

- Two books on clean energy policy development in Asian cities and energy systems modeling
- Ten peer-reviewed journal papers.
- Eight expert workshops on LEDS with the local stakeholders in the selected cities.
- One student training workshop (Canada-Japan) on Low Emission Development Strategies
- One web-based tool and one app on comparative analysis of the LEDS in the Asia-Pacific region (USDI tool)

Project outcomes:

- Improved knowledge on the implications of the LEDS and clean energy policies in Shanghai, Delhi and Kuala Lumpur
- Evidence provided to decision-makers on formulating the multiple energy, environmental, public health, and economic benefits cost-effectively in Asia-Pacific cities.
- Formulating the Urban Sustainable Development Index for the comparative analysis of the LEDs in 12 cities in the Asia-Pacific region.
- Local stakeholder engagement in quantifying the climate co-benefits from clean policy development in urban areas in the Asia-Pacific region.

Key facts/figures

- A comprehensive database on current LEDS was built up, including current clean energy policy developments, countermeasures, and challenges in the selected cities of Shanghai, Delhi, Tokyo, Sydney, and Kuala Lumpur.
- A composite index, so-called "Urban Sustainable Development Index" (USDI) was developed based on a unique set of 4 dimensions (energy and climate, City planning, social welfare, and economic) for 12 megacities in Asia-Pacific region, including the selected cities in this research. This index was used to compare the chosen cities for potential changes in the final ranking based on the quantified LEDS.
- Analysis of two main scenarios of Clean Transport (CT) and Zero Electricity Deficiency (ZED) in the case of Delhi, India revealed a significant reduction of CO_2 and other local air pollutant emissions by 4.8 and 0.4 million tons, respectively,

prevention of about 22,000 cases of mortality, and cost savings of more than USD 35 million by 2030.

- Analysis of the master plan in Shanghai revealed this policy significantly contributes to the job creations and raise GDP by the tertiary sector and to increase the share of green employment in Shanghai total workforce by 46% in 2030.
- The “Sustainable urban energy system scenario” and “Green mobility plan” will contribute to a 24% reduction in GHG emissions and about 27.3% reduction in final energy consumption in Kuala Lumpur.
- Concerning the LEDS implementation in the selected cities, the local governments need to profound challenges through a collaboration with the relevant stakeholders. In this context, several expert workshops with local and regional authorities in the selected cities were organized in order to engage stakeholders, enhance communication, and update of LEDS to understand how goals are set, how strategies are elaborated to achieve them, and to what extent the interface between development and climate change planning is addressed. To this aim, we organized a series of international workshops at Kyoto University and Kyushu University between 2016-2018, In addition to a one-day stakeholder workshop in Delhi (May, 21, 2018, ISARD), Shanghai (June, 8, 2018, Tongji University) and Kuala Lumpur (May, 3, 2018, University of Malaya). The stakeholders included business, industry, non-governmental organizations and local and regional authorities in the selected cities.
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Potential for further work

- Further analyses and exploration of LEDS in the Asia-Pacific region.
- Based on the insight gained from this research, we will focus on exploring locality perceptions for the rapid development and diffusion of Low Carbon Technologies and LEDS in developing countries in this area.

Publications

Books:

1. Farzaneh, H. (2019). Energy Systems Modeling: Principles and Applications. Springer Nature.
2. Farzaneh, H. (Ed.). (2019). Devising a Clean Energy Strategy for Asian Cities. Springer Nature.

Peer-Reviewed Journal Papers:

1. Farzaneh, H.; de Oliveira, J.A.P.; McLellan, B.; Ohgaki, H. (2019). Towards a Low Emission Transport System: Evaluating the Public Health and Environmental Benefits. *Energies*, *12*, 3747
2. Farzaneh, H. (2019). Design of a Hybrid Renewable Energy System Based on Supercritical Water Gasification of Biomass for Off-Grid Power Supply in Fukushima, *Energies, 12(14), 2708.*
3. Mohd Amran Mohd Radzi, Nasrudin Abd. Rahim, Hang Seng Che, Hideaki Ohgaki, Hooman Farzaneh, Wallace Shung Hui Wong, and Lai Chean Hung. (2019). Optimal Solar Powered system for long houses in Sarawak by using Homer tool, *ASEAN Engineering Journal, 1:9, 1-14.*
4. Farzaneh, H. (2018). Techno-economic study of an innovative PV-hydrogen-biomass system for off-grid power supply, *IET Digital Library*
5. Esteban, M., Portugal-Pereira, J., Mclellan, B. C., Bricker, J., Farzaneh, H., Djalilova, N., ... & Rober, V. (2018). 100% renewable energy system in Japan: Smoothening and ancillary services. *Applied energy, 224, 698-707*.
6. Farzaneh, H. (2017). Multiple benefits assessment of clean energy development in Asian Cities. *Energy Procedia, 136, 8-13*.
7. Farzaneh, H. (2017). Development of a Bottom-up Technology Assessment Model for Assessing the Low Carbon Energy Scenarios in the Urban System. *Energy Procedia, 107, 321-326.*
8. Ohgaki, H., Farzaneh, H., Rahim, N. A., Che, H. S., Radzi, M. A. M., Wong, W. S., & Hung, L. C. (2017). Study on Quality of Life Change for Rural Community through Rural Electrification by Renewable Energy: Preliminary Result, *ASEAN Journal of Management & Innovation, 4, 2, 1-8.*

Peer-Reviewed Conference Papers:

1. Naoto Takatsu and Hooman Farzaneh (2019), Techno-economic analysis of a Hybrid Solar-Hydrogen-Biomass System for off-grid power supply, *EcoDesign and Sustainability, Springer*,
2. Yuichiro Yoshida, Nagashima Keisuke and Hooman Farzaneh (2019), Optimal design and operation of a residential hybrid microgrid system in Kasuga city, *EcoDesign and Sustainability, Springer*

Awards and honours

1. Recipient of the JSPS Grant-in-Aid for scientific research (C-general) (2016-2019)
2. Recipient of the Kurata grant from the Hitachi Global Foundation (2019)
3. Best paper award: The 5th IET International Conference on Clean Energy and Technology Malaysia (2018)
4. Winner of the France Embassy award on France Exploration Program 2019.

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1. Introduction

Many local governments in Asia-Pacific cities face a dual challenge in achieving top priority local development goals, such as improving standards of living through extending access to modern energy and increasing employment while also supporting national climate change action. To support broader development goals while also reducing GHG (Greenhouse Gas) emissions, some governments are developing and implementing LEDS (Low Emission Development Strategies) which aim to achieve development priorities with minimal GHG emissions as part of their national objectives. Historically, the literature on evaluating the impacts of a shift to a low emissions pathway has focused on the costs (i.e. GDP, etc.), but in fact, the benefits may outweigh the costs when considering broader impacts (public health, for example). By including the more extensive set of benefits in the cost-benefit analyses conducted during planning processes, local governments get more comprehensive assessments of their potential LEDS investments. In concert with sustainable development frameworks, a successful LEDS should be integrated with the "economic, social and environmental objectives of society, using a multiple benefit assessment approach. Studies seeking the knowledge-based approach to assess the multiple benefits of LEDS are therefore increasingly important in order to identify where the most prospective points for public policy intervention exist.

National action on climate change and international negotiations are interlinked and mutually reinforcing. The international negotiations in the past years have stimulated national action, especially on the LEDS meaning development with the minimal output of emissions. The concept of LEDS has been included in the negotiating texts under the UNFCCC since the run-up to COP15 in Copenhagen in 2009 and is part of both the Copenhagen Accord and the Cancun Agreements (UNFCCC, 2011), which recognize that a LEDS is indispensable to sustainable development and that incentives are required to support the development of such strategies in developing countries. In practice, the plans are often combinations of new and existing elements, all combined in a new way to address pre-existing policy objectives along with the need to slow climate change and prepare for its impacts. A growing number of international organizations and consultancies have also been involved in LEDS, including the UNDP, UNEP, the World Bank (including through its Energy Sector Management Assistance Program (ESMAP)), Climate Works, the Climate Development Knowledge Network, WWF, the European Union and a variety of bilateral donors. Japan currently has an edge in a majority of environmental and energy technologies. However, it is vitally important to layout medium- to long-term LEDS to keep responding to global needs in the future and contributing to the reduction of 50% global GHG emission by 2050.

Different institutions and organizations have a different understanding, definition, and interpretation of benefits assessment of LEDS. The different use of this term in "Climate co-benefits" and "Climate and air co-impacts" indicated that there is almost no agreement on assessing co-benefits with diverse methods and tools. Some studies made in a similar research area, mostly focus on qualifying the co-benefits of mitigating GHG emissions and reducing air pollutants through policies of energy conservation, climate change, and air pollutant control. The multiple benefits assessment which will be discussed in this research is far beyond a simple co-benefits approach and will refer to the achievement of mitigating climate change, solving local environmental and developmental problems as well as improving public health and local economy through the implementation of LEDS in the urban areas. Applying the multiple benefits assessment methodology which we develop in this research will result in formulating specific strategic plans that are consistent with sustainability goals such as: reducing environmental impacts along with improving public health and the local economy.

Two common challenges exist with the previous studies: 1) Quantitative Analysis (QA) efforts have mostly focused on specific aspects of LEDS in individual sectors, but there have been few attempts to develop an integrated modeling approach that span across multiple benefits of LEDS in urban areas ; 2) There is no holistic consideration of the Implementation Analysis to test the outcomes of QA.

To address the two challenges above, this research will try to develop effective science-policy interaction to discuss the opportunities where LEDS can be used to support energy system, environmental, and economic development planning strategies across the Asia mega-cities. In this research, we argue that the urgency of bold and timely LEDS coupled with the social, environmental, and economic opportunities. With this in mind, we elaborate an interest-oriented approach to mobilizing multiple benefits and argue that multiple benefits assessments can be important drivers of ambitious and effective social policy. It will reveal that the LEDS, nonetheless, continue to be of strategic importance for constructing the necessary enabling environment, such as de-risking investment in renewable energies, as well as social policies to cushion the social challenges of decarbonizing energy systems, to seize these co-benefits and unlock investment in the selected cities.

The insight gained from this research will help us to move LEDS from the side-lines to the center of climate- and energy-related debates on 1) promoting the national economy, local businesses, and jobs; 2) increasing people’s health and wellbeing; 3) unburdening governments and freeing resources; and 4) empowering local communities and citizens. Based on the social and economic benefits associated with the LEDS, we can elaborate on the possibility of more effectively anchoring sustainable energy policy within the interest structure of society.

2. Methodology

This research focuses on demonstrating how clean energy policies and LEDS can help achieving multiple energy, environmental, public health, and economic benefits cost-effectively in Asian mega-cities. To this aim, the specific target is set to design and develop an analytical approach which helps policymakers and relevant stakeholders to determine opportunities for LEDS and also to address the main relevant policy instruments available, based on the analysis of the practical experience with LEDS and related processes to date in their respective cities.

Identifying objectives of a LEDS are the first step. These objectives are more concrete than the general scope determined initially and should connect the urban-LEDS to the country's development priorities, clearly articulating how a LEDS would contribute to reaching national development goals.

Second step: sectors that represent the highest priority for low emission development in the urban area should be determined, wherein this proposal, the selected sectors are: 'Buildings', 'Waste' and ‘Transport. The modeling framework is used in assessing BAU and LEDS scenarios to study the effects of different policies on emissions generated by these sectors. The evaluation of the BAU and LEDS scenarios developed during this project would serve as a good basis for the decision making, in particular in determining economy-wide and sectoral goals for limitation of GHG emissions growth or for setting absolute quantified goals for GHG emission reduction.

The research methodology includes two main parts: quantitative analysis and qualitative analysis which is shown in Figure 1.

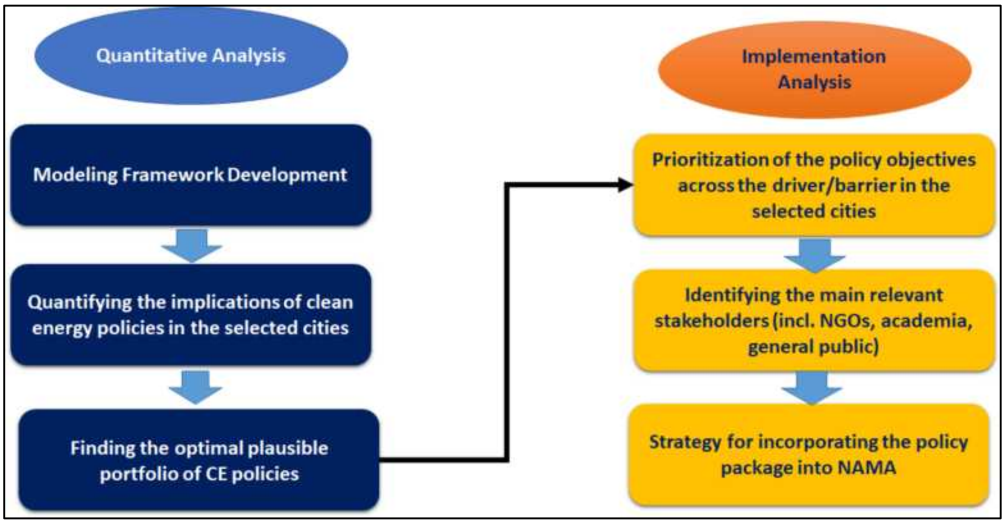

Fig 1. Research methodology used in this project

2.1. Quantitative Analysis (QA) framework:

In this investigation, to be able to quantify the multiple benefits (energy, environment, health, and economy), the concept of LCS (Low-Carbon Society) has been used. The LCS is defined as "*A development path that simultaneously restrains energy demand growth, drives new production towards low carbon sources, and provides sufficient, secure energy supply for global economic growth in societies*". Consider the LCS concept, Figure 2 shows how the notion of development sustainability can be translating into the context of the urban energy system, through linking the specific targets of designing of this system to economic growth, environment and social equity simultaneously.

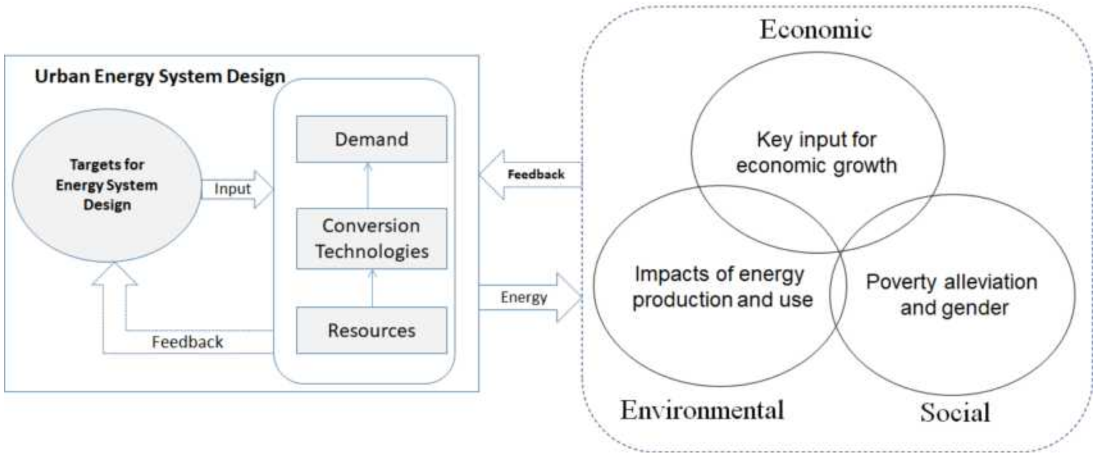

Fig 2. Application of the LCS vision in the urban energy system design

The implications of the LCS vision in a society must balance the multidimensional interactions between the society and the urban energy system which is a complex task that necessitates the development and utilization of analytical tools. To this aim, an integrated Quantitative Analysis modeling framework was developed in this research which can be used to quantify the implications of the LEDS and estimate the potential impacts on a society as the city-level (Farzaneh, 2017a) (See Figure 3).

The QA modeling framework includes the following sub-models:

2.1.1. CGE (computable general equilibrium) model:

A city-level CGE (computable general equilibrium) model was developed based on the general equilibrium theory. It uses actual economic data from a SAM (social accounting matrix) which is an accounting framework that reflects the circular flow of city's economic activity to estimate how a city might react to changes in clean energy policies. The CGE model has two main parts: supply and demand. On the supply side, the microeconomic principles have been utilized to develop a concept that would represent the behaviour of an urban energy system in a market with perfect competition. The local government, as a decision-maker in this market, strives for maximum satisfaction (minimization of the total cost) of delivering certain energy service to the end users, such as providing required electricity at the end-user level. On demand side, a spreadsheet simulation model based on bottom-up end-use method and the Avoid-Shift-Improve (A-S-I) approach has been applied to the end-user level (buildings, transport, and waste) in order to assess the effect of different scenarios of socioeconomic, technological, and demographic developments on energy consumption and emissions of the citywide energy system in a multi-sectoral context. The model systematically relates the GHG and air pollution emissions based on the specific energy demand in the end-user sectors in cities to the corresponding social, economic, and technological factors that affect this demand (Figure 4).

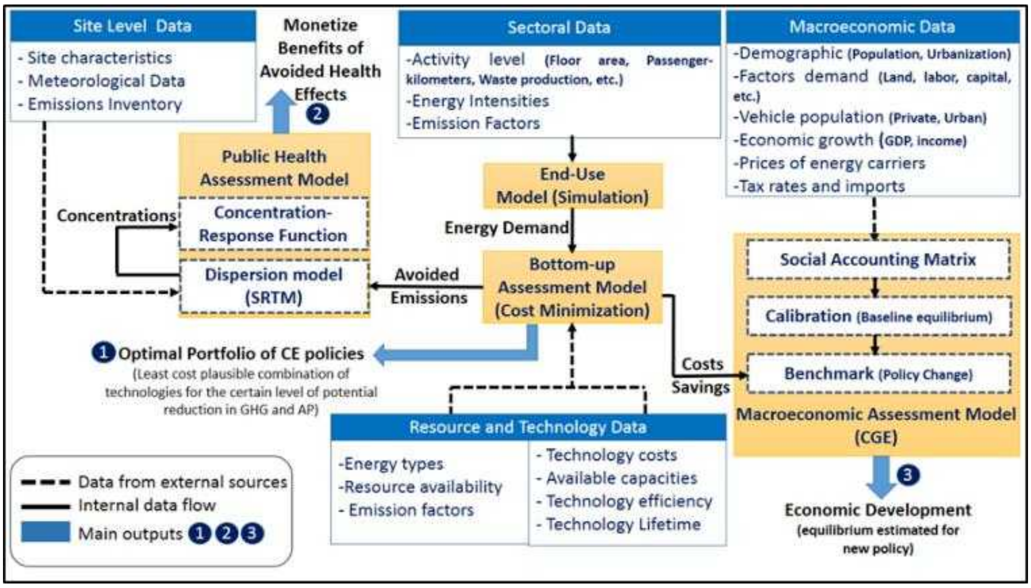

Fig 3. QA modeling framework

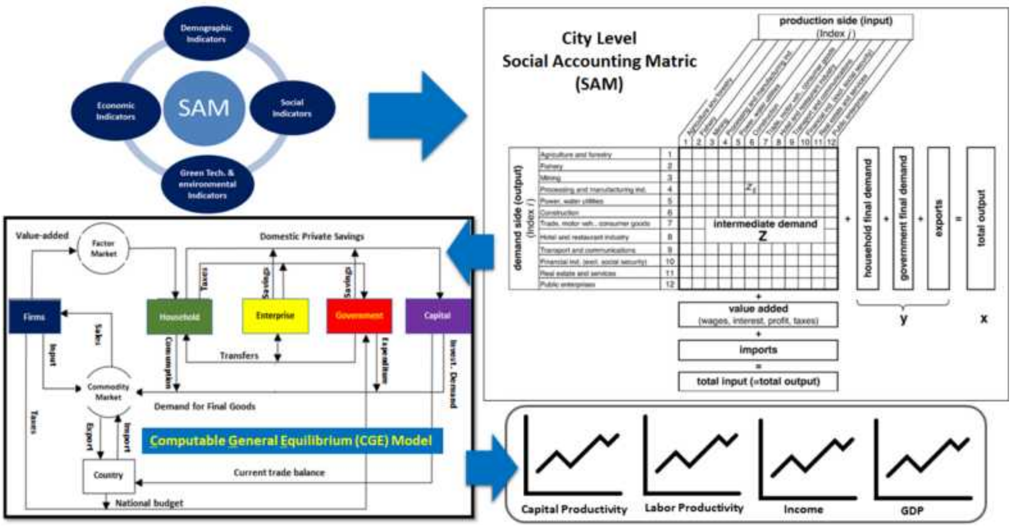

Fig 4. CGE sub-model

The CGE model was implemented as a mixed integer linear programming problem using the GAMS (General Algebraic Modeling System) to find the minimum total cost of delivering a certain level of energy service through the optimal combination of available technologies and resources in the urban energy system (Farzaneh, 2017b).

2.1.2. Public Health Co-Benefit Assessment (PHCBA) model:

Assessing the public health benefits of clean energy development in the selected cities was based on the concentration-response (C-R) functions of the health effects include premature mortality and exacerbation of health conditions such as asthma, respiratory disease, and heart disease, which were collected from epidemiological research. The C-R functions were used to link the estimated changes in concentrations to several health endpoints though introducing the impact function of health effects as follows:

$$IM_i = \frac{RR_{id}-1}{RR_{id}} \tag{1}$$

RR_{id} represents the relative risk at the exposure category d (i.e. cardiovascular mortality, respiratory mortality, etc.) of each pollutant i. In general, the values of the relative risk for each exposure category can be estimated through linking the change of the pollutant concentration to the particular health disease, using Concentration-Response (CR) function (Maizlish et al., 2013; Xia et al., 2015; Macmillan et al., 2014; Rojas-Rueda et al., 2012). Recommended RR per 10 μg/m^3 for Ozone, nitrogen dioxide and, particulate matter and on all-cause mortality in the long term and short-term and exposures were given by (WHO, 2013).

The expected number of deaths can be estimated by using the following formula (Farzaneh, 2019):

$$EM_{id} = \mathrm{IM}_{id} \times \mathrm{D}_d \times \mathrm{P}_d \times C_i \tag{2}$$

Where D_d stands for the mortality rate of disease (i.e., deaths/10000 people); P_d is the share of the population in the exposure category and C *is* the concentration of pollutant. To evaluate the effect of avoided emission of each pollutant (t/y) on its concentration ($\mu g/m^3$), the following formula can be used:

$$C_{it} = \frac{E_{it}}{v_t.L.H} \tag{3}$$

Where, E_{it} is the amount of avoided emission . v_t , L, and H denote wind speed (m/s), the length (m), and the mixing height (m) of the selected location, respectively.

Figure 5 shows the linkage between the CGE and the public heath co-benefit assessment sub-model.

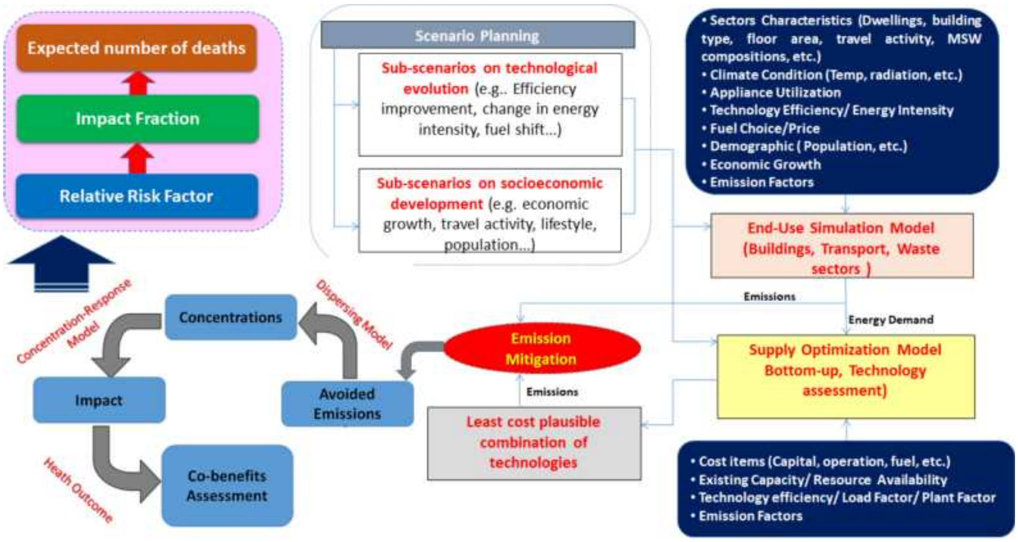

Fig 5. Linkage between the CGE and PHCBA sub-models

2.2. Data gathering:

Required detail data were collected from the local energy office and academic organizations in selected cities. We organized several collaboration trips to the selected cities to visit our research collaborators and related stakeholders to obtain insight into specific proposed LEDS including scale, challenges and plans in their cities and to ensure common understanding and consensus by all parties involved.

2.3. Scenario Development:

The scenario assessment involved taking a look at the historical energy demand/supply portfolio and emissions within the selected cities and projecting it forward, based on assumptions about the future. The QA model was used to forecast the energy demand of each customer type by analysing the historical consumption of energy carries and changes in the level of activities. The projections of GHG emissions and air pollution were directly estimated based on energy demand forecast. The QA model then used to Quantify the implications of the proposed LEDS and estimate the potential impacts on both sides of demand and supply in each city, through the following steps:

- Finding the optimal (least cost) plausible portfolio of LEDS in the selected cities of Tokyo, Shanghai, Delhi, and Kuala Lumpur.
- Estimating the multiple benefits (Energy, environment, public health, and economic development) of the optimal portfolio of LEDS in the selected cities.

2.4. Implementation Analysis

The policy objectives of the optimal plausible portfolio were prioritized across the drivers/barriers in each city and finally, a roadmap (strategic plan) of LEDS was developed

2.5. Comparative Analysis:

Based on the results obtained from the QA, we developed a composite index which is called Urban Sustainable Development Index (USDI). Comprehensive desk research conducted on data collection from 12 megacities in the Asia-Pacific region, including our selected mega-cities in this research and applied this index to compare the selected cities for potential changes in the final ranking based on the quantified LEDS.

At the local level, the USDI benchmarks cities based on 13 indicators related to energy and climate, city planning, local economy, and social welfare. The index is applied to 12 cities in the Asia-Pacific region. Energy and climate-related indicators include GHG emissions, air pollution (NOx, PM_{10}, and $PM_{2.5}$) and final energy consumption. City planning indicators include clean water accessibility, public transport development, waste collection and management, and urban green space area. The Local economy and social welfare progress are assessed by measuring the local GDP, labor productivity, unemployment rate, life expectancy, public health, and education (see Figure 6).

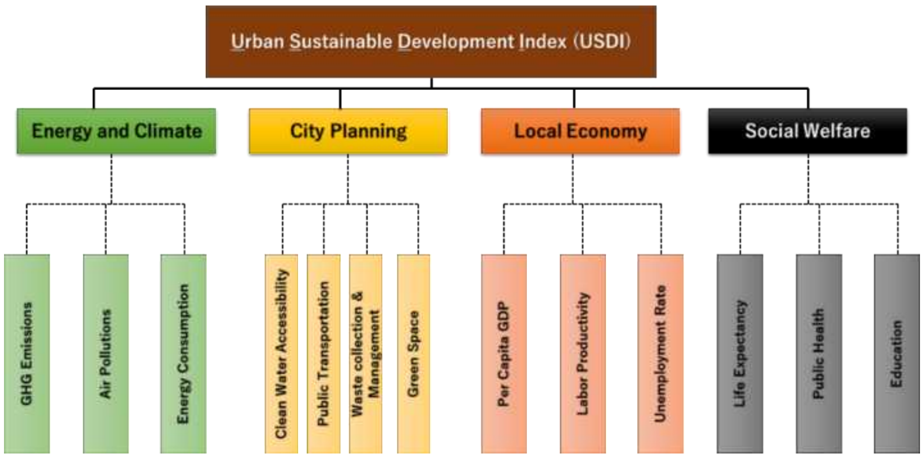

Fig 6. The multi-dimensional context used in developing the USDI

The application of the USDI Index to the 12 cities in the Asia-Pacific region required an extensive process of data collection for each city. The collected input data were involved in the main indicators. This stage is represented based on the collection of data entries ($i_{x,y}$) for each city C_m which is depicted in Figure 7.

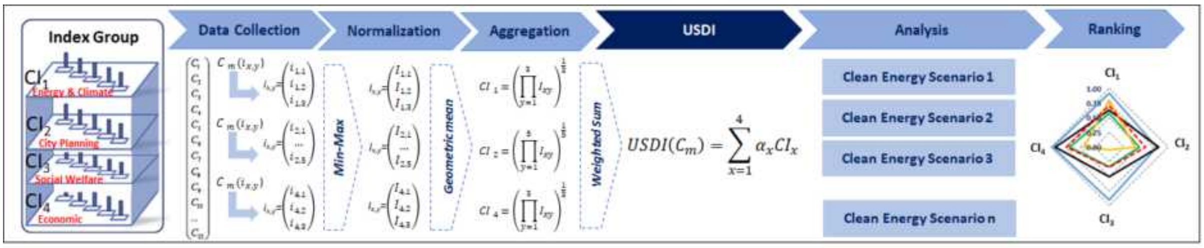

Fig 7. Overview of the data processing method of the USDI

2.5.1. Benchmark Indicators:

The total final energy demand includes the sum of energy consumption in three sectors of industry (electricity, manufacturing, agriculture, and constriction), buildings (residential and commercial), and transport (public, private and municipal fleets. Locally developed emission factors were used to estimate the amount of GHG emissions and air pollutions in each city. The performance of the public transportation system was evaluated based on the total length of urban rails per metropolitan land area in each city. The per capita green area was approximated from the OECD statistics (APO, 2017). Labour productivity measures the efficiency of the people in a city. It shows the total volume of output (measured in terms of Gross Domestic Product, GDP) produced per unit of labour (measured in terms of the number of employed persons) in each city, during a given time reference period (OECD, 2019).

Life Expectancy Index (LEI) is a statistical measure of the average time a person in a city is expected to live, based on the year of its birth and its current age which can be calculated as follows:

$$LEI = \frac{LB-20}{85-20} \tag{4}$$

Where LB is the life expectancy at birth. Data for LB were collected from the United Nations Development Program database (UNDP, 2019). The education Index is calculated as follows:

$$EDI = \frac{MSI-ESI}{2} \tag{5}$$

MSI and *ESI* refer to the mean years of schooling and expected years of education, respectively. Data for *MSI* and *ESI* were collected from the United Nations Development Program database.

2.5.2. Normalization of the data entries:

The data entries for each indicator for a city are normalized based on the Min-Max method. This method normalizes the data entries based on the actual range of the values in the data set.

$$I_{x,y} = \frac{i_{x,y}-Max(i_{x,y})}{Min(i_{x,y})-Max(i_{x,y})} \tag{6}$$

For an indicator of the type “more is better”:

$$I_{x,y} = \frac{i_{x,y} - Min(i_{x,y})}{Max(i_{x,y}) - Min(i_{x,y})}$$

(7)

2.5.3. Value aggregation:

$$CI_i = \left(\prod_1^n I_{i,n}\right)^{1/n} \quad (8)$$

The above equation represents the means of aggregating the normalized data $I_{x,y}$ into a composite index value per city C_m. n is the number of indicators for each dimension.

2.5.4. Weighted USDI:

The following formula gives equal weight to each composite index so that each composite index contributes equally to the USDI:

$$USDI(C_m) = \sum_{i=1}^{4} \alpha_i \, CI_i \quad (9)$$

Weights α_i may also be differentiated for each dimension.

3. Results and Discussion

3.1. Case of Delhi, India

The level of LEDS efforts in the city of Delhi could be established by evaluating urban energy consumption and related GHG emissions, underscoring most significantly contributing activities. According to data from a recent study (IIT Kanpur Study, 2016), for the overall GHG emissions of 37.91 $MtCO_{2e}$ emanating from Delhi, power plants and vehicles could be regarded as significant contributors to the city's GHG emissions (43% and 32% of the total, respectively), followed by Municipal Solid Waste burning and Domestic emissions as moderate contributors (8% and 7% respectively), and Refrigerant, Livestock, Industry, Cropland, Incinerator, etc. as minor contributors (1-3% each). The emission of GHGs is not just sectoral diverse, but spatially quite varied. The analysis of GHG emissions from a geographical grid of 2 Km x 2 Km identifies significant contributions from the location of thermal power plants, sites of municipal waste dumps and incineration plants. Most of these facilities are located along the Yamuna River and parts of East Delhi. As evident, a major cause of the GHG emissions and local pollutants is rooted in the use of dirty fuels for energy production and consumption in and around Delhi. One of the first systems analysis of Delhi's energy profile (Farzaneh et al., 2016) tracks different energy sources and consumption profiles. It affirms that while primary energy is dependent upon fossil fuel, energy use is dominated by transportation sector and generation of electricity from thermal power plants to be ultimately used in residential and commercial sectors.

Though Delhi and New Delhi are used interchangeably to refer to the jurisdiction of the National Capital Territory (NCT) of Delhi, these are two distinct entities, the latter being a small part of NCT Delhi. Thus, New Delhi is the capital of India and one of Delhi city's 11 districts. On the other hand, the National Capital Region is a much larger entity comprising the entire National Capital Territory along with 22 districts of the adjoining states of Haryana, Uttar Pradesh and Rajasthan (NCRPB, 2017). In addition, there are 7 union territories (UTs), directly administered by the union government. The subjects on which the union (national/central government or Government of India) and respective state governments could legislate has been decided by the division of powers. This is defined by subjects listed in Union List and State List within the Constitution. In addition, there is a Concurrent List, on which both the center and the state could make laws and govern, but the central laws would gain precedence. Both central and state laws and policies are executed by the *zila parishad* or district administration. The districts have their rural and urban constituencies. In the case of rural, a *taluk/tehsil* or development block is the concerned unit of governance, followed by a village panchayat, which is a group of villages. In the case of urban, there are *nagar panchayats* or city councils, *nagar palika* or municipality and *mahanagar palika* or municipal corporation. These are constitutionally mandated bodies under the 73/74th Constitutional Amendment Act, 1992. In addition, a city can also have a cantonment board (administered by the M/o Defense, Government of India), parastatal agencies

Delhi has five local agencies to execute municipal functions. These five local bodies along with the respective government they report to is listed in Table 1.

Tab 1. An overview of the five urban local bodies in Delhi (Farzaneh, 2018)

Genesis of ULBs	Current Status	Reports to
Imperial Delhi Committee (constituted on 25 March 1913) became New Delhi Municipal Committee on 22 February 1927	New Delhi Municipal Council (1994)	Ministry of Urban Development, Government of India
Cantonment Authority (established in 1914)	Renamed as Delhi Cantonment Board in 1938	Ministry of Defence, Government of India
Municipal Corporation of Delhi (Established 7 April 1958)	North Delhi Municipal Corporation (2012)	State Government: Government of the National Capital Territory of Delhi (GNCTD)
	South Delhi Municipal Corporation (2012)	State Government: Government of the National Capital Territory of Delhi (GNCTD)
	East Delhi Municipal Corporation (2012)	State Government: Government of the National Capital Territory of Delhi (GNCTD)

3.1.1. LEDS in Delhi

It is a union territory, with a special state status constitutionally governed by the Lieutenant Governor having multi-tiered jurisdictions of the center, state, local bodies (with some local bodies directly reporting to the ministries/ departments in the central government), Delhi exhibits a large number of concurrent policies. The policy framework for clean energy in New Delhi could be logically analyzed for different ongoing policies on the basis of their origin, which may be either from the national government or the state government itself. In case, a policy is derived from an overarching national policy/plan or mission, the state policy could be regarded as a sub-policy that largely conforms to or augments the provisions of the national policy. For instance, the Climate Change Agenda for Delhi 2009-2012.

An in-depth policy evaluation demonstrates that the agenda for climate change in New Delhi largely continues with the implementation of the National Action Plan for Climate Change (NAPCC). Through the preparation of the Climate Change Agenda for Delhi (2009-12), the policy followed the NAPCC framework with targets and objectives in the areas of *Sustainable Habitat, Enhanced Energy Efficiency, Strategic Knowledge, Green India, Solar Mission, and Water Mission*.

Accordingly, it is *Solar Mission* aimed to promote renewable energy, through supporting 10% of all energy needs by setting the standard in tariff order. The mission focused on having solar water heating with 500,000-liter capacity, giving monetary incentives of Rs 6000 for a house, institution, group housing, etc., and also on installing the solar water heater in all government buildings. Clean source of energy supply was further taken care by the Agenda's Sustainable Habitat component whereby closing coal-fired plants were targeted within next 5 to 6 years and substituting the supply by augmenting the capacity of CNG based power plants.

Clean transport was taken care of by the Sustainable Habitat sub-mission, through augmenting public transport, i.e., through adding 6000 compressed natural gas (CNG) buses in the transport sector along with the restructuring of the bus system. Increase in the supply infrastructure, such as CNG stations, common ticketing, and automatic fare collection, were other useful options to promote seamless and clean mobility. The Agenda further stressed on the need of using Air Ambience Fund and Creating Transport Development Fund to finance clean transport projects, along with Congestion tax to check the growth of private vehicles. The Agenda also acknowledged that rigorous monitoring of industrial units was crucial to ensure clean air in Delhi.

The Enhanced energy efficiency (EEE) component of the Agenda took care of replacing old bulbs with CFL and LED and reducing 5% energy consumption in the government building. EEE set a target of making 250 green buildings, 50% new and 50% by retrofitting. It also poised to create a database on energy consumption to pursue efficiency. Although the identified measures are quite discreet, the ambition of these targets seems rather moderate in scale.

The Agenda also addressed the urgency to convert *municipal waste into energy*, though not as a stated policy but under several components, like (a) EEE: the Agenda envisioned setting up an E-waste facility in collaboration with NGOs and also, to set up a 100% treatment facility in Delhi along with providing advice to departments on safe disposal of waste (b) Sustainable Habitat: Stipulated to have 100% treatment of hazardous waste facility over 50 acres in Delhi (c) Strategic knowledge: Planned to promote research and demonstration of bio-fuel usage from waste oil used in restaurants (100% target). In the absence of an exclusive and comprehensive policy for clean energy in Delhi, several programs related to clean energy are being implemented at different levels of governance. Provisions for RE, EE and WTE within the multi-level governance framework (national, state, local) is discussed in Table 2. In addition, some ad-hoc decisions undertaken in compliance with executive or judicial orders are also included.

Tab 2. Policy framework for RE, EE, and WTE in Delhi (Farzaneh, 2018)

Policy	Renewable Energy	Energy Efficiency	Waste to Energy
CENTRAL GOVERNMENT			
	National Solar Mission Large scale solar power generation (750MW+) • Solar Park Scheme • CPSU Scheme • Defense Scheme • VGF Scheme	National Mission on Enhanced Energy Efficiency • Perform Achieve and Trade Scheme (PAT) • Market Transformation for Energy Efficiency • Energy Conservation Building Code • Energy Efficiency in SMEs • Capacity Building of DISCOMs • Star Labeled Appliances	
Ministry of New and Renewable Energy (MNRE) policies	Strategic Plan For New and Renewable Energy Sector 2011-17, including solar power generation		
National Urban Transport Policy 2014		• Promotion of mass transport (Metro) • Improvement of Intermediate Public Transport System (IPT) • Controlling Vehicular Pollution • Road Infrastructure • Integration issues • Amenities for Commuters • Support for purchase of EV	
Auto Fuel Policy – BSIV		• Early implementation of superior BS standards	
STATE GOVERNMENT			
State Climate Change Agenda	• Solar Mission • Sustainable Habitat (closing of coal fired plants)	• Sustainable Habitat • Enhanced Energy Efficiency	• Enhanced Energy Efficiency • Sustainable Habitat • Strategic Knowledge
Solar Policy of Delhi	• State Nodal Agency: EE&REM • Grid connected solar plants • Solar plants under REC to • Promotion in Govt/Public institutions • GBI 2/KW and exemption on electricity tax 5% • Capacity building		
LOCAL AUTHORITY (DDA, NDMC, local municipal corporations, cantonment board)			

Solid Waste Management (SWM) Rules 2016			• 1 WTE plant operational • 2 WTE plants on trial • Notified revised BMWM Rules, 2016, for DPCC • Revised E-waste Management Rules 2016 • capacity 2000 MTD has been installed by M/s IL & FS and is operational at Jahangirpuri • GOI has notified the Construction and Demolition Waste Management Rules, 2016. As per these Rules, the Secretary in-charge of Urban Development shall prepare their policy
Master Plan of Delhi 2021		• Control of polluting industry • Promotion of public transport- metro, buses, etc. • Transit-oriented development project in Karkardooma • Delhi Multimodal Transport Systems established • MLU regulations introduced	• Alternatives to landfill
ADHOC POLICIES AND DECISIONS (by Judicial Orders or Executive Orders of the Government)			
	• Scrapping of subsidy (USD 90) on solar PV and solar heater	• Phasing out of diesel commercial vehicles • Odd and Even Formula • Registration tax on diesel vehicles • Parking rates and congestion charges • Proposal for annual registration/ parking tax on cars • Scrapping of BRT corridor	• Policy delay in installing more WTE plants • WTE plants on trial run waiting approvals • Allowing or banning of WTE in the residential zone

As evident from findings in Table 2, the renewable energy component in Delhi is largely driven by the New Solar Policy. This policy has recently been rolled out as the prevailing national policy had limited potential to augment RE generation at the micro or end-user level. The new policy is largely a high investment-driven policy with a little upfront incentive to the consumer. The energy efficiency component, on the contrary, is dominated by nationally driven policies that cover respective transport, building, and electric appliances sector. These include the promotion of electric mobility (both public transport like mass rapid and personalized vehicles like cars), promotion of certified green buildings, star labelling of electric appliances, plan for improving fuel standards from BS (Euro equivalent) IV to BS VI, etc. to which the state government broadly follow on. Solid waste management (SWM) being a mandate of municipal governments in India; waste to energy projects are essentially driven by the local agencies. The sector lacks a formidable policy or plans to tackle the challenge of increasing waste and tap into its energy potential in a systematic manner. In absence of a specific plan at the state level for energy efficiency or waste to energy (if not a complete policy on promotion of clean energy in the city), the policy-action vacuum is filled up by numerous ad-hoc measures and decisions undertaken through the means of executive orders of the government or strict judicial orders passed by the High Court of Delhi, Supreme Court of India or the newly formed National Green Tribunal. For want of a long term energy policy for the capital city, these orders are seen to provide short-term action and immediate relief in response to growing environmental challenge and public angst against policy paralysis and indecisiveness.

3.1.2. Multi-impact assessment of the LEDS in Delhi

3.1.2.1. Delhi clean urban transport system

Delhi's transportation sector is the largest consumer of energy and represents a major contributor to GHG emissions and local air pollution. This sector is expected to experience a large increase in fossil fuel consumption resulting from the fast growth of private vehicles. Delhi already has exceptionally high levels of private car use with around 2 million cars in the city (Farzaneh et al., 2016). The average annual exponential growth rate is estimated to be 1.92% by 2050 (DPCC, 2015). The city also experienced the rapid expansion of demand in urban transport which has led to transportation networks with high traffic volumes of private transportation modes and congestion, which has resulted in adverse health effects such as respiratory and heart diseases. Figure 8 shows the per capita passenger-kilometre for road transport in Delhi. Public transport in Delhi is currently dominated by buses but the recent construction of a metro system has attracted much attention as a solution to Delhi's transport problems. Population levels in Delhi have shown variations in major pollutants like CO, NOx, and PM. Owing to policy interventions and market demand for the road vehicle, the rise of PM in Delhi is a surprisingly recent phenomenon (from 2007 to 2012). It followed a decline in particulate pollution (during 2002 to 2006) due to the introduction of CNG in 1998, yet subsequent rise thereafter due to the rapid increase in the number of registered vehicles from about 200+ lakhs (2006) to 270+ lakhs (2012). A major reason for the spike in PM levels has been in continuous use of diesel fuel in transport, particularly for personal vehicles of all variants- ranging from expensive SUVs to smaller car variants. The trend is quite alarming, as diesel vehicle sales in recent times (2013) formed more than half of the new car sales, a significant increase from 1998 of around 5%. The nuisance was so acute that the Supreme Court of India banned registration of new diesel engine SUVs above 2000cc capacity.

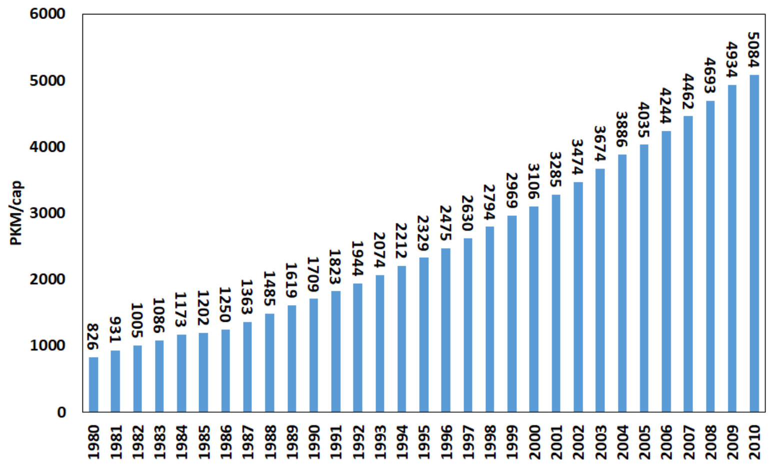

Fig 8. Per capita passenger kilometer in Delhi

3.1.2.1.1. Baseline Scenario

Along with the expanding population and intensified urban development, the projection of the travel demand and its related energy consumption is represented in Figure 9.

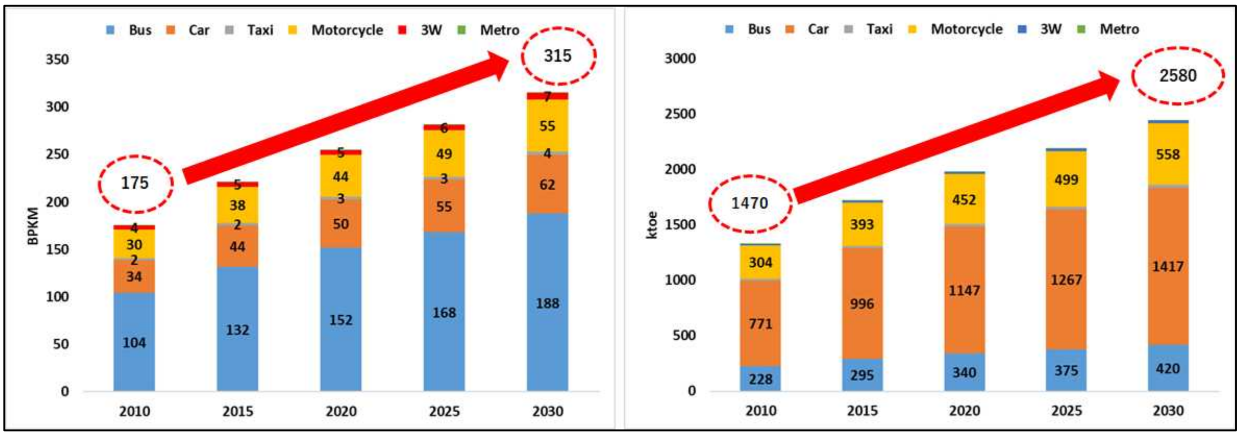

Fig 9. Projection of travel and energy demand in Delhi's transport sector

The demand for energy in this sector will experience a massive increase from 1470 ktoe in 2010 to 2580 ktoe in 2030, which would be dominated by gasoline fuel. Depicted in Figure 10, the total GHG emissions show an increasing trend from 5.4 Mt CO2-eq in 2010 to 9.9 Mt CO2-eq in 2030.

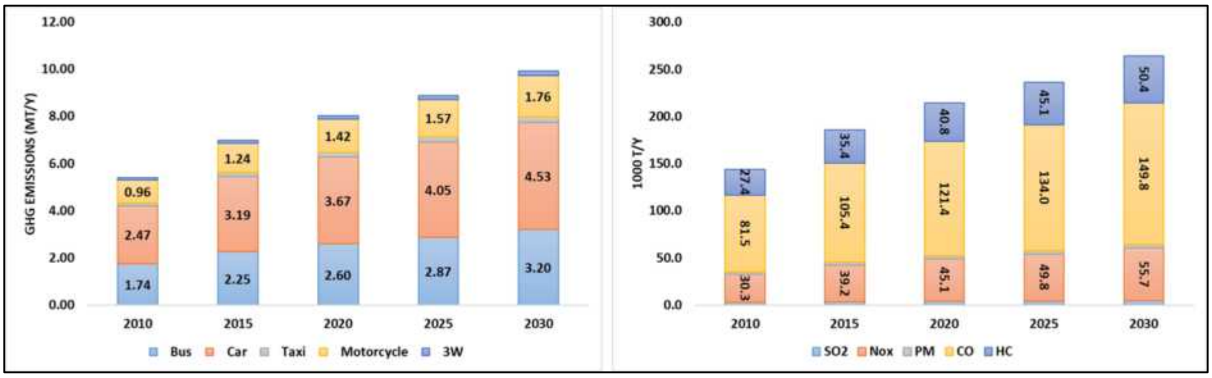

Fig 10. Projection of GHG and air pollution emissions in Delhi's transport system

The pollutant CO has the greatest weight in the air pollution indicator, while SO_2 has the lowest weight. CO emissions from the transport sector are expected to increase significantly to 150 thousand tons in 2030, which is mainly affected by the average age of the fleet, combustion efficiencies, and the driving strategy in different traffic conditions in the Delhi metropolitan area.

3.1.2.1.2. Clean transport scenario

There are several opportunities and challenges in introducing clean energy in the transport sector (See Table 3).

Tab 3. Supporting strategies or actions for clean transport seeking priority (Farzaneh, 2018)

Technological Measures	Governance Measures
Leapfrogging to BS-VI emission standards of new vehicles	More articulated decision making based on a long-term plan and short-term priorities (emergency measures/ alerts)
Refinery upgrades for improved fuel standards by 2019 would be expensive	There is a need for a robust and clear road map for control/ phase-out of dirty/ traditional fuels like petrol, diesel, etc. to cleaner options like CNG, EVs, and hybrids.
Need for technology in automatically collecting congestion charges, parking fees, and annual maintenance road tax.	Promoting market mechanisms (pricing based) in favor of cleaner transport like vehicle price, fuel price, parking fees, road tax, etc.
Need for greater use of advanced technology in vehicular pollution monitoring.	Introducing strict regulatory mechanisms like monthly and annual vehicle fitness tests, on the spot tests and challans on polluting vehicles, making pollution norms more stringent, etc.
Use of technology in issuing fines and ensuring compliance.	Increase share of public transport – metro, city bus, rigorously supported by amenities/ infrastructure, rules and financial incentives that promote EVs, NMT, and pedestrians.
	A series of demand-side measures to actually reduce/ shift traffic peaks, jams and unnecessary trips.

The three most crucial interventions that bear the significant potential to promote clean transport are:

A) Fuel Efficiency: Early adoption of BSES V and BSES VI auto fuel norms:

BSES (Bharat stage emission standards) are emission standards instituted by the Government of India to regulate the output of air pollutants from internal combustion engines and Spark-ignition engines equipment, including motor vehicles. In 2016, the Indian government announced that the country would skip the BS-V norms altogether and adopt BS-VI norms by 2020 (DieselNet, 2017). By moving to BS-VI, the transport sector of the city of Delhi will use the highest specifications of fuel standard available in the world (Figure 11).

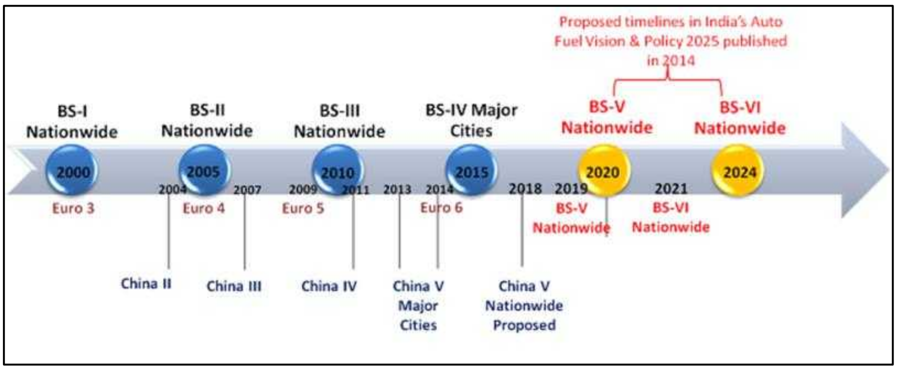

Fig 11. Early adoption of BS V and BS VI auto fuel norms

B) Battery Vehicle: Promotion of battery operated vehicles/ EVs:

Delhi government through Delhi Pollution Control Committee provides financial subsidy on newly purchased Battery Operated 4 and 2 wheelers. The financial subsidy is provided by the Delhi Pollution Control Committee from the Air Ambient fund, created by levying 25 paisa per liter of Diesel (DPCC, 2015). Besides one time fixed subsidy of 15,000 Rs is also provided to battery-operated e-rickshaw owners, authorized by the Transport Department and registered with registering authority of Transport Department (Table 4).

Tab 4. Financial subsidy for the battery operated vehicles/ EVs (Farzaneh, 2018)

Type of Vehicles	**Cost of Vehicles (base price)**	**Subsidy is given by Govt. of Delhi (in Rs.)**
4 Wheeler	Up to 5 lakhs	30,000/-
4 Wheeler	More than 5 lakhs	1,50,000/-
2 Wheeler	Up to 20,000/-	1,000/-
2 Wheeler	20,001/- 25,000/-	2,000/-
2 Wheeler	More than 25,000/-	5,500/-

C) Modal Shift: Increasing ridership in Delhi metro:

With almost 23 hundred thousand passengers using the Delhi Metro network every day, increasing ridership has been the Delhi Metro Rail Corporation's biggest challenge. It is also the most significant challenge as trains struggle to keep up with expanding ridership. At present, the total ridership of Delhi metro is estimated to be about 25%. While Delhi Metro has been trying to expand its fleet-it is currently in the process of converting six-coach trains into eight coach ones on the mainline. It has been planned in rapid Metrorail Gurgaon with a total length of 11.7 kilometers serving 11 stations.

Based on these actions and objectives of the initiatives as mentioned earlier (Clean Transport Scenario), the model was used to evaluate the GHG emissions reduction potential and the multiple benefits achievable by improving air quality. According to the results, the modal shift from private modes to the public transport systems, including the metro, can help reduce energy consumption, CO_2 emissions, and pollution load in the city of Delhi. Figure 12 shows the expected GHG emissions reduction from the implementation of the above plans, which is estimated to be about 4.3 million tons in 2030.

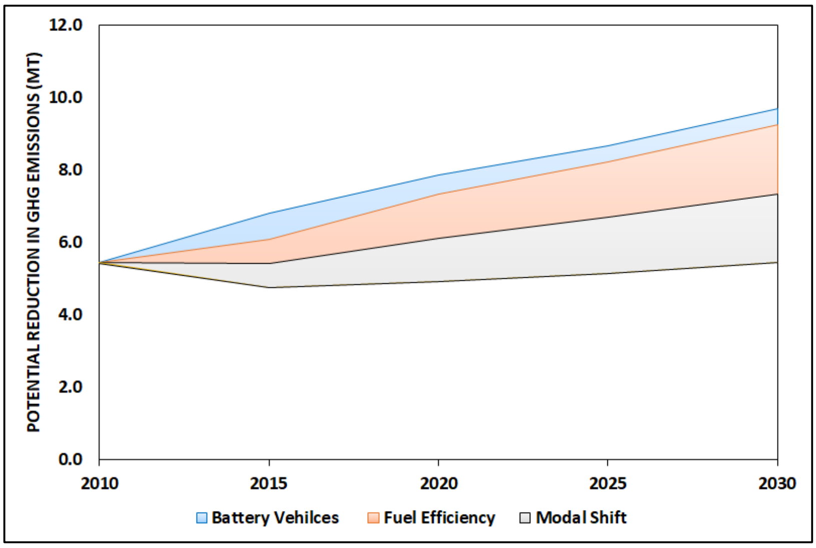

Fig 12. Expected GHG emissions reduction from the clean transport scenario

The high-quality public transport system in the clean transport scenario can provide additional benefits besides emission reduction, including improved public health. As shown in Figure 13, the model predicts that the total amount of harmful gases emissions, such as SO_2, NO_X, and PM_{10}, would decline in the clean transport scenario compared to the baseline scenario by approximately 48%.

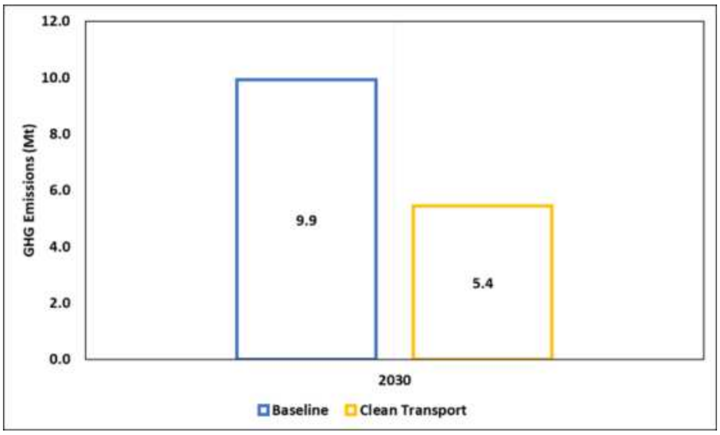

Fig 13. GHG emissions reduction from the clean transport scenario

Using the mortality rates collected from the Ministry of Health and Family Welfare for 2008-2011 [7] and also annual average data for concentration of SO_2, NO_X, and PM_{10}, which were derived from continuing measurement taken in the period of 2008–2011, from five monitoring stations throughout the Delhi metropolitan area, the estimated annual reductions in the mortality rate from the clean transport scenario are given in Table 5.

Tab 5. Estimated annual health outcomes from the clean transport scenario

Exposure metric and subgroups	**Health outcomes (deaths prevented/ year)**		
	SO_2	NO_X	PM_{10}
Total mortality and short term exposure (all ages)	419	2390	19200

According to the results, the annual reduction of cases of mortalities varies from 19200 (exposure to PM10) to 419 (exposure to SO2) in Delhi. The larger numbers for the projected reduction of cases of cardiovascular mortalities imply that the pollution impact on these cases is more serious than others. Among all pollutants, the reduction of PM10 plays a significant role in achieving the desired health outcome.

Tab 6. Expected Co-benefits from the clean transport scenario (kt/y)

	SO_2	NOX	CO	HC
2015	-1.3	-3.1	-18.7	-2.6
2020	-1.7	-4.0	-23.8	-3.3
2025	-2.0	-4.8	-28.6	-3.9
2030	-2.6	-6.1	-36.7	-5.0

3.1.2.2. Delhi zero electricity deficiency

Delhi's power demand has been steadily increasing, and the dependence on power from outside has been increasing with that demand. Satisfying this rapidly rising demand requires investments: these investments inevitably are associated with significant social, and environmental consequences. Despite a total installed power generation capacity of about 7249 MW (as of April 2017), Delhi is still struggling to meet increasing power demand (DTL, 2008) Delhi is a city-state with declining rural areas and a reduction in agricultural activities. The desired outcome on the energy front in Delhi is to have an uninterrupted power supply and to meet increases in the power demand. Growing demand has resulted in a gap estimated at 6.5% between the demand and supply in the present phase. In the coming years, it is believed that demand in Delhi may increase to 23 TWh/y or even more, with a widening of the gap between demand and supply. The power requirement in Delhi is met by generating capacity within Delhi, at allocations from Central Generating Stations (CGS). The total installed capacity in Delhi is represented in Table 7. The existing network of DTL consists of a 400KV ring around the periphery of Delhi interlinked by the 220KV network spread all over the city (GOI, 2016). The share of coal and other fossil fuels is expected to be about 88.8 per cent in total commercial energy produced. Other renewables such as wind, geothermal, solar, and hydroelectricity represent a 9.2 per cent share of the Delhi state electricity mix. Nuclear holds a two per cent share. Delhi has the highest per capita power consumption of electricity among the States and Union Territories of India The per capita consumption of electricity in Delhi has increased from 1259 GWh per annum in 2000-01 to 1448 GWh in 2014 (DTL, 2010).

Tab. 7. Installed power capacity in Delhi (Farzaneh, 2018)

State	Ownership/ Sector	Mode-wise breakup							Grand Total
		Thermal				Nuclear	Hydro (Renewable)	RES (MNRE)	
		Coal	Gas	Diesel	Total				
Delhi	State	135.00	1800.40	0.00	1935.40	0.00	0.00	0.00	1935.40
	Private	445.50	108.00	0.00	553.50	0.00	0.00	39.87	593.37
	Central	4421.37	207.61	0.00	4628.98	122.08	762.64	0.00	5513.70
	Sub-Total	5001.87	2116.01	0.00	7117.88	122.08	762.64	39.87	8042.47

In Delhi, domestic (Residential and Commercial) customers dominate the electricity consumption profile. Total consumption of electricity in the domestic sector as a percentage of total demand was increased to 52% in 2010. Total consumption of electricity in Delhi was 21700 GWh: 10396 GWh used for domestic purposes, 6253 GWh used for non-domestic purposes, 2989 GWh used for industrial purposes and rest was used for other purposes (GNCTD, 2016). There has been a consistent gap between electricity requirement and availability and between peak demand and peak supply. The peak seasons in Delhi coincide with those of the other nearby states, thereby creating a significant deficit in the grid. The peak demand increases year by year, while load shedding has reduced tremendously. Figure 14 represents the electric power deficiency in Delhi. The gap between demand and supply is expected to grow to 6.5%. Because of their dominance in the overall consumer profile, residential demand by domestic consumers contributes significantly to the peak load. For this reason, it is meaningful to examine strategies for managing demand and improving the efficiency of various end-use appliances to reduce residential power demand in homes and commercial buildings and the impact of this demand on the overall load profile of the city. It seems that the air conditioners are the major contributor to the peak load in summer and lighting is the second leading contributor. In winter, space heating and water heaters contribute significantly to the peak load.

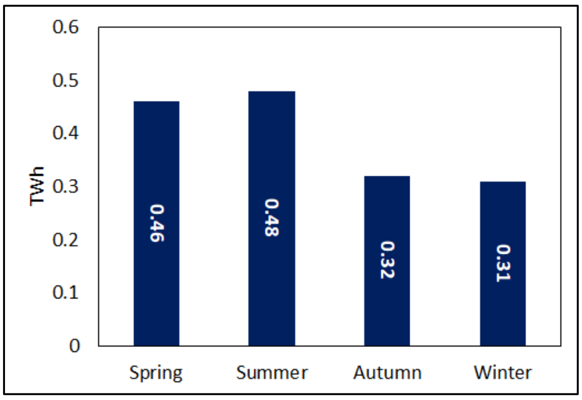

Fig. 14. Electric power deficiency in Delhi

In 2016, it came up with New Solar Policy (NSP), a five-year program from 2016 to 2021, which actually started implementation in 2017. The policy is applicable to solar PV generation of 1KWp or more at the local/rooftop level and aims at improving energy security along with cutting down of electricity expenses for Delhi, especially during peak demand. The policy will accommodate 10% peak demand by 2025. It will also reduce the need for a new power purchase agreement (PPA). Upon offsetting power from thermal power plants, the policy aims to attain the co-benefits of having lesser air-pollution. The agenda is “Achieve aggressive yet realistic rooftop solar growth in Delhi”. This would be achieved through two targets of generating: (a) 1.0 GW solar energy by 2020 (14% of peak load, 4% of total energy), and (b) 2.0 GW solar energy by 2025 (21% of peak load, 7% of total energy). The annual target set under this agenda by the government (GNCTD, 2016) is shown in Figure 15. The NSP envisages creating an additional generation capacity of 1945 MW by 2025.

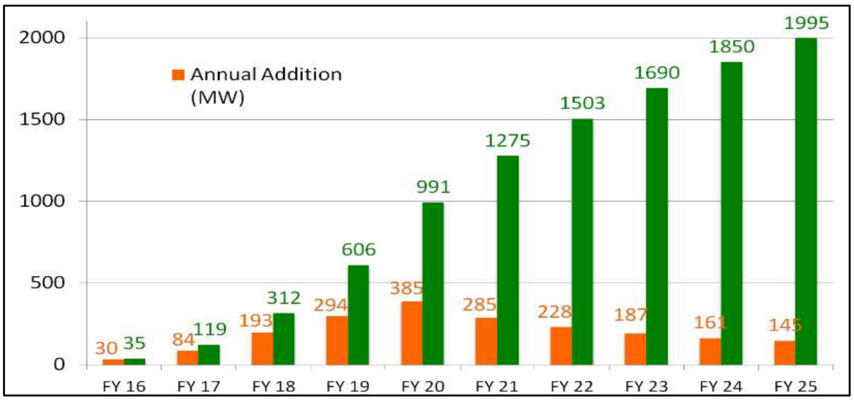

Fig. 15. Annual targets for rooftop solar energy

The policy provisions allow net metering for every solar installation at or above 1 kW. The electricity generated by the system is self-consumed first and then allowed to feed sanctioned load into the grid. The owner gets monthly credits on exported energy. At the year-end, the local electricity distribution company (DISCOM) pays for surplus solar energy at the average power purchase cost. The generation-based incentive (GBI) is earmarked incrementally, based on increasing units of solar power generated. It is proposed that a limited-time incentive will reduce payback time and increase adoption, hence GBI is for 3 years. The minimum eligibility criteria for GBI has also been prescribed at 1000 units (kWh) per annum per kWp and shall be capped at 1500 kWh per kWp. The electricity produced is INR 2/kWp generated. It is notable that while the payback time will be reduced by 1-2 years but there will not be any subsidy benefit of the lower slab. While preparing the policy, it was felt that there needs to be a provision for people wherein those who have shared roof-rights or do not possess any or sufficient roof-rights can also become stakeholders. The NPS thus provides for Virtual Net Metering, where consumers can be beneficial owners of a part of a collectively owned solar system. As far as scale is concerned, the policy has set certain benchmarks to promote its use. Solar system up to 200 KWp is exempted from certification by Electrical inspector. While it is mandatory to deploy solar PV on Govt./Public institution of the area above 500 sqm.

Tab 8. Potentials and Constraints of the New Solar Policy of Delhi (Farzaneh, 2018)

Opportunities	**Costs and Barriers**
• Since 2007, energy tariffs in Delhi risen by 7% per annum while solar panel prices dropped 6-8% per annum, with a sharp drop during 2014-16. • Discom networks relatively better than elsewhere in India (low power loss or theft) • Very little grid downtime, ideal for solar installations without batteries ("the grid is the storage") Economic benefits: • 400 MW on Delhi govt. rooftops can save approximately 200 crores/year. In 20 years, the Delhi government can save over 5,100 crores • Delhi can cut its electricity expense, improve energy security, and shave off over 10% of peak demand by 2025, reducing the need for new power purchase agreements (PPAs).	Costs 1 kW Solar System Parameters –Cost of about INR 55,000 Includes panels, inverter, installation –Rooftop space needed is about10 sq. meters (3m x 3.3m) –Generates about 1,300 kWh (units)/year –Households generate electricity worth INR 11.5K/year: PBP is 6-7 years. –Commercial/Industrial/government generate electricity worth INR 15000/year: Payback period is about 5 years. • After payback, rooftop earnings are pure profit for the next 18-20 years • Tariff and payback time vary by consumption. Household calculation is for the 400-800 units/month band. Barriers • Absence of upfront incentive to the end-user • Non-inclusion of security ad insurance costs against hail and material damage over the life cycle of PV
Note: Savings for 1 MW with INR 3.5/unit gap = INR 51 lakhs/year; with 0.5% annual output reduction; 5% CAGR in conventional power	

In addition to the generation of clean energy, its efficient utilization in buildings, mobility/ transport sectors, it is now imperative to deal with energy in a resource cyclic and circulatory economy perspective. One of the hallmarks of this paradigm is treating waste to convert/generate it into energy, basically as municipal heat and electricity. India, largely being a country with tropic and sub-tropic climate conditions, waste to energy (WTE) in practice is understood as the production of electricity from municipal waste, although other byproducts are also evident. There seems to be immense potential for megacities like Delhi that generates about 9500 tons of waste daily (CSE, 2017). As evidence, this investigation covers two types of CE initiatives being undertaken in the waste sector in Delhi: (1) Centralized Model, being practised by municipal corporations wherein waste is converted to electricity, and (2) Decentralized Model, being practised by local occupants to convert waste into manure, biofuel, etc.

Under the centralized model, there are 3 main landfill sites in the city namely Bhalswa landfill site at Ghazipur (commissioned in 1984), Bhalswa (1994), and Okhla (1996). In the absence of availability of landfill sites, all the 5 ULBs are using these three sites as dump yards of MSW. In order to scientifically treat MSW, an integrated MSW management plant of 4000 TPD capacity has been developed at Narela-Bawana (near Bhalswa) and the plant is operational for

2000 TPD. In addition, there are 3 WTE plants developed with capacity ranging from 1300-3000 MTD and electricity generation ranging from 12-24 MW (refer Table 9).

Tab 9. Plant capacity and electricity generated in three WTE plants of Delhi

S. No.	Name	Plant Capacity (MTD)	Electricity Generated (MW)	Status
1.	Timarpur - Okhla Waste to Energy Plant	1950	20	Operational
2.	Ghazipur Waste to Energy Plant	1300	12	Consent to trial
3.	Narela Bawana Waste to Energy Plant	3000	24	Consent to trial

As evidence, this investigation conducts case studies from both centralized and decentralized types of WTE plants. Amongst the centralized model, the study covers Timarpur-Okhla Waste to Energy Plant and Ghazipur WTE project, while in the decentralized model, Zero Waste Project at GPRA Complex and the BioBoxX at Delhi Metro are studied. In 2005, Government of NCT Delhi and IL and FS started developing WTE project in Delhi on public-private partnership (PPP) model (in accordance with MSW Rules 2000. Accordingly, Jindal Ecopolis set up India's first large scale commercial WTE facility at Timarpur-Okhla in New Delhi (Figure 7-top). The facility processes municipal solid waste and generates clean and renewable energy. The consent to operate was received on 21st December 2011 and began operations on 1st September 2012. Till now, the plant has handled 26.5 million tons of garbage. The plant, promises of being able to provide power to 6 lakh homes. It is spread across 15 acres of land. The load factor of the plant is 98%, which receives 2000 tons of waste per day. It stores MSW in pits/bunkers which are maintained under negative pressure to prevent bad smell or odour into the neighbourhood. The current storage capacity of the waste is 10,000 tons. The power generation of the plant was 16-18 MW, which has now been elevated to 20 MW. The facility has been installed with a sophisticated Continuous Emission Monitoring System (CEMS) supplied by Yokogawa Japan, one of the foremost technology suppliers in this field. Ghazipur WTE project is a PPP project of Delhi Government with a 25-year concession agreement (Figure 7-below). The project is designed to process 2000 tons per day for East Delhi Municipal Corporation. The plant has 2 major parts, one is called the processing plant and the other is the power plant. This Integrated Waste Management (IWM) facility presently has a capacity to process 1300 TPD of MSW and generate about 433 MT of Refuse-derived fuel (RDF) as a byproduct. The boiler for the power plant consumes about 16.27 TPH of this RDF fluff per hour in boiler generating 50 TPH of steam) for the generation of 10 MW of power. The power plant has air-cooled condenser for condensing the exhaust steam from turbogenerator to reduce the water requirement to a large extent. The water requirement, in the plant, is generally 471 m3/day. The dust emissions occurred during the processes, are monitored by the provision of dust control systems such as cyclones, bag filters, to control the dust emissions. This process thus, results in the average annual reduction of CO_2 by 111,949 tons. Meanwhile, under the decentralized WTE model, Zero Waste Project at GPRA Complex, New Moti Bagh (Figure 8-top) is a unique model developed by the Govt. of India through National Building Construction Corporation. GPRA Complex in New Moti Bagh is a 110 Acres complex with over 1000 families residing in the complex. The average waste treated at the complex is 1.5 tons of household and 1 ton of green and horticultural waste, household waste that includes wet kitchen waste. The waste is collected and brought to the segregation site from where the segregated organic, green and plastic waste is treated at the plant. The other dry waste is stored and sent for recycling to the respective recycling plants. The resultant product from organic waste treatment is organic fertilizer (organic khad) and from green waste, the plant produces biomass pellets. Plastic Waste is treated to produce Low-density oil (LDO), carbon and liquefied petroleum gas (LPG). LDO can be further refined to a better quality fuel like petrol and diesel.

Another example of decentralized WTE is the use of BioBoxX technology by Delhi Metro at their Shastri Park Office (Figure 8-Below). It is seen that about 40-45% urban solid waste is the organic fraction, which can be easily treated by anaerobic digestion. Solids in the organic waste decompose rapidly and can be treated by biomethanation process method. In this process, solid waste is treated in closed vessels wherein the absence of oxygen microorganisms break down the organic matter into a stable residue and generate methane-rich biogas in the process. Biogas so formed can then be used as a source of renewable energy to produce electricity whereas; solid residue can be utilized as manure. In Delhi, the containerized technique being marketed as BioBoxX has two Biomethanation plants, one at Ghazipur and the other one is situated near Basti Sarai, where the land has been provided by the railway colony for biomethanation process. The anaerobic digester system (for anaerobic digestion of biodegradable waste) is used for biogas production and recovery.

The policy options and assumptions are given in Table 10. The end-user efficiency improvement has a lead role to play through the improvement in lighting and the coefficient of performance of space conditioning in the residential and commercial sectors. Lighting improvement is possible when the consumers shift from the use of incandescent bulbs to compact fluorescent light bulbs (CFLs); savings accrue to them by way of reduced consumption due to the lower wattage rating of CFLs. Commonly used appliances for space conditioning during summer in the residential sector are air-coolers and air conditioners. There are many air-coolers with a low COP (< 2) in lower-income groups of the city of Delhi: these can be replaced with high COP air conditioners (> 2.5). Small Hydropower is playing an essential role in the competitive power supply sector in Delhi. It can provide sustainable energy services, based on the use of routinely available, indigenous resources and provide better solutions to the longstanding energy problems encountered by the power supply system.

Tab. 10. Policy options and assumptions for the baseline and zero electricity deficiency scenarios

Scenario	Policy option
Alternative Energy usage ***(Shift)***	1) Introducing 50 MW solar PV (NDPC, 2010) 2) Increasing the installed capacity of hydro up to 100 MW (Lakhwar Multi-Purpose project) 3) Increasing the installed capacity of waste-electricity to 46 MW (with three plants at Okhla and Timarpur (16 MW), Gazipur (10 MW) and Narela-Bawana Road)
End-user efficiency improvement ***(Improve)***	1) Replacing the regular lighting system with Compact Fluorescent Lighting for 3 million Delhi households 2) Improving COP of air conditioning to 2.7

Solid waste management remains one of the most neglected sectors in Delhi. On average, 80% of the municipal solid waste generated is collected: 90% of the collected solid waste is disposed of in landfills, and the remainder is composted. At a total of 5500 tons per day, the contribution of municipal solid waste to the total CH_4 emission is estimated at approximately 80%. The implementation of technologies like incinerators would facilitate electricity production on the supply side and reduce the emission of GHG and other air pollutants in this city.

Table 11 shows the potential of the calculated co-benefits of the implementation of the policy intervention scenarios considered in this survey.

Tab. 11. Potential reduction of GHG and Air pollutions from the LEDS

Kt/y	*Baseline*	*Zero elec. deficiency*	*Difference*
GHG	15658.3	11982.7	-3675.6
CO	29.00	19.68	-9.32
NOx	46.91	32.61	-14.30
SO_2	123.90	84.74	-39.16
PM10	5.74	3.96	-1.78
PM 2.5	1.80	1.22	-0.58

3.1.3. Local economy improvement

Implementation of the LEDS in both the transport and electricity sectors in Delhi has a direct and indirect impact on the local economy of this city. Direct effects are changes in sales, income, or jobs associated with the on-site or immediate effects created by expenditure or change in final demand; for example, the employment and wages for workers who assemble batteries at a manufacturing plant. Indirect effects are changes in sales, income, or jobs in upstream-linked sectors within the region. These effects result from the changing input needs indirectly affected sectors; for example, increased employment and wages for workers who supply materials to the battery assemblers. Induced effects are changes in sales, income, or jobs created by changes in the household, business, or government spending patterns. These effects occur when the revenue generated from the direct and indirect impact is re-spent in the local economy. The expected growth rate of GDP and its absolute employment caused by the implementation of the LEDS in Delhi are represented in Figure 16.

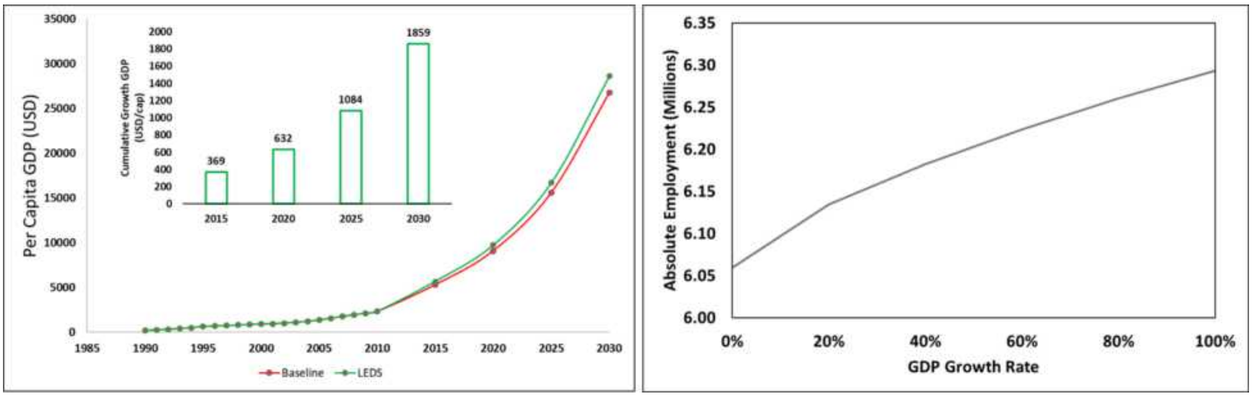

Fig 16. The cumulative growth of GDP and its absolute employment caused by the LEDS

3.2. Case of Shanghai, China

Shanghai is one of the four direct-controlled municipalities of China, with a population of more than 26.3 million as of 2018 and it is the most populous city in China. Shanghai covers one area of 6340 Km^2, and it has divided into 16 districts. The center city of Shanghai bounded with the outer ring road covers one area of 660 Km^2. According to the latest issued Shanghai 2035 Master Plan, Shanghai has different management policy and planning target upon the different spatial scale of the city.

Shanghai shows one growing city power in the global cities network with rapid social-economic development in recent years. In the 2011-2016 Global Power City Index (GPCI) issued by Mori Memorial Foundation, Japan annually, Shanghai's rank in 40 global cities grew from 26th in 2011 to 14th in 2013 and 12th in 2016, with the comprehensive power comparison including economy, research and development, culture interaction, livability, environment and accessibility (World Bank, 2018).

With the rapid growth of the population and urbanization in recent years, the demand for energy is also increased and results in the growth of the total energy consumption in Shanghai. The six drivers include "*population and urbanization*, *Economic growth*, *Industrial Structure*, *Technology Progress and innovation*, *Welfare*, *Energy Supply structure"*. These main drivers impact Shanghai's energy consumption and related emissions. Shanghai's economy has built up in the post-1978 reform era. Its GDP increased from 25 billion CNY in 1995 to 494 billion CNY in 2018. Figure 17 shows the growth rates of GDP and energy demand (World Bank, 2018).

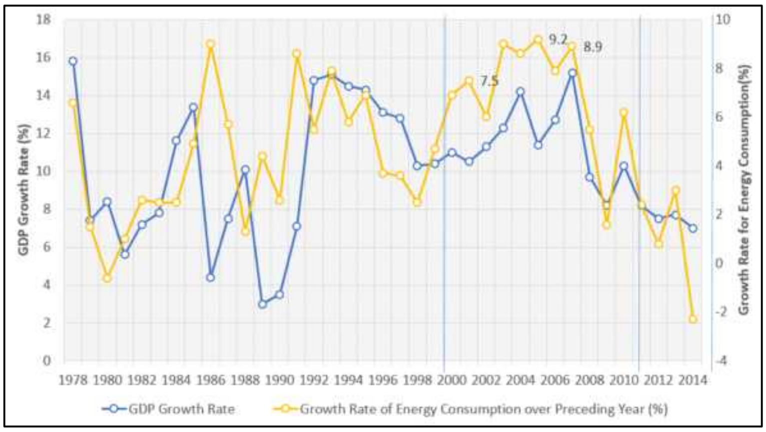

Fig 17. Growth Rate of GDP and Energy Consumption in 1978-2014 (SSY, 2017)

The historical trends of final energy demand and electricity consumption are depicted in Figure 18 which shows the rapid growth of energy consumption during in 2001-2010, with the highest growth rate in 2005 up to 9.2 %., After that, energy consumption decreases during 2011-2015. Among all sectors in Shanghai, the industry sector, including the mining, manufacturing, power, and construction accounts for the largest consumer of energy, followed by the transport sector and other sub-sectors in the tertiary industry. Energy supply mainly relies on fossil energy and Electricity imported from other provinces, and the share of new energy is still negligible. Percentage of different energy carries in final energy demand is shown in Figure 19.

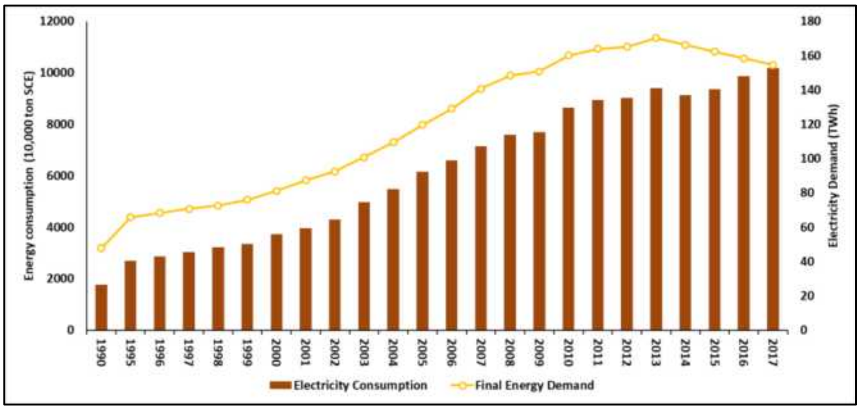

Fig 18. Trends of final energy and electricity demand in Shanghai (SSY, 2017)

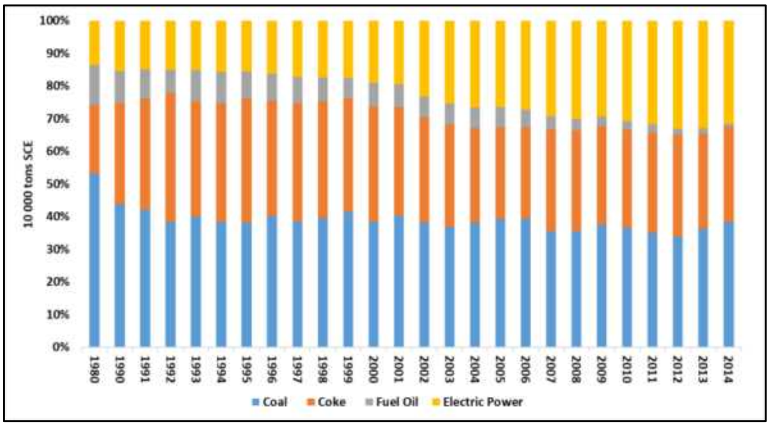

Fig 19. Share of different energy carries in Final energy demand in Shanghai (SSY, 2017)

Shanghai’s energy intensity (energy consumption per unit of GDP) has decreased consistently. In 1990, Shanghai’s energy intensity was 2.1 (ton SCE/10000 CNY), in 2014 was 0.48 (ton SCE/10000 CNY). However, the pace of this decrease has slowed down in recent years as the economy has become more efficient (Figure 20).

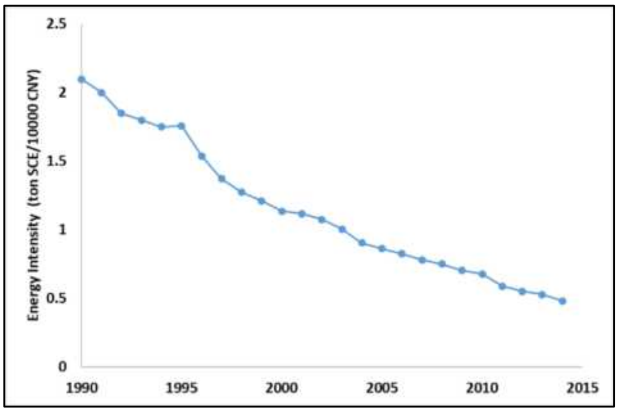

Fig 20. Energy intensity levels of Shanghai (SSY, 2017)

Figure 21 presents the structure of the final energy consumption per industry, in which the shares of three “industries” and living consumption are illustrated. It is evident that the primary sector, namely agriculture, is decreasing over time (from 1.85 in 1995 to 0.6% in 2014), while the percentage of the tertiary sector, mainly service industry, is increasing. Additionally, the secondary sector keeps stable.

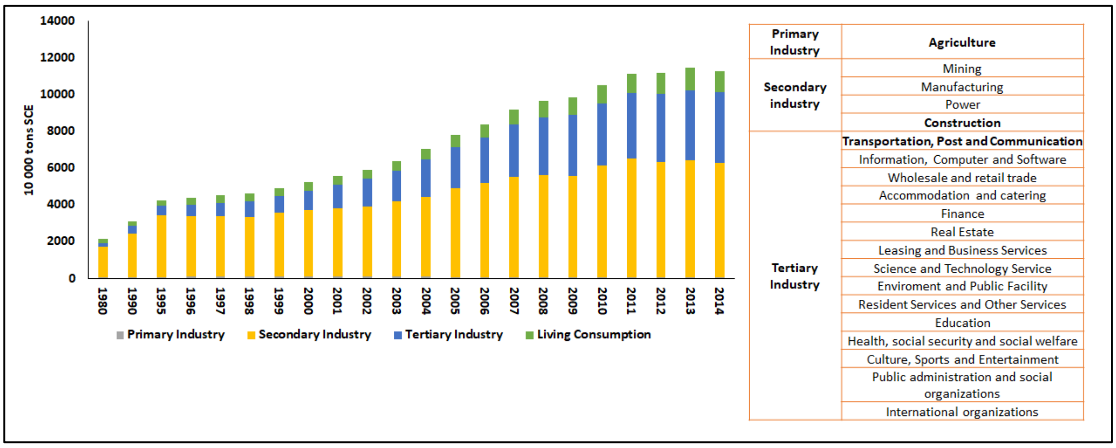

Fig 21. Structure of final energy consumption per industry (SSY, 2017)

With the actions of energy saving and emission reduction, overall air quality shows getting better in recent years. The main indicator of $PM_{2.5}$ concentration shows seasonal pollution in Autumn-Winter period. Besides, $PM_{2.5}$ source analysis shows 26-36% regional influence on $PM_{2.5}$ pollution import from other regions in the west and north to Shanghai. The leading indicator of PM2.5 concentration shows seasonal pollution in Autumn-Winter period. Besides, PM2.5 source analysis shows 26-36% regional influence on PM2.5 pollution import from other regions in the west and north to Shanghai.

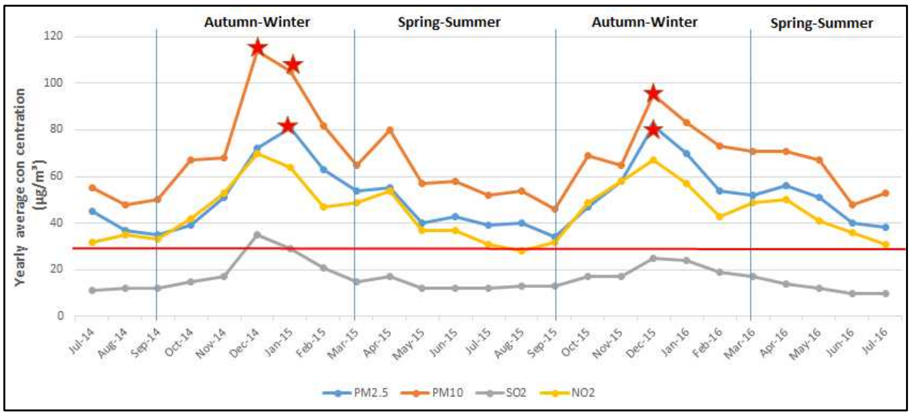

Fig 22. Air Quality Indicator (monthly) Change in many years 2014-2016 (SMBEE, 2018)

Figure 23 illustrates the contribution of different sources of air pollution in Shanghai. According to this figure, the contribution of the local sources such as industrial productions and mobile sources is estimated in a range from 64% to 84%.

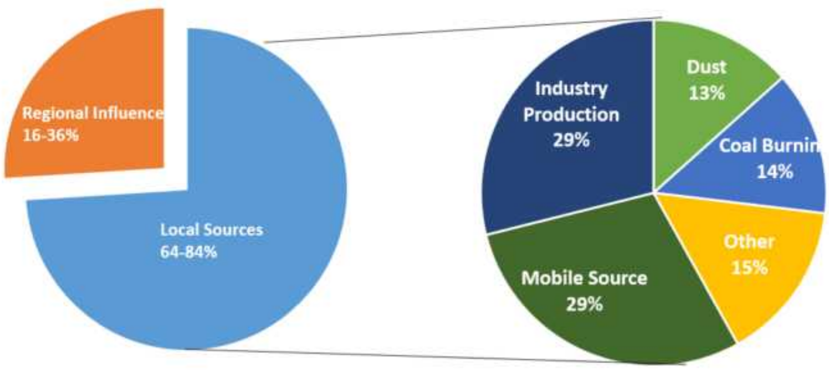

Fig 23. $PM_{2.5}$ Source Analysis for Shanghai in 2016 (SMBEE, 2018)

3.2.1. LEDS in Shanghai

3.2.1.1. Policy structure and innovative elements:

China's energy policy system includes the authorities complex and frequently adjusted in special period/ priority recent 20 years. The strong vertical linkage between the central government and local government provides the favorable institutional setting for LEDS experiments. In China, municipal authorities are required to achieve targets set by the central government, although the actual input may vary greatly depending on their level of motivation and capacity. There are three layers of plans in the policy related to spatial planning and territorial development in China; socioeconomic development plans, national spatial plans (land use plans), and urban and rural plans. Socioeconomic development plans are drafted at the national, provincial, prefectural and county levels. Urban and rural plans can be divided into urban system plans, urban plans, town plans, township plans, and village plans. Urban and rural plans are drafted at the national, provincial, prefectural, county, township, and village levels. (See Figure 24).

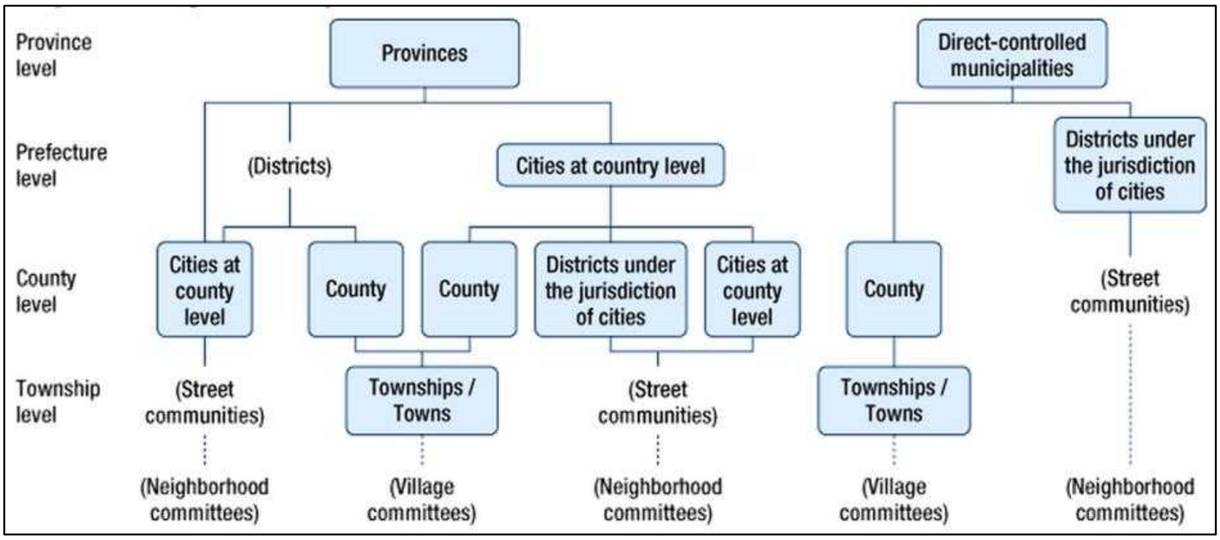

Fig 24. Structure of local authorities in China

As shown in figure 25, such an institutional setting leaves much room for local governments to conduct policy experiments aiming at policy learning while fulfilling the task. Shanghai is designated as a Pilot Low-carbon City, which opened opportunities for various policy experiments to incubate innovations.

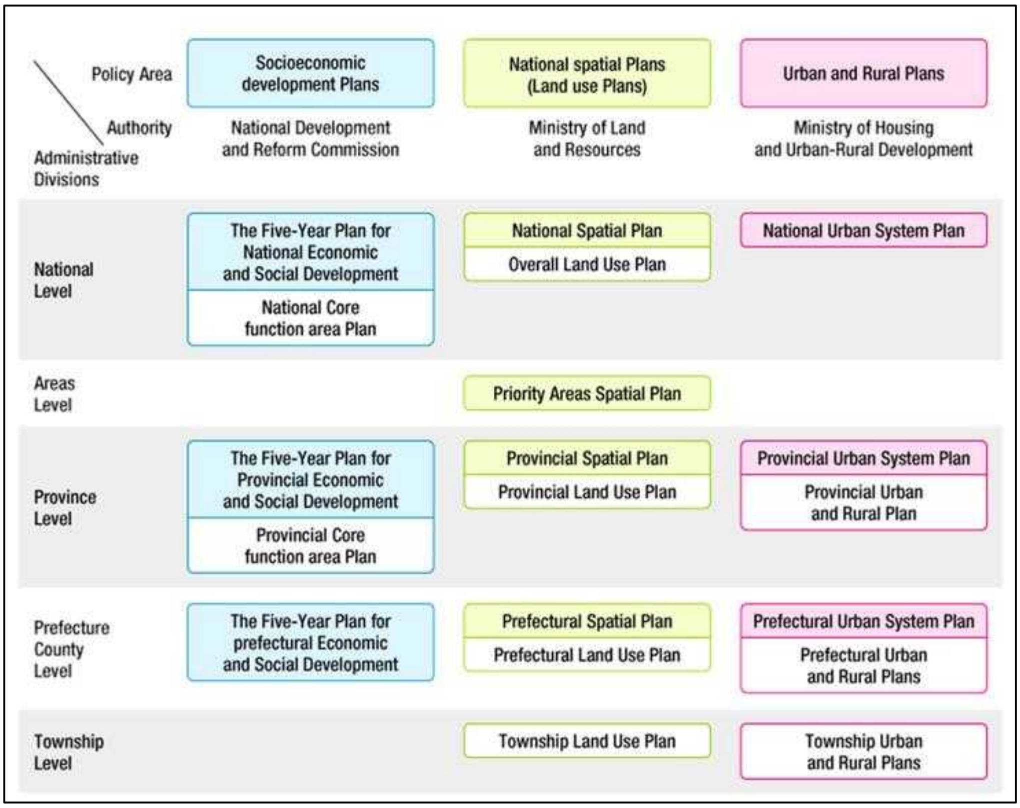

Fig 25. System of Spatial Planning and Territorial Development Policy in China

With the city's efforts, several creative policy practices emerged in Shanghai, e.g., introducing regular planning cycle at a local level, and going beyond the top-down target. In this sense, the vertical cooperation of governments across levels presented in Shanghai case is facilitated by the institutional setting in China.

There are several characteristics of Shanghai's LEDS, as summarized below. City's LEDS are embedded and integrated into the existing policy framework, instead of an entirely new strategy. LEDS in Shanghai can be divided into two stages:

1) **The implicit stage:** Before 2009, which is the implicit stage, Shanghai has been on its way of adjusting industrial structure, improving energy efficiency and controlling air pollution, etc., the co-benefits of which contribute to GHG control.
2) **The explicit stage:** In precise scene, Shanghai LEDS were introduced, which is an integrated policy strategy tackling multiple challenges. The LEDS root in the city's existing policy framework. The strategy of hooking "low-carbon" onto other local policies schemes is common and not necessarily initiated in Shanghai. However, Shanghai's LEDS are more than re-interpreting traditional policy schemes with low-carbon implication, but with new low-carbon policy measures such as local pilot low-carbon developing districts, carbon labeling.

The general classification of the LEDS instruments is given in Table 12.

Tab 12. Classification and definition of the LEDS Instruments in Shanghai

Instrument	Definition
Legislation	The legislation is a law that has been enacted by some governing body (Congress, the President, or some other governing body); before it was passed into law, it was likely referred to as a bill.
Planning	Planning Policy is concerned with preparing and implementing plans that help us decide where and when development takes place.
Regulations	Regulations are the details of implementation for achieving the desired effects of legislation.
Incentives and Grants	Incentives and grants - some regulations address energy issues by offering incentives and grants rather than explicitly requiring the action of any kind. These could include direct payments for a specific type of project or research, grant money to support research in part or in whole, tax credits for particular kinds of purchases or activity, or a price support/subsidy for a specified activity.
Tax incentives	*Taxation - involves levying a charge on a unit of good or service.*
Standards	Standards - are established to achieve a certain amount of environmental benefit, like the Renewable Portfolio Standards developed across the country by individual states to increase the percentages of electricity generated with renewable energy resources.
Guidelines	Guidelines - like incentives and grants, guidelines represent a voluntary opportunity to encourage citizens, businesses, or communities to adopt certain practices. Guidelines are there to facilitate the adoption of specific practices should someone want to undertake them; however, no one is required to follow them.
Market-based approach	Sometimes policies lay the framework for the establishment of a market-based system to achieve policy goals. One of the most notable forms of this is a system of tradable permits, also known as a cap and trade system.
Program	A program is a portfolio comprised of multiple projects that are managed and coordinated as one unit with the objective of achieving (often intangible) outcomes and benefits for the organization.

Project	A project is a temporary entity established to deliver specific (often tangible) outputs in line with predefined time, cost and quality constraints. A project should always be defined and executed and evaluated relative to an (Executive) approved business case which balances the costs, benefits and risks of the project. The project business case should be managed under change control.

Shanghai LEDS to reduce its energy-related challenges are divided into the following categories:

- Developing renewable energies
- Increasing gas supply
- Improving energy efficiency, particularly in industries, transport, and buildings.

The complete list of the implemented LEDS in Shanghai is given in Table 13.

Tab 13. List of implemented LEDS in Shanghai

Title	Authority Department	Period	Objective/Sub-policy instruments	Target
Economic and social development of Shanghai Thirteenth Five-Year Plan	Shanghai Municipal People's Government	2016-2020	Promoting the economic structure transformation	● Achieving the average rate of GDP growth at 6.5% and the total GDP reach 2500 billion RMB in 2015 and 150,000 RMB per capita GDP by2020; ● Contribution of Tertiary Industry in total GDP more than 67% ● Per capita disposable income in Urban and Rural resident reach 52,962 and 23,205 RMB
			Emission reduction	Annual average concentration of PM2.5 reduced to around 42ug/m3
			New Energy Development	● Natural gas supply capacity reach to 10 billion m^3, and reach 12% in total primary energy consumption ● Promoting the research and development for new material, facilities for nuclear, Wind and Solar power generation and promoting the development for biomass, geothermal, and marine energy ● Promoting decentralized energy system and smart grid
			Population control	Population resident controlled in 25 million by 2020
			Construction land control	Total construction land area controlled in 3226 Km2
			Clean technology transformation	● Implementation of clean energy use in distributed coal burning facilities ● Centralized heating and power facilities ● Coal consumption reduction in Chemical and Power industries

				● Installation of the coal burring facilities with energy saving and emission reduction
			Emission reduction	Both control on the total amount and intensity of energy consumption and CO_2 emission， by 2020 the total energy consumption controlled at the level of 0.125 billion tons SCE and emission of CO_2 at 0.25 billion tons
Shanghai manufacturing transformation and upgrading Thirteen Five-Year plan	Shanghai Municipal People's Government	2016-2020	Promoting the growth rate of economy, innovation, structure transformation	● Manufacture industry in total GDP reaches 25% ● Service sector's contribution in total GDP reaches 35%
			Promoting energy saving and emission reduction	● Design and implementation of standards of energy saving in construction and promoting the energy saving program in buildings. ● enhancing the use of renewable energy in building, public transportation sectors
			Climate change response	● Through energy saving and efficacy improving, increasing the capacity of carbon sink like forest, wetland and ocean. ● Reducing the emissions of Green House gas including CO_2,CH_4,HFCs,etc.
Shanghai 2016 annual PV construction plan	Shanghai Municipal Development and Reform Commission	2016	Promoting the construction of PV systems	New installed capacity of PV power in 2016 is around 136 trillion W including 40 trillion centralized PV power stations, 23.8 trillion W for Rooftop PV project and 82.2 trillion W for decentralized PV power project
Shanghai Electric Vehicle Charging Infrastructure Special Plan	● Shanghai Municipal Development and Reform Commission ● Shanghai Economic and Information Technology Commission ● Shanghai Municipal Commission of Commerce ● Shanghai Science and Technology Commission ● Shanghai Municipal Transportation Commission ● Shanghai Finance Bureau	2016	Guide the new energy vehicle development by Subsidy cut and Encouraging people to purchase by EVs and refunding on license plate	Subsidy 10,000RMB for the electric vehicle with distance per charge at 100-150km
				Subsidy 30,000RMB for the electric vehicle with distance per charge above 150km
				● Subsidy 10,000RMB for Plug-in Hybrid vehicle (30,000RMB in 2015) with distance per charge above 50 km; and another subsidy at 14,000RMB for vehicle meet the standard that engine below 1.6L, Fuel consumption below 5.9L in Hybrid mode and size of fuel tank below 40L ● Number of charging stations reach to 103,000 by 2017,and 211,000 by 2020

3.2.2. Key drivers of Shanghai's LEDS

Population and economic growth are the two main drivers that are behind Shanghai's urban expansion. Both population and economic growth in Shanghai have moderated since their height in 2007, yet both remain high, generating continued pressure on urban infrastructure. Figure 26 shows that as energy intensity decreased over the period, the economic growth partially decoupled from energy use. The combined growth in population and per capita GDP led to a dramatic increase in carbon emissions in this city between 1995 and 2014. Increases in population and per capita GDP result in more production and consumption activities, which, in turn, raise energy consumption and emissions. Shanghai's energy intensity decreased by 77%, but this improvement in energy efficiency had minimal impact on carbon emissions, which means that most of the energy efficiency improvement is off set by increased energy consumption.

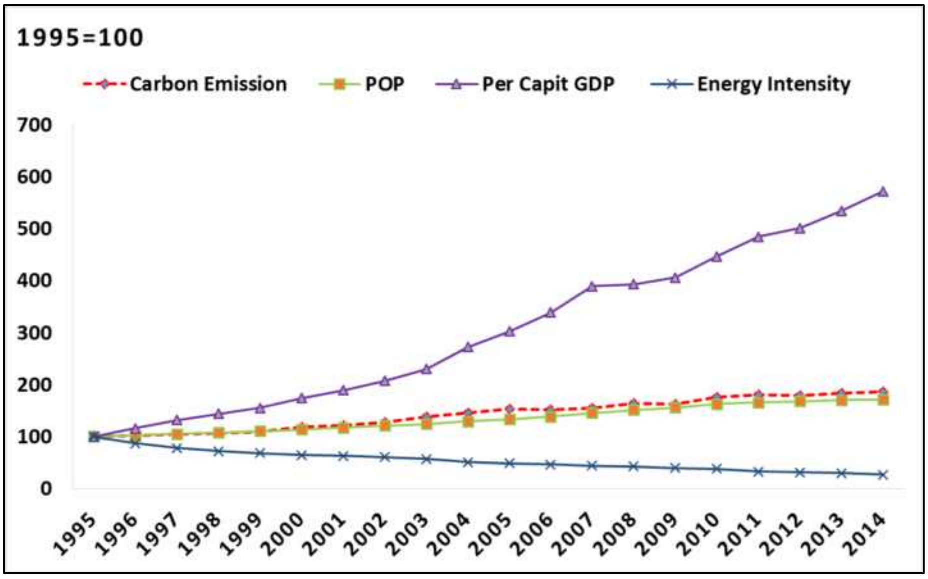

Fig 26. Key drivers of Shanghai's carbon emissions

The results of the analysis of the historical trends of carbon emissions, population, per capita GDP, foreign direct investment and the different sector's share of GPD are reported in Table 14.

Tab. 14 Carbon Intensity Elasticities in Shanghai

	Elasticity
Population	0.1747
Per Capita GDP	0.3862
Primary sector's share of GDP	0.0100
Secondary sector's share of GDP	0.2950
Tertiary sector's share of GDP	-0.0959
Foreign direct investment	0.0624

Among the variables, per capita GDP (0.386), population (0.175), secondary sector's share of GDP (0.2950) and foreign direct investment (0.0624) are positively correlated with carbon emissions, whereas the tertiary sector's share of GDP is negatively correlated (-0.0959), respectively. Shanghai's economic development has led to increased construction and land use development in both the residential and commercial sectors over the last few years. The increase in economic growth also brought forth Foreign Direct Investment (FDI), which has contributed to the higher energy consumption and carbon emissions of Shanghai. The secondary sector comprises energy-intensive, fossil fuel users and plays leading role in increasing carbon emissions through enhancing both direct and indirect consumption resulting in increased carbon emissions. The negative value for the tertiary sector shows that the growth of this sector based on modern, knowledge-intensive, and service-based, has been effective in reducing carbon emissions. Therefore, Shanghai's government should continue to pursue its policy to relocate its heavy industry to make room for the tertiary sector. Moreover, the local government needs to strengthen its economic restructuring policy, not only rely on technological improvements alone to reduce carbon emissions.

3.2.3. Multi-impact assessment of the LEDS in Shanghai

In this section, the multiple benefits from the implementation of the Shanghai Master Plan 2016-2040, as one of the most promising LEDS in Shanghai will be evaluated.

By 2040, Shanghai aims to become an excellent global city, an international economic, finance, trade, shipping, and scientific innovation center, as well as a cultural metropolis. To achieve these goals, the city will take measures to better control construction and population growth, as well as protect the environment and improve urban safety. According to the plan, the city's population will be limited to 25 million by 2040, the same target is set for 2020. Shanghai had 24.3 million residents at the end of 2014.

The total land area allocated for construction will be limited to 3,200 square kilometers, 26 percent of which will be residential, according to the plan. The city's construction land area reached 3,124 square kilometers in 2014, meaning 46 percent of the land area has been developed. Forests and parks will occupy the rest of the city's land to make it ecologically friendly. Forest coverage will reach 25 percent, and each resident will have 15 square meters of public parks or green area on average by 2040, according to the plan. The city's current per capita public green space is about 7 square meters. The average density of PM2.5 emissions will be reduced to about 20 micrograms per cubic meter, compared with last year's 53 micrograms. The total carbon emissions of the entire city and carbon emissions per capita will reach the peak by 2025. By 2035, the total carbon emissions will be reduced by about 5% of the peak value. The city plans to add about 1,000 kilometers to the subway network, 1,000 kilometers to the intercity railway network and another 1,000 kilometers of tram lines.

over 60 percent of residents will have a subway station within 600 meters of where they live. By 2040, the central city public transportation accounted for more than 50% of the total travel mode. The proportion of traffic travel reaches 85%, rail transit. The site's 600-meter area coverage rate is 60%. The detailed information about the Shanghai Master Plan 2016-2040 is given in Table 15.

Tab. 15. Main objectives and targets in Shanghai Master Plan 2016-2040 (LCCI, 2015)

Objective	Target
Population Control	Population resident will be controlled at 25 million by 2040
Construction land control	Construction land will be controlled at 3200km^2 by 2040
Public transportation coverage	Length of Railway (designed speed as 100-250km/h) planned to be more than 1000KM

	Length of subway (designed speed as 80km/h)and light rail (60-80km/h) increases to 1000km
	Use of public transportation reach to 50% in main urban zone
	Use of green transportation researches up to 85% by 2040
	Density of rail transit increases to 1.1 km/km2 in the center city
	Rail transit accessible for the new town with a population more than 100,000
Green Space increase	Public green space per capital reaches to 15 m^2 by 2040
	Forest coverage area reaches to 25%
	Public green space per capital reaches to 7.6m2 by 2040
Green Building Construction	All newly built building should completely meet the green construction standard
Air Quality Improvement	Annual average concentration of PM2.5 which is controlled at25ug/m3
Climate Adaption	Share of renewable energy y reaches to 20% in total primary energy supply mix.
	Total carbon emission reduces to 85% of the peak emission by 2040

Required data for the multiple benefits assessment of the Shanghai Master Plan, were mainly drawn from government statistical yearbooks. Shanghai's energy data can be found in the China Energy Statistical Yearbooks (National Bureau of Statistics, 2016). Other statistics for Shanghai, including GDP, population, sectoral output, government investments in the environment, and foreign direct investment were obtained from the Shanghai Municipal Statistical Yearbooks (Shanghai Municipality Bureau of Statistics, 2016).

To simulate future changes in carbon emissions, we compared the results of the Shanghai Master Plan with three scenarios of future socio-economic development. Among all determinants in all scenarios, GDP and population are the most important ones. Meanwhile, the results reveal that energy consumption and renewable energy generation significantly affect carbon emissions in Shanghai. Based on the findings discussed above, four planning indicators were selected for scenario construction. The predicted values of these planning indicators were based on expert workshops and interviews with the local experts and also literature reviews. Accordingly, the average annual GDP growth rate for Shanghai is expected to be approximately 7% for 2016-2020 and 6% for 2020-2040 (China National Energy Administration, 2012). The indicators of population growth rate, GDP growth rate, Annual decrease rate of energy consumption and growth rate of the share of renewable energies in total energy mix were adjusted as shown in Table 16 to obtain the following four scenarios: slower socio-economic development, rapid socio-economic development and the master plan which was defined as a slower socio-economic development with reinforced energy efficiency programs.

Tab. 16. Scenario definition for the LEDS assessment in Shanghai

	Baseline	**Slow Socio**	**Rapid Socio**	**Master plan**
Average annual growth rate of permanent population (%)	1	0.5	1.3	0.5
Annual GDP growth rate (%)	7	6	8	6
Annual decrease rate of energy consumption (%)	-5	-5	-5	-6
Share of Renewable energy in total supply (%)	<1	<1	<1	20

As shown in Figure 27, future carbon emissions in Shanghai show an increasing trend in all scenarios. The baseline scenario predicts that the cumulative carbon emissions will reach 114.7 MtCO2-eq., while three scenarios predict emissions of 103.8 (slow Socio), 122.8 (Rapid Socio) and 97.1 (Master plan), respectively. The master plan predicts the least amount of carbon emissions. Comparison of the master plan and the baseline scenario reveals that with slower socio-economic development and stronger energy efficiency policies, the cumulative carbon emissions can be reduced by approximately 17.6 MtCO2-eq. Thus, reinforcing energy efficiency policies through relocating the carbon-intensive industries and making room for the knowledge-intensive and service-based tertiary sector could have a significant impact on reducing the total carbon emissions in Shanghai. Although current energy efficiency policies in electricity generation and industries in Shanghai are contributing to total carbon emission mitigation, it is difficult to ignore the fact that a high rate of socioeconomic development will increase carbon emissions in the absence of a major breakthrough in energy-saving technologies.

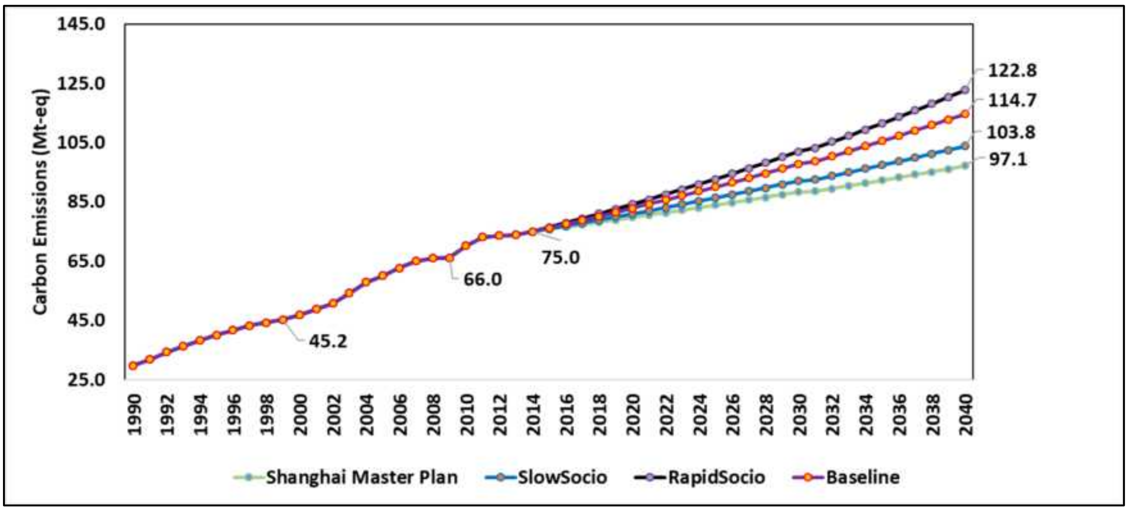

Fig 27. Prediction of carbon emission in the different scenarios

This indicates that the implementation of the Shanghai master plan leads to more efficient resource use, and merely curbing the economic development and population growth does not improve efficiency and may even reduce the efficiency of resource use. The comparison between the energy mix in the baseline scenario and the master plan is represented in Figure 12. This effect is due to the rate of GDP growth being slower than the rate of carbon emissions growth as shown in Figure 29.

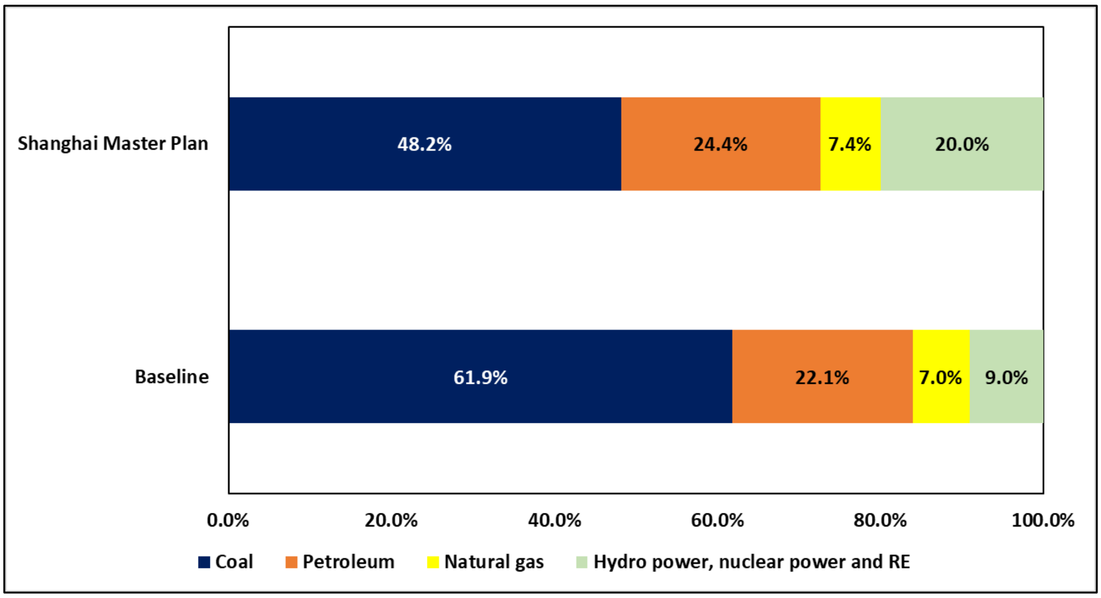

Fig 28. Comparison between energy mix in the baseline and the master plan

The major reduction in coal consumption is expected from boosting green mobility, shutting more outdated steel and coke capacity and gradually improving clean coal's share in the industry sector through replacing it with natural gas and alternative fuels.

The decline in the total amount of carbon emissions from the major sectors such as iron and steel complexes, power plants, transport sector, service sector, chemical industries, and other sectors, compared to the baseline scenario are expected are expected to be approximately 2.8, 5.6, 4.9, 1.1 ,0.9 and 2.3 MtCO2-eq, respectively (Figure 30). As coal has often been criticized for its higher impact on the environment, Shanghai has made a move to close down smaller old coal-fired plants to open bigger high technology ones which not only have higher capacities but are also more energy efficient. In fact, the older coal-fired plants are estimated to consume 30 to 50 percent more coal than newer models. While they make up for half of Shanghai's yearly coal use, they can only generate 30 percent of Shanghai's total power supply. For Shanghai Municipality, all power plants with small generation units of 2.108 GW shall be shut down during the implementation of the master plan. The Three Gorges Dam mainly generates the 8000 MW of Shanghai's imported power. Acceding to the master plan, Shanghai municipality is supposed to import more hydropower which is considered as renewable and clean energy to reduce its controversial high share of coal-generated power. Shanghai municipality will increase the wind power installed capacity to 200-300 MW in 2030. Nevertheless, offshore wind farms bear a higher potential for Shanghai in the future.

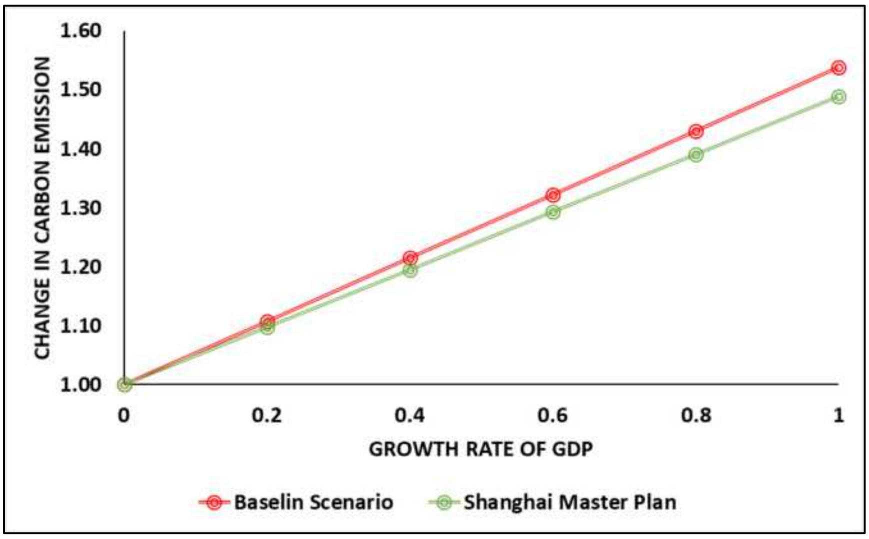

Fig 29. Change in carbon emission Vs. Growth rate of GDP

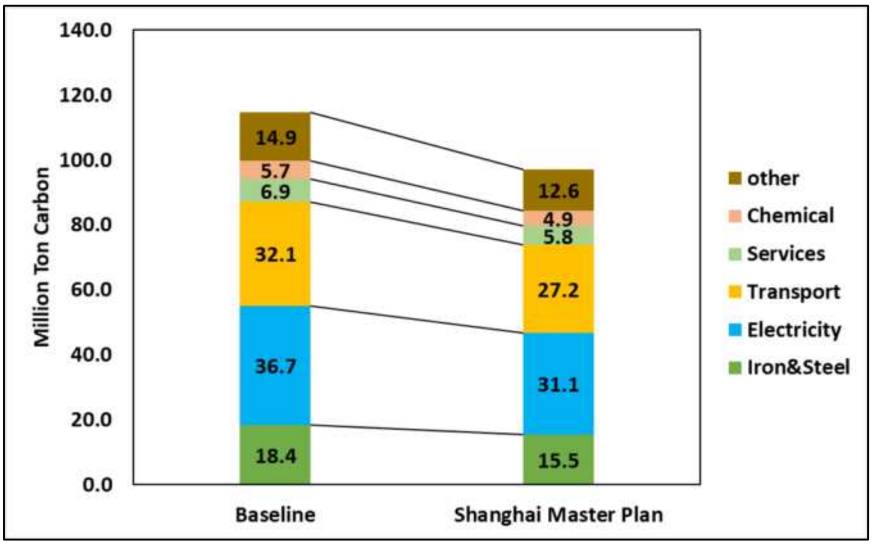

Fig 30. Sector-wise comparison between carbon emission in the baseline and the master plan

While Shanghai tries to promote clean energies, it must be noted that the main goal will remain to ensure power supply security. Even state authorities acknowledge that renewable energies will only play a marginal role in the future, mainly because of higher generation costs and lack of space. Shanghai Municipality is favoring the extension of the domestic natural gas network as it is considered cleaner energy. Thus, efforts are made to increase the population's access to natural gas, especially in populated areas.

Comparison of the Shanghai master plan and other scenarios also shows that reinforcing energy efficiency policies will have positive effects on per capita carbon emissions and per unit GDP carbon emissions, and the lowest per capita carbon emissions occurred in the master plan. Hence, controls on economic development and population growth are essential in reducing total carbon emissions in Shanghai. However, it is challenging to realize sustainable socio-economic development by controlling only economic development and population growth. Therefore, to realize more sustainable and environmentally friendly socio-economic development, evaluating the economic and social benefits of the Shanghai master plan is essential.

Implementation of the Shanghai master plan presents excellent opportunities to contribute significantly to the job creations and raise GDP by the tertiary sector to increase the share of green employment in Shanghai total workforce by 46% in 2030 (Figure 31).

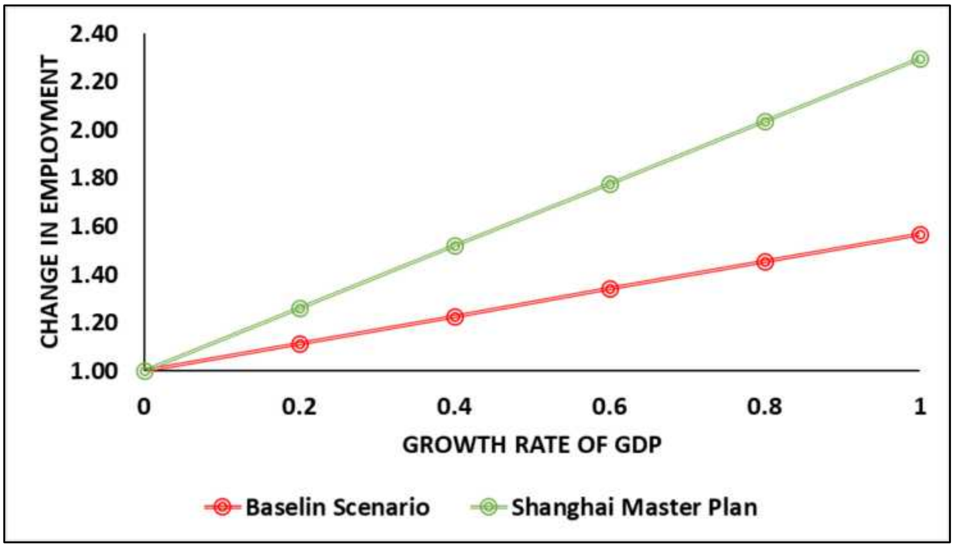

Fig 31. Change in employment Vs. The growth rate of GDP

3.3. Case of Kuala Lumpur, Malaysia

Kuala Lumpur is the capital city of Malaysia, while Putrajaya is the administrative capital, both situated on the west coast of Peninsular Malaysia. Located at the heart of the Selangor state, the economic and social functionality of Kuala Lumpur intertwine with its neighbouring parts of the state of Selangor. As a matter of fact, Kuala Lumpur district was part of Selangor prior to the formation of Malaysia in 1963, which encompassed the current Federal Territory of Kuala Lumpur, Ampang, Batu Caves, Gombak, Ulu Klang, Petaling Jaya Puchong, and Sungai Buloh. In 2010, the term Greater Kuala Lumpur (GKL)/Greater Klang Valley was introduced under the Economic Transformation Program (ETP), to describe the Metropolitan Kuala Lumpur which includes ten municipalities under the Federal Territory of Kuala Lumpur, Putrajaya, and the state of Selangor. These include Klang, Kajang, Subang Jaya, Petaling Jaya, Selayang, Shah Alam, Ampang Jaya, and Sepang from the state of Selangor, together with Federal Territory of Kuala Lumpur and Putrajaya. Kuala Lumpur is located at the center of the Greater Kuala Lumpur/Klang Valley which covers an area of 2422 km^2 as the largest metropolis in Malaysia, contributing to approximately 15% of the whole country's GDP (see table 1). As of 2017, the population of Malaysia stood at 32 million (DOSM 2016b), with approximately 1.79 million in Kuala Lumpur city itself (DOSM 2016a).

Tab. 17. Population and Per capita GDP of Kuala Lumpur (KLLCSB2030, 2017)

	2010	2030
Population	1.6	2.5
Per capita GDP (MYR)	50,670	213,249
KL/National GDP Share	15%	16%

In terms of energy consumption, the final energy demand and electricity demand for Kuala Lumpur from 2005 to 2015 have been shown in Figure 33. The final energy demand has increased by 35.3% from 4922 ktoe in 2005 to 6660 in 2015. For the year 2015, the transport sector makes up the most significant chunk of final energy usage, i.e., 62.2%, followed by industrial (21.5%) and then residential and commercial (12.9%).

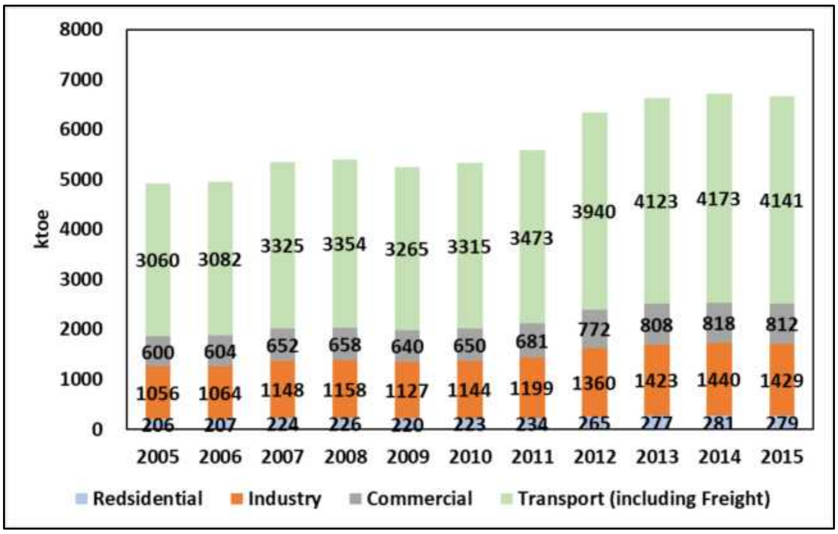

Fig 33. Final energy demand by sector in Kuala Lumpur

Figure 34 shows the trend of GHG emissions in Kuala Lumpur. It can be observed from this figure that, the GHG emissions in Kuala Lumpur has increased from 16.3 Mt_{CO2eq} in 2010 to 18.6 Mt_{CO2eq} in 2015. The GHG emissions from the commercial sector accounted for 63.3% of total GHG emission, followed by the transport sector (36.8%) and Industry (23.4%).

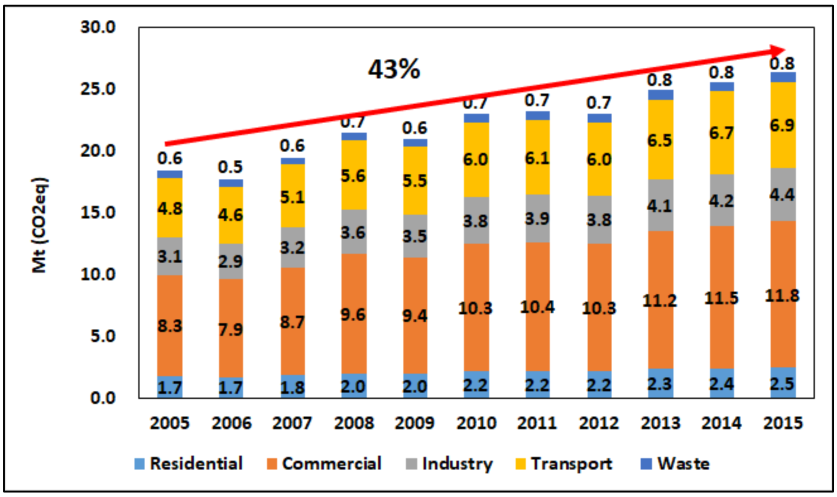

Fig 34. GHG emissions by end-use sector in Kuala Lumpur

It is expected that LEDS will play an important role in reducing the GHG emissions in this city, and comprehensive policies that support the development of LEDS will be instrumental toward this cause.

3.3.1. LEDS in Malaysia and the Greater Kuala Lumpur

Malaysia is a federation consists of 13 states and 3 federal territories. While the governing power of the country, as a whole, lies in the hand of the federal government, each state has its own state government holding a certain level of legislative powers. The partitioning of legislative powers between state and federal government is defined under Schedule 9 of the Federal Constitution. The powers are classified into three lists: The Federal list, the State list, and the Concurrent list, with the federal law prevailing over the state law in the event of any inconsistency. Within each state, there are several municipalities with their own governing local authority which are controlled by the state government, except for the municipalities within the federal districts. In Malaysia, the federal government controls the main economic revenues in the country and hence is more dominant over the state government in deciding policies and their implementation.

At the federal government level, the recent restructuring of the government has seen the formation of a new ministry known as the Ministry of Energy, Science, Technology, Environment and Climate Change (MESTECC). MESTECC consolidates the Ministry of Science, Technology and Innovation (MOSTI) with the energy and green energy components from the Ministry of Energy, Green Energy and Water (KeTTHA), as well as the environment and climate change components from Ministry of Natural Resources and Environment (MRE) into a single ministry. Currently, MESTECC is the custodian to energy development in Malaysia, inheriting the statutory bodies and agencies previously under KeTTHA, such as Energy Commission (EC), Sustainable Energy Development Authority (SEDA), and Malaysia Green Technology Corporation (MGTC). At the higher level, the Economic Planning Unit (EPU) under the Prime Minister’s Office influences the general direction of the development of energy sector in Malaysia through the high-level policymaking, including the formulation of Malaysia Plans (MPs) every 5 years. Under EPU, there is an Energy Section dedicated for drafting policies and strategies for the sustainable development of the energy sector, promoting oil and gas industries development and the utilization of renewable energy and energy efficiency in the energy sector, and providing a fiscal allocation for energy-related development programs (See Table 18)

Tab. 18. Governance structure of LEDS in Malaysia (Nasrudin et al., 2018)

Governing Body	Role	Action
Ministry of Energy, Science, Technology, Environment and Climate Change (MESTECC).	Planning and implementation of policies and programs related to energy, green technology as well as environment in Malaysia	Green and Efficient Energy - To increase the percentage of renewable energy in generation mix from 2% to 20% - To improve energy efficiency in the nation - To improve the efficiency and transparency of the energy market to ensure the best rate for the users. Environment and Climate Change - To lead the country towards (non-biodegradable) plastic-free future - To reduce pollution through better education and enforcement - To prepare the country to resolve climate change issues through adaptation and mitigation Science and Technology - To encourage demand driven R&D through close collaboration with industry. - To increase commercialization of technology to the market - To increase productivity of the industry through the application of science and technology
Energy Commission (EC)	Ensuring regulations on the economic, technical, and safety aspect of the electricity and gas energy	- To promote economy in the generation, transmission, distribution, supply, and use of electricity and in the reticulation and use of gas - To promote competition, enable fair and efficient market conduct, and prevent the misuse of monopoly or market power in the electricity and piped gas industries - To ensure security, reliability, efficiency, and quality of supply and services in the electricity and piped gas supply industries - To protect the industry, consumers, and public from dangers arising from the generation, transmission, distribution, supply, and use of electricity and the distribution, supply, and use of piped gas.
Sustainable Energy Development Authority (SEDA)	Managing the implementation of - Renewable Energy Programs, most notably Feed-in tariff (FiT) and Net energy metering (NEM) - Commercial sector energy efficiency program through Energy Audit Conditional	- Focus on sustainable energy which includes - developing, promoting, implementing, and monitoring of sustainable energy-related policies - Handling of feed-in tariff (FiT) and later Net Energy Metering (NEM).

	Grant under RMK11 Energy Efficiency Projects.	
Malaysia Green Technology Corporation (MGTC)	Planning and research on energy and energy efficiency and helping to achieve the objective of the National Green Technology Policy, via four flagship programs	- To perform studies related to the development or demonstration of energy technologies - To collect related energy data - To help finance companies that venture into green businesses (Green Technology Financial Scheme). - To lead the development of the Green Technology Master Plan - To help identify and promote product and services that meet international environmental standards - To support electric mobility through the installation of electric vehicle chargers around Malaysia - to assess and guide the development of townships/cities based on Low Carbon Cities Framework (LCCF), toward the awarding of the Diamond Rating Certificate by KeTTHA. - To handle the Energy Management Gold Standard certification process.

Due to the governance structure explained in the previous section, the policies and their implementation in Malaysia are often done in a top-down manner, where the federal government decides the direction of developments. The most important central government policy in Malaysia is the Malaysia Plan, presented every 5 years to outline the general directions for the nation's development and influence the funding allocations for the subsequent 5-year duration. On top of the Malaysia Plan, policies will be developed and implemented, sometimes as general guidelines or masterplans and sometimes enforced as Acts. The direction of energy usage in Malaysia was set forth in the 1970s where Malaysia relies mainly on fossil fuels as its primary source of energy (Bujang et al. 2016). In 1979, the National Energy Policy was introduced in the wake of the oil price crisis in the 1970s, covering the following objectives: (1) ensure an adequate and cost-effective supply, in essence, maximum use of domestic resources, (2) utilize energy efficiency and conservation and eliminate wasteful consumption, and (3) protect the environment or achieve the other two objectives without degrading Malaysia's rich ecological and social heritage. Shortly after, the Four-Fuel Diversification Strategy was introduced in 1981 to strategize the source of energy based on four main resources, namely, oil, natural gas, coal, and hydro.

As the center of administrative and economic development in Malaysia, the implementation of renewable energy and energy efficiency measures in the Greater Kuala Lumpur (GKL) is important. Nevertheless, gathering energy data specific for this region appears to be a challenging task due to the following reasons:

1. Lack of a single governing body for GKL:

   As explained before, the Greater Kuala Lumpur encompasses multiple municipalities under the Selangor state government as well as the federal government. As a result, there is a lack of a single administrative entity that caters for the policy-making and implementation-specific for the GKL region. Currently, the development of clean energy policies and renewable energies (RE) in GKL is subjected to the same central policies explained in the preceding sections. On the policy level, there is no clear focus toward or away from GKL, such that the final decision lies on the implementing agencies or RE installers based on subjective considerations for, e.g., cost and convenience.

2. Lack of data collection specific to GKL region:

   Being officially coined during the introduction of the Economic Transformation Program in 2010, the definition of GKL is relatively new. As of now, data related to RE are collected based on different classifications of regions depending on the data collection agency. Data collected are usually classified according to region (Peninsular, Sabah, and Sarawak) or based on states. Since GKL contains part of the, but not entire, state of Selangor together with Kuala Lumpur and Putrajaya, extracting data specifically for GKL remains challenging.

In terms of RE installation (under the FiT scheme) within the GKL region, data can be manually extracted from the RE Capacity Map from SEDA (n.d.). Apart from solar PV systems, an only limited amount of biogas and biomass plants have been installed in the region, as shown in Table 19. Due to the geographical reason, mini-hydropower is not possible within the GKL. Among the four main types of Res, solar PV remains the most feasible RE source in GKL. Under the new NEM scheme, it is anticipated that solar PV installation will continue to grow in GKL area. However, for LSSPV, the potential for installation in GKL is not high due to (i) high land cost and (ii) relatively lower solar potential compared to other parts of Malaysia, particularly in the Northern region. Nevertheless, since GKL draws its electric power supply from the same supply network in Peninsular Malaysia, installation of any grid-tied RE within the Peninsular will practically benefit the GKL region in terms of GHG reduction. Instead of relying on direct RE installation, the effort toward developing cleaner and greener GKL should consider other measures such as through improving the energy efficiency and embracing greener mode of transportations.

Tab. 19 Company, location and installed capacity for biogas and biomass RE under FiT scheme (Nasrudin et al. 2018)

RE type	Company	Location	Capacity (MW)
Biogas	SOLAR PATH SDN BHD	KUALA LUMPUR, W.P. KUALALUMPUR	0.064
	BIOGAS SULPOM SDN BHD	DENGKIL, SELANGOR DARUL EHSAN	2.5
	JANA LANDFILL SDN BHD	PUCHONG, SELANGOR DARUL EHSAN	1.9572
	JANA LANDFILL SDN BHD	KUALA SELANGOR, SELANGOR DARUL EHSAN	1
	SIME DARBY INDUSTRIAL POWER SYSTEMS SDN. BHD.	BESTARI JAYA, SELANGOR DARUL EHSAN	1.6
		Total	7.1212
Biomass	TENAGA SULPOM SDN BHD	DENGKIL, SELANGOR DARUL EHSAN	7
	TEX CYCLE (P2) SDN BHD	KLANG,SELANGOR DARUL EHSAN	2.5
	COMINTEL GREEN TECHNOLOGIES SDN BHD	GOMBAK, SELANGOR DARUL EHSAN	2.2
		Total	11.7

3.3.2. Multi-impact assessment of the LEDS in Kuala Lumpur

3.3.2.1. Green mobility plan in the transport Sector:

The transportation sector is one of the major contributors to global carbon emissions in Kuala Lumpur. The population of Kuala Lumpur is expected to reach 2.5 million by 2020. Alongside population growth in this city, increase in the use of individual motorized transportation has been consistently growing. Although the population growth rate is considered to be an important factor that affects vehicle ownership, another critical factor is the city's GDP. Figure 35 shows the per capita Passenger- kilometer (PKM) mobility in Kuala Lumpur. The city experienced the rapid expansion of demand in urban transport during past decay. These changes have led to transportation networks with high traffic volumes of private transportation modes and congestion, which has resulted in adverse health effects such as respiratory and heart diseases. Figure 36 shows the projection of the vehicle population in this city. It can be observed from this figure that, the saturation level for the road vehicles is estimated at 6.5 million cars in 2030.

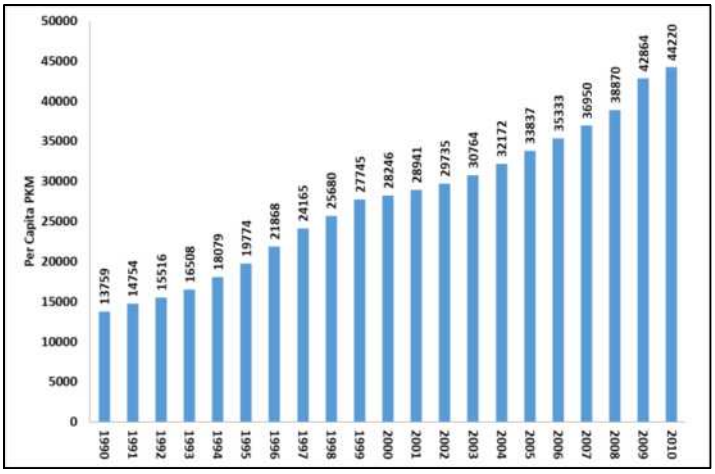

Fig 35. Per capita PKM in Kuala Lumpur

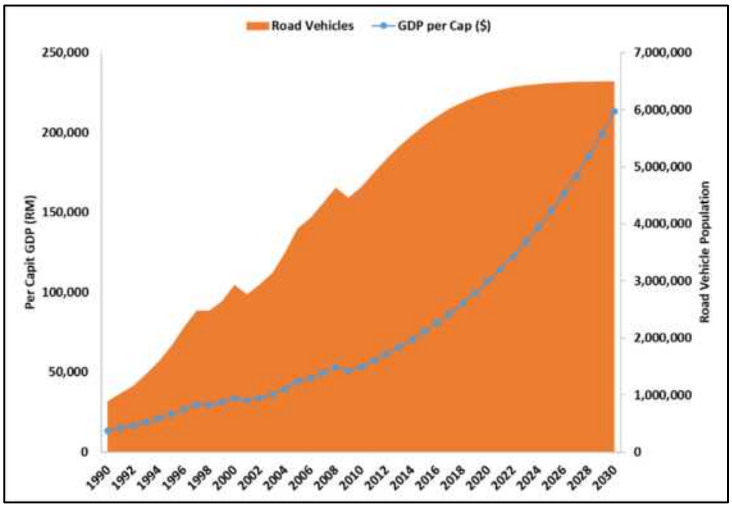

Fig 36. Baseline projection of the road vehicle population with per capita GDP in Kuala Lumpur

Along with the intensified urban development, the prediction of the travel demand is represented in Figure 37. As a direct result of the incremental growth of private vehicles, the demand for energy in the transport system in Kuala Lumpur is predicted to increase by a factor of 1.5, and the city is expected to experience a significant increase in fossil fuel consumption. Figure 38 shows the projection of energy consumption from 2010 to 2030 in the transport sector. The massive increase in demand for energy in this sector from 1873 ktoe in 2010 to 2900 ktoe in 2030 will be dominated by gasoline fuel. As depicted in Figure 39, the total GHG emissions show an increasing trend from 6 Mt CO_2-eq in 2010 to 9.2 Mt CO_2-eq in 2030.

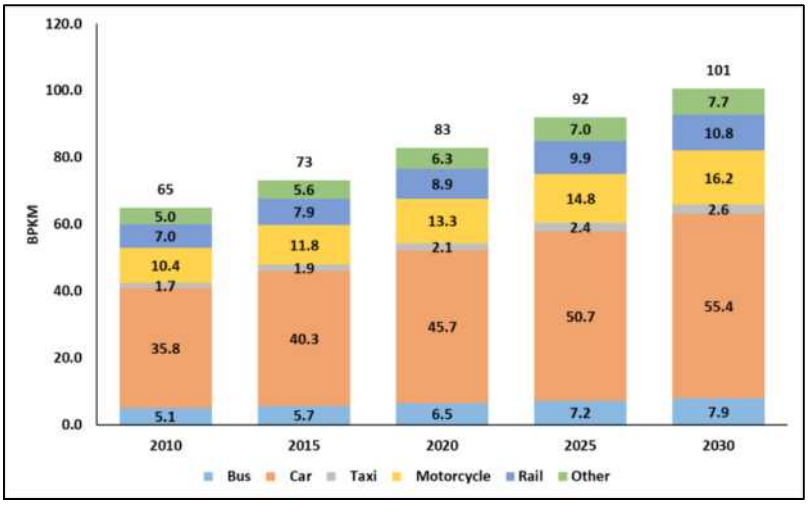

Fig. 37. Baseline projection of travel demand in Kuala Lumpur's urban transport sector (excluding Freight)

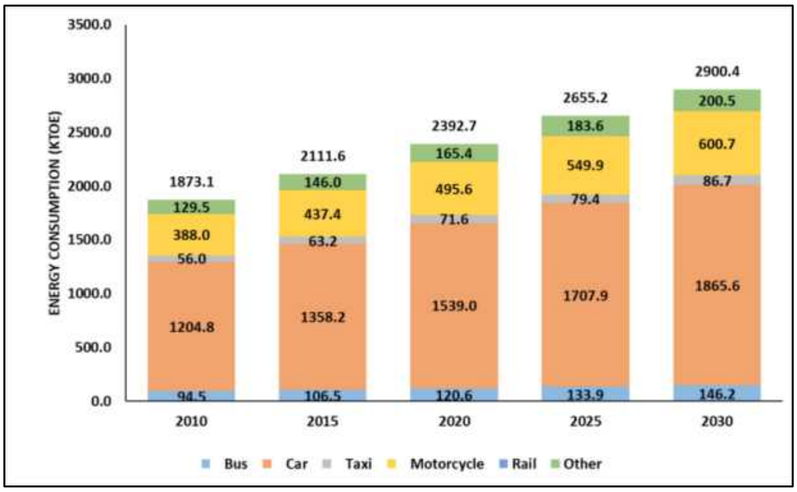

Fig. 38. Baseline projection of energy demand in Kuala Lumpur's urban transport sector (excluding Freight)

In the air pollution indicator, the highest weight is pollutant CO, and the lowest weight is SO_2. The significant rise in CO emissions from the transport sector to 100 thousand tons in 2030 can be mainly attributed to the combustion efficiencies and traffic conditions in the Kuala Lumpur metropolitan area. Similarly, THC, NOx, and PM_{10} levels are expected to increase to 13.7, 14.5, and 2.3 thousand tons by 2030, respectively (Figure 40).

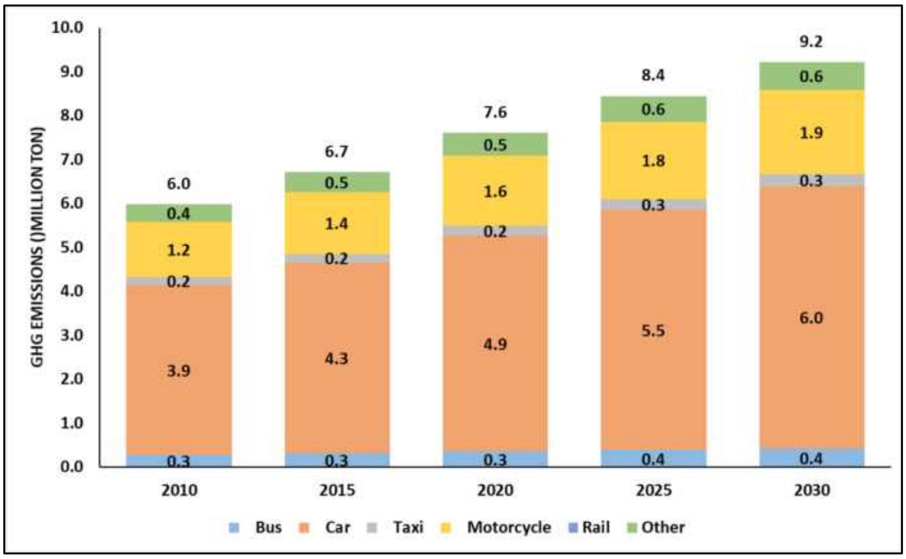

Fig. 39. Baseline projection of GHG emissions in Kuala Lumpur's urban transport sector

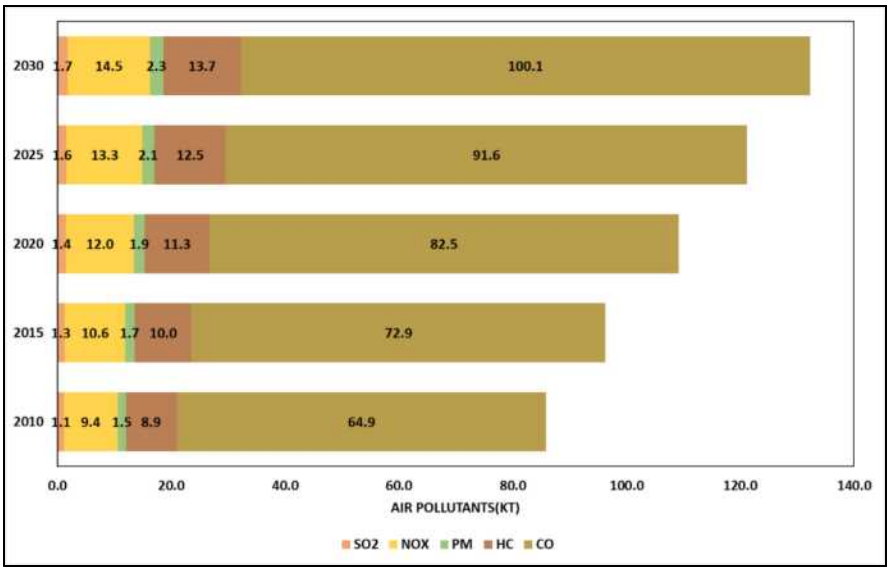

Fig. 40. Baseline projection of Air pollution in Kuala Lumpur's urban transport sector

The local government needs to develop greener and more efficient transportation system shortly to reduce the GHG emissions and air pollution and also to provide a better quality of life for Kuala Lumpur residents. Basically, "*Green Mobility"* is about making transport convenient, more comfortable, accessible, and more efficient to get around in Kuala Lumpur, which is possible through introducing the following actions in this sector:

1) **Increase in share of Mass Rapid Transit:** A medium-term transit network plan has been commissioned to complement the newly operational Mass Rapid Transit (MRT) line and extension of existing Light Rapid Transit (LRT) and Monorail lines.

2) **Increase in share of None Motorized Transport:** In the context of Kuala Lumpur, promoting walking and cycling as an alternative to short car trips are seen as one of the essential strategies to decelerate the increase in car use. It would be possible through designing and allocating an exclusive space for cyclist with the use of pavement markings, bicycle parking and storage facilities

3) **Shift from Diesel bus fleet to CNG and electric bus fleet:** Local government needs to start phasing out 20% of current conventional diesel buses with the CNG or electric buses.

4) **Shift from cars to public transport:** Increasing the share of rail transport from 10.7% to 20%. Also, replacing 25% of cars, LVs, and SUVs with buses.

5) **Increasing share of hybrid vehicles:** Promoting 15% of hybrid vehicle fleet through the implementation of the tax intensive mechanism. The government should consider reducing taxes for any green transport purchased by the operators.

6) **Transport Demand Management (TDM):** In order to reduce the demand for roadway travels, especially in single occupancy vehicles, Transportation Demand Management (TDM) is seen as one of the best measures for Kuala Lumpur. A Congestion Pricing Scheme (CPS) would be needed to avoid increasing traffic congestion in the selected areas such as: Jalan Sultan Ismail, Jalan Parlimen, Jalan Damansara, Jalan Hang Tuah, Jalan Hang Jebat, Jalan Maharajalela, Jalan Pudu, Jalan Bukit Bintang, Jalan Kia Peng, Jalan Ampang, Jalan Yap Kwan Seng, Jalan Tunku Abdul Rahman and Jalan Raja Abdullah. It will result in reducing the transport demand from 4.3 to 3.7 trips per person per day by 2030.

According to the Green mobility plan, a modal shift from private modes to the public transport systems, including the metro and BRT, can help reduce energy consumption, CO_2 emissions, and the pollution load in the city of Kuala Lumpur. On major streets in this city with relatively high traffic congestion, public transportation modes, like such as buses and trains, are more fuel efficient. Therefore, improving BRT priority lanes in the Kuala Lumpur will increase energy efficiency in transportation by reducing traffic congestion, and the travel speed and comfort level of the passengers will also be improved. Based on the Green mobility plan, the future modal splits in Kuala Lumpur is shown in Figure 41. The modal share of the public transport will increase from 19% in the baseline scenario to 42% in the Green mobility plan.

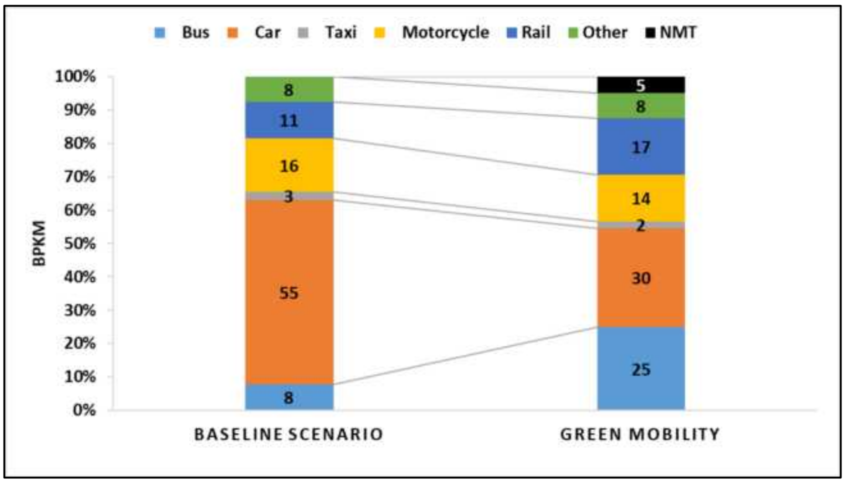

Fig. 41. Modal Split in 2030 (Baseline Vs Green Mobility)

The fuel-saving potential from the implementation of the Green mobility plan is estimated at about 27.3% of the total energy consumption of Kuala Lumpur's transport system in 2030. The most significant saving, estimated at 531 million liters in 2030, is expected to result from reducing gasoline consumption by private vehicles, as shown in Figure 42.

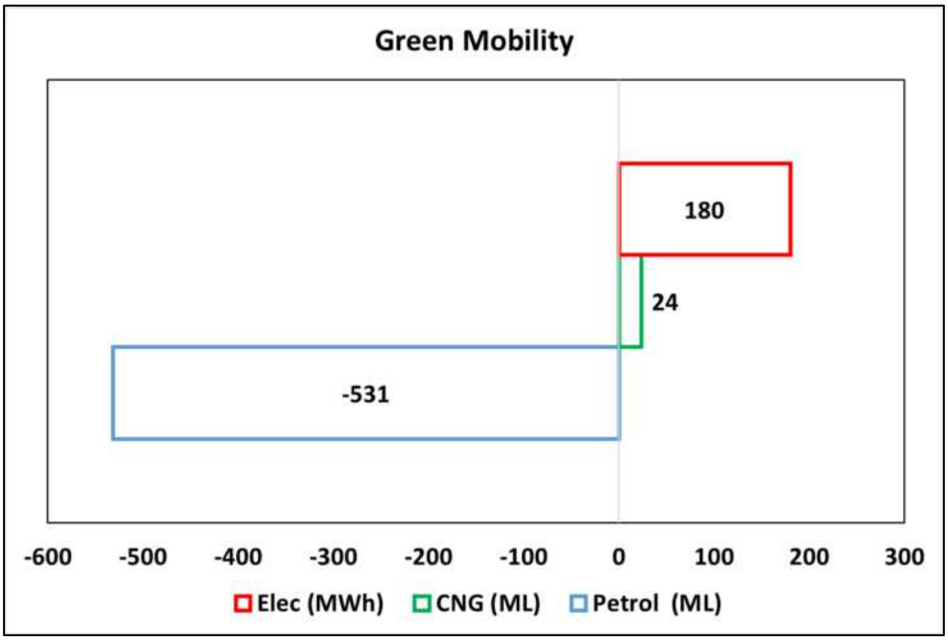

Fig. 42. Energy consumption reduction in Green mobility compared to the baseline scenario in 2030

As shown in Table 20, the decline in the total amount of harmful gas emissions, such as SO_2, NO_X, PM_{10} and CO, compared to the baseline scenario are expected to be approximately 23%, 15.8%, 13% and 23.8%, respectively. Table 21 shows the estimated annual reductions in the mortality rate from the Green mobility in Kuala Lumpur.

Tab.20. Expected GHG emissions reduction and co-benefits from the Green Mobility in 2030

		Air Pollutants (kt)			
	GHG (Mt)	**SO2**	**NOX**	**PM**	**CO**
Baseline	9.2	1.7	14.5	2.3	100.1
Green Mobility	7.3	1.3	12.2	2	76.2
Reduction	-1.9	-0.4	-2.3	-0.3	-23.9

Tab 21. Estimated annual health outcomes from the LEDS in Kuala Lumpur

	Health outcomes (deaths prevented/ year)		
Exposure metric and sub groups	SO_2	NO_X	PM_{10}
Total mortality and short term exposure (all ages)	542	1154	3334

3.3.2.2. Sustainable urban energy system

Kuala Lumpur's energy profile is affected by many factors, including population, income, economic structure, energy prices, end-use efficiencies, climate conditions, urban forms, built environments and access to regional and national energy markets. Implementation of mitigation measures in the energy sector can play an essential role in increasing the sufficiency of resources to meet energy demand at competitive and stable prices as well as improve the resilience of the energy supply system in this city. Specifically, mitigation actions result in:

- Strengthened power grid reliability through the enhancement of properly managed on-site generation and the reduction of the overall demand, which result in reduced power transmission and distribution losses and constraints;
- Increased diversification of energy sources as well as the share of domestic energy sources used in a specific energy system

In Kuala Lumpur, GHG emissions reduction measures in the building and waste sectors offer substantial urban climate mitigation potential through the implementation of efficiency measures.

The sustainable urban energy system scenario, which is defined here covers the following actions:

1) **Solar energy utilization**: This action includes an efficient enhancing and conversion of solar energy into electricity through utilizing the rooftop photovoltaic system, a small-scale solar farm and solar water heater system. The building area in Kuala Lumpur is about 2700 hectares, where 30% of its roof areas can be installed with PV. Kuala Lumpur receives approximately 1500 kWh/m^2 of solar radiation a year. Therefore, the Roof-top PV systems are expected to generate up to 1970 GWh/y of electricity in this city. The new Net Energy Meter (NEM) scheme is expected to encourage the uptake of solar PV system among consumers. A typical solar collector can be used to replace an electric water heater with a saving of 10 kWh/y. Estimating that 80% of total dwellers replacing their current electric waters, a total saving up to 260 GWh/y of electricity can be expected from the installation of the solar water heaters in this city. Due to land scarcity and high land value in Kuala Lumpur, a solar farm project can be a big challenge. "*Taman Beringin Solar Farm"* is one of the suitable projects to be built on the landfill about 16 hectares capable of generating up to 48 GWh/y of electricity.

2) **Waste-to-Electricity:** Existing solid waste expenditure levels increased in Kuala Lumpur in line with the pattern of the economic standard of living and consumption rate. The government's participation in waste campaign program in early 2010 has yet to bring significant positive impact on the communities. Recovering energy from Municipal Solid Waste (MSW) and convert it into electricity by introducing new waste-to-electricity system contributes to GHG emissions reduction in Kuala Lumpur. On average, solid waste per capita output is about 0.85 kg/capita/ day in Malaysia. In the Kuala Lumpur State Territory estimated of 1.5 kg /capita/ day which results in 1.36 million tons of solid waste in a year which consists of: 45% are organic waste (food waste), 24% are plastics, 7% paper, 6% metal and 18% are glass and others. With incineration technology, one ton of MSW can be used to produce up to 1 MW of electricity. MSW Incineration process can be a promising technology to manage waste and produce the energy needed to promote the economic growth in this city. Modern incineration facilities can generate combustion temperatures of more than 850 degrees Celsius, which is the minimal level necessary for maximum efficiency in the destruction of potentially hazardous organic materials. However, scrubbing technology eliminates most of the contamination in flue gases before it is released, and only trace amounts of dioxin will exit smokestacks. Large-scale modern solid waste incineration plants can process 250 tons or more of garbage per day.

3) **End-use Energy Efficiency (EEE) improvement:** Besides promoting renewable power generation and waste-to- electricity, another way of minimizing the carbon emissions from the anthropogenic activities is by enhancing energy efficiency. Despite having industrial sector gradually phased out from Kuala Lumpur city, the direct and indirect emissions from both commercial and residential sectors are still undeniably significant. As a countermeasure, a practical implementation of the energy management system and some useful End-use Energy Efficiency (EEE) programs shall be scrutinized. The application of a EEE program based on the international standards like ASEAN Energy Management Accreditation Scheme (AEMAS) is an important step for this city too cut the GHG emissions and other air pollutant emissions. Implementation of the energy monitoring system in the residential, commercial and industrial sectors is one of the critical steps to track the energy usage based on the different consumption patterns which could lead to a significant savings of energy and GHG emissions. For a practical implementation of this system, smart meters, network infrastructure, and online monitoring software should be invested. Statistically, the implementation of the EEE program contributes to a 15% reduction in energy usage in Kuala Lumpur. However, these energy efficiency strategies are always economically less favorable and barely achieve quick payback. Therefore, sufficient funding and subsidies have to be provided for incentivizing these energy efficiency strategies.

The total potential reduction in GHG emissions from the implementation of the sustainable urban energy system scenario in Kuala Lumpur is estimated at 26.4% which is illustrated in Figure 43. The most significant reduction can be obtained from the EEE program, followed by solar energy utilization and waste-to-electricity. The expected co-benefits in improving the air quality from this scenario is given in Table 22.

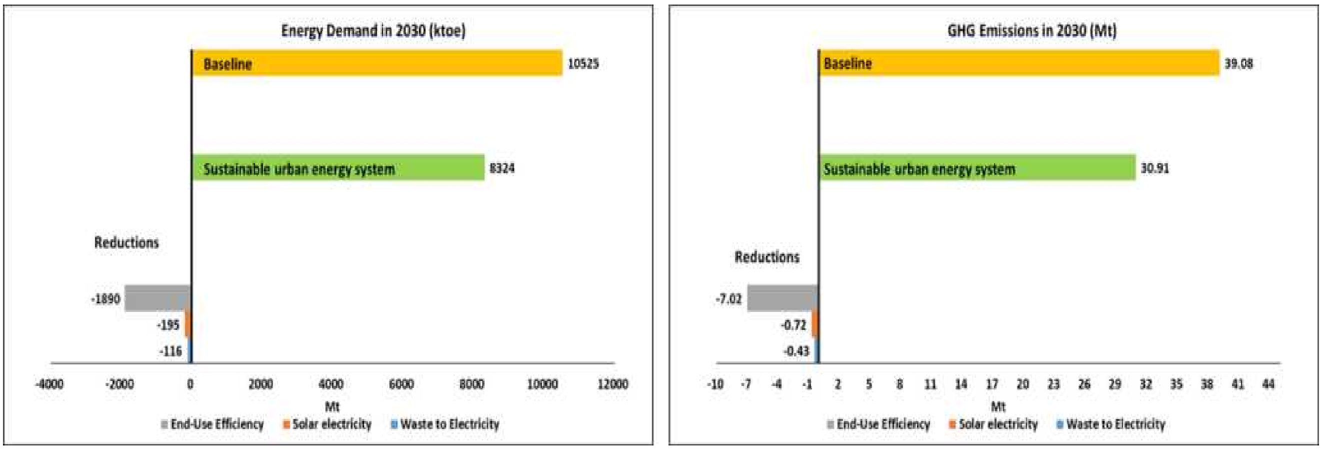

Fig. 43. Potential reduction in energy demand and GHG emissions from the sustainable urban energy system scenario in 2030

Tab.22. Expected co-benefits from sustainable urban energy system scenario in 2030

	CO	NMHC	NOx	SO2	PM10	PM2.5
Waste to Electricity	-0.2	-0.9	-5.4	-19.2	-0.6	-0.2
Solar electricity	-0.4	-1.6	-9.1	-32.2	-0.9	-0.3
End-Use Efficiency	-4.0	-15.3	-87.8	-312.5	-9.0	-2.5

3.4. Best Practices in LEDS

In this section, two best practises from Sydney, Australia and Tokyo, Japan will be analysed.

3.4.1. Sustainable Sydney 2030

In 2011, the City of Sydney became the first of any level of Government in Australia to be certified as Carbon Neutral under the Australian Government National Carbon Offset Standard (NCOS). The City has been measuring, reducing and offsetting its operational GHG emissions since 2006 (Figure 44). The city reduced its GHG emissions by 25.2 % since 2006. Buildings contributes to more than 50% of the total GHG emissions in Sydney, followed by parks and street lighting. (Figure 45). However, the potential reduction in buildings are more than 30% below 2006 levels.

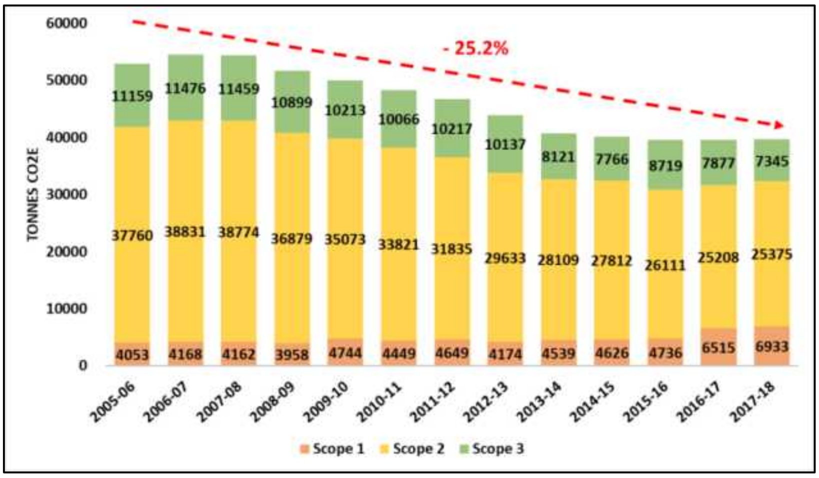

Fig 44. Annual emissions by scope in Sydney (Council)

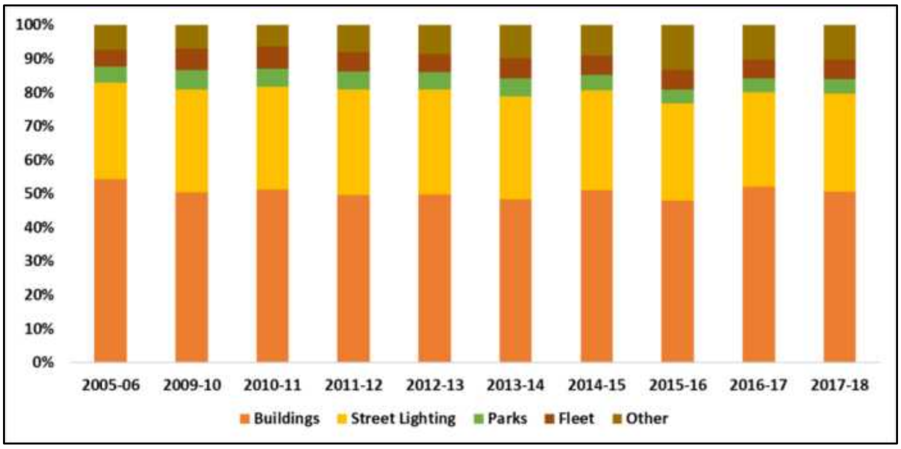

Fig 45. Share of different sectors in total GHG emissions in Sydney (Council)

Table 23 shows energy consumption data for the city of Sydney (LGA). It is important to note that while the city's natural gas consumption has been increasing due to its substitution with electricity, total energy consumption has decreased which an annual decline rate of 2.7%.

Tab 23. Energy consumption in the city of Sydney (LGA)

Unit: PJ	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
Electricity	15.1	15.1	15.3	14.9	14.7	14.5	14.0	13.6	13.1	13.0
Gas	3.0	3.1	3.1	3.2	3.2	3.2	3.3	3.3	3.3	3.5
Total	18.2	18.2	18.4	18.1	17.9	17.7	17.3	16.9	16.4	16.5

Since 2006, energy used by buildings has already dropped by five per cent – at the same time as Sydney experienced one of the fastest economic growth rates in Australia. This falling energy trend has occurred at the same time as rapid economic growth. This trend is measured as improved "energy productivity", the amount of economic output per unit of energy input which is shown in Figure 46. It demonstrates clearly how economic growth no longer requires more energy consumption in this city as a developed and modern urban area and how Economic growth in Sydney is becoming decoupled from growth in energy use.

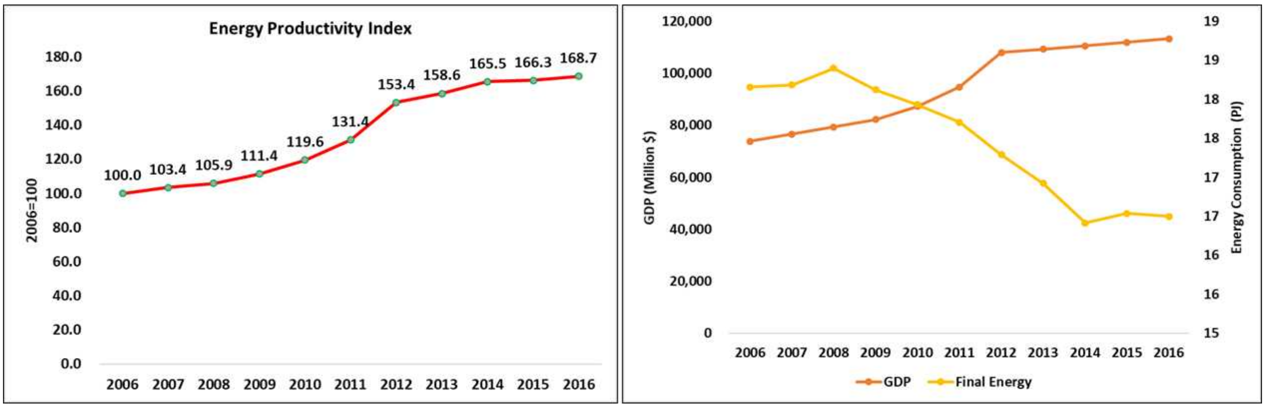

Fig 46. Energy Productivity Index with progress in GDP and decline in final energy consumption in Sydney

Sustainable Sydney 2030 is a set of goals within the long-term plan for reducing GHG emissions, supporting Sydney's culturally and socially diverse community, increasing the economic prosperity of the citizens and making the city dynamic that's safe (COS, 2019). The plan has different fronts including 1) Low carbon city, water sensitive city, zero waste city, active and connected city, green and cool city. Among all goal, those which are related to the LEDS are listed as follows:

1) Co/Trigeneration: It includes combined cooling, heat and power (CCHP), the facilities by which some of the heat produced by a cogeneration plant is used to generate chilled water for air conditioning or refrigeration (Clarke Energy, 2019). These facilities will be installed at Town Hall House, Cook and Phillip Park Aquatic Centre, Ian Thorpe Aquatic Centre and Gunyama Park Aquatic and Recreation Centre (COS, 2012).
2) Building upgrades which includes savings from efficiency improvements in the most resource intensive buildings
3) Rooftop solar Photovoltaics coupled with battery storage which can deliver 15 % of electricity demand (COS, 2018)
4) LED lighting upgrades based on an agreement with Ausgrid (the owner of the street lights) to replace the conventional lighting system with the more efficient LED lights. It is expected to replace about 3500 street lights on residential streets in the City.
5) Off-site renewables which can integrated into the city's green power projects.
6) Waste diversion/advanced waste treatment which reflects savings from avoided landfill emissions.
7) Transport emissions reductions through using the low carbon-intensive vehicles and managing the

transport demand by following ways (COS, 2018):

- 33 % of trips to work during the AM peak undertaken by walking by 2030, by city residents
- 10 % of total trips made in the city are undertaken by bicycle by 2030
- 80 % of trips to work during the AM peak are undertaken by public transport by2030, by city residents and those travelling to Central Sydney from elsewhere
- 30 per cent of city residents who drive (within unrestricted driver's license) are members of a car sharing scheme by 2030.

8) Offsets and future opportunities include savings that could be made from transport, waste, renewable energy, energy efficiency, regulatory and/or technological improvements, or other opportunities. Offsets could be purchased by those entities generating emission.

According to the Sustainable Sydney 2030, the total emissions across the city should be reduced by 70% below 2006 levels. The program main achievements as at June 2018 based on the council green environmental sustainability progress report are reported as follows:

- ✓ 4261 Solar PV panels installed to date across 38 sites
- ✓ 7% reduction in combined fleet emissions from 2014 baseline of 2417 t CO2-e
- ✓ 59% commercial office space in partnership
- ✓ 21% commercial office space committed to program
- ✓ 77 buildings with carbon neutral commitments
- ✓ 10 CitySwitch members become carbon neutral
- ✓ 138 tonnes reduction in waste generation by city properties
- ✓ 8% increase in recycling of waste from city streets and parks
- ✓ 32370 new shrubs and grasses planted in city parks and streets
- ✓ 48% of the hotel rooms involved in program
- ✓ 1313 apartment buildings involved in program

Figure 47 represent the potential to reduce carbon dioxide (CO_2) emissions by Sustainable Sydney 2030. An emission reduction potential of 36 kt would be expected by 2030 which, the largest reduction will result from continuing the existing policies, introducing the offsite renewables and upgrading the buildings in this city (Figure 47).

3.4.2. Tokyo metropolitan environmental master plan

The Tokyo Metropolitan Government replaced the Tokyo Metropolitan Pollution Prevention Ordinance, which was primary focused on industrial pollution at the time, with the Tokyo Metropolitan Environmental Security Ordinance in 2000, in an attempt to tackle emissions from residential and commercial buildings. With the establishment of the policy, two programs were introduced as the two cornerstones of Tokyo's climate change policy, namely, the Tokyo Carbon Reduction Reporting program and the Tokyo Green Building program. These two initiatives, which were enacted in 2002, applied a mixture of voluntary and mandatory reporting measures to large-scale facilities (buildings and businesses) in the industrial and commercial sectors.

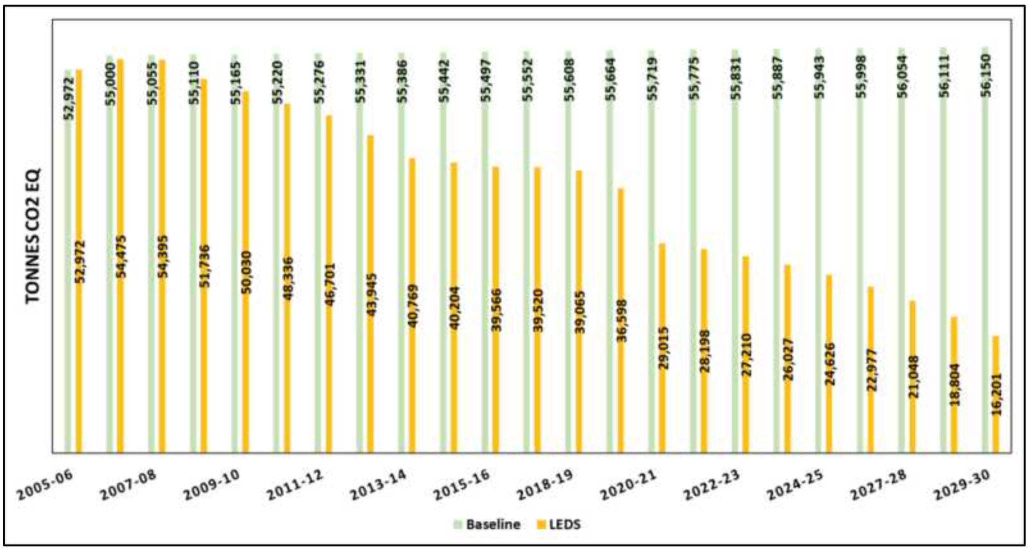

Fig 46. Reduction potential of CO_2 from the implementation of Sustainable Sydney 2030

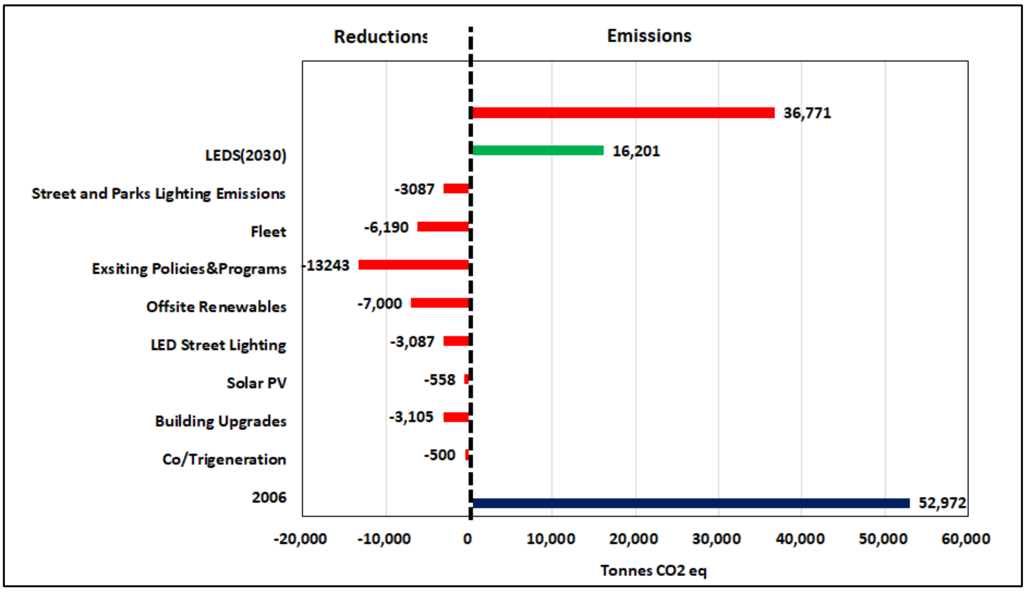

Fig 47. Operational emissions target of Sustainable Sydney 2030

The Tokyo Carbon Reduction Reporting program mandated from existing largescale facilities (facilities with an annual energy consumption of over 1.500 kL crude oil equivalent) the submission of a report outlining the CO_2 emissions of the previous fiscal year as well as the implemented or planned emission reduction strategies for the following 3 years (Rudolph and Kawakatsu 2012). Although emission reductions were voluntary, the facilities that were bound by the mandatory reporting scheme were required to include their energy consumption broken down by month and energy sources. Since its enactment, the program has been revised twice. Following the first revision in 2005, Phase 2 of the program introduced a comprehensive system of collection, evaluation, and publication of information pertaining to the emissions of the covered facilities. Specifically, upon collecting the report, Tokyo Metropolitan Government evaluated the performance of each entity based on a five-tier scale (look at Table 24) and instructed the participants to reduce their emissions accordingly. The second revision took place in 2010 and shifted the programs' attention from large- to small- and medium-sized facilities.

Tab 24. Five-scale rating system of Tokyo's Carbon Reduction Report program

Tiers	Requirements
AA	>5% emission reduction planned through additional measures
A+	>2% emission reduction planned through additional measures
A	Basic planned measures
B	Only planned no-cost operational improvements
C	No planned basic measures or improvements

The new threshold for mandatory participation was now set between 30 and 1.500 kL of annual energy consumption in crude oil equivalent. In the event where an entity possessed multiple facilities, the report would be structured around the aggregated data of all facilities. Consequently, any entity which possessed an individual or a collection of facilities which exceeded the limit of 1.500kL crude oil equivalent per annum, would be required to abide by the regulations of the Tokyo Cap-and-Trade Program, as will be discussed in the next section. The total number of facilities participating in the mandatory and voluntary reporting programs as of 2015 was 23,023 and 11,476, respectively (out of approximately 660.000 small- and medium-sized facilities in Tokyo) (Tokyo Metropolitan Government et al. n.d.). The latest data from the aforementioned facilities submitting reports over a five-year period from 2010 to 2014 indicate a 13.3% drop in CO_2 emissions. In conjunction with the above program, Tokyo Metropolitan Government enacted the Green Building Program in 2002, which mandated the owners of new buildings with a floor area over 10,000 m^2 the submission of a report prior to the application of the building permit. This "Building Environmental Plan" report would outline the facility's projected environmental performance through the evaluation of 12 components (Table 25) and would eventually be published on the website of the Tokyo Metropolitan Government.

Tab 25. The rating system of the Green Building Program (International Emissions Trading Association, 2014)

Facilities covered	**Newly planned large buildings**	
Items Assessed	**Categories**	**Items**
	Energy	Building thermal load (insulation) Renewable energy devices (on-site renewables) Energy efficient systems (improving equipment) Building energy management systems
	Resources, materials	Use of eco-friendly materials Ban the use of fluorocarbons Longer building life Water recycling
	Natural environment	Greening Landscaping Bio-diversity Water conservation
	Heat-island effect	Heat emissions Ground service cover Wind environment
Rating	Each item is rated using three rating grades (1 – 3)	
Reporting, Disclosure	Environmental plan and rating results must be explored before applying for a building permit, ratings are displayed with a chart on Tokyo Metropolitan Government Website	

Following the attainment of the building permit and finally the construction of the facility, the owners were obliged to submit a second, highly comprehensive report, presenting the same parameters. Much like the previous program, the first amendment of the Green Building Program took place in 2005 and introduced additional evaluation items and regulatory measures to place higher emphasis on climate change and the reduction of heat island effect (Tokyo Metropolitan Government 2012). Through this revision, the Green Building Program pioneered the creation of the "Green Labeling Program for Condominiums" which tackled condominiums larger than 10,000 m2. This plan was designed to impel condominium owners to disclose the environmental performance of their facilities on their advertising materials. In 2010, the program was revised once more to further strengthen the measures that were being implemented and facilitate the integration of renewable energy sources into the energy mix of buildings through tax incentives. Particularly, the new revision expanded the program coverage to include voluntary participant facilities with a total floor area from 2000 to 5000 m2 and mandated energy-saving measures to a certain extent from buildings that exceed the total floor area of 10,000 m2, excluding condominiums. Moreover, the threshold of the total floor area for the mandatory submission of the "Building Environmental Plan" was reduced from 10,000 to 5000 m2. Additionally, the revision formulated the District Planning for Energy Efficiency policy, which required from property developments larger than 50,000 m2 the submission of an energy conservation plan, 180 days prior to the application for the building permit. Finally, since the establishment of the program, more than 1300 buildings have disclosed their energy performance (approximately 40% of new building stock) (Nishida 2013).

3.4.3. Tokyo Climate Change Strategy

In December 2006, Tokyo Metropolitan Government announced the project "Tokyo's Big Change – 10-Year Plan" as means of achieving economic growth with minimal environmental footprint. Particularly, the policy aimed at reducing Tokyo's greenhouse gas emissions by 25% by 2020, compared to the level in 2000 (Tokyo Metropolitan Government 2007). In an attempt to realize such an environmentally friendly society, the government established five initiatives which, in short, collectively aimed at (1) promoting the use of energy efficient technologies; (2) increasing the adoption of renewable energy sources; (3) creating a sustainable, eco-friendly transport network; (4) encouraging all economic sectors to reduce emissions; and (5) developing the "Carbon Minus" and "Green Tokyo" movements. To finance such campaigns, Tokyo instituted the "Fund to Promote Measures Against Climate Change," which allowed them to invest approximately 50 billion yen to the development of the project (Edahiro 2008). In June 2007, Tokyo Metropolitan Government revealed the "Tokyo Climate Change strategy," setting forth measures to achieve the goals that were established by the "10-Year Project for a Carbon-Minus Tokyo" mentioned above. These measures included among others the ratification of the "Tokyo Cap-and-Trade" Program, the promotion of energy conservation measures to medium- and small-scale facilities, and the introduction of the "Tokyo Renewable Energy Strategy," which aimed at increasing the proportion of renewable energy in Tokyo to around 20% by 2020 (Green Local Government Portal n.d.). Tokyo Cap-and-Trade Program in 2010 and was designed to cover all commercial and industrial facilities that have an annual energy consumption equal to or greater than 1500 kL of crude oil equivalent (Tokyo Metropolitan Government 2010). This project is considered one of the most important among all the energy-related policies that were implemented in Tokyo's urban environment, predominantly due to the fact that participation is compulsory and is centered around an absolute cap on CO_2 emissions over a 5-year period (Bureau of the Environment – Tokyo Metropolitan Government 2010). The first compliance period of the program was scheduled to take place between fiscal year 2010 and fiscal year 2014 and had set the cap on emissions to between 6% and 8% (International Carbon Action Partnership 2018). The second compliance period would run from 2015 to 2019 and would further reduce emissions by 15% to 17% (International Carbon Action Partnership 2018). A third compliance period is projected to eventually take place between 2020 and 2024, but targets have not been determined as of yet. For the first and second compliance periods, the cap on emissions was based on the following three criteria (International Carbon Action Partnership 2018):

- Category A: 8% or 17% (first and second compliance period, respectively) reduction for office buildings, public institutions, commercial buildings, educational facilities, medical facilities, etc.
- Category B: 6% or 15% reduction for buildings in which air-conditioning/heating from district cooling/heating plants make up more than 20% of energy consumption.
- Category C: 6% or 15% reduction for factories that do not fit into either category.

To ensure the realization of these targets, the participants were encouraged to register their surplus when their emissions were less than the cap imposed by the policy. This mechanism would enable them to credit that surplus and would thus serve as a protection layer for the participants, as it allowed space for unexpected drawbacks. Finally, penalties were imposed to the facilities that failed to meet their targets. Particularly, the participants that did not meet their reduction targets, and failed to cover their shortfall through purchased credits, were imposed penalties that consisted of a JPY 500.000 fine, publication of the failure, and an additional emission reduction that scaled in proportion to the failure to fulfill the obligation (Bureau of the Environment – Tokyo Metropolitan Government 2010). In light of such consequences, it was observed that during the first compliance period, more than 90% of the 1300 participating facilities were able to meet their reduction targets through energy conservation initiatives, whereas the remaining 10% met their targets through emission trading (Tokyo Metropolitan Government 2016a). In FY 2016, the agglomerated CO2 emissions across all covered facilities were estimated at 12.13 million tons, achieving a 26% reduction compared to the base year1 and a 1% reduction compared to the previous year (Bureau of Environment 2018).
In 2009, Tokyo Metropolitan Government launched the "Certification System for High-Efficiency Household Water Heaters" in an attempt to highlight and promote the usage of highly efficient water heaters, devices which account for approximately 30% of Japanese household energy consumption (Tokyo Metropolitan Government 2007). Further, in conjunction with the enactment of Tokyo Cap-and-Trade Program, Tokyo Metropolitan Government announced the initiative "Household Energy Consultant Program," which aimed at enhancing energy conservation at the residential level. Under this system, the stakeholders involved in the provision of energy to households, such as gas companies and electric utilities have the opportunity to register under the program as household energy consultants. These experts were then called to facilitate the reduction of household energy consumption through the provision of free-of-charge energy-saving consultations. In addition to the reduction of greenhouse gas emissions and the consumption of energy, Tokyo Metropolitan Government, as aforementioned, set a target to increase the ratio of the renewable energy consumption to about 20% by 2020 (Tokyo Metropolitan Government 2006). This strategy encompassed a number of initiatives such as green power certificates, or the provision of subsidies, which aimed at facilitating the integration of higher shares of renewable energy into the current energy mix. Specifically, this goal would be achieved through the installation of photovoltaic systems on 40,000 households over 2 years, which would add the equivalent of 1 million kilowatts of solar energy capacity in the metropolitan area (Tokyo Metropolitan Government 2006).

Although the previous two policies were successful in terms of – among others – reducing CO_2 emissions and increasing the penetration of renewable energy sources, the socio-environmental circumstances of Tokyo have changed significantly over the last decade, calling for a fundamental change. Climate change has now become a global challenge, as indicated by the Paris Agreement under the United Nations Framework Convention on Climate Change, and Tokyo in particular is facing many challenges such as the increasing energy demand, growing resource constraints, and environmental pollution. In light of such ever-changing hurdles, Tokyo Metropolitan Government was poised to develop additional initiatives that aimed at encouraging society as a whole to realize sustainability. This determination led to the formulation of the new Tokyo Environmental Master Plan, which was introduced in 2016 and consisted of five major plans: (1) realization of a smart energy city, (2) facilitation of 3Rs/proper waste disposal and promotion of sustainable use of resources, (3) succession of urban environment symbiosis with diverse forms of life in rich nature, (4) ensuring comfortable air environment and quality soil and water cycle, and (5) comprehensive and cross-sectional promotion of environmental initiatives.

According to the Fifth Assessment Report 2014 by the Intergovernmental Panel on Climate Change, if we are to maintain the global average temperature below 2 0C above preindustrial levels, then it is requisite to reduce the global concentration of GHG by 40–70% by 2050 compared to 2010 levels. However, although the establishment of long-term goals is of vital importance in achieving targets at the global and national level, the measures associated with the realization of these goals cannot easily be assimilated by the residential and commercial sectors, due to their limited foresight which is restricted by financial and social barriers. As such, to facilitate the participation of these sectors into current and future energy-related policies, Tokyo Metropolitan Government announced 2030 as an intermediate step, based on the aforementioned long-term target levels. To achieve the long-term greenhouse gas reduction targets, it was estimated that Tokyo's emissions should decrease by 30% compared to 2000 level by 2030 (Tokyo Metropolitan Government 2016b). Per sector, this decline translates into 20% for the industrial and commercial sectors (approximately 20% for the commercial sector) and 20% and 60% for the residential and transport sectors, respectively (Tokyo Metropolitan Government 2016b). Figure 48 indicates the projected GHG emission reductions in 10,000 t-CO2 from FY 2000 to FY 2030.

Further, these targets would be realized through the implementation of a collection of mandatory and voluntary measures such as the promotion for energy conservation, the enhancement of energy efficiency, and the adoption of renewable energy sources, which collectively aim at reducing the energy consumption from traditional sources (i.e. coal, oil) across all sectors. Figure 49 illustrates the projected reduction of energy consumption in PJ, from FY 2000 to FY 2030. Tokyo's total reduction of energy consumption is estimated at 38% below 2000 levels by 2030 (Tokyo Metropolitan Government 2016b). This can be broken down per sector as follows: 30% reduction in the industrial and commercial sectors (approximately 20% for the commercial sector) and 30% and 60% for the residential and transport sectors, respectively (Tokyo Metropolitan Government 2016b). In addition to these measures, Tokyo Metropolitan Government's long-term strategy includes the increase of power generated by renewables to 30% by 2030 and the integration of 1.3 million kW of solar power capacity by the same year. The "Realization of a Smart Energy City" project encompasses all these measures and is comprised of three subdomains, namely, (1) Promotion of Energy Efficiency Measures and Energy Management, (2) Expansion of Introduction of Renewable Energy, and (3) Creating a Hydrogen-Based Society. In turn, these subdomains are to a large extent being driven by a collection of policies that fall under eight major categories, four of which are directly relevant to industrial, commercial, and residential buildings. These are (a) measures for large and small-to-medium scale facilities, (b) measures for the residential sector, (c) measures for urban development, and (d) measures for TMG's facilities (Tokyo Metropolitan Government 2016b).

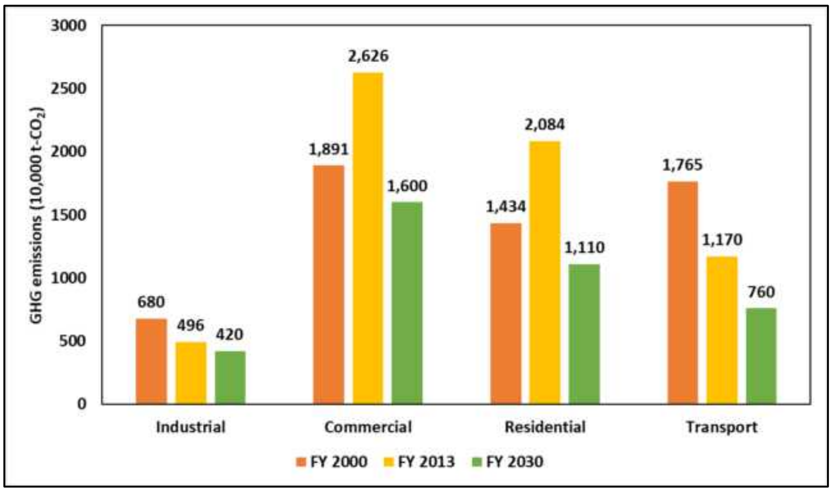

Fig. 48. Total GHG emission estimates in Tokyo by 2030

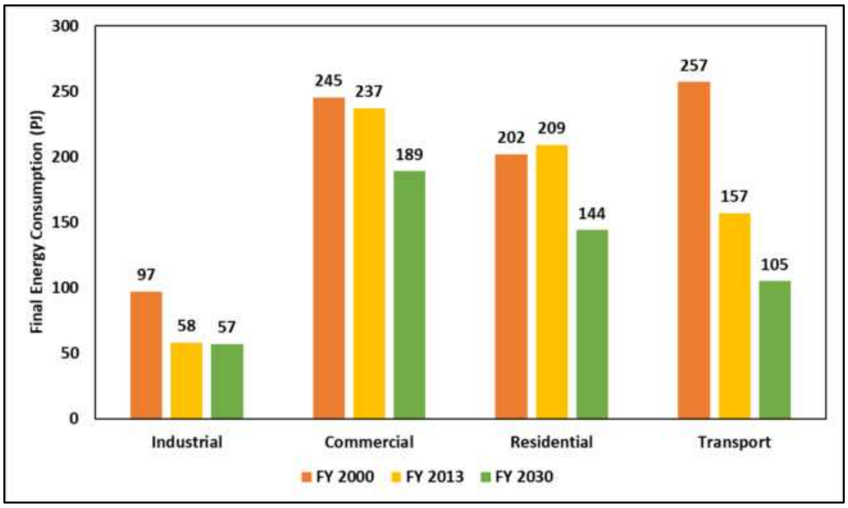

Fig. 49. Total final energy demand estimates in Tokyo by 2030

As of 2018, Tokyo Metropolitan Government's efforts toward engaging large and medium-scale facilities in activities pertaining to environmental sustainability have achieved exceptional results. As such, Tokyo Metropolitan Government is planning to continue improving campaigns such as the Tokyo Cap-and-Trade Program and the Carbon Reduction Reporting program through the implementation of additional incentives and regulations. Moreover, to increase the participation and alleviate some of the hurdles that small- and medium-scale facilities are facing in their attempt to improve their environmental performance, Tokyo Metropolitan Government is impelled to further promote voluntary measures such as low carbon benchmarks, as well as other forms of support such as the provision of subsidies. Although most policies are predominantly focused on large- to medium-scale facilities, the buildings within the residential sector have an unequivocal influence on urban emissions. To promote energy efficiency action at the residential level, Tokyo Metropolitan Government will facilitate the implementation of demand-side management technologies (e.g., smart meters, smart appliances) within the home area network, attempt to raise awareness regarding the importance of thermal insulation and airtightness, and consider the possibility of introducing mandatory energy-efficient standards in the future. Given that buildings in urban areas are utilized for a long period of time once erected, Tokyo Metropolitan Government is impelled to strengthen the programs that target newly constructed buildings. More specifically, to facilitate the adoption of environmental standards, Tokyo Metropolitan

Government will aggressively introduce additional energy efficiency measures through the Green Building Program and the Program on Effective Use of District Energy and increase the integration of renewable energy and distributed power sources in the planning stage of the construction. Being among the largest energy consumers in Tokyo, Tokyo Metropolitan Government has vouched to establish initiatives that aim at reducing the greenhouse gas emissions and increase the energy efficiency of its own agglomerated operations. The current targets suggest a 25% reduction of greenhouse gas emissions and energy consumption from Governor's Bureaus by FY 2019, compared to FY 2000, and the introduction of 22,000 kW of solar energy by 2020 (Tokyo Metropolitan Government 2016b). These targets will be achieved through measures that tighten the operations related to lighting and air-conditioning and encourage the adoption of highly efficient energy-saving equipment and renewable energy sources.

3.5. Comparative analysis

In this section, we developed a composite indicator, so-called USDI, as explained in the research methodology section, which can measure the social-environmental performance of the selected case studies in this research. In addition to the cities which was discussed in this study, we also included the information of the major mega-cities in the Asia-Pacific region in order to enhance the Index's credibility and comparability.

The availability and comparability of data across cities are limited in Asia. The Index has sought to include the most recent data available for each city, even though this may mean that in some cases, because of differences in the capacity of cities to gather and publish information quickly, the comparison points are several years apart. City-level related data were collected from the available statistics in local authorities of each city. Table 26 shows the aggregated input data used in this study.

Tab 26. Input data used in calculating the main indicators for each city (Base year: 2017)

	Average cities	Tokyo	Seoul	Shanghai	Delhi	Bangkok	Hanoi	Jakarta	Kuala Lumpur	Manila	Singapore	Sydney
Energy and Climate												
GHG emissions (Mt)	59.15	60.26	36.15	255.30	45.55	55.48	14.78	11.52	51.84	19.20	41.44	4.80
Annual mean NOx (ppm)	34.43	17.00	68.40	51.20	44.20	39.80	18.20	16.10	38.30	31.20	19.90	10.20
Annual mean PM10 (ug/m3)	71.40	22.00	49.00	79.00	286.00	38.00	86.00	48.00	36.00	49.00	21.00	9.00
Annual mean PM2.5 (ug/m3)	35.66	10.00	22.00	36.00	152.60	20.00	39.00	21.00	17.00	22.00	17.00	5.00
Final energy consumption (PJ)	1272.26	420.79	1000.45	7306.14	774.57	339.87	253.14	253.67	1007.68	429.06	937.28	16.80
City Planning												
Clean water accessibility (%)	92.20	100.00	100.00	95.00	90.00	94.00	80.00	95.00	98.00	70.00	100.00	100.00
Public transportation system (km/km2)	0.29	0.94	0.64	0.07	0.08	0.04	0.01	0.19	0.02	0.00	0.94	0.10
Waste collection and management (%)	79.20	100.00	100.00	83.00	67.00	63.00	85.00	37.00	80.00	77.00	100.00	100.00
Green area per capita (square meter)	43.03	163.82	133.23	13.50	21.52	6.18	2.00	9.41	8.50	6.10	66.00	224.90
Local Economy												
Per capita GDP (USD)	24064	68776	32000	18756	5300	6729	3425	11010	27991	8939	57714	84700
Per worker labor productivity (US$)	50640	112000	66000	38000	37000	25000	8900	23000	54500	17000	125000	117600
Unemployment rate (%)	5.73	3.60	4.80	4.20	5.30	5.70	7.50	5.60	4.50	13.90	2.20	3.20
Social Welfare												
Life expectancy index	0.86	0.98	0.96	0.86	0.74	0.84	0.86	0.75	0.84	0.74	0.97	0.96
Health index	0.68	0.95	0.92	0.77	0.19	0.72	0.59	0.45	0.79	0.44	0.94	0.92
Education index	0.69	0.88	0.87	0.63	0.52	0.64	0.62	0.62	0.70	0.64	0.81	0.92

In order to compare data points across cities, and to calculate aggregate scores for each city, the data gathered from various sources had to be made comparable. For this purpose, the quantitative indicators were "normalized" on a scale of zero to ten, with the best city scoring ten points and the worst zero (see Figure 7).

Cities use varying definitions for certain indicators, notably definitions of green spaces, municipal waste collection, public transportation system, and social welfare. In such cases, the USDI has sought to standardize the definition used. Qualitative indicators were scored by analysts with expertise in the relevant city through organizing several expert workshops, based on objective criteria that consider cities' targets, strategies, and concrete actions. For the "greenhouse gas (GHG) monitoring" indicator, for example, cities were assessed according to whether they regularly monitor GHG emissions and publish their findings every one.

The process of data collection as depicted in Table 27 leads to the results of the USDI. Table 27 provides the normalized values of the 4 indicators in the USDI for the selected cities in this study. Based on the results, Tokyo obtains the highest overall index score (0.91) followed by Sydney (0.9) and Singapore (0.86). These top three cities consistently exceed well above the average in the most number of dimensions which indicates that policy execution plays a role in richer cities, though a well-organized relationship between the local government and citizens (See Figure 50). The output of the calculation is a spider-web diagram that clearly indicates regions of good performance and concern (Figure 51).

Tab 27. Results of the USDI calculation

	Average cities	Tokyo	Seoul	Shanghai	Delhi	Bangkok	Hanoi	Jakarta	Kuala Lumpur	Manila	Singapore	Sydney
GHG emissions (Mt)	0.783	0.779	0.875	0.000	0.837	0.798	0.960	0.973	0.812	0.943	0.854	1.000
Annual mean NOx (ppm)	0.584	0.883	0.000	0.296	0.416	0.491	0.863	0.899	0.517	0.639	0.833	1.000
Annual mean PM10 (ug/m3)	0.775	0.953	0.856	0.747	0.000	0.895	0.722	0.859	0.903	0.856	0.957	1.000
Annual mean PM2.5 (ug/m3)	0.792	0.966	0.885	0.790	0.000	0.898	0.770	0.892	0.919	0.885	0.919	0.999
Final energy consumption (PJ)	0.828	0.945	0.865	0.000	0.896	0.956	0.968	0.968	0.864	0.943	0.874	1.000
Energy and Climate	0.747	0.904	0.650	0.323	0.376	0.799	0.854	0.918	0.796	0.850	0.887	1.000
Clean water accessibility (%)	0.740	1.000	1.000	0.833	0.667	0.800	0.333	0.833	0.933	0.000	1.000	1.000
Public transportation system (km/km2)	0.309	0.998	0.678	0.071	0.082	0.039	0.007	0.199	0.021	0.000	1.000	0.103
Waste collection and management (%)	0.670	1.000	1.000	0.730	0.476	0.413	0.762	0.000	0.683	0.635	1.000	1.000
Green area per capita (square meter)	0.184	0.726	0.589	0.052	0.088	0.019	0.000	0.033	0.029	0.018	0.287	1.000
City Planning	0.457	0.927	0.807	0.375	0.304	0.281	0.240	0.228	0.360	0.136	0.791	0.723
Per capita GDP (USD)	0.254	0.804	0.352	0.189	0.023	0.041	0.000	0.093	0.302	0.068	0.668	1.000
Per worker labor productivity (US$)	0.360	0.888	0.492	0.251	0.242	0.139	0.000	0.121	0.393	0.070	1.000	0.936
Unemployment rate (%)	0.698	0.880	0.778	0.829	0.735	0.701	0.547	0.709	0.803	0.000	1.000	0.915
Local Economy	0.425	0.857	0.530	0.396	0.302	0.263	0.157	0.280	0.484	0.045	0.883	0.950
Life expectancy index	0.475	1.000	0.899	0.497	0.000	0.410	0.496	0.048	0.428	0.001	0.969	0.925
Health index	0.642	1.000	0.968	0.767	0.000	0.704	0.525	0.350	0.788	0.328	0.993	0.967
Education index	0.435	0.901	0.868	0.281	0.000	0.306	0.247	0.259	0.454	0.296	0.735	1.000
Social Welfare	0.515	0.966	0.911	0.502	0.000	0.464	0.417	0.212	0.548	0.199	0.895	0.964
USDI	0.536	0.914	0.725	0.399	0.245	0.452	0.417	0.409	0.547	0.307	0.864	0.909

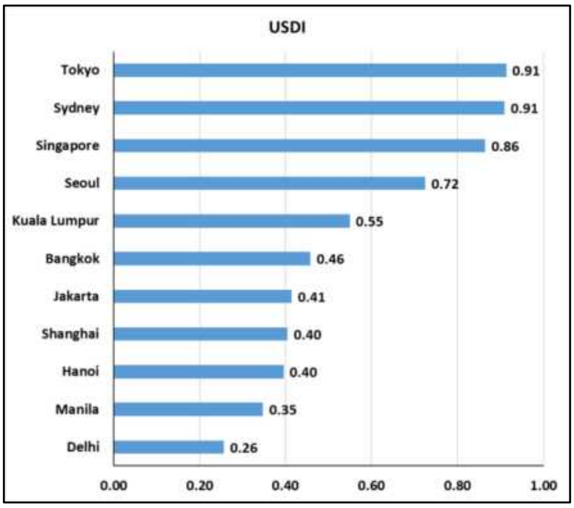

Fig. 50. USDI ranks among the selected mega-cities

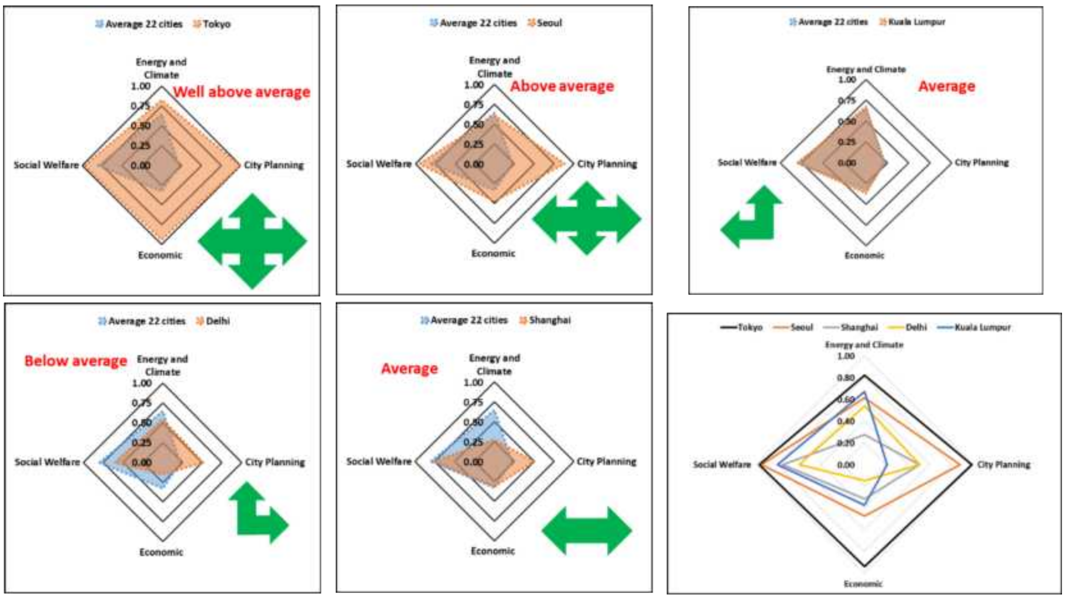

Fig. 51. Comparison between different sub-indicator

4. Conclusions

Implementation of two main scenarios of Clean Transport (CT) and Zero Electricity Deficiency (ZED) in the case of Delhi, India revealed a significant reduction of CO_2 and other local air pollutant emissions by 4.8 and 0.4 million tons, respectively, prevention of about 22,000 cases of mortality, and cost savings of more than USD 35 million by 2030. The larger numbers for the projected reduction of cases of cardiovascular mortalities implied that the pollution impact on these cases is more serious than others. Among all pollutants, the reduction of PM_{10} plays a significant role in achieving the desired health outcome. Improving energy efficiency at the end-user levels results in a rapid, cost-effective decrease in emissions in this city. The proposed scenarios help to motivate both the power supply system and the energy consumers to participate in reducing the emissions in the city. The power supply system in Delhi also needs to be reformed through the deployment of large scale renewable energy sources and by introducing a method to generate electricity from municipal waste. It is imperative that the LEDS has to be integrated, considering demand and supply characteristics of all major sectors, including power, transport, waste, buildings, household fuel, etc. Reliable energy scenarios for clean energy should guide policy and decision making considering different economic instruments, policy alternatives incl. Urban planning. It would distinctively identify regulatory, enabling, provisionary, and voluntary mechanisms for various government agencies and other stakeholders.

Three scenarios of slower socio-economic development, rapid socio-economic development and the master plan which was defined as a slower socio-economic development with reinforced energy efficiency programs were considered. The major reduction in coal consumption is expected from boosting green mobility, shutting more outdated steel and coke capacity and gradually improving clean coal's share in the industry sector through replacing it with natural gas and alternative fuels. The decline in the total amount of carbon emissions from the major sectors such as iron and steel complexes, power plants, transport sector, service sector, chemical industries and other sectors compared to the baseline scenario are expected to be approximately 2.8, 5.6, 4.9, 1.1 ,0.9 and 2.3 $Mt_{CO2\text{-}eq}$, respectively, which contributes significant to the job creations and raise GDP by the tertiary sector to increase the share of green employment in Shanghai total workforce by 46% in 2030.

Implementation of a transport convenient, easier, accessible and more efficient in Kuala Lumpur was assessed through the "*Green mobility plan"*. The modal share of the public transport will increase from 19% in the baseline scenario to 42% in the Green mobility plan. The fuel-saving potential from the implementation of the Green mobility plan is estimated at 27.3% of the total energy consumption of Kuala Lumpur's transport system in 2030. The most significant saving, estimated at 531 million liters in 2030, is expected to result from reducing gasoline consumption by private vehicles. The decline in the total amount of harmful gas emissions, such as SO_2, NO_X, PM_{10}, and CO, compared to the baseline scenario are expected to be approximately 23%, 15.8%, 13% and 23.8%, respectively. The "*Sustainable urban energy system scenario"* was introduced for increasing the sufficiency of resources to meet energy demand at competitive and stable prices as well as improve the resilience of the energy supply system in this city. The major actions include solar energy utilization, waste-to-Electricity, and End-use Energy efficiency. The total potential reduction in GHG emissions from the implementation of this scenario is estimated at 26.4%. The largest reduction can be obtained from the EEE program, followed by solar energy utilization and waste-to-electricity. Unlike other cities in this project, the energy consumption at Kuala Lumpur is closely linked with the overall energy supply and consumption of the West (Peninsular) Malaysia. In particular, the electricity network for Kuala Lumpur is part of the electrical network for Peninsular Malaysia. As a result, Kuala Lumpur may benefit indirectly from the increasing RE installations at other parts of Peninsular Malaysia where the emission factor of the electricity generation can be reduced. In terms of transportation, the development of greener transportation for inter-city travelling will also contribute to the reduction of transport related emissions in Kuala Lumpur, since a significant portion of the traffic in Kuala Lumpur is intercity travel.

Tokyo performs reasonably well in USDI with almost equal share of different indicators which showed that, Tokyo Metropolitan Government developed and successfully implemented a number of policies and subprograms including the Tokyo Metropolitan Environmental Security Ordinance, the Tokyo Climate Change Strategy, and finally the Tokyo Metropolitan Environmental Master Plan that collectively aimed at reducing the energy-related GHG emissions of urban facilities. In addition to the reduction of GHG emissions and the consumption of energy, these policies set a target to increase the ratio of renewable energy consumption to about 20% by 2030. The strategies that are incorporated within these policies such as mandatory emission reductions, stakeholder interaction, and predefined emission targets should be considered as the most effective in terms of alleviating environmental pollution within the boundaries of an urban environment. The results of the comparative analysis also revealed that the cities like Delhi with using the least energy tend to have the lowest incomes. In qualitative terms, Delhi's policy is primarily top-down, influenced by the national discourse in climate change and energy. At present, there is no single or specific policy towards pushing clean energy applicable to Indian cities; the case of Delhi appropriately demonstrates this state of affairs. The Delhi government's focus seems to be more on gradual supply augmentation of traditional sources than envisioning a road map for a radical shift towards cleaner fuels or major demand-side management. On the contrary, it is seen that bold and strict decisions from the government or the judiciary like bans seem to work in Indian cities. Various urban amenities in Delhi are highly subsidized, and their price does not adequately reflect the input and operational cost, be it for electricity, water, LPG, waste disposal, etc. In the cities like Shanghai and Kuala Lumpur, the urbanization was correlated with the increase in air pollution. However, when the income rises, average emissions decline and policy execution like the LEDS which were proposed in this research play a key role in these cities. In Shanghai, reinforcing LEDS will have positive effects on per capita carbon emissions and per unit GDP carbon emissions. Evaluation of USDI in Shanghai showed that the growth of the tertiary sector based on modern, knowledge-intensive and service-based will result in increasing the USDI. Therefore, Shanghai's government should continue to pursue its policy to relocate its heavy industry to make room for the tertiary sector. Moreover, Shanghai's local government needs to strengthen its economic restructuring policy, not only rely on technological improvements alone to reduce carbon emissions.

5. Future Directions

In our past investigations, we undertook comprehensive quantitative research on "assessing the multiple benefits (energy-environment-local economy-public health) of low emission development strategies in Asian urban areas." our research results have revealed that the twin challenges of global climate change and energy insecurity can be solved with rapid development and diffusion of Low Carbon Technologies (LCTs), both for energy supply and energy efficiency. There has been a recent understanding in the literature that the development, diffusion, and use of new technology are influenced by the establishment of *Energy Technological Innovation Systems (ETIS)* surrounding the technology in focus. ETIS emphasizes that innovation is a collective activity involving many actors and knowledge feedbacks and that innovation processes are influenced by their institutional settings, and corresponding incentive structures, including the market as well as government policy and all of the actors and processes, operate under conditions of uncertainty. As the future direction of our research, we will attempt to capture and synthesize core elements from the existing literature to build an initial conceptual model of the low carbon energy innovation system which can be used in developing countries. The primary focus of this research would be on developing better indicators and quantitative data as well as operational models and criteria to answer the following fundamental questions:

1) What is the most appropriate policy instrument for the diffusion of a particular low carbon energy innovation system in selected developing countries? The focus will be given to the energy efficiency improvement.

2) What resources are required, and what are the likely response times of the innovation system to policy interventions?

We will pursue the argument that the system functions with a modified set of indicators can explain the technology-specific innovation systems in developing countries.

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7. Appendix I

Workshops and Conferences

2nd International Workshop on Clean Energy Development in Asian Cities

(Learning From Real Cases)

22 February 2017

Venue:

Institute of Advanced Energy, Kyoto University, Japan

Organized by:

Unit of Academic Knowledge Integration Studies of Kyoto University

Background

Cities throughout Asia have experienced an unprecedented economic development over the past decades. In many cases, this has contributed to their rapid and uncontrolled growth, and has resulted in multiple problems, which include a rapid population increase, enhanced environmental pollution, collapsing traffic systems, dysfunctional waste management, as well as a rapid increase in the consumption of energy, water, and other resources. Cities in rapidly industrialized regions of Asia face many tasks related to economic and environmental issues. So far, the energy use and emissions are not well understood. Urban authorities are largely not aware of the multiple benefits of energy management and GHG reduction.

Given their growing scale and significance, Asian cities will have to be active in the global fight against climate change if it is to be effective. Municipal authorities in Asian cities therefore have a significant scope to pursue urban Low emission strategies and clean energy initiatives in ways that will also foster economic development. Moreover, clean energy initiatives at the city scale could generate knowledge and innovations that can have wider economic and social benefits, in addition to inspiring climate action in other cities and at a national scale. Without more coordination between international, national, regional and local institutions, integration into different sectoral priorities and policies, and engagement between the public, private and civic sectors it seems likely that the cities in Asia will lock in more fully to high-cost, high carbon development paths. Because of the global significance of Asian cities, policies and programs, facilitating large-scale adoption and deployment of clean and renewable energy will need to play a central role in this area.

The first International workshop on clean energy development in Asian cities was held on 28-29 March 2016 at our institute. The main achievement of the first workshop was to create a knowledge sharing environment for further cooperation and dialogue between different scholars in order to identify challenges and possibilities. The second workshop enabled a sufficient amount of dialogue between scientists and policy- makers for the specific case studies which may lead to the definition of new collaboration projects on clean energy development in Asian cities. Therefore, the main objective of the 2nd workshop was to address the case studies of successful clean energy solutions in Asian cities (India, China and Japan) with a special focus on:

- ✓ How clean energy planning contributes to urban resilience and sustainability?
- ✓ Which initiatives are most promising? What are their policy implications?
- ✓ What is the rule of local governments in deploying clean energy policies in cities?
- ✓ What are the main drivers and challenges for clean energy development?
- ✓ What are the international experiences for clean energy development and key learnings?

The workshop was built around a number of presentations from invited expert speakers in order to further explore best practices for clean energy development in Asian cities. The expected outcomes were:

- ✓ Sharing knowledge and experiences of practical clean energy projects/challenges and lesson learned from the successful case studies in Asia.
- ✓ The future direction of the clean energy development in Asian cities from the point of view of the intersection among policy and technology.

✓

Workshop Program

	INTRODUCTORY:	
10:00 – 10:15	Welcome Address	Prof. Hideaki Ohgaki, Kyoto University, Japan
10:15-10:30	**Project Status Briefing**: Assessing the multiple benefits of clean energy development in Asian mega cities	Jr. Assoc. Prof. Hooman Farzaneh, Kyoto University, Japan
	Session I	
	Moderator: Assoc. Prof. Benjamin McLellan,	Kyoto University
10:30 – 10:50	Opportunities and Challenges of Decentralized Roof PV Development in Shanghai	Dr. Wang Xin, UNEP-Tongji Institute of Environment for Sustainable Development (IESD), Shanghai, China
10:50 – 11:00	Discussion	
11:00 – 11:20	Clean energy and low carbon development strategy in Shanghai, Challenges and opportunities	Mr. Haixing Meng, College of Architecture and Urban Planning, Tongji University, Shanghai, China Jr. Assoc. Prof. Hooman Farzaneh, Kyoto University, Japan
11:20 – 11:30	Discussion	
11:30 – 11:45	**Break**	
11:45-12:05	Seoul's One Less Nuclear Power Plant program	Mr. Inchul Hwang, International Cooperation Team, Global Strategy Division, Korea Energy Agency (KEA), South Korea

12:05-12:15	Discussion	
12:15-13:45	Lunch	
	SESSION II	
	Moderator: Prof. Keiichi N. Ishihara, Kyoto university	
13:45 – 14:05	Making Low Carbon Development Locally Relevant: Cases from Indonesia and Japan	Dr. Eric Zusman, Institute for Global Environmental Strategies (IGES), Japan
14:05 – 14:15	Discussion	
14:15- 14:35	Participatory Backcasting Approach to Vision Creation for Sustainability, Case of Toyama city	Dr. Yusuke Kishita, The University of Tokyo, Japan
14:35 – 14:45	Discussion	
14:45- 15:05	Health co-benefits of the clean energy development in Asian cities	Dr. Mehrnoosh Dashti, United Nations University, Institute for the Advanced Study of Sustainability, Tokyo, Japan
15:05-15:15	Discussion	
15:15 – 15:30	**Break**	
	SESSION III	
	Moderator: Prof. Hideaki Ohgaki, Kyoto University	
15:30- 15:50	Clean Energy Development in Delhi: Targets and supporting strategies	Dr. Mahendra Sethi, Indian Society For Applied Research & Development New Delhi, India
15:50- 16:00	Discussion	
16:00-16:20	Climate policies and intergovernmental relations in Malaysian cities	Dr. Jose Puppim Deolviera, Getulio Vargas Foundation, Brazil
16:20- 16:30	Discussion	
16:30- 16:50	Building a Sustainable City Against the Odds: a case study of the City of Sydney	Dr. Scott Kelly, University of Technology Sydney, Australia
16:50- 17:00	Discussion	
17:00 – 17:15	**Break**	
17:15-17:35	Workshop wrap-up Session	Jr. Assoc. Prof. Hooman Farzaneh, Kyoto University, Japan Assoc. Prof. Benjamin McLellan, Kyoto University, Japan
17:35 – 17:50	Closing Remarks	Prof. Keiichi N. Ishihara, Kyoto university, Japan
18:30-20:30	Dinner (KIHADA restaurant)	

Organizing Committee:

- Dr. Hooman Farzaneh, Institute of Advanced Energy, Kyoto University, Japan
- Prof. Hideaki Ohgaki, Institute of Advanced Energy, Kyoto University, Japan
- Dr. Benjamin McLellan, Graduate School of Energy Science, Kyoto University, Japan
- Prof. Keiichi N. Ishihara, Graduate School of Energy Science, Kyoto University, Japan
- Ms. Yumiko Nagaya, Institute of Advanced Energy, Kyoto University, Japan
- Ms. Sasha Yoshioka, URA Office, Kyoto University, Japan
- Ms. Keiko Takimoto, URA Office, Kyoto University, Japan

Abstracts

Making Low Carbon Development Locally Relevant: Cases from Indonesia and Japan

Dr. Eric Zusman, Institute for Global Environmental Strategies (IGES), Japan

Cities are major contributors to global climate change, accounting for up to 70 percent of the world's greenhouse gas (GHGs) emissions. The past decade has witnessed cities developing and developed countries introduce low carbon reforms that can help reduce GHGs. This raises an important question: how do cities translate a global climate change agenda into locally relevant actions? This presentation will draw upon some of the research that the Institute for Global Environmental Strategies (IGES) has conducted on low carbon urban development in Japan and Indonesia. The research underlines the importance of framing low carbon reforms in ways that clearly demonstrate their local benefits; continuously sharing information on the local relevance of low carbon reforms; and providing tangible examples of how people can contribute to making their cities both low carbon and sustainable.

Health co-benefits of the clean energy development in Asian cities

Dr. Mehrnoosh Dashti, United Nations University, Institute for the Advanced Study of Sustainability, Tokyo, Japan

Increasing of GHG emissions and climate change due to the rapid growth of urbanization and accelerated socioeconomic development is a challenging problem particularly in the developing countries. Considering the development of sustainable urban areas, the evolution and utilizing more environmentally efficient technologies is one of the main solutions. In this way, the assessment of public health and environmental risks of mitigation and adoption technologies are becoming a major concern, particularly in the capital cities. This presentation aims to present the analytical frameworks to address health co-benefits of energy technologies. The emissions based studies and epidemiological investigations methods are introduced as assessment approaches. Case studies have chosen to show the results of the health assessment analysis based on these methods.

Building a Sustainable City against the Odds: a case study of the City of Sydney

Dr. Scott Kelly, University of Technology Sydney, Australia

The City of Sydney is committed to the elimination of green-house gas emissions. At present 80% of the cities emissions come from the production of electricity, primarily from coal-fired power stations. The City of Sydney has therefore enacted a plan to reduce green-house gas emissions by 70% and meet 30% of its electricity demand from renewable sources and 100% from local generation. This represents a significant transition in the way that energy is produced, distributed and consumed across the city. On the demand side, Sydney has already embarked on a transition to improve energy efficiency across the city that will eliminate two million tonnes of CO2 by 2030 and save $600m in energy bills whilst simultaneously doubling energy productivity. After returning from the C40 summit in Mexico in November, the Mayor of Sydney, Clover Moore, tabled a commitment to “to do twice as much in half the time”. The strong stance to meet ambitious climate change targets that is being taken by many local authorities across Australia, is at a discord with the Federal Government, who have failed to take an adequate stance on climate change, despite ratifying the Paris agreement. In this presentation, I will argue that strong local action can still achieve positive net outcomes, despite beleaguered and insufficient attempts at a national level to implement any coherent plan to mitigate emissions. The City of Sydney will be used as a case study to explore how emission reductions strategies and clean energy solutions have been implemented and had a net positive outcome on the city.

Clean Energy Development in Delhi: Targets and supporting strategies

Dr. Mahendra Sethi, Indian Society For Applied Research & Development New Delhi, India

There is a growing significance of clean energy (CE) globally. The latest edition of World Energy Outlook (2016), the International Energy Agency’s flagship publication foresees a strong potential in the growth of CE to meet the increasing energy demand until 2040. Its relevance to urbanization and cities is immense particularly in rapidly developing Asia, as evident from IPCC’s Fifth Assessment Report. Recent research suggests that while Indian cities host only 32% of the national population, they produce 85% of energy through thermal plants and 66.5 to 70.3% of the national GHGs. However, their response towards clean environmental and energy issues is relatively incipient, as demonstrated by the capital city- New Delhi. This research would examine these early initiatives – public policy, targets and supporting strategies undertaken for CE development in Delhi, focusing on three essential components - rooftop solar energy generation, clean transportation and waste to electricity. In doing so, the study reviews the current situation, demand-supply gaps, main drivers, challenges and opportunities. The research would attempt to address some key agendas of the workshop like how CE planning contributes to urban sustainability, which initiatives are promising, the role of various stakeholders, etc. and thereby draw upon major lessons for national and international learning.

Participatory Backcasting Approach to Vision Creation for Sustainability

Dr. Yusuke Kishita, The University of Tokyo, Japan

There is an increasing need to envision sustainable futures on community scale by capturing diversified needs of lay citizens. In my presentation, I will talk about a research project that aims to envisage sustainable visions of Toyama City to 2064, followed by devising effective policies and actions to be taken by local stakeholders. In the project, a participatory backcasting approach was taken to generate various ideas that help the city more sustainable with discontinuous changes from the present in mind. Three participatory workshops were organized by involving about 20 citizens and several scholars to describe multiple scenarios, which consist of sustainable visions and pathways to reach them. To facilitate the participants' backward thinking from sustainable visions to the present, logic trees were used for clarifying the causal relationship between ideal states in 2064 and potential measures to achieve them. In the end, two distinct visions were crafted, with which potential policy options and other actions were also derived. As each vision was built upon discussions in the workshops, the scenario design process helped to understand the difference of the participants' views on sustainability.

Opportunities and Challenges of Decentralized Roof PV Development in Shanghai

Dr. Wang Xin, UNEP-Tongji Institute of Environment for Sustainable Development (IESD), Shanghai, China

Under the policy promotion, pressure of carbon emission reduction and relatively mature development of PV technology, enterprises with suitable conditions using decentralized energy system are working together with the decentralized PV power generators to install this kind of new power producing system in their spare space. Depends on the installed capacity of the project, it can reduce the power usage in varying degrees from the national grid. If there are any left electricity generated from PV, it can be sold to national grid. This project with 2.5MW designed electricity generation capacity, is installed on the roof of 3 different buildings of one company, which is located at Pudong District, Shanghai. It was designed to provide up to 30% power consumption of the whole company according to the current power requirement. The first phase of project with 1.7MW generation capacity has been installed in late 2015 and began to operating. The contract of this project was signed in May 2015 and the first phase 1.7MW capacity roof facility has been finished in December 2015.This project was selected to be one case study with the reasons as follows: 1) this project is one typical demonstration decentralized solar power project in china, which is a profitable, replicable and sustainable commercial model can be referenced by other areas and countries. 2) Following the definition of decentralized energy system in China, this project is one typical project with a certain size (installed capacity and technical operation) can be a reference for other areas. 3) the relative mature experience on implementation of policy, subsidy incentives and cooperation between different stakeholders. As the investment cost and efficiency of PV power generation, the profit-making of the generator still mostly rely on the subsidy from the government, and it will take different years to get the investment cost back depending on the size of the project. There are still some challenge and difficulties faced by the frontrunner of decentralized power generator, such as looking for the suitable consumer with good condition for project implementation, funding-raising for investing new projects, etc. However, experience of running this project on technical cooperation and operation mechanism can be shared with other area with similar condition for developing decentralized PV energy system.

Seoul's One Less Nuclear Power Plant program

Inchul Hwang, International Cooperation Team, Global Strategy Division, Korea Energy Agency (KEA), South Korea

Seoul Metropolitan Government came up with its flagship energy program of One Less Nuclear Power Plant in 2012. The initiative set its goal at reducing 2 million TOE of energy, equivalent of power produced by one nuclear power plant by 2014. The first phase of the program made a success by achieving energy reduction of 2.04 million TOE (renewable energy: 0.26 million TOE, energy efficiency: 0.87 million TOE, energy saving: 0.91 million TOE) by June 2014, six months earlier than the original timetable. Seoul's power consumption in 2014 was reduced 4% to 45,091GWh compared to that of 2011, whereas national power consumption was increased 4.9% in the same period. Encouraged by the success of its first phase, Seoul Metropolitan Government entered into the second phase of the initiative, named 'Seoul Sustainable Energy Action Plan'. Under the Action Plan, Seoul city pursues an energy self-reliant city with the slogan of 'Seoul, Energy Producer.' It has 3 core values: Energy Self-Reliance; Energy Sharing; Energy Participation. Its goals include energy saving of 4 million TOE, 20% power self-reliance by 2020, GHG emissions reduction of 10 million TCO_2e. The program has 88 projects under 4 energy policy areas. The 4 policy areas are Decentralized Energy Production with 19 projects including 40 thousand mini photovoltaic plants, Lower Energy Consumption with 34 projects including Replacement of Street Lamps and Security Lights to LED, Creation of Quality Energy Jobs with 17 projects including 25 Energy Hub Centers, Energy-Sharing Welfare Community with 18 projects including Energy Welfare Platform.

Clean energy and low carbon development strategy in Shanghai, Challenges and opportunities

Haixing Meng, College of Architecture and Urban Planning, Tongji University, Shanghai, China

Dr. Hooman Farzaneh, Kyoto University, Japan

The city of Shanghai has experienced a rapid social- economic development of urbanization in recent 20 years. Meanwhile, the huge energy demand and consumption of the city also brings challenges such as air pollution, increased carbon emission and also security of energy supply in the future. This presentation firstly gives the current energy consumption and air pollution in recent years and then introduces the policy framework for analysis Shanghai's recent policies on clean energy and low carbon development strategy. Considering both sides of energy demand and supply, the policy framework separates the policies in two systems, including fossil energy system and alternative energy system. Under this policy framework, we extract the classified information and indicators from the policy documents published by Shanghai local government, and related projects by different objectives including energy efficiency improving, emission reduction and new energy development.

Climate policies and intergovernmental relations in Malaysian cities

Dr. Jose Puppim Deolviera, Getulio Vargas Foundation, Brazil

Institutions in public administration evolve differently across sectors. They also vary in the same sector when governments in the two levels (state/local and federal) have different political alignments. As the policy environment becomes more complex, and politics more dividing, scholars and practitioners need to understand how best to build institutions in public administration to bridge the various levels of government in different political environments and policy sectors. This research analyzes the influence of intergovernmental relations climate policy by comparing with waste management sector in two localities with contrasting political alignments between levels of government. It draws lessons from solid waste management for climate policy in two Malaysian states. In an evolving State and new policy areas, when formal institutions for intergovernmental relations may not be effectively in place, politics play an even larger role through the discretionary power of federal and subnational authorities. An open political process can help engaging different political groups and civil society to bring legitimacy, resources and efficiency to public administrations, if it is done in a transparent democratic way with robust institutions; otherwise, administrations can also become a tool for cronyism and patrimonialism, which can undermine the political system, and result in inefficiencies and ineffectiveness in the public sector.

3rd International Workshop on Clean Energy Development in Asian Cities

(Experiences from Asia and Latin America)

3 February 2018

Venue:

Institute of Advanced Energy, Kyoto University, Japan

Organized by:

Unit of Academic Knowledge Integration Studies of Kyoto University

Organizing Committee:

- Jr. Associate Prof. Hooman Farzaneh, Institute of Advanced Energy, Kyoto University, Japan
- Prof. Hideaki Ohgaki, Institute of Advanced Energy, Kyoto University, Japan
- Associate Prof. Benjamin McLellan, Graduate School of Energy Science, Kyoto University, Japan
- Prof. Keiichi N. Ishihara, Graduate School of Energy Science, Kyoto University, Japan
- Ms. Yumiko Nagaya, Institute of Advanced Energy, Kyoto University, Japan
- Ms. Sasha Yoshioka, URA Office, Kyoto University, Japan
- Ms. Keiko Takimoto, URA Office, Kyoto University, Japan

Workshop Program

	INTRODUCTORY:	
10:00 – 10:15	Welcome Address	Prof. Hideaki Ohgaki, Kyoto University, Japan
10:15-10:30	Workshop program overview	Dr. Hooman Farzaneh, Kyoto University, Japan
	Session I	
	Moderator: Prof. Keiichi N. Ishihara, Kyoto university, Japan	
10:30 – 11:00	A Post Evaluation of Solar City Demonstration Project in Turpan, China	Dr. Wang Xin, UNEP-Tongji Institute of Environment for Sustainable Development (IESD), Shanghai, China
11:00 – 11:30	Towards a Cleaner Nation - Renewable Energy Motivations in Malaysia	Prof. Nasrudin Abd Rahim, University of Malaya, Malaysia Dr. H.S. Che, University of Malaya, Malaysia

11:30 – 11:45	**Break**	
11:45-12:15	Compact Energy Consumption: Urban Way of Energy Saving	Mr. Inchul Hwang, International Cooperation Team, Global Strategy Division, Korea Energy Agency (KEA), South Korea
12:15-13:45	Lunch	
	SESSION II	
	Moderator: Prof. Ialnazov Dimitersavov, Kyoto University, Japan	
13:45 – 14:15	Co-benefits: A Comparative Analysis of Enablers and Barriers	Dr. Eric Zusman, Institute for Global Environmental Strategies (IGES), Japan
14:15- 14:45	Pragmatic Collaboration for Resilient Climate Co-benefits Policy Implementation	Prof. Antonio Botelho, Visiting Professor, Kyoto University, Japan & Universidade Candido Mendes, Brazil
14:45- 15:15	A tale of five cities: How Tokyo, Sydney, Shanghai, Kuala Lumpur and Delhi are creating strategies for low emissions development	Dr. Scott Kelly, University of Technology Sydney, Australia
15:15 – 15:30	**Break**	
	SESSION III	
	Moderator: Assoc. Prof. Benjamin McLellan, Kyoto University, Japan	
15:30- 16:00	The way forward for a clean and sustainable transport in Asian cities	Dr. Yuki Kudoh, AIST, Japan
16:00-16:30	Targets and Supporting Strategies for the Clean Energy Development in Delhi	Dr. Mahendra Sethi, ISARD, New Delhi, India
16:30- 16:45	**Break**	
	SESSION IV	
	Moderators : Prof. José Antônio Puppim de Oliveira, FVG, Brazil Prof. Hideaki Ohgaki, Kyoto University, Japan	
16:45- 18:15	Case studies from Latin American and Asian cities	Young researchers (FAPESP-JSPSP joint workshop)
18:15 – 18:30	Closing Remarks	Prof. Keiichi N. Ishihara, Kyoto university, Japan
18:30-20:30	Dinner	

Abstracts

Targets and Supporting Strategies for the Clean Energy Development in Delhi

Dr. Mahendra Sethi, Indian Society For Applied Research & Development New Delhi, India

The World Energy Outlook estimates urban energy related CO_2 emissions as above 20Gt, i.e. over 70% of the global total (IEA 2016). Cities in non-Annex I countries (which are mostly developing countries) generally have much higher levels of energy use compared to the national average, in contrast to cities in Annex I countries, which generally have lower energy use per capita than national averages (GEA 2012). Indian cities host 32% of the national population, yet these contribute to 85% of energy production through thermal plants and 66.5-70.3% of national greenhouse gas (GHG) emissions. Low-grade coal, low efficiency and power-load factor of these plants is responsible not only for growing global GHGs, but poor air-quality in the cities too. Meanwhile, there is an emerging interest and application in favor of clean energy (CE) globally. IEA's flagship World Energy Outlook (2016) foresees a strong potential in the growth of CE to meet the increasing energy demand until 2040. Its relevance to urbanization and cities is immense, particularly in rapidly developing Asia, as given due credence by IPCC's 5th Assessment Report too. However, response of Asian cities towards clean environmental and energy issues is relatively incipient and riddled with several technical and policy related challenges, as demonstrated by India's capital city- New Delhi. This research qualitatively examines some of the key initiatives, including public policy, their targets and supporting strategies undertaken for CE development in Delhi, focusing on 3 main components - rooftop solar energy, clean transportation and waste to electricity. In doing so, the study reviews the current situation, demand-supply gaps, main drivers, intervening issues and opportunities for a clean and green future.

A Post Evaluation of Solar City Demonstration Project in Turpan, China

Dr. Wang Xin, UNEP-Tongji Institute of Environment for Sustainable Development (IESD), Shanghai, China

Although solar city is widely acknowledged as a sustainable urban form, the real operational performance of solar eco-cities is rarely reported. This paper presents the analysis of the performance of Turpan New City Demonstration project, which was launched with the initiative to explore new method of sustainable city development. Turpan Renewable Energy Demonstration District - the first and so far the largest solar city, the first PV integrated microgrid pilot project and the first distributed solar power generation pilot in China - was launched in 2008, with the purpose to explore a new paradigm of sustainable urban development. It is a mixed-use area with residential units as the dominant function. The first phase of the Turpan Demo District was finished and commissioned at the end of 2014, with a total site area of 1.43 square kilometers and total building area of 809.4 thousand square meters. To understand how Turpan Demo District performs in energy, economy, and carbon emission, a detailed analysis has been conducted and the results are presented in this paper. The electricity consumption data of the demo project in 2015 and 2016 is analyzed. Insights are given regarding the design concept, operational problems, and scalability of this project. It is found

that the demo project has attained outstanding significance in both economic and ecological aspects while several deficiencies existing in operating and controlling requires further improvements. The outcome is helpful for both researchers and practitioners in the field of sustainable urban development.

Towards a Cleaner Nation - Renewable Energy Motivations in Malaysia

Prof. Nasrudin Abd Rahim, University of Malaya, Malaysia

Prof. H.S. Che, University of Malaya, Malaysia

As one of the ratifying nation of COP21, Malaysia has pledged its commitment towards reducing greenhouse gas emission and adopting cleaner energy. According to Malaysia's Intended Nationally Determined Contribution, this involves the reduction of greenhouse gas emission by 45% based on the emission intensity of GDP in 2005. In order to achieve this target, the Malaysian government has taken various measures to improve energy efficiency as well as to reduce fossil fuel usage, including the stepping up of renewable energy policies in the country. As a matter of fact, the adoptable of renewable energy has profound impacts to the government, industry as well as the common energy users. In this paper, an overview on the development of renewable energy policies in Malaysia is given, highlighting the corresponding opportunities and challenges towards building a cleaner nation through renewable energy usage.

The way forward for a clean and sustainable transport in Asian cities

Dr. Yuki Kudoh, National Institute of Advanced Industrial Science and Technology

Transport is the basis of our socioeconomic activities which are indispensable for the current human life. On the other hand, a large amount of energy is consumed by the means of transport, which results in an increase in environmental emissions. Since it is estimated that transport demands should increase steadily towards the future in most of the Asian cities, it is necessary to figure out the way forward to establish a clean energy and environmentally friendly transport system by taking into account the current transport profile and the needs of the citizens living there. There are two approaches to reduce the energy use and improve the environment in the transport sector: technical and demand approaches. Technical approach refers to improving the energy efficiency and reduce the environmental emissions of the means of transport. Demand approach relates to the modal shift to the means of transport that has a better energy and environmental performance than the conventional ones. Both approaches are necessary to move towards a clean energy and sustainable transport. This article introduces how can the energy consumption and environmental emissions profiles in transport sector be understood and important aspects, both in technical and demand approaches that should be considered to establish a clean energy and sustainable transport in Asian cities.

Compact Energy Consumption: Urban Way of Energy Saving

Inchul Hwang, Korea Energy Agency

From 1960 to 2010, urban population grew 350%, whereas global population grew 233%. This global trend of urbanization is a serious challenge to global resources and environment, considering the fact that urban residents, 50% of the global population are consuming 70-80% of global resources. Human influx to cities cause environmental destruction, resource scarcity. And that's why new models of sustainable city have been suggested such as Compact City, Eco City and New Urbanism. Besides designing new urban development models, behavioral changes in energy consumption will help easing urbanization pressure. There are 3 Ws in energy consumption: when; where; with whom. During daytime, workers consume electricity together with their colleagues in the office or consume oil alone on the road and housewives consume electricity or gas at home alone by watching TV or cooking. During nighttime, family consume electricity or gas by having dinner together and some workers consume electricity alone by working late in the office. By pursuing a new way of life, energy can be saved in daily urban life. Energy can be saved when people consume energy together in one place rather than consuming separately in different places. Energy consumption can be avoided when people stay outside rather than inside the buildings – another form of energy saving. An interesting case of energy saving happened in Seoul during November 2016-January 2017. 1.1 MWh of energy was saved by peaceful candle-lit vigil demonstrations calling for the step-down of president on Gwanghwamoon Street. Around one million demonstrators saved energy by staying outside in cold Saturday nights, when they would have consumed energy by staying inside their homes.

Co-benefits: A Comparative Analysis of Enablers and Barriers

Dr. Eric Zusman, Institute for Global Environmental Strategies (IGES), Japan

Over the past two decades, the term "co-benefits""—the multiple benefits of actions that mitigate climate change and meet other development needs—has moved from idea discussed in research to concept applied in practice. There have nonetheless been few attempts to determine what are the factors that enable or impede the successful implementation of actions with co-benefits across several case studies. The purpose of my talk will be to fill this important gap in understanding. Drawing upon a growing collection of co-benefits case studies that the Institute for Global Environmental Strategies (IGES) has compiled, the presentation will take a look at what patterns appear in enablers and barriers to achieving co-benefits. It will also offer some preliminary thoughts on what are some of the reasons behind varying degrees of success in implementing actions with co-benefits. The presentation will conclude with some suggestions on how policymakers and international organizations can increase the likelihood of success.

Pragmatic Collaboration for Resilient Climate Co-benefits Policy Implementation

Prof. Antonio José Junqueira Botelho, Kyoto University, Japan & Universidade Candido Mendes, Brazil

A main challenge facing Asian and Latin American cities seeking win-win intervention towards a sustainable maximization of climate co-benefits lies in the complex governance of policy implementation. These urban commons are nested within multiple governmental levels (federal, regional, state, metropolitan, province, county and municipal) and have diverse institutional arrangements for the provision of services and infrastructure to their population as well as for the promotion of development and a healthy environment. Further, they also have contrasting arrangements for both aggregating and processing demands (shaping patterns of collective action), delivering results (implementation) and communicating outputs to their different constituencies. Thus, the practical politics of urban climate co-benefits policy implementation is fraught with conflict and misunderstandings. These are further amplified in the urban commons by the long-term, fragmented and uncertain nature of the co-benefits. This paper suggests that the pragmatic collaboration (PC)/learning-by-monitoring (LBM) experimentalist approach may contribute to the construction of a resilient governance framework for the implementation of policy towards climate co-benefits (Sabel 1993; Helper, MacDuffie and Sabel 2000). The approach was originally developed to provide a resilient self-evolving analytic routine to collaboration among firms in volatile globalized customer–supplier relations, beyond traditional hierarchies and markets. As PC, a practice-oriented theory, takes into account the diversity of (customer-supplier) relations, analogously one can suggest that it may also be capable of incorporating diverse relations among urban commons' governmental actors and stakeholders, as well as citizens, the last critical link in the implementation chain. For it sees this diversity resulting from "alternative interpretations of how, under ambiguous conditions, to build the process of iterated co-design at the heart of PC, and that the ambiguity fueling the diversity is rooted in the nature of iterated co-design itself (although it may be exacerbated by other factors, starting with power disparities)." (Sabel 2010: 81). Further PC models the governance of these relations so that "the design and provision of supra-firm coordination mechanisms—a kind of public good—requires a kind of second-order application of LBM principles: just as the actors are learning to co-design products, they have to learn how to co-design the institutions that make this first-order cooperation more robust." (Ibid: 82) Recent applications of the PC/LBM approach to build alternative frameworks for the promotion of productive development strategies seem to indicate the promise of its application to the implementation of climate co-benefits policy in urban commons.

A tale of five cities: How Tokyo, Sydney, Shanghai, Kuala Lumpur and Delhi are creating strategies for low emissions development

Dr. Scott Kelly, University Technology Sydney, Australia

In this research, I compare low emissions development strategies (LEDS) for five large Asian cities, namely: Tokyo, Sydney, Shanghai, Kuala Lumpur and Delhi. These cities have a combined population of over 100 million inhabitants and are predicted to grow by a further 20 million people by 2030. In 2017 the combined economic output of these cities was US$2.6 Trillion representing over 3.5% of total global output. Over the last decade all five cities have struggled with their own set of challenges for achieving a low carbon development pathway. For example, Delhi is India's most populated city and must combat the simultaneous problems of extreme heat, extreme poverty and extreme pollution. Despite these internal challenges, government policy has aggressively implemented vehicle emissions standards, renewable energy targets and has increased tax on coal and carbon by a factor of eight. Kuala Lumpur is amongst one the lowest rated cities within the Climate Change Performance Index (52 out of 57) and climate policies are well behind many other cities within the region. However, Kuala Lumpur could achieve several quick wins by switching away from diesel as a fossil fuel which presently accounts for 75% of all transport emissions and by making buildings more energy efficient which presently accounts for 55% of total emissions. Over the last decade, Shanghai has experienced a period of unprecedented growth and development. It is now home to world's largest underground metro and one of the largest electric bus fleet in the world. Whilst Shanghai has some of the most progressive climate policies for the cities studied, it is also a city that is at high risk of being submerged due to rising sea levels. Sydney has one of the highest per capita median incomes in the world and was branded alongside London as the second best city for brand appeal and image by the Anholt-GfK City Brands Index. Like other Australian cities, Sydney's biggest struggles are from politics. While local government continues to set ambitious climate change targets, these are frequently undermined by the federal government who insists on the construction of new coal fired generation. Tokyo has by far the largest economy and largest population from the cities included in this analysis. Despite its size, Tokyo has shared a similar stagnant economic conditions to the rest of Japan. Tokyo suffers from rising temperatures due to the 'heat island' effect and this is predicted to get worse under the effects of climate change. Despite this Tokyo's per capita CO_2 emissions are 20-30% below those of New York and London and it is already achieving one of the highest levels of efficiency for an advanced economy. Tokyo aims to reduce emissions by 25% from 2000 levels. In summary, all five cities are plotting their own path for low emissions development. While not all solutions are relevant all the time, some of the solutions are relevant some of the time important lessons are to be learned for how the climate change risks and solutions can be shared across the region.

Expert Workshop on Low Emission Development Strategies in Kuala Lumpur

3 May 2018

Organized by:

UM Power Energy Dedicated Advanced Centre (UMPEDAC), University of Malaya

Kyushu University Platform of Inter / Transdisciplinary Energy Science

Venue:

CAPRI Hotel residences, Bangsar South City, Kuala Lumpur

Introduction:

Given their growing scale and significance, cities in the Asia-Pacific region will have to be active in the global fight against climate change if it is to be effective. Municipal authorities in these cities therefore have a significant scope to pursue urban Low Emission Development Strategies (LEDS) and clean energy initiatives in ways that will also foster economic development. Because of the global significance of Asia-Pacific region, policies and programs, facilitating large-scale adoption and deployment of clean and renewable energy will need to play a central role in this area.

Since August, 2017, a research project, entitled" Multiple Benefits Assessment of the Low Emission Development Strategies in Asia Pacific Cities" has been approved to receive funding from the APN (Asia-Pacific Network) under CRRP (Collaborative Regional Research Program) and started at the Institute of Advanced Energy (IAE), Kyoto University, to demonstrate how clean energy policies and programs can help achieve multiple urban energy, environmental, health and economic benefits in a cost-effective way in Asia-Pacific urban area. This research will center primarily on cities of: Tokyo, Shanghai, Seoul, Delhi, Sydney and Kuala Lumpur.

As a part of aforesaid research project, this workshop will be held Indian Society for Applied Research & Development, Delhi to provide insights on successful ways to promote, design and implement the low carbon urban energy system in Kuala Lumpur.

Aim and Purpose of this workshop

The main objective of this expert workshop is to enable a sufficient amount of dialogue between scientists and policy-makers in order to discuss about the following central issues regarding the LEDS in Kuala Lumpur:

1) Determine the phase of development of the LEDS

- Direction of the industry
- Speed of adoption
- Workforce development (Incentives and needed strategies)

2) Holistic understanding of the expert's opinions on the interrelated barriers to the LEDS

- What are the most important barriers to the development of LEDS in Kuala Lumpur?
- What measures can be implemented to overcome these barriers?

Participants:

- Prof. Nasrudin Abd Rahim, UMPEDAC, University of Malaya, Malaysia
- Assoc. Prof. Hooman Farzaneh, Kyushu University
- Dr. H.S. Che, University of Malaya, Malaysia
- Assoc. Prof. Benjamin McLellan, Kyoto University
- Mr. Ahmad Zuhairi, Economic Planning Unit
- Mr. Huzaimi, Malaysian Green Technology Cooperation
- Mr. Jamal Nasir, Tenaga Nasional Berhad
- Mr. Ong Hang Ping, Fabulous Sunview

- Dr. Ong Hwai Chyuan, Energy Research Centre, University of Malaya.
- Dr.Md Hasanuzzaman, UMPEDAC, University of Malaya, Malaysia
- Dr. Asiful Habib, UMPEDAC, University of Malaya, Malaysia

Workshop tentative program

9:00-9:30 am: Introductory presentation by the workshop coordinators

9:30-10:30 am: Presentations by the invited speakers (Stakeholders) - Part One

10:30-11:00 am: (coffee break)

11:00-11:30am: Presentations by the invited speakers (Stakeholders) - Part Two

11:30am - 12:30pm: Group discussion on particular issues

12:30pm - Close then Lunch

ASIA-PACIFIC NETWORK FOR GLOBAL CHANGE RESEARCH

Expert Workshop on Low Emission Development Strategies in Delhi

28 May 2018

Organized by:

Indian Society for Applied Research & Development, Delhi

Venue:

Indian Society for Applied Research & Development, Delhi

KYUSHU UNIVERSITY

Workshop Programme

9:30-10:00 am: Registration and Tea

10:00-10:05 am: Welcome Note

10:05-10:10 am: Inauguration by the Organizers

10:10-10:45 am: Introductory presentation by the network coordinators

- Multiple Benefits Assessment of the LED Strategies in Asia Pacific Cities: Dr. Hooman Farzaneh
- LEDS workshops and progress: Dr. Benjamin McLellan
- Introduction to LED in Delhi: Dr. Mahendra Sethi

10:45-11:30 am: Policy and Financial Perspective of LED in Delhi (Chair: Dr S.K. Saha)

- Transport Systems and Air Quality in New Delhi (15 min): Dr Sewa Ram
- Breathing Green in Delhi: A Proposal for Carbon Tax (15 min): Dr Rohit Azad
- Q & As (15 min)

11:30 – 11:45 : Tea Break

11:45-12:30 am: Research and Best Practices for a Greener Habitat (Chair: Dr B. McLellan)

- Relevance of LED for Enhancing Quality of Life (15 min): Shilpi Mittal
- Decentralized Waste Treatment Solutions (15 min): Rakesh Prashar
- Experiences of Energy Efficiency in Built Environment (15 min): Kanagaraj Ganesan

12:30 -12:55 pm: Group discussion on implications for Delhi (Chair: Dr Mahendra Sethi)

12:55 pm – Vote of thanks, followed by Lunch

Welcome Note by Dr. Ajeet Prasad, Secretary, ISARD

Respected Participants

On behalf of Indian Society for Applied Research and Development – ISARD, it is my immense pleasure to welcome you to the today's workshop on Low Emission Development Strategies in Delhi.

ISARD is an interdisciplinary group with committed participants drawn from various fields of activities such as economics, health, education, social sciences, environment, planning, infrastructure development etc. The organization is committed to sustainable environment, community development, gender empowerment and socio-economic upliftment of the disadvantaged people at the grass root level through participatory and applied research, capacity building, and issue based interventions having its network among urban, rural and tribal constituents.

While this workshop is being organized by ISARD, it is a part of larger collaborative indo-japanese research network involving Kyushu University, Kyoto University duly supported by Asia Pacific Network for Global Change Research, under the project title, "Multiple Benefits Assessment of the Low Emission Development Strategies in Asia Pacific Cities"

As you area aware, changing climate has become a reality today. It poses a huge challenge to governments and societies to function effectively, efficiently and sustainably for the betterment of people. Urban systems, particularly in developing countries are under great stress to be not just industrious, economically productive, job-providing, but also expected to be clean and green in their outlook, as good as their other global counterparts. In this context, today's workshop would give insights into Delhi makes attempt to deal with the climate problem, and how does it fare up against some other Asian megacities being covered in this research like Tokyo, Shanghai, Seoul and Kuala Lampur.

Accordingly, the workshop has a packed 3 hour program for today morning. The first session would host presentations from the network coordinators, introducing the project. This would be followed by second session that would discuss Policy and Financial Aspects of low emission development in Delhi. The third session would showcase Research and Best Practices for a Greener Habitat. Finally the last session would be an open house, inviting a focused discussion on different low-emission possibilities in Delhi. I look forward to thoughtful contribution by speakers and equally interesting ideas by other participants.

At this juncture, I would like to mention that with this workshop, ISARD has come a long way since its establishment in 2002. While it has a strong portfolio of grass-root projects, studies and research in the country, this workshop makes a special mark in meaningfully informing the public policy on the basis of empirical and international research partnership. In this regard, I would like to congratulate Dr Mahendra Sethi for his able guidance in bringing together all of you in this room today. I once again thank and welcome all the participants, particularly speakers and moderators who have committed to this workshop at such a short notice. I declare today's workshop open and look forward to some productive deliberations. Thank You.

10:10-10:45 am: Introductory presentation by the network coordinators

Topic: Multiple benefits assessment of the lower emission development strategies in Asia Pacific Cities

Addressed by: Hooman Farzaneh

Key points discussed

1) Cost effective ways to achieve **economical, social and environmental sustainability.**
2) Need of **integrated modelling framework**
3) **Practicability** of the models
4) **Great potential in sustainable economy**
5) Urgent international and domestic problems to be addressed and mitigated
6) Most important is **Climate change and local benefits**
7) Air pollution, water pollution and waste management
8) Model should be competent enough to be able **to achieve the SDGs**.
9) Model: i) **Quantitative Analysis** (identifying policies and strategies to find out optimal plausible portfolio) and ii) **Implementation Analysis** (prioritizing policies considering barriers across the countries)
10) Sectoral approach: Transport, Building, energy etc.
11) **Bottom up approach:** site level **-->** sectoral level –> National **-->** international level
12) **Optimum mix of strategies and technologies**
13) **Potential for Delhi**
    i) Rooftop solar policy
    ii) Waste to electricity generation (current capacity and future plans)
    iii) Energy improvement in Buildings and different sectors
    iv) Promotion of EVs.

Topic: LED workshop and progress

Addressed by: Prof. Benjamin McLellan

Key points discussed

1) To gain insight from experts and stakeholders and to understand current LED plans, progress till date, barriers to the progress and the enablers.
2) **Kulala Lumpur (Initiatives)**
    i) Has a National plan
    ii) Challenges of subsidy removal for fossil fuel
    iii) Changes in plan to boost renewable energy
    iv) Fit and tax breaks

v) Increasing public transport

3) **Sydney** (35 local councils, Large area of the city)
   i) **Initiatives: GHG emission reduction**
   ii) Land use, Infrastructure, Transportation sectors in focus
   iii) Need of place-based interventions.
   iv) Coal fired power stations in Australia to be examined.

4) Best options for **cost and equity for CO2 reduction.**
5) Equity in renewable energy transition
6) **Social equity**
   Equity based approach: GHG reduction and Employment; Health and electricity supply/consumption
   Cost based approach: Mitigation cot (wind power, coal substitute, renewable energy cost etc.)

Topic: LED strategies in Delhi

Addressed by: Dr. Mahendra Sethi

<u>Key points discussed</u>

1) **Baseline emissions**
   Major contributors: **Power plants, vehicles, industries**
   Moderate contributors: MSW burning, domestic
   Minor contributors: refrigerants, crop fields and incinerators
2) **Solar potential of Delhi**
   High solar energy potential in Delhi
   National Solar mission created a need for state level policy to prioritize (**rooftop) small scale solar energy generation.**
3) **Waste to Energy**
   Centralized (Okhla, Timarpur) and Decentralized (Ghazipur)
4) **Need of generation-based incentive**
   To reduce payback time and reduce adoption of solar energy
5) **Opportunities:**
   High energy tariffs and lower solar panel prices,
   Clean transport initiatives
   TOD projects
   EVs promotions
   Waste to energy (5 ULBs in this regard)
6) **Barriers:**
   Long pay-back period
   Absence of generation-based incentive
   No policy towards pushing use of clean energy
   Govt. focus is merely on enhancement of supply
7) Top down approach
8) Lateral decision-making being done by Supreme court, **EPCA**
9) Need for enhancing govt. **Multiple level capacity building and coordination.**

10:45-11:30 am: Policy and Financial Perspective of LED in Delhi (Chair: Dr S.K. Saha)

Topic: Transport Systems and Air Quality in New Delhi

Addressed by: Prof. Sewa Ram

<u>Key points discussed</u>

1) **Delhi being unstable in terms of population and built form (low rise high density) Change in built form on the outer areas from Low rise-high density to High rise-high density.**
2) **Kenya:** the most sustainable society.
3) Problem of pollution in Delhi started in 1980s with the expansion of the city beyond Yamuna bank (Vikas Marg): **Urban sprawl and strengthening of transport network**
4) Delhi's pollution is not caused by Delhi alone rather it is **regional problem**.
5) Delhi has highest car traffic (private vehicle).
6) Air Quality is considerably bad
   High built up
   High pollution
   High night temperature
   Heat island effect add up to the discomfort.
7) **Metro helped** in combating air pollution to some extent
8) Cars should be reduced (Highest PM 2.5 emission)
9) Freight Vehicles should also be controlled
10) Apart from road capacity, **Environmental capacity of the area should be considered**
    <u>*30% reduction in the Capacity of road = Environmental capacity*</u>
11) **Delhi needs to work on its policies**
12) **Role of SC is better than the ULBs**
13) Studies on Fuel based systems are dine in India but
14) **India does not have any future target for emission reduction**
15) **Economics is the key**
16) **High scope of EVs rather EHVs (Electric Hybrid Vehicles)**
    Better technologies of battery should come up
    Change in infrastructure (Favorable to EVs)
17) **Need of travel Demand Management in India** (London and Singapore are best examples for the same)
18) **Car sharing launched in Delhi in 2015 (Ola, Uber)**
    Since then considerable reduction in GHG emission
    Fuel saving
    Reduction in travel cost.
19) **Regional Rail Transit System** (RRTS) is required in Delhi - Rail an effective mass transit system.

Topic: Breathing Green in Delhi (A Proposal for Carbon Tax)

Addressed by: Dr. Rohit Azad

Key points discussed

1) **Energy Policy with Equity** (EPE) Programme in **Ecology and Equity**
2) **Carbon emission control thorough** (SUPPLY SIDE)
   Fossil fuel with low carbon emitting properties
   Efficient energy usage
   Greener forms of energy should be encouraged
3) India is a **price-sensitive market** hence changing price can help
4) Carbon emission control through (DEMAND SIDE)
   Quantity control
   Carbon tax
5) **Tax burden** as a share of income for the LIG & MIG
6) **Income and consumption inequalities** between poor and the rich
   Poor: low income low carbon footprint
   Rich: High income high carbon footprint
   How can the tax be same for both the classes?
7) Plan: 1-300 units consumption (no pay)
   301 < (pay for the entire unit consumed)
   To keep a check on the consumption rates.
8) **Climate injustice Quotient**
   Affluent has 9 time more carbon footprints and GHG emission than the poor.
9) **Potential**
   i) There are high employment opportunities in the greener sectors.
   ii) **Substitution effect-** replace by clean energy.
   Higher fossil fuel prices will force the richer households to look for greener substitutes.
   iii) **Access to all** – government initiatives
   iv) Poor would move away from the traditional energy forms if provided with zero cost clean energy options.
   v) Though free energy would address the issue of stealing of energy
   vi) Reduction in indoor and outdoor air pollution levels
10) Free energy to the Indian population might not be the solution as there is a tendency of stealing.

11:30 – 11:45 : Tea Break

11:45-12:30 am: Research and Best Practices for a Greener Habitat (Chair: Dr B. McLellan)

Topic: Relevance of LED for Enhancing Quality of Life

Addressed by: Shilpi Mittal

Key points discussed

1) Quality of Life is compared with quality of environment with respect to Low Emission Development
2) Quality of Life definition by different author's and researchers were discussed.
    i) QOL is a **multidimensional concept** and it is **context dependent.** (e.g. Good life, Happy life expectancy, People's perception, Degree of Excellence, Happiness, Subjective wellbeing, Life satisfaction, etc.)
    ii) The basic definition of QOL lies in the concept of **Maslow's theory** of five different kinds of needs, which linearly accrete from **objective physiological needs to subjective sense of self-fulfillment** (Bardhan et.al, 2011).
    iii) The QOL of a community has been debated and controversial issue.
3) Dimensions of Quality of Life was discussed
    i) Objective Dimension- **External condition of life** (it is not detailed or qualitative).
    ii) Subjective Dimension- **Satisfaction from objective condition – psychological responses** (vary with time and situation).
    iii) According to ecological economist Robert Costanza: Quality of life has been an explicit and implicit policy goal, adequate definition and measurement have been elusive. Diverse " objective" and " subjective" indicators are used to measure quality of life.
    iv) The QOL of a community has been debated and controversial issue.
4) Relationship between Development, GHGs Emission, Fuel consumption and Environment cost (CO2 emission and natural resources) is stated.
    i) Environment implications of non-renewable and renewable resources.
5) Environmental aspects in QOL Assessment are discussed.
6) Environmental Domain of QOL is derived and discussed.
    i) Environmental
    ii) Physical
    iii) Economical
    iv) Political
    v) Social
    vi) Mobility
    vii) Psychological

    These were in relation with environmental categories like air pollution, climate, natural environment, energy.
7) Low emission development can be achieved through the following parameters to improve Quality of life :
    i) Reduction in Energy Consumption,
    ii) Reduction in the release of air pollutants
    iii) Mitigating rising temperature (Climate & Natural Environment)
8) QOL Rank of Indian Mega Cities v/s their carbon emission shown Hyderabad having Global Rank of 139 and New Delhi-161.
    i) Parameters taken: CO2 emission, City Infrastructure
    ii) Sector wise carbon emission compared
9) New Delhi taken as a Case Study
    i) Urban growth throughout decades was compared
    ii) Ranks 1 in Livability Index , criticized for safety and housing (2011)
    iii) Lowest ranked city for 3rd consecutive year in Mercer Quality of Living Ranking (2018)
    iv) Top Indian city in City Prosperity Index (2012)

10) Suggestive measures to reduce GHG's emission and to enhance QOL in New Delhi, both at Government and Community level :
    i) Promote NMT (Non- Motorized Transport)- Cycling, Walking.
    ii) Use PPS (Public & Para Transit System)
    iii) Alternative Transport Technologies
    iv) Promote Low Carbon Mobility- electric vehicles, avoid congested roads, limit use of private vehicles
    v) Reduce energy demand- Green rated buildings, behavioral change.
    vi) Create energy Security
    vii) Develop Energy Ethics.

Topic: Decentralized Waste Treatment Solutions

Addressed by: Rakesh Prashar

<u>Key points discussed</u>

1) Composting has been acknowledged as an emission reduction methodology by the UNFCCC (United Nations Framework Convention on Climate Change)
2) The Extra emission can be reduced by Decentralize method of composting no waste can be transported to land fill site.
3) A good composting process reaches high temperature which reduces the risk for pathogens.
4) Soil fertility iv increased.
5) SWM RULES 2016
6) Composting machine - Developed on the principle of providing complete composting system in a single machine.
    i) **Aerobic Mechanical Composting-**
        a) Both the shredding &composting take place in a machine employing thermophiling micro organisms to convert the shredded organic waste to compost.
        b) The temperature required for thermophilic process 50-55 Degree Celsius.
        c) Aerobic composting being exothermic reaction generates heat which further helps in removing the moisture by evaporation and renders dry, ready to use compost in a few days (3 to 4 days)
        d) The air exchanges from the composting chamber ensure adequate availability air required for Aerobic composting.
7) Projects done:
    i) **1st Panchayat In Himachal Pradesh, AIMA Palampur –**
    Capacity 250kg/day, from approx 600 houses, Organic Waste Treated 3. 8kg/Greenhouse Gas. 950kg/Gas/Reduced+Co2 Emission
    ii) NOIDA SECTOR 121-
    Capacity 550kg, from approx 1350 flats/family, Organic Waste Treated approx 2090kg/Greenhouse Gas Reduced
8) Benefits:
    i) Improve local living conditions.
    ii) Compost improves the water holding capacity
    iii) Compost improves soil quality

iv) Compost helps clean up contaminated soil.
v) Compost helps control erosion.
vi) Compost makes and save money water is at a premium these days and composted soil reduces the amount of water consumed by plants etc.

Topic: Energy Efficiency in Built-Environment

Addressed by: Kanagaraj Ganesan

<u>Key points discussed</u>

1) Why to design energy efficient built environment-
   i) India is the fourth largest consumer of energy in the world, seventh largest producer of energy
   ii) Shortage of electricity.
   iii) plant efficiencies along with transmission & distribution losses
   iv) energy that is not used is cleaner than any other source of energy.
   v) Energy Consumption Scenario - The electricity consumption in commercial sector has increased at a much faster pace compared to other sectors during 2005-06 to 2013-14 with CAGRs of 8.82%
   vi) Implementation of Energy Conservation Building Code will ensure construction of energy efficient buildings with reduced electrical energy by 30% to 40%
2) Energy Efficiency in ULBs (Urban Local Bodies)
   i) Implementation of Energy Conservation Building Code
   ii) Energy Efficiency in Water Pumping
   iii) Energy Efficiency in Street Lighting
   iv) Energy Efficiency in Municipal Buildings
3) **Energy Conservation Building Code**
   i) Evolution of the Code
   ii) ECBC Revised in 2017
   iii) Development of Code
   iv) Governance system :
      a) Central Government- ECBC development and updating,
      b) State Government- Amend ECBC to meet state requirements, Revision of DCR/Model Building Bye-law
      c) Local Government- Revision of ULB bye-laws and approval process, Enforcement of ECBC
   v) **ECBC Implementation Support**
      a) Capacity Building
      b) Demonstration Projects
      c) Revision of Schedule of Rates
      d) Compliance Tools
      e) Monitoring and Verification (M&V) system, etc.
   vi) ECBC provides the minimum requirements for energy efficient building design, construction and operation.
   vii) The Code also provides two additional sets of incremental requirements for buildings to achieve enhanced levels of energy efficiency that go beyond the minimum requirements

viii) The Code is applicable to buildings or building complexes that have- **Connected load =100 kW or Greater or Contract demand = 120 kVA** and are intended to be used for commercial purposes.

ix) Buildings intended for private residential purposes only are not covered by the Code.

x) **Energy Efficiency Performance Levels -** The code prescribes the following three levels of energy efficiency:
   a) **ECBC Building** (Energy Conservation Building Code Compliant Building)
   b) **ECBC+ Building** (Energy Conservation Building Code Plus Building)
   c) **SuperECBC Building** (Super Energy Conservation Building Code Building)

xi) Components of ECBC
   a) Comfort system & Controls,
   b) Lighting & Controls,
   c) Electrical & Renewable Energy Systems.

xii) Compliance Approach
   a) Applicable Components,
   b) Compliance method- Mandatory Requirements(required for all), Prescriptive Method, Whole building Performance method,

xiii) ECBC Amendment & Notification

xiv) Life cycle of a Building
   a) Project Pre Sanction Stage,
   b) Sanction Stage,
   c) Building Permit Approvals,
   d) Construction stage,
   e) Completion cum Occupancy Stage,
   f) Operational Stage.

xv) ECBC Approval and Steps

xvi) Integrated Approach for Building Energy Performance- Building Stage

xvii) Energy Service Companies

xviii) Energy Efficiency Improvements

4) Difference between an Consulting Firms & ESCO
5) ESCO- Energy Services Companies offer energy efficiency improvement services which may also include guarantee of the savings. Energy Services Companies offer energy efficiency improvement services which may also include guarantee of the savings.
   i) Integrated Service Provider
   ii) Project Execution Process
   iii) ESCO Model : Shared Saving, Guaranteed Savings.
6) **International Protocol for Measurement and Verification (IPMVP)**
   i) **Option A:** Partially Measured Retrofit Isolation
   ii) **Option B:** Retrofit Isolation
   iii) **Option C:** Whole Facility
   iv) **Option D:** Calibrated Simulation
7) **Climate Change and Urban Form (Design Innovation Center – SPA)**
   i) The project aims to consider energy and comfort as deterministic parameters to develop three-dimensional forms for mass housing in India.
   ii) Aims to explore the relationship between factors that influence the making of built environment and resultant urban form.

iii) The track examines the defining role played by factors like climate, nature, culture, landform, technology, real estate, etc. in the shaping of forms and spaces of past, present and future city environments.

iv) As per McKinsey, it is expected that India will add more than 20 billion square metres of residential floor area to meet the housing needs of the increasing population. It is both, a challenge as well as an opportunity for designers to develop

v) These prototypical design explorations will offer design and technological solutions from the macro level to micro level.

vi) **Research Output:**

   a) At the macro scale (i.e. at site level), this project will investigate the indices of Urban Heat Island (UHI) and outdoor comfort of prototypical urban forms as per existing DCR.

   b) The project will focus on the impact of anthropogenic contributions, surface finishes and landscape interventions.

   c) The project will evaluate the passive building components (e.g. building envelope) and low energy ventilation systems to reduce overall energy intensity (embodied and operational energy) of housing stock.

   d) To develop an easy-to-use tool integrated with the design software (Revit or Rhino etc.) used by designers.

vii) This tool will foster informed decisions by assessing design implications for different sustainability criteria through the various stages of design. The projected outcome of this experiment will enable us in devising optimal typologies of housing for different city contexts.

12:30 -12:55 pm: Group discussion on implications for Delhi (Chair: Dr Mahendra Sethi)

Participants' opinions and group discussion on challenges and opportunities of LEDS in Delhi, with a special focus on the following areas:

1- Rooftop PV and solar policy
2- Waste-to Electricity policy in New Delhi
3- End-use energy efficiency improvement (buildings and industry)
4- Promotion of Battery Operated Vehicles

COMMENTS GIVEN BY OBSERVERS (Dr Subhakanta Mohapatra, IGNOU and Ms. Raina Singh, TERI)

<u>Key points discussed</u>

I. Holistic Planning and Implementation Measures ,

   a) Amravati- Net zero energy consumption & GHG Emission
   b) High risers= 30-40% higher energy consumption (due to elevators, etc.)
   c) Paris Agreement
   d) Local & State Level Implementation
   e) Green city implementation ratings (Govt. of India+ GRIHA)
   f) Tools to identify mode of transport as per population and energy consumption.
   g) Taxation and penalties

II. APN project
   a) Communicate research to government
   b) Policy brief & share with MoUA or MoEFCC.

III. Integration of Social, Cultural & Spatial Parameters

IV. More case studies of Delhi required

V. Awareness of problem and implications on decision making

VI. Transport-
   a) Lack of Infrastructure for battery operated vehicles or solar vehicles.
   b) Mileage of these vehicles is a problem
   c) Battery replacement cost is higher than vehicle replacement.
   d) Registry of vehicles as per parking availability (followed in Japan)
   e) Car is no longer a status symbol, it has become a necessity due to lack in public transport.
   f) Metro better than car (traffic congestion). More congestion, lesser cars.
   g) Number of cars as per household size

VII. Smart cities-
   a) Energy efficiency
   b) Renewable energy
   c) Integrated approach
   d) Compliance requirements
   e) Rating and incentive given
   f) Regulations and Economic parameters (savings is directly dependent on Cost)

VIII. Housing groups or economic status- as per energy consumption not income (LIG, MIG,HIG)

IX. Energy & Resource Savings= Incentives & Finance

X. Social & Cultural Habits (behavioural change with respect to quality of life, land & parking)

12:55 pm – Vote of thanks, followed by Lunch

Expert Workshop on Low Emission Development Strategies in shanghai

8 Jun 2018

Organized by:

UNEP-Tongji Institute of Environment for Sustainable Development

Kyushu University Platform of Inter / Transdisciplinary Energy Science

Venue:

UNEP-Tongji Institute of Environment for Sustainable Development

Coordinators:

- WANG Xin, Vice Dean of UNEP-Tongji Institute of Environment for Sustainable Development (IESD)
- Hooman Farzaneh, Associate Professor, Kyushu University Platform of Inter / Transdisciplinary Energy Science
- Yuki Kudoh, Group Leader of Advance LCA Research Group, Research Institute of Science for Safety and Sustainability, National Institute of Advanced Industrial Science and Technology (AIST).

Workshop tentative program

9:00-9:30 am: Introductory presentation by co-organizers

9:30-10:30 am: Presentations by the invited speakers (Stakeholders) - Part One

10:30-11:00 am: (coffee break)

11:00-11:30am: Presentations by the invited speakers (Stakeholders) - Part Two

11:30am - 12:30pm: Group discussion on particular issues

12:30pm - Close then Lunch

Minutes:

1. Prof. Hooman firstly introduced the ANP organization. The sponsors of ANP are the Ministry of Environmental Protection of Japan, New Zealand and Korea. ANP's work is mainly to assess the benefits of LED in Asia Pacific cities, including air, water and waste. The first

phase of ANP research has come to an end. ANP conducted research on the carbon emissions of Asia-Pacific countries (China, India, Japan, Korea, Malaysia, Australia, etc.) and analyzed the carbon emissions data in combination with the economy, society, and the environment. Currently, carbon emissions and future predictions in Shanghai are being studied. The attending teachers stated that research on low-carbon development in Shanghai needs to be conducted based on the locality of the data and reference to the latest policies. For example, existing research needs to update Shanghai Planning 2040 content to Shanghai Planning 2035 to present the current research. The situation is that the meeting is to see the benefits of everyone's views on China's situation and policies, and to see the future scenarios (positive impacts of low-carbon emissions on the economy, health, etc.)

Comments:
Clean energy accounts for less than 20% of the total, and in 2025 it will receive peak time, if will try to reduce 5% of the carbon emission

Renewable energy should be 2% in 2020 (shanghai), 20% around the whole china

2. Prof. Liao Zhenliang spoke about the situation of China's carbon emissions market under the context of the Paris Agreement; at the global level, he introduced the flexible mechanism of the post-Paris era global carbon market. According to the level of the framework of the mechanism framework, the type of mechanism, the content of the subject matter, and the operation and management of the mechanism, the cooperation method (cooperative mode), and the sustainable development mechanism (Sustainable Development Mechanism) are designed.
Comments:
The data from the National Data Center comes from open documents on the UNFCCC website. The model of the mechanism construction framework adopts similar models of some of the previous studies of the New Market Mechanism (NMM) and briefly describes the current development of the Chinese carbon market.

3. Prof. Guo Ru first'y introduced the importance and determination of the global response to climate change, and then introduced China's emissions from international carbon emissions. At the Shanghai level, the Shanghai 2035 Master Plan proposes that carbon emissions will reach a peak value by 2025 and carbon emissions by 2035 It is 5% lower than in 2025. At present, the carbon emission intensity in Shanghai is decreasing, and the energy-intensive sector is still the industrial sector; at the Chongming level, Guo Ru introduced the carbon neutrality research situation in Chongming as a world-class As for the Chongming Island of ecological islands, land use changes have an important impact on carbon balance. Overall, the task of carbon reduction is very arduous and the road is very long-term, but we are always on the road. The main reasons for the carbon emission targets, documents, conditions, changes in energy structure, and carbon emissions in Shanghai were introduced. The carbon deposition in Chongming Island was outstanding, and the CNC indicators.
Comments:
It is very close to our research content. I hope to further discuss and study the content. (include Health and Safety)

4. Dr. Hu Jing introduced the basic conditions of green development and low-carbon development in Shanghai. In terms of green development, per capita public green space in Shanghai has grown from $0.132m^2$ in 1949 to $12.75m^2$ in 2015, using remote sensing and GIS tools to Shanghai. Greenland is classified. In the aspect of low-carbon development, the challenges faced by the 13th Five-Year Plan in Shanghai are: the pressure of GHG control, the

challenge of environmental protection, the men of energy conservation and pollution prevention, and the ecological civilization policy has brought new opportunities; and then introduced the thirteenth five-year plan. Emission reduction requirements and environmental protection requirements for different sectors during the period. In the comparison of international cities, Hu Jing introduced the relevant situations in London, New York, Tokyo, Rome, Stockholm, and Shanghai. Overall, the per capita carbon emissions of Shanghai (1.5vs2.6) and the per capita carbon emissions of industry (0.7vs5.1) Higher, but the per capita carbon emissions from buildings are lower (4.8 vs. 1.9), and per capita water use and waste generation are lower.

5. Dr. Li Jin introduced the basic situation of China's carbon emissions trading market, and introduced in detail the history of carbon emissions trading in Shanghai, the method for allocating carbon emission initial rights, the types of industries involved in carbon emissions trading, and the status of enterprises.

Through this workshop, guests exchanged the views on low-carbon development research with teachers from Tongji University and explored the possibility of further research. It is believed that with the joint efforts of Tongji and ANP in the future, LEDS research can effectively help the low-carbon development of Asia-Pacific cities.

4th International Workshop on Clean Energy Development in Asian Cities

26 October 2018

Venue:

Kyushu University, Ito Campus

Organized by:

Kyushu University Platform of Inter / Transdisciplinary Energy Science

Sponsors:

KYUSHU UNIVERSITY

APN

JAPAN SOCIETY FOR THE PROMOTION OF SCIENCE 日本学術振興会

Aim and Scope of the 4th workshop

The 4th workshop is designed to provide a solid understanding of key policies and instruments which can be developed in order to boost the capacity of societies to establish Low Emission Strategies Development (LEDS) in Asian cities and achieve the local and global goals of sustainable development. This workshop will capitalize on three hot topics:

1- Low Emission Strategies Development (LEDS) in Shanghai, Kuala Lumpur and Tehran:

a. How the concept of LEDS has evolved in the climate policy discourse in these cities

b. The gaps that LEDS could fill in these cities;

2- Lesson learned from the implementation of LEDS in Tokyo and Sydney

3- The future direction of LEDS in Asian cities from the point of view of the intersection between policy and technology.

Chairs

- Associate Professor Hooman Farzaneh, IGSES, Kyushu University, Japan
- Professor Hideaki Ohgaki, IAE, Kyoto University, Japan

Scientific Committee

- Professor Jun Tanimoto, IGSES, Kyushu University, Japan

- Professor Takahiko Miyazaki, IGSES, Kyushu University, Japan
- Professor Aya Hagishima, IGSES, Kyushu University, Japan
- Professor Keiichi N. Ishihara, Graduate School of Energy Science, Kyoto University, Japan
- Associate Professor Benjamin McLellan, Graduate School of Energy Science, Kyoto University, Japan
- Associate Professor Robert Lindner, Q-pit, Kyushu University, Japan

Workshop Program

	Introductory:	
9:00 – 9:30	Registration	
9:30-9:45	Welcome Address	Prof. Akira Harata, Kyushu University, Japan
9:45-10:00	Workshop program overview	Assoc. Prof. Hooman Farzaneh, Kyushu University, Japan Prof. Hideaki Ohgaki, Kyoto University, Japan
	Session I Moderators: Prof. Keiichi N. Ishihara, Kyoto university, Japan Prof. Aya Hagishima, Kyushu University, Japan	
10:00 – 10:30	Carbon Balance Analysis and low carbon development in the context of climate change the case study of Chongming Island in Shanghai, China	Assoc. Prof. GUO Ru, Environmental Planning and Management Institute, Tongji University, China
10:30 – 11:00	Future Design of Sustainable Energy Visions Using a Backcasting Approach	Dr. Yusuke Kishita, The University of Tokyo, Japan
11:00 – 11:30	**Break**	
	Session II Moderators: Prof. Jun Tanimoto, Kyushu University, Japan Assoc. Prof. Benjamin McLellan, Kyoto university, Japan	
11:30-12:00	Regional revitalization through collaboration among industry, government and academia: Focus on energy infrastructure in Japan	Assoc. Prof. Muhammad Aziz, Institute of Innovative Research, Tokyo Institute of Technology, Japan
12:00-12:30	Governance for integrated solutions to climate change and sustainable development: From linking issues to aligning interests	Nobue Amanuma, Institute for Global Environmental Strategies, Japan
12:30-14:00	**Lunch**	
	Session III Moderators: Prof. Hideaki Ohgaki, Kyoto University, Japan Assoc. Prof. Robert Lindner, Kyushu University, Japan	
14:00 – 14:30	Designing for renewable energy and resource cycles: Opportunities in a circular economy	Prof. Damien Giurco, University of Technology Sydney, Australia
14:30- 15:00	Low Emission Development Strategies in Iranian cities: Challenges and Strategies	Prof. Yadollah Saboohi, Sharif University of Technology, Iran
15:00 – 15:30	**Break**	

	Session IV Moderators: Prof. Takahiko Miyazaki, Kyushu University, Japan Assoc. Prof. Hooman Farzaneh, Kyushu University, Japan	
15:30- 16:00	Ideas from Baseline Study for Low Carbon Langkawi, Malaysia	Prof. Nasrudin Abd Rahim, UM Power Energy Dedicated Advanced Centre, University of Malaya, Malaysia
16:00-16:30	Solar power and Japanese cities: "duck back" electricity demand and the role of batteries	Prof. Miguel Esteban, Global Center for Science and Engineering Waseda University, Japan
16:30 – 17:00	**Break**	
17:00-17:15	Launch of the workshop book : Devising a Clean Energy Strategy for Asian Cities	Assoc. Prof. Hooman Farzaneh, Kyushu University, Japan Dr. Mei Hann Lee, Springer Nature
17:15-17:40	Workshop wrap-up	Prof. Keiichi N. Ishihara, Kyoto University, Japan
17:40-18:00	Closing remarks	Prof. Jun Tanimoto, Kyushu University, Japan
18:00-20:30	**Dinner**	

Abstracts:

Carbon Balance Analysis and low carbon development in the context of climate change the case study of Chongming Island in Shanghai, China

Assoc. Prof. GUO Ru, Environmental Planning and Management Institute, Tongji University, China

Increasing urbanization raises both opportunities and challenges for global sustainability and low carbon development. With the increasing carbon constraints in the context of climate change, the capacity of carbon sequestration becomes an important resource to address regional sustainable development. However, there is still a lack of an integrated methodology to evaluate urban sustainability within a local urbanization process from a carbon cycle perspective. The concept of carbon neutral coefficient (CNC) is proposed based on the estimation of carbon emissions and sinks, which emphasizes the fundamental role of carbon sinks in achieving low carbon development and improving local sustainability. Taking Chongming Island of Shanghai (China), the largest alluvial island in the world, as a case study, carbon emissions and sinks are calculated respectively according to an integrated carbon inventory and local coefficients. The results showed a temporal-spatial variation of CNC in the study area, owing to the different growth rate of carbon emissions and sinks. Furthermore, a spatial variation of change of CNC was detected, caused by the imbalanced spatial distribution of carbon emissions and sinks. Remote Sensing based analysis shows that the change of land use and cover which was induced by human activities can greatly influence local carbon balance and sustainable development. Consequently, sustainability requires balance between emissions and sinks at different levels according to local situations, which needs integrated assessment of mitigation and adaptation actions.

Future Design of Sustainable Energy Visions Using a Backcasting Approach

Dr. Yusuke Kishita, The University of Tokyo, Japan

A summary of my presentation (250 words) The adoption of Sustainable Development Goals (SDGs) by the United Nations brings a good opportunity to design energy visions for sustainable futures. In particular, Japanese local governments are strongly encouraged to plan long-term energy policies in a way that is consistent with SDGs. This presentation aims to propose a method for designing sustainable energy visions on municipal scale by integrating a backcasting approach and Future Design. Future Design refers to a concept to exploit the voices of imaginary future generations, aiming to reflect them in the decision-making process. With discontinuous change in mind, we propose a six-step procedure to design energy visions where we integrate brainstorming sessions by holding participatory workshops and a computer-aided scenario design methodology using Sustainable Society Scenario (3S) Simulator developed by the author's laboratory. Drawing on four participatory workshops, we carried out a case study to describe sustainable energy visions and associated pathways for Suita City to 2050. Four different energy visions were eventually created, all of which achieved a 75% CO_2 reduction target for 2050 set by the city. The results showed that the four visions differ in goals to be achieved, such as CO_2 reduction, energy self-sufficiency, and compact city. It was also revealed that there is difference in the needs between future generations and the present generation.

Regional revitalization through collaboration among industry, government and academia: Focus on energy infrastructure in Japan

Assoc. Prof. Muhammad Aziz, Institute of Innovative Research, Tokyo Institute of Technology, Japan

The effort of regional revitalization in Japan has been initiated in 2014 and strongly emphasized as the effort from the local regions to improve and boost their economic performance. Therefore, this revitalization covers all the living sectors, including energy, economy, social, and environment. As a research organization under Tokyo Institute of Technology focusing on the development of energy systems, AES (Advanced Energy Systems for Sustainability) Center has also involved in several activities related to the regional revitalization in Japan. It creates and promotes research project in order to identify the optimum solutions to such issues through open innovation, in which the industries, governments, and academia are able to equally participate. Several regional revitalization projects have been established in collaboration with the industries, local governments and academia. In this opportunity, two representative projects are presented: Smart City Hamamatsu and Tsuhima Environment and Energy Consortium. The concept and characters of each project, as well as the challenges faced during the development, are discussed.

Designing for renewable energy and resource cycles: Opportunities in a circular economy

Prof. Damien Giurco, University of Technology Sydney

Access to clean energy is pivotal for supporting sustainable development goals. The majority of humanity now lives in cities which creates a pervasive demand for resources, including to underpin the clean energy transition. Ensuring the responsible stewardship of resources and energy for all remains an important under-addressed challenge. This paper focuses on the role of the city and the citizen (using examples from Sydney and Australia) to explore the intersection of the resource-energy nexus at different scales, from households and organizations, to the impacts of cities on regions and nations. The paper proposes strengthening critical perspectives and governance regarding the resource-energy nexus by being explicit about who benefits in future demand and efficiency scenarios. It examines how resource and energy business models are changing – including opportunities as the circular economy develops – and the new policy challenges arising from the clean energy transition, for example, managing end-of-life photovoltaics and energy storage batteries. Finally, it questions the captivating influence which the rise of the smart cities agenda has on progressing renewable energy and resource cycles and sustainable development more generally – where does connected data help? where does it hinder? and how might we ensure that technology and policy are thoughtfully deployed to benefit future societies.

Ideas from Baseline study for low carbon Langkawi, Malaysia

Prof. Nasrudin Abd Rahim,University of Malaya

In 2007, Langkawi was declared by UNESCO as one of the global Geoparks and the first Geopark Island in South East Asia. Naturally, this prestigious international recognition has inspired Government to embark on the Low Carbon Langkawi (LCL) program to transform the island into a Low Carbon Island by 2030. Subsequently, this work was initiated to establish a baseline study on the energy consumption, CO_2 emission and avoided in Langkawi, which will facilitate a comprehensive Low Carbon Langkawi study in the future. This report presents the data collected and the analysis, covering the social-economic, energy and environmental aspects of Langkawi, which are subdivided into nine (9) sectors, namely, Transportation, Industry, Commercial, Residential, Agriculture, Power Generation, Waste, Water and Forest. Two types of data mining activities were conducted throughout the project; preliminary data mining using a top-down approach, and detailed data mining using a bottom-up approach. The data presented in this report includes data which are obtained directly from the relevant agencies or published documents, as well as primary data extracted through surveys, measurements and stakeholder engagements done by the project team.

Solar power and Japanese cities: “duck back” electricity demand and the role of batteries

Prof. Miguel Esteban, Global Center for Science and Engineering Waseda University, Japan

As the uptake of solar power continues in cities and urban areas throughout the world, concern about the intermittency of renewable energy is being replaced by the appearance of “duck back” electricity demand profiles. Such problems already exist in California, which have required the development of new classes of fast-reacting resources to help meet the very steep ramp in demand that can take place in the late afternoon, when solar power fades yet electricity demand stays steady (or even increases). This problem is yet to impact Japan, but given the large increases in installed solar PV capacity it the country, it will likely manifest itself in the near future. To compensate for such issues there will clearly be a need to integrate a wide range of types of renewable energy that are geographically distributed throughout the country. The use of a variety of electrical storage mechanisms can also play a role in balancing such a system. The author will present work that outlines the magnitude of the problem and potential solutions to it, through the analysis of a realistic model of the Japanese grid that uses renewable energy sources and electrical batteries. The simulation uses hourly meteorological data to simulate the amount of electricity that could be produced, and this was compared with the hourly electricity demands imposed on the system. The conclusions will highlight how it will be necessary for the Japanese government to incentivise private individuals to not only install PV panels on their rooftops, but to also start acquiring the batteries or electric cars that will be necessary to smoothen the overall electricity demand curve.

Governance for integrated solutions to climate change and sustainable development: From linking issues to aligning interests

Nobue Amanuma, Institute for Global Environmental Strategies, Japan

Energy is one of the key issues included in the Sustainable Development Goals (SDGs). Energy is also closely interlinked with other goals of the SDGs, making it important to tackle energy issues in an integrated manner. In fact, many policymakers are responding to the SDGs by integrating multiple concerns, including energy issues, into their development plans. However, much of the recent research to support policymakers on SDGs implementation has focused on developing models and analytical frameworks to identify linkages across a wide range of issues. Fewer studies have examined the governance arrangements needed to align agency and other stakeholder interests behind integrated solutions. The recent IGES policy report titled "Governance for integrated solutions to sustainable development and climate change: from linking issues to aligning interests" aimed to fill this gap by determining whether and to what extent three different dimensions of governance—horizontal coordination, vertical coordination, and multi stakeholder engagement—affected integrated approaches concerning climate and other sustainable development issues. Based on this publication, this presentation will briefly discuss linkages between energy and other sustainable development issues and introduce some integrated approaches addressing linkages between energy and other goals such as 1) co-benefits, 2) sustainable transport, and 3) the water-energy-food nexus. Then, the presentation will discuss, based on case studies, whether and to what extent three different dimensions of governance were important to align agency and other stakeholder interests behind integrated solutions.

Model framework of innovative transition pathways of energy in mega cities: Case of Tehran

Prof. Yadollah Saboohi, Sharif University of Technology, Iran

Rapid growth of large cities in Iran has been due to social and economic development, concentration of administration and services in large cities and migration of population from other parts of the country, specially from rural areas, to metropolitans. But development of infrastructures has not been compatible with rapid growth of population and urban planning has rarely supported changes that have been taken place in last 3 decades. As a result, cities with large number of populations in general and mega cities in particular have been confronted with multidimensional and complex problems. Persistence of multi facet issues in mega cities has led to increased consumption of energy, considerable accumulation of pollutants in air, waste of time due to intense traffic system, extensive production of waste materials, unreliable supply of water, social disparity and inefficient uses of resources. Present state of affairs in mega cities has caused extensive external costs and it has reduced quality of life. The consequence of externalities has undermined stability and sustainability of life and society. A central element of lack of sustainability has been observed to be the growing fossil energy demand. Increased energy demand is involved with high emission of air pollutants and formation and concentration of low size particles. Such a phenomenon has also caused inversion in certain times of the year and it has contributed to low economic productivity and reduced life time and chaotic social behavior. Improvement of energy efficiency, substitution of fossil fuel consumption with renewable energies, changes in the structure of mobility and optimal maintenance of utilities in household and service sectors are understood as important undertakings. Therefore, identification of reliable solution to complex problems requires innovative measures and transition pathways. Identification, formulation and implementation of innovative transition pathways have investigated in various case studies in Tehran as a mega city in Iran and an integrated model for analysis of different development paths towards a clean and resilient city are being developed. The integrated model includes different modules that are being used as analytical tools for better understanding of different dimension of problems in mega cities. The general framework of the integrated model shall be presented that could support investigation of transition pathways towards identifying optimal options which could help developing roadmap for energy transition in mega cities. The presentation shall be concluded by introduction of a policy framework that has been formulated based on the result of model application.

Kyushu University Platform of Inter/Transdisciplinary Energy Research (Q-PIT)

<Date> 14:00-18:00, 29th January 2019

<Venue> Inamori Hall, Kyushu University Ito Campus

<Language> English

<Theme> "Q-PIT & APN Workshop: Low-Carbon Energy Transitions in Asia: Interdisciplinary Perspectives"

< Program and Speaker>

Time	Program and Speaker
14:00-14:10	**Introduction** ● Welcoming remarks
14:10-15:15	**Session 1: Global Perspectives on Energy Transitions** (Moderator: Assoc. Prof. Robert Lindner) • Marilyn A. Brown (Regents' and Brook Byers Professor of Sustainable Systems in the School of Public Policy, Georgia Institute of Technology) • Scott Valentine (Professor and Associate Dean of Sustainability and Urban Planning, School of Global, Urban and Social Studies, Royal Melbourne Institute of Technology)
15:15-16:15	**Session 2: Low-Emission Development Strategies in Asia** (Moderator: Assoc. Prof. Hooman Farzaneh) ● *RPS Mechanism and REC trading for Low Carbon Energy System* (Development in China); Zhang Qi, Professor, Dean, Academy of Chinese Energy Strategy, China University of Petroleum-Beijing ● *Making Asia and the Pacific's Skies Blue Again: Implementing 25 Solutions to Help 1 Billion People Breathe Cleaner Air by 2030;* Eric Zusman, Research Director, Institute for Global Environmental Strategies (IGES), Japan
16:15–16:30	Short break

16:30-17:30	**Session 3: Research Projects on Energy Transitions in Asia at Kyushu University** (Moderator: Assoc. Prof. Robert Lindner) ● *How Does Information and Communication Technology Capital Affect Productivity in the Energy Sector? Evidence from 14 Countries*; Hidemichi Fujii, Associate Professor, Department of Economy and Business, Kyushu University ● *Contrasting Bottom-Up and Top-Down Policy Approaches to the Japanese Energy Transition*; Andrew Chapman, Assistant Professor, I2CNER, Kyushu University ● *Multiple impact assessment of the Low emission development strategies in Asian cities*, Hooman Farzaneh, Associate Professor, Q-PIT, Kyushu University ● *Climate change and ecosystems*; Wataru Nozawa, Assistant Professor, Department of Urban and Environmental Engineering, Faculty of Engineering, Kyushu University
17:30-18:00	**Session 4: Panel Discussion & Wrap-up** (Moderator: Prof. Shunsuke Managi)
18:00	End of session

Student training workshop on low carbon urban energy system

Period: August 18th to August 24th, 2019

Place: Energy and Environmental Systems Laboratory (EES), Department of Energy and Environmental Engineering, IGSES, Building E, Room 106, Chikushi Campus, Kyushu University, Japan

Participants:

Canada: Students from the School of Engineering Technology and Applied Science (SETAS), Centennial College, SaGE, Toronto, Canada
Japan: Students from EES laboratory, IGSES, Kyushu University, Japan

Purpose:

Understanding of key policies and instruments which can be developed in order to establish a low carbon urban energy system:

- ✓ How clean energy planning contributes to urban resilience and sustainability?
- ✓ Which initiatives are most promising? What are their policy implications?
- ✓ What is the rule of local governments in deploying sustainable urban energy system?
- ✓ What are the main drivers and challenges for the sustainable urban energy system?

Organizers:

- Q-PIT: Kyushu University Platform of Inter / Transdisciplinary Energy research
- Centennial College, SaGE, Toronto, Canada

Program

	10:00-12:00	12:00-13:00	13:00-15:00
August 19, 2019	Introduction to the EES lab's research activates and orientations	Lunch break	Lecture on: Low Emission Development Strategies in the urban energy system **Prof. Hooman Farzaneh, Kyushu University, Japan**
August 20, 2019	Lecture on: Climate change co-benefit and sustainable development in Asia **Dr. Eric Zusman, Institute for Global Environmental Strategies, Japan**	Lunch break	Lecture on: 2050 energy scenarios in Japan **Dr. Hadi Farabi-Asl, Kyushu University, Japan**
August 21, 2019	Laboratory Tours & Visits	Move to Ito Campus by shuttle bus	1) Lecture on: Fuel cell and Hydrogen Technology **Prof. Stephen Lyth, Kyushu University, Japan** 2) Visiting Hydrogen and fuel cell laboratory
August 22, 2019	Introduction to Urban Co-Benefits Assessment Tool (UCAT)	Lunch break	Hands-on exercise with the tool
August 23, 2019	Hands-on exercise with the tool	Lunch break	Showcase presentation
August 24, 2019	Cultural tour in Fukuoka		

Urban Co-Benefits Assessment Tool (EES laboratory)

This tool is a simulation model designed for evaluating the climate co-benefits of an urban energy system in the short term. The tool assesses climate co-benefits of the urban energy system based on different scenarios of socioeconomic, technological, and demographic developments. http://farzaneh-lab.kyushu-u.ac.jp/Tools.html